Practical domestic hygiene / by J. Lane Notter and R.H. Firth.

Contributors

Notter, J. Lane 1843-1923.
Firth, R. H. Sir, 1858-1931.

Publication/Creation

London : Longmans, Green, 1897 (London : William Clowes.)

Persistent URL

https://wellcomecollection.org/works/rpw96t7j

PRACTICAL DOMESTIC HYGIENE

NOTTER & FIRTH

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BY

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LONGMANS, GREEN, AND CO.
39 PATERNOSTER ROW, LONDON
NEW YORK AND BOMBAY
1897

PREFACE

THIS little work is intended for those who, without any previous knowledge of the subject, desire to acquire a knowledge of Elementary Hygiene. Inasmuch as this cannot be gained without some acquaintance with Elementary Physiology, it has been deemed advisable to furnish a few short chapters upon this latter branch of science. These chapters, however, are not intended to take the place of the elementary text-books upon Physiology, necessary for young students, but should be considered rather as furnishing a concise statement of the essential facts connected with the subjects to which they refer, and upon which the principles of sanitary science are based.

As bearing closely upon the general subject of Public Health, the authors have embodied in this volume certain chapters dealing with the purely domestic aspect of preventive medicine. This portion of the book is intended to give some plain rules and information to non-professional persons, to enable them to render immediate aid in the many circumstances of accident or illness which occur in our daily life; these chapters have been made essentially practical, and freed as much as possible from all theoretical statements. If used and regarded strictly as an aid in the absence of a medical man, rather than as a substitute for him, we hope these chapters may be of very considerable value.

In no sense is this little work to be regarded as an alternative for the regular and more advanced books which discuss the subject of hygiene in its many bearings ; it is put forward merely as an introductory manual for domestic use, preparatory to a more extended and practical study of public health work.

WOOLSTON, HANTS,
July, 1897.

CONTENTS

PART I.

ELEMENTARY HUMAN ANATOMY AND PHYSIOLOGY.

PART II.

ELEMENTARY HYGIENE.

PART III.

DOMESTIC ECONOMY.

PRACTICAL DOMESTIC HYGIENE

PART I.

ELEMENTARY HUMAN ANATOMY AND PHYSIOLOGY.

CHAPTER I.

ANIMAL EVOLUTION.

THE first and highest duty of every person is to keep himself healthy; if he succeed in doing this, he will be in a fair way to perform his duty to his neighbour and himself. If a person lose health and become sick, he not only suffers himself, but causes trouble, expense, and discomfort to those about him, and, in some cases, causes loss of health to others as well.

The health of a nation or community depends upon the health of the units which compose it; and upon this condition of health depends the moral and intellectual progress of both single persons and communities. Since national health depends upon the health of individuals, patriotism and a desire for self-preservation ought equally to prompt each person to keep well. The health of the individual is mainly, though not entirely, in his own keeping, and the study of disease prevention constitutes the subject called Hygiene; the same subject is sometimes called Sanitary Science, and includes a study of the natural conditions under which we live and which are necessary for our well-being—such are the water we drink, the air we breathe, the food we eat, the conditions of our houses and towns, our clothing, and our daily habits. Subsidiary to the subject of Hygiene is that of Domestic Economy, or the study of certain questions closely connected with our daily life, more particularly the causes and management of sickness and disease. Hygiene is based largely upon Anatomy or the science of the structure of our body, and upon Physiology or the science of the functions of our bodily organs; to understand the principles and practice of the first, an elementary knowledge of the other two is absolutely necessary.

Life in its simplest form is best illustrated by the little mass of jelly to be found in most ponds and rivers, called the **amœba.** Such a mass consists of **protoplasm** (*protos*, first; *plasma*, form), that is, a "first form," no single part of which differs from any other part. The amœba digests without a stomach, breathes without lungs, feels without nerves, and moves without muscles. The amœba eats by flowing round a substance, embedding it in the jelly of its body, and thus at once digesting or swallowing it. After a time, the matter which it cannot digest is ejected or thrown off as useless. It breathes by absorbing oxygen from the dissolved air in water, and gives it out again as carbon dioxide. The amœba is in a continual condition of flow, for, pushing out first one part and then another, it moves or flows from one place to another. It propagates its kind by simple buds, a little bit becomes detached, and then starts life on its own account, being, like its parent, a shapeless mass of protoplasm.

Life in its highest and most complicated form is **man,** and he is nothing but a collection of just such minute masses of protoplasm as the amœba. There is, however, this difference, that, in the great collection of protoplasm masses which we call man, the greater number of the amœba-like masses of protoplasm have lost the power of moving from place to place, but, rooted to one spot, they have, by changing their shape and nature, acquired special functions and duties. One set of protoplasmic masses has become altered into hard material called bones, another into muscles, another into brain and nerves, while others constitute the organs of special sense, such as our eyes and ears. Each of these differentiated masses of protoplasm constitute a tissue or a mixture of tissues. If such a tissue be examined under a microscope, it is found to consist of a number of units or **cells** built up together. One tissue differs from another in the nature of its cells, and the way they are connected together, "just as one wall may differ from another wall in its bricks, and in the way in which the bricks are laid."

If these tissues be examined chemically, they will be found to be composed of a number of organic and inorganic compounds.

The organic compounds of the body may be classified into the nitrogenous and the non-nitrogenous. The **nitrogenous** contain nitrogen as well as carbon, hydrogen, and oxygen. They include the bodies known as proteids, such as albumin, globulin, myosin, fibrin, gelatin, and chondrin. The **non-nitrogenous** compounds contain carbon, hydrogen, and oxygen only; they include the fats, oils, starches, sugars, and certain organic acids.

The **inorganic** or mineral compounds found in the bodily tissues are mainly derived from our food and drink. The chief are water, calcium carbonate, calcium phosphate, and common salt.

With a little reflection we can understand how each human being is in himself a small city. Each little citizen or mass of protoplasm or cell has its appointed place and duty. Those in the brain store up the nervous force, those in the muscles store up power of movement, those in the bones the power of rigidity, and so on; high up in the brain resides a something called "mind," which should rule over all. Just as any departure from a state of health of any one of the body-citizens or protoplasm masses disturbs the whole human being, so in a community of human beings the disease of any single individual reacts upon, and is a source of danger and weakness to, the whole of that society.

We have to study how this city, the city of Human Life, has to be kept in health and order; and as we pursue this inquiry, we shall find that in all the requirements of life, and in all our work, there are many circumstances which may cause disease, and which we must therefore avoid. In the air we breathe, in the water we drink, in the food we eat, in the clothes we wear, in our habits, our occupations, and our houses, we shall find diseases awaiting us; these we can only hope to control or avoid by a thorough knowledge of their methods of attack.

SUMMARY.

The health of the community being closely identified with the health of the individual, patriotism and a desire for self-preservation ought equally to prompt each person to keep well. How to secure this end is the object of the study of Hygiene. Hygiene, however, is based largely upon Anatomy and Physiology; hence, to follow the one an elementary knowledge of the others is absolutely necessary.

Life in its simplest form is typified in the simple amœba. Man himself is but a conglomeration of differential amœboid masses; and just as any departure from a state of health of any one group of protoplasmic masses in the human body tends to disturb the whole human being, so in a community of human beings the disease of any single individual reacts upon and is a source of danger to the whole of that society.

CHAPTER II.

GENERAL CONSTRUCTION OF THE BODY.

THE simplest division of the human body is into the head, the trunk, and the limbs. These divisions are made up of a framework or skeleton formed of bones and cartilages. The bones and cartilages are bound together by means of ligaments, and are so arranged as to support the flesh or soft parts and to protect delicate organs.

The Head consists of the skull and the face, and is connected to the trunk of the body by the neck. The skull or cranium consists of eight bones immovably united together, and in shape resembles a spheroid, being compressed on the sides, and broader behind than before. Within the cranium is situated the brain. The face is composed of fourteen bones, all these, excepting the lower jaw, being closely united to each other. The face surrounds the mouth and nasal passages, and with the cranium completes the orbits or cavities for the eyes.

The Trunk owes its chief support to the spine or vertebral column. The spine is composed of a series of bones called vertebræ, which are so joined together by cartilages and ligaments that, although the amount of movement allowed between each pair is small, the total movement is sufficient to make the whole **vertebral column** extremely flexible. The vertebral column may be said to consist primarily of thirty-three vertebræ; of these, the upper twenty-four (seven cervical, twelve dorsal, and five lumbar) remain separate and mobile throughout life; the lower nine gradually, as years advance, consolidate into two masses, known respectively as the sacrum (five vertebræ), and coccyx (four vertebræ). (Fig. 1.)

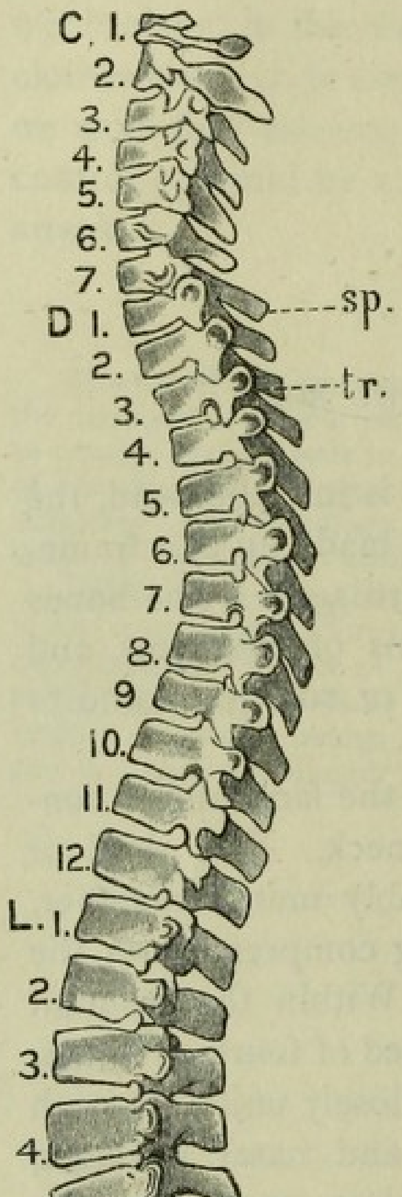

FIG. 1.—The Vertebral Column. *C*, 1–7, cervical vertebræ; *D*, 1–12, dorsal vertebræ; *L*, 1–5, lumbar vertebræ; *S*, sacrum; *C*, coccyx; *sp*, spinous processes; *tr*, transverse processes.

Each individual **vertebra** consists in front of a cylindrical disc, or body, and behind of an aperture enclosed by two symmetrical portions which spring from the posterior surface of the vertebral body to meet behind in a bony projection readily felt in the middle of the neck and back; this bony projection is known as the spinous process of the vertebra. On either side from the base of the spinous process springs another bony projection known as the transverse process. The vertebral apertures or rings are so arranged one over the other that the whole form a hollow canal extending from the skull above to the coccyx below; in this canal lies the spinal cord. One of the dorsal vertebræ is shown in Fig. 2; this will serve as a type of the whole class.

The Thorax.—The upper part of the trunk consists of the chest or thorax, which is formed by the spinal column behind and a flat bone called the **sternum** or breast bone in front, with the ribs joining them together on either side (Fig. 3). The **ribs**, twelve in number on each side, constitute a series of arched and very elastic bones extending outwards and forwards from the vertebral column to form the lateral walls of the thorax. Each rib is attached to the corresponding dorsal vertebra, so that each dorsal vertebra carries a pair of ribs. In front the ribs are prolonged into cartilages, the upper seven pairs of which pass forwards and inwards to join the breast bone. The cartilaginous prolongations of the five lower ribs do not join the sternum, but each of the upper three of these five lower ribs has its cartilage attached along its superior border to the cartilage of the rib above it; the two last have no such attachment, and are in consequence sometimes called free or floating ribs.

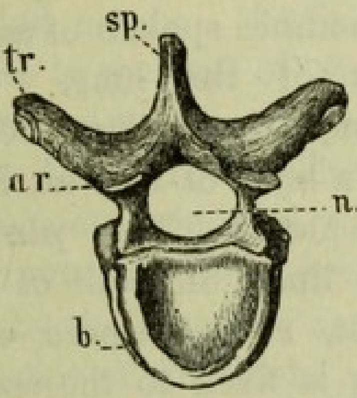

FIG. 2.—A Dorsal Vertebra.

b, body; *sp*, spinous process; *tr*, transverse process; *ar*, place where it articulates with vertebra next above; *n*, canal for spinal cord.

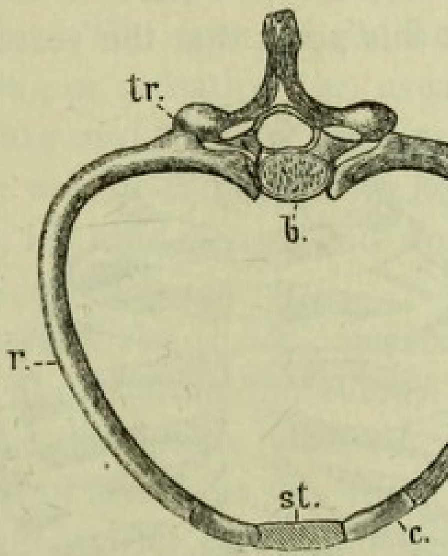

FIG. 3.—Articulation of a pair of Ribs to a Vertebra.

b, body of vertebra; *tr*, transverse process; *r*, rib; *c*, costal cartilage; *st*, sternum.

The skeleton of the thorax (Fig. 4), therefore, consists of the dorsal vertebræ, the sternum, the ribs and their cartilages. The whole is somewhat conical in shape, flattened from before back and much longer behind than in front. The sides are sloped outwards to about the ninth rib, are slightly convex from above down, and distinctly arched from before back. The upper aperture is contracted, being formed by the first rib, which with the muscles at the root of the neck constitutes the upper limit of the cavity. The lower aperture is irregular in shape, and filled by the diaphragm or large muscle which separates the cavity of the thorax above from that of the abdomen below. At the sides of the thorax between the ribs are the intercostal muscles, the whole being covered by large muscles passing from the back and front over the chest to the arms. Over these muscles are some fat and skin. On the inner surface of the chest wall is a thin membrane called the pleura.

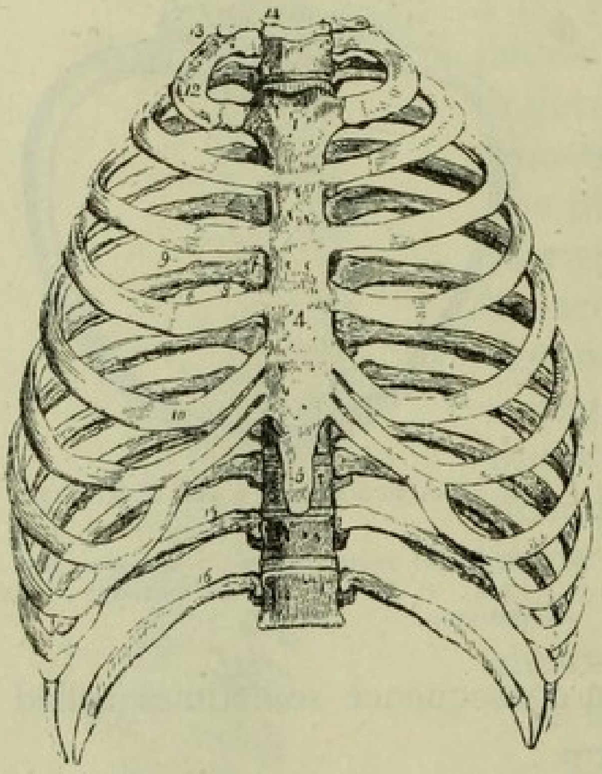

Fig. 4.—Skeleton of the Thorax.

1–4, sternum; 5, ensiform cartilage; 6, groove along upper border of ribs; 7, vertebral end of rib; 8, 9. neck and tuberosity of rib; 10, costal cartilage; 12, 13, first rib; 14, first dorsal vertebra; 15, eleventh rib; 16, twelfth rib.

Within the cavity of the thorax are situated the lungs, the heart, and some of the great vessels. The lungs are placed one in each half of the thorax; each lung is free from the chest wall, except where it is fixed to the vertebral column; it is at this point that the vessels from the heart and the tube from the trachea or windpipe go into it; this part is sometimes spoken of as the root of the lung. Surrounding each lung, forming a kind of bag for it, is the pleura. This pleura also lines the wall of the chest, except where each lung is fixed to the spinal column; here it meets the root of the lung and passes over the whole of the surface of the lung so as to complete its bag-like shape. From the lung tissue, the pleura cannot be readily separated; in fact, it is this closely adhering pleura which gives the lung its smooth appearance. Owing to each lung, during life and health, being filled with air, it entirely fills each lateral half of the chest cavity, and consequently causes the layer of pleura stretched over the surface of the lung to be closely applied to the layer of pleura which lines the chest wall. By this arrangement there is practically no space between the lung and wall of the thorax, or at most only sufficient room for a thin layer of fluid, which suffices to keep the surfaces of each pleural layer moist, so that they may readily glide on or against each other.

Lying between the lungs, and obliquely across the left front of the thorax, is the heart. This organ, like the lungs, is contained in a membranous bag, known as the **pericardium.** It is about as large as the closed fist of the person to whom it belongs, is shaped like a cone, with its base just underneath the sternum at the level of the third rib, and with its apex touching the front wall of the chest in the space between the fifth and sixth ribs on the left side. The apex of the heart touches the chest wall, and its beating or pulsation can usually be distinctly felt about one inch below and half an inch inside of the left nipple. While the front wall or surface of the heart lies close to the wall of the thorax, its hinder part and upper and outer edges are covered by the left lung.

The Abdomen.—The lower part of the trunk consists of the abdomen, which is separated above from the thorax by the thin muscular partition called the diaphragm; behind, it is limited by the vertebræ and muscles of the loins; in front, by the muscles of the flanks and of the anterior wall; and below by the pelvis or bony girdle formed by the two hip or haunch bones with the sacrum and coccyx. To the hip bones are attached the thigh bones. The lowest portion of the abdomen, or that part enclosed by the pelvis, is often spoken of as the **pelvic cavity.** Lining the whole abdominal and pelvic cavities is a thin membrane called the **peritoneum**; this membrane covers also all the various organs contained in these cavities.

Within the cavity of the abdomen are situated the stomach and intestines, the liver, the pancreas, the spleen, the kidneys, the bladder, and the rectum. The **stomach** lies on the left side, just under the diaphragm; its right end is prolonged or passes into the first portion of the small intestine called the **duodenum.** This first portion of the bowel is about ten inches long and passes slightly to the right, then down and to the left, so as to form a loop or bend; its continuation is the **jejunum** or second part of the small intestine, which again is prolonged into the **ileum** or chief portion of the small bowel, which finally at the lower part of the abdomen, on the right groin, opens into the large intestine. The whole length of the small intestine, that is duodenum, jejunum, and ileum, in the form of innumerable coils, is about twenty feet. The large intestine begins in the right groin in a somewhat dilated portion called the **cæcum**; it is here that the small intestine opens into the large, the junction being marked by two folds of tissue which form a valve known as the **ileo-cæcal valve**; this valve is so arranged that, while matter can pass from the small into the large intestine, any reverse movement is not possible. In general characters the large intestine is broader and less coiled than the small intestine. It is continued from the cæcum up the right side of the abdomen to just below the liver, there it turns to the left and crosses below the stomach to pass down the left side, where it passes on as a more or less straight tube some nine inches long called the **rectum,** to end at the external opening or **anus.** The whole large intestine, including the rectum, is about six feet long; that portion between the cæcum

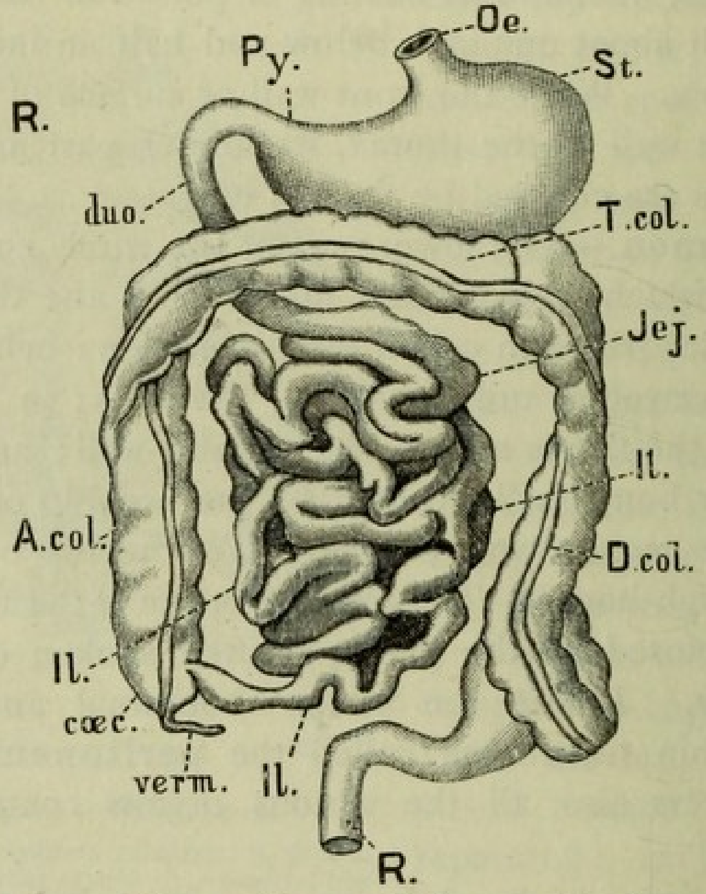

FIG. 5.—Diagram of Alimentary Canal.

R, right; L, left; *œ* œsophagus; *st*, stomach; *Py*, pylorus; *duo*, duodenum; *Jej*, jejunum; *Il*, ileum; *cæc*, cæcum; *A. col*, ascending colon; *T. col*, transverse colon; *D. col*, descending colon; *R*, rectum; *verm*. vermiform appendix.

and the rectum is known as the **colon**, and, according as to whether it is passing up, across, or down the abdomen, is spoken of as the ascending colon, the transverse colon, or the descending colon (Fig. 5).

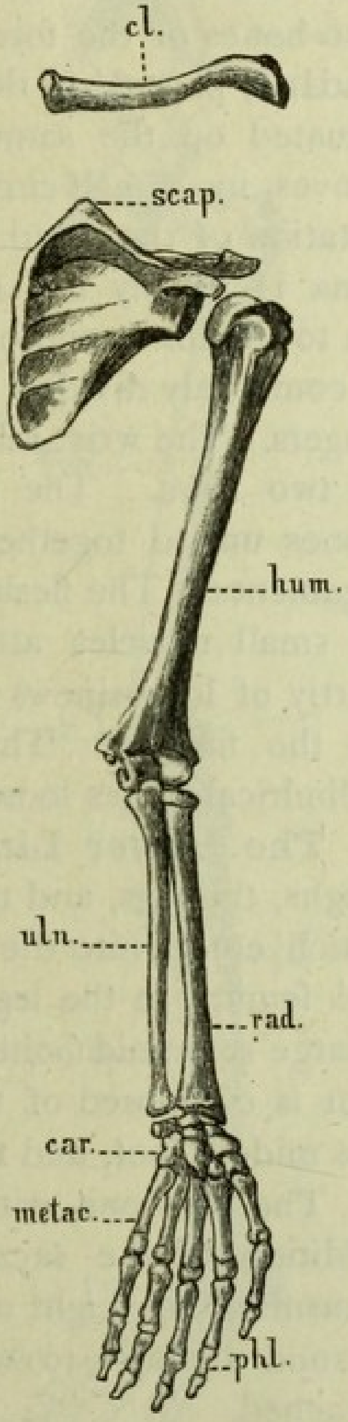

Fig. 6.—Bones of the Upper Limb.

The **liver** lies in the abdominal cavity high up on the right side, close under the arch of the ribs and diaphragm.

The **pancreas** is some seven inches long, and lies across the abdomen in the bend or loop of the duodenum; it is covered in front by the transverse colon and by the stomach.

The **spleen** lies on the left side of the abdomen, under the stomach, and just to the left of the end or tail of the pancreas.

The **kidneys** lie deep in the abdomen, one on each side of the vertebræ. The right kidney is under the liver, the left one close under the spleen.

The **bladder** lies quite at the lower part of the abdomen, right in the pelvic cavity; it is situated in front and in the middle line. Immediately behind it passes the rectum.

The Upper Limbs consist of the shoulders, the arms, the forearms, and the hands. The bones of the shoulder are the clavicle and scapula, which together form the pectoral arch or shoulder-girdle. The **clavicle** or collar bone is curved like an italic *f*, and extends horizontally outwards and backwards at the root of the neck from the top of the sternum or breast bone. At its outer end it connects with the **scapula** or shoulder-blade. This scapula is a flat triangular bone lying on the back of the upper part of the thorax. It is not attached directly to the trunk, but is simply articulated with the outer end of the clavicle, and from it is suspended the arm bone or **humerus.** This arm bone is strong and reed-shaped, extending from the shoulder to the elbow, where it articulates with the two bones of the forearm. The bones of the forearm are the **radius**, placed on the same side as the thumb, and the **ulna**, situated on the same side as the little finger. The radius moves in a half-circle round the ulna, and so allows of rotation of the hand. The peculiar hook-shaped end of the ulna is readily felt at the back of the elbow-joint. Joined on to the lower end of the radius and ulna is the hand, which is commonly divided into the wrist, the middle hand, and the fingers. The wrist really consists of eight small bones arranged in two rows. The middle hand consists of five elongated bones united together and to the wrist and fingers by strong ligaments. The fleshy part or palm of the hand consists partly of small muscles attached to the middle-hand bones, and partly of long sinews or tendons which pass from the forearm to the fingers. The fingers themselves consist of small cylindrical bones loosely united together by ligaments.

The Lower Limbs consist of the haunches or hips, the thighs, the legs, and the feet. In the haunch is the hip bone, which enters into the formation of the pelvis; in the thigh is the femur; in the leg the tibia and fibula; and at the knee a large sesamoid bone known as the patella or knee-cap. The foot is composed of three parts, namely, the tarsus or ankle, the middle foot, and the toes.

The hip bone, with its fellow of the opposite side, and the addition of the sacrum and coccyx, forms the **pelvis**; it transmits the weight of the body to the lower limb, and affords a solid support to which the powerful lower limb can be attached.

The thigh bone or **femur** is the longest and strongest bone in the human body. Its ball-shaped enlargement at the upper end forms, with the socket in the hip bone, the hip or thigh joint. Of the two bones in the leg, the inner one is the **tibia** or shin bone, while the outer one is the **fibula.** At the upper end of the tibia is the joint surface, which articulates with the lower end of the femur to make the knee joint; in front of this joint, embedded in a strong tendon and supported by ligaments, is the **patella** or knee-cap. The lower ends of the tibia and fibula form the inner and outer ankles, and, with one of the seven bones of the tarsus called the astragalus, form the joint of the ankle. Of the other six bones of the tarsus, the most important is the heel bone or os calcis, this lies immediately beneath the astragalus and goes to form the heel; to the hinder end of this heel bone is attached a strong sinew or tendon belonging to the muscles of the calf of the leg; this sinew is known as the tendon of Achilles.

The foot is composed partly of the bones of the tarsus and partly of the metatarsus or middle foot and those of the toes. The middle foot bones are five in number as in the middle hand, and like the metacarpal bones are long, slightly convex from end to end on the upper aspect, and have rounded ends which articulate with the phalanges or bones of the toes. There are three phalanges in each toe except the big toe, which has two only.

The foot is narrowest at the heel, and, as it passes forward, becomes broader as far as the heads or ends of the metatarsal or middle foot bones. The foot is arched from behind, forward and also transversely, the hinder pier of the arch being the heel, and the front one the heads of the metatarsal bones. In a standing position the foot rests on these piers or supports, so that the outer edge of the foot touches

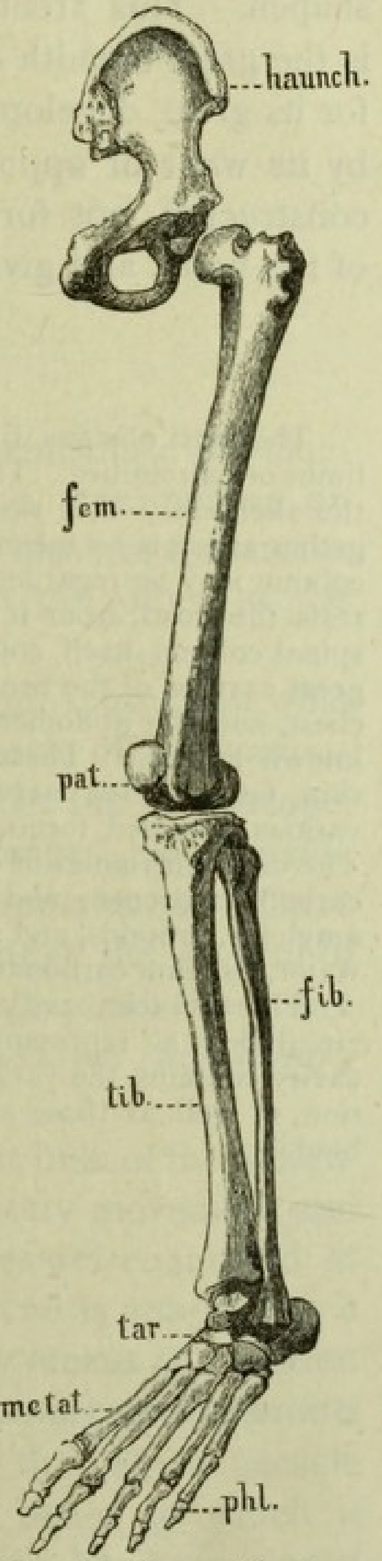

FIG. 7.—Bones of the Lower Limb.

the ground; the inner edge is so much arched that it does not touch the ground, except in those whose feet are really misshapen. This arching of the foot is peculiar to man, so also is the great breadth of the sole. The great toe is distinguished for its great development, and especially from that of the ape by its want of opposability; the reason of this is that it is constructed, not for grasping, but for supporting the weight of the body, and giving spring to the step.

SUMMARY.

The most obvious division of the human body is into head, trunk, and limbs or extremities. The body itself is built upon a bony framework called the skeleton. This skeleton consists of bones and cartilages united together at joints by means of fibrous bands called ligaments. The vertebral column may be regarded as the central portion of the skeleton, as upon it rests the head, from it spring the upper and lower extremities, while the spinal column itself constitutes an important portion of the walls of the great cavities of the trunk. These cavities are two, namely, the thorax or chest, and the abdomen. The soft parts of the body constitute what is known as flesh. These soft parts consist of a variety of tissues, such as skin, fat, muscles, nerves, and blood vessels; all these tissues again, in various modified forms, enter into the structure of the internal organs. The different tissues of the body contain the four chief elements, oxygen, carbon, hydrogen, and nitrogen; also such organic substances as fats, amyloids, proteids, and albuminoids, as well as such inorganic substances as water, calcium carbonate, calcium phosphate, and common salt.

The thoracic cavity contains the important organs of respiration and circulation, as represented by the lungs and heart; while the abdominal cavity contains the various organs connected with digestion and assimilation, as well as those associated with excretion, such as the kidneys and bladder.

CHAPTER III.

THE MUSCULAR SYSTEM.

The Muscular System.—The muscles constitute the chief part of the flesh of the body, forming the prominences on the limbs and most of the soft tissues; they also are the means by which the bones are moved one upon the other at the joints.

The general character of muscle is familiar to us in what we call lean meat, this being really the muscle of the various animals used for food. When examined under the microscope, muscle is seen to consist of long fibres arranged side by side in bundles, and bound together by a thin membrane. There are two kinds of muscles, namely, those under the control of the will, or the so-called *voluntary* muscles, and those not under the control of the will, or the so-called *involuntary* muscles.

The voluntary muscles form the great bulk of the muscular system, and give us the power of voluntary movement and locomotion. The majority of these muscles are connected at one or both ends with bones; usually one end is attached to a fixed bone, and the other end connected by means of a tendon or sinew to the bone to be moved. This arrangement permits that when the muscular fibres contract, the whole muscle shortens and thickens, causing one of the bones to which it is connected to be moved. After the bone has been moved by any given muscle, it is brought back to its original position by the contraction of a second muscle placed so as to be antagonistic in its action to the other. The fibres of which voluntary muscles are composed are marked, when observed under the microscope, by minute transverse lines or stripes; for this reason they are often spoken of as striated fibres.

The involuntary muscles are found chiefly in the muscular walls of the internal organs and blood vessels. The fibres which compose them are really fine elongated cells with pointed ends, but not marked transversely or striated.

Every muscle contracts on the application of some stimulus or irritation. In the body, the stimulus is conveyed to the muscular fibres from the brain by means of the nerves which are freely distributed among the fibres.

Most of the muscular acts of the body are mechanically carried out on the principle of the lever, which is nothing more than a rigid bar capable of being turned freely about a fixed point called the fulcrum. **Levers** are classified under three orders, according to the position of the fulcrum, the power, and the weight. In the movements of the body we find examples of all three forms of lever. Thus, the movement of the head backwards and forwards is an example of the first order, the fulcrum being in the middle, and formed by the spinal column supporting the head. When the muscles at the back of the neck contract, the face is raised; when the opposing muscles in the front of the neck contract, the back of the head is raised. In this case, the face and back of the head represent alternately the power and the weight. Raising the body on the toes is an example of the second kind of lever, as the fulcrum is the ground, the power is applied at the end or behind the heel, and the weight of the body is in the middle. The third variety of lever is represented in the action of raising the forearm. Here the elbow-joint forms the fulcrum, the hand is the weight to be raised, and the power is applied by the contraction of the biceps muscle attached to the forearm.

Muscular effort is manifested in the maintenance of the erect position, as demonstrated by the fact that a dead body will not stand upright. During life, the muscles of the calf and of the front of the leg contract and hold the tibia in an erect position; similarly the muscles of the thigh keep the femur erect above the tibia, and those in front and behind the hip-joint fix the pelvis ; also the muscles of the back and abdomen fix the trunk, and the muscles of the neck steady the head. Thus, standing still, like walking, running, or jumping, requires much and carefully adjusted muscular action.

SUMMARY.

Muscles are of two kinds, namely, voluntary or striped muscles, and involuntary or unstriped muscles.

Voluntary muscles are under the control of the will, and are composed of bundles of fibres. These bundles are composed of smaller bundles, visible to the naked eye ; these bundles again are made up of fibres, each of which is itself composed of minute fibrillæ. Each of the fibrillæ is composed of a number of disc-like bodies, and are consequently striated transversely.

Involuntary muscles are not under the control of the will. They exist chiefly in the muscular walls of the internal organs and blood vessels. Their fibres are composed of elongated cells with pointed ends, not marked transversely.

The muscles are concerned in all body movements ; and in the case of the voluntary muscles have attachments to one or more bones, which they move at the joints. The various movements of the bones and parts of the body can be mechanically explained upon the principle of the lever. There are three orders of levers, namely, the first, in which the fulcrum is between the power and the weight ; the second, in which the weight is between the fulcrum and the power ; and the third, in which the power is between the fulcrum and the weight. All three orders of lever are represented in the body. Thus, the first order is illustrated by rocking of head on top of spine, and by the motion of the body on the hip ; the second is illustrated by raising the body on the toes, and by lifting the leg off the ground ; the third is illustrated by raising the forearm, and by extending the leg.

CHAPTER IV.

THE CIRCULATORY SYSTEM.

The Blood is that red and opaque fluid which flows in every part of our bodies, and which, if we are cut or wounded, flows from us. The blood really consists of a transparent, colourless fluid, named the **plasma**, in which are floating a vast number of minute, solid particles, or corpuscles. These corpuscles are of two kinds—the coloured and the colourless; the former are the more abundant, and are known as the red corpuscles; the latter as the white corpuscles. The number of white corpuscles varies much more than the red, the proportion of white to red varying from 1 to 1000 to 1 to 250; as a general statement, it may be said that there are about five hundred times as many red corpuscles as white or colourless ones.

The plasma of the blood is a viscid fluid, coagulating spontaneously when blood is drawn from the body. When blood is drawn from the body, the plasma separates into two parts, namely, into **fibrin**, or a solid mass of fine interlacing filaments, in which are entangled the corpuscles; and a pale yellowish liquid called **serum.** What is the precise origin of the material called fibrin, and which really constitutes the chief portion of an ordinary blood clot, is not absolutely certain; but it is generally believed to be produced by a change in, or the decomposition of, a soluble globulin present in the plasma called *fibrinogen*, coupled, possibly, with the action of a ferment developed by the breaking up of the white blood corpuscles.

The **red corpuscles** are minute bi-concave discs. Their size varies often even in the same drop of blood; the greater number measure $\frac{1}{3200}$ of an inch in diameter, and about one-fourth of that in thickness. If viewed singly by transmitted light, the red corpuscles do not appear red, but rather reddish yellow, or yellowish green; it is only when a layer of them is seen together that a distinct red colour is apparent. When blood is drawn from the body, the red corpuscles sink in the plasma; they, moreover, have a peculiar tendency to run together or cohere by their broad surfaces, so as to form cylindrical columns, like piles or rouleaux of money. The corpuscles are very soft and flexible, readily changing their shape when pressed against each other; this physical property of the corpuscles enables them to be forced or squeezed through spaces which are much smaller than their diameter. Each red corpuscle is formed of two parts—a coloured and a colourless; the former being a solution of *hæmoglobin*, the latter a spongy, elastic substance called the *stroma.* If water be added to a preparation of blood under the microscope, the water is imbibed, and the concave sides of the corpuscle bulge out until it becomes spherical. If the blood be treated with salt water, the corpuscles shrink and wrinkle up. The **hæmoglobin,** which is characteristic of the red corpuscle, is a complex body consisting of globin, united with a nitrogenous substance rich in iron, called hæmatin. The hæmoglobin of human blood decomposes very rapidly, and becomes converted into globulin

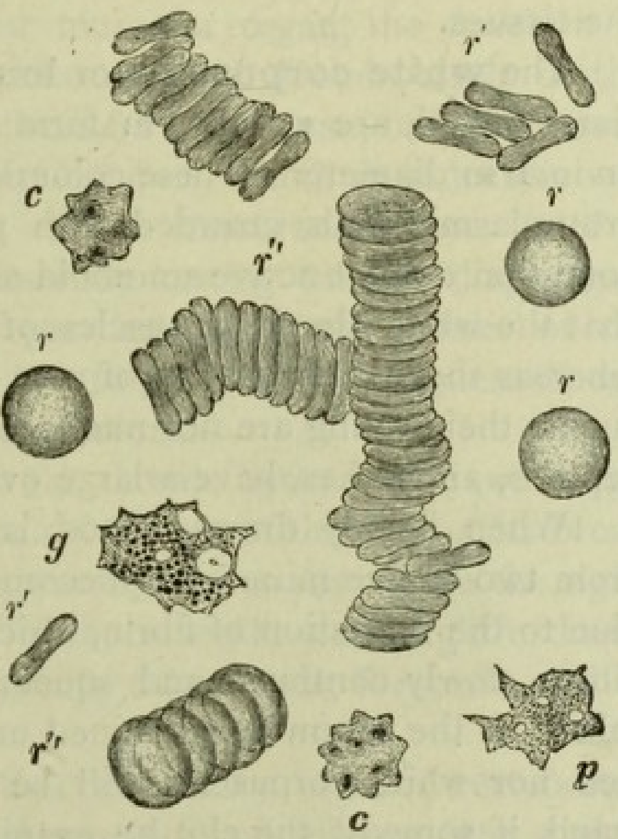

FIG. 8.—Human Blood Corpuscles.

r, *r*, single red corpuscles seen lying flat; *r'*, *r'*, red corpuscles viewed in profile; *r''*, red corpuscles arranged in rouleaux; *c*, *c*, crenate red corpuscles; *p*, a finely granular pale corpuscle; *g*, a coarsely granular pale corpuscle.

and hæmatin. The relations of hæmoglobin to oxygen are important, as it is this substance which carries oxygen from the lungs to all parts of the body. In the lungs the hæmoglobin absorbs oxygen, which enters into a loose chemical union with it; hence, in the red corpuscles of arteries we meet with oxy-hæmoglobin; and in those of venous blood, reduced or deoxidised hæmoglobin. The changes of colour in the blood are entirely due to these conditions of oxidation or deoxidation of the hæmoglobin, the deoxidation occurring in the tissues.

The **white corpuscles**, or **leucocytes**, as they are sometimes called, are variable in form and measure about $\frac{1}{2500}$ of an inch in diameter. These colourless corpuscles are nucleated protoplasmic cells crowded with granules, and in the living condition exhibit active amœboid movements. It is noteworthy that the white blood corpuscles of all animals are nucleated, whereas the red corpuscles of man and of those animals which suckle their young are not nucleated; those, however, of birds, reptiles, and fishes, have a large oval nucleus.

When freshly drawn, blood is perfectly fluid, but within from two to five minutes it becomes viscid or thick. This is due to the formation of fibrin, which solidifies the whole. The fibrin slowly contracts and squeezes out the serum from the **clot.** If the serum be examined under the microscope, neither red nor white corpuscles will be found in it; on the other hand, if some of the clot be examined, the fine meshwork of fibrin will be seen to be crowded with corpuscles. If any delay occurs in the clotting, some of the corpuscles have time to sink, with the result that the upper layers of the clot are lighter in colour than the rest—these layers are called the buffy coat. The formation of the clot is hastened by anything which favours the breaking up of the white corpuscles, and the formation of fibrin from fibrinogen present in the plasma. In the living body a clot is formed when the lining of the blood vessels is damaged; so also the formation of a blood clot is the normal manner in which hæmorrhage is arrested when blood vessels are injured.

In addition to the fibrinogen existing in solution in the plasma and bodies known as globulin and albumin in both the serum and the plasma, these fluids contain salts; they are chiefly carbonates, chlorides and phosphates of potassium and sodium, with some of calcium and magnesium. It is owing to these salts that the blood is alkaline.

About one-thirteenth of the weight of the body consists of blood, and just as the whole organism lives on the things around it, so do the various tissues of the body live on the blood, which is to them their immediate means of nourishment.

The Heart is a hollow muscular organ, the function of which is to propel the blood through the blood vessels of the body. Its general form is that of a blunt cone, being enclosed in a serous sac called the *pericardium*, which is reflected over its whole external surface. This membranous sac is of a somewhat conical shape, its base resting on the diaphragm, while the upper narrower part surrounds the trunks of the great vessels. It consists of two layers, one external and fibrous, the other internal and serous.

The heart is situated in the thorax, between the two lungs, being nearer to the front than the back of the chest; its broad end or base is directed upwards, backwards and to the right, and placed opposite the sixth, seventh, and eighth dorsal vertebræ; while the apex points downwards, forwards, and to the left.

The heart of man, like that of all warm-blooded vertebrates, is divided by a longitudinal partition or septum into a right and a left half, each of which is again subdivided by a transverse constriction into two compartments, communicating with each other and named *auricle* and *ventricle*. This division of the heart into four chambers is more or less manifest from the outer surface, where a deep transverse groove or furrow divides the heart into the auricular and ventricular portions, and longitudinal furrows on the anterior and posterior surfaces mark its further division into a right and left chamber. In these furrows run the special arteries, veins, lymphatics, and nerves of the heart, embedded usually in a certain amount of fat.

The **right auricle** of the heart occupies the right and anterior portion of the base of the organ. It is of a quadrangular form, the upper and lower venæ cavæ occupying respectively the upper and lower posterior angles, while an ear-shaped appendix part projects from the anterior and upper angle. The interior of the right auricle presents a smooth

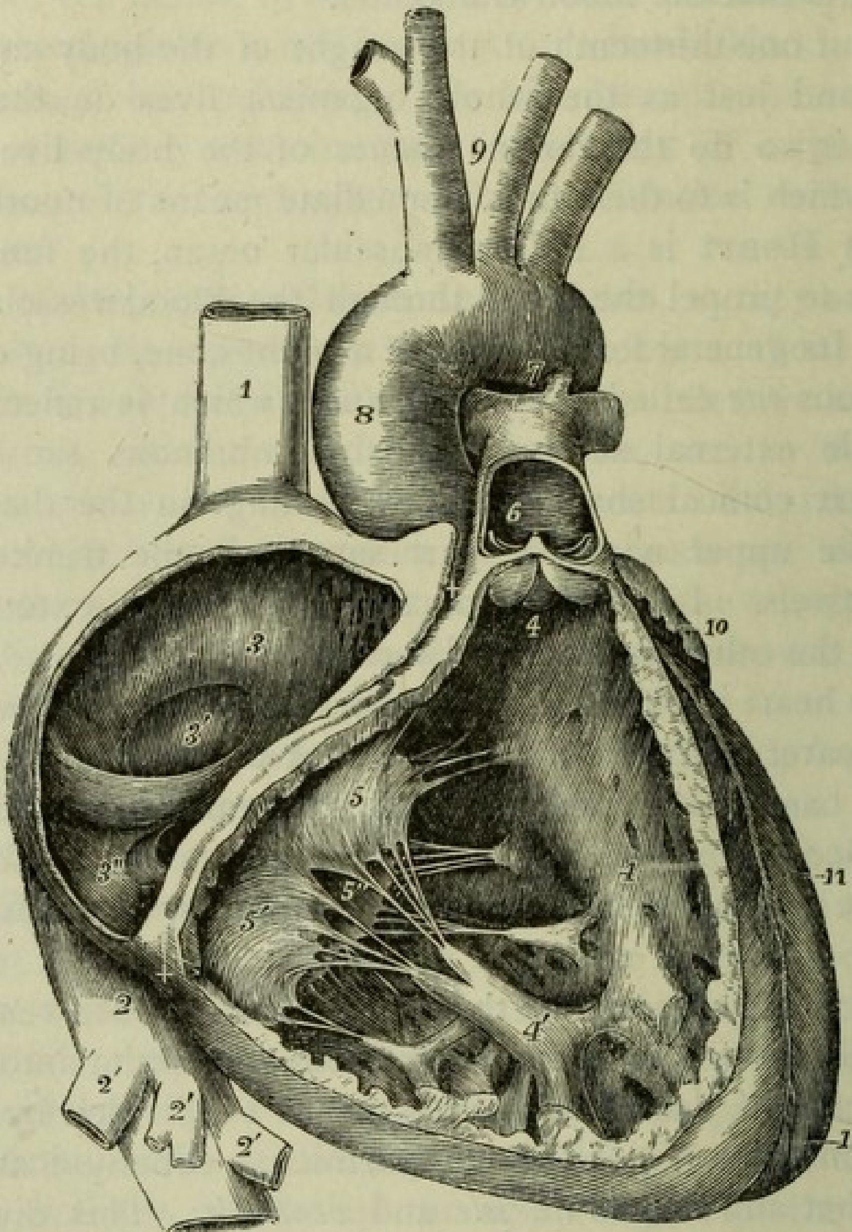

Fig. 9.—Interior of the Right Auricle and Ventricle.

1, superior vena cava; 2, inferior vena cava; 2', hepatic veins; 3, septum between the auricles; 4, septum between the ventricles; 4', a papillary muscle; 5, 5', 5'', segments of the tricuspid valve; 6, pulmonary artery with valve; 7, arch of the aorta; 8, ascending aorta; 9, placed between the innominata and left common carotid arteries; 10, appendix of the left auricle; 11, left ventricle.

surface, except in the appendix, which is ridged by muscular bands known as the *musculi pectinati* because they are arranged like the teeth of a comb.

The **right ventricle** occupies the chief part of the front surface and right border of the heart, extending nearly to the apex. It is triangular in shape, with its upper and left angle prolonged like a funnel to the commencement of the pulmonary artery. At the base of the ventricle are two orifices protected by valves; the one to the right is of an oval form and leads into the right auricle, being known as the auriculo-ventricular opening; the other orifice, more to the left and smaller, is that of the pulmonary artery. In cross-section the cavity of the right ventricle is crescentic.

The valve guarding the right auriculo-ventricular opening is composed of three triangular segments or flaps; hence the valve is called the *tricuspid.* The flaps are mainly formed of fibrous tissue covered by endocardium. At their bases, the flaps are continuous with one another; their apices are directed downwards, and are retained in position within the ventricle by fine tendinous cords, which, springing from the ventricular wall, are attached to the ventricular surfaces and margins of the flaps. During the contraction of the right ventricle, the segments of the tricuspid valve are applied to the opening leading from the right auricle and prevent blood escaping into that cavity.

The valve at the orifice of the large thick-walled vessel leading out of the right ventricle, and known as the pulmonary artery, because it carries blood from the right ventricle to the lungs, consists of three half-moon-shaped flaps of transparent membrane arranged around the inside of the vessel. From their shape these flaps are called the *semilunar* valves. Each flap forms a pocket open on the side away from the ventricle, and allows blood to pass from the ventricle into the artery, but not back again.

The inner surface of the right ventricle is marked by muscular bundles called the *columnæ carneæ*, some of which are attached by each extremity to the wall of the ventricle and are free in the middle, while others are attached at their base to the ventricular wall, and by the other end are prolonged into small tendinous cords or *chordæ tendineæ*, by which they are connected with the segments of the auriculo-ventricular or tricuspid valve.

The **left auricle** occupies the left and posterior part of the base of the heart. In front it is in contact with the pulmonary artery and aorta, while behind it receives two pulmonary veins on each side. Like the right auricle, it has an ear-shaped

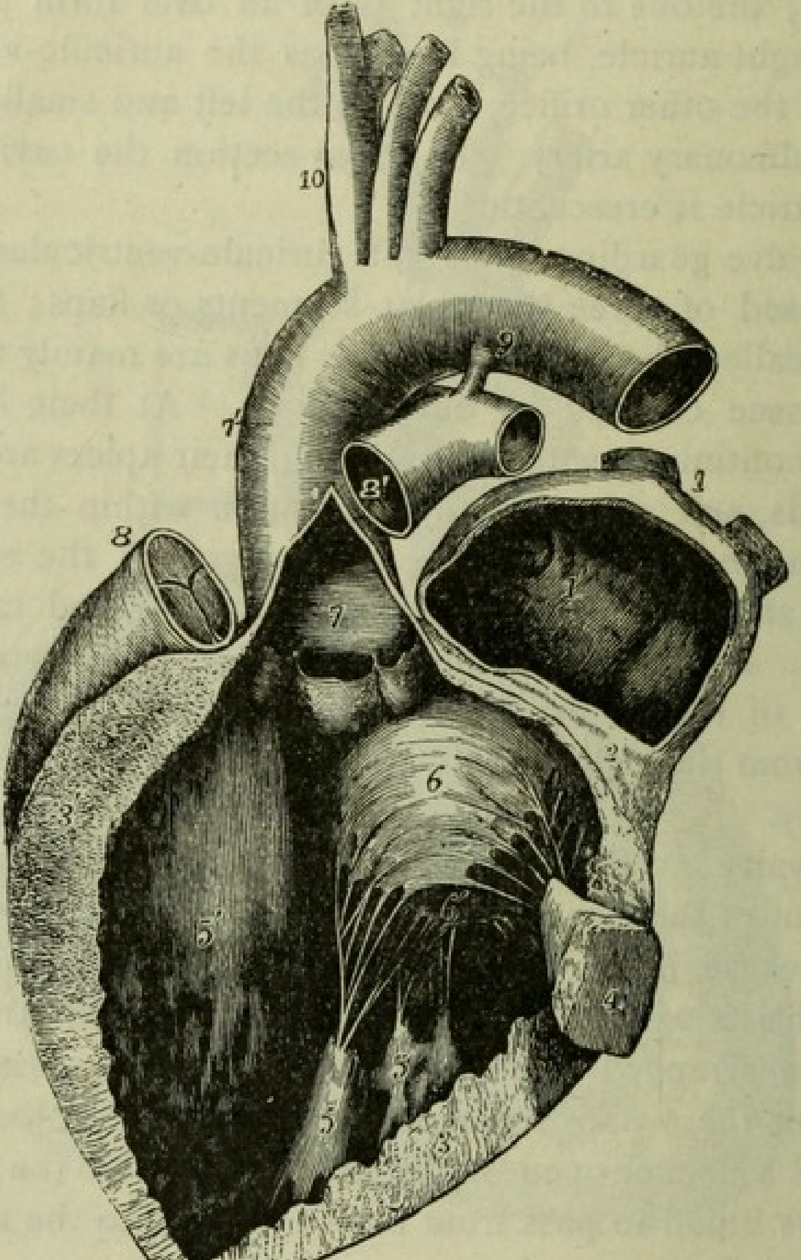

FIG. 10.—Interior of the Left Auricle and Ventricle.

1, right pulmonary veins cut short; 1', cavity of left auricle; 2, portion of wall or septum between auricle and ventricle; 3, 3', cut surface of the wall of left ventricle; 4, wall of ventricle with papillary muscle attached; 5, papillary muscles; 6, segments of mitral valve; 7, 7', aorta; 8, commencement of the pulmonary artery and its valve; 10, arteries arising from aortic arch.

appendix, which is marked on its inner surface with *musculi pectinati;* the inner surface of the other parts of the auricle is smooth.

The **left ventricle** occupies the left border of the heart, but lies almost entirely on the posterior surface. It is longer and narrower than the right ventricle, and in cross-section its cavity is oval. Its walls are much thicker than those of the corresponding cavity on the right side, while its inner surface presents columnæ carneæ with chordæ tendineæ, and two orifices guarded by valves. One opening leads from the left auricle, while the other is the orifice of the aorta. The valve guarding the left auriculo-ventricular opening resembles in structure and function the tricuspid valve of the right ventricle, but it is much thicker and stronger, and consists of only two segments. From a fancied resemblance to a bishop's mitre, it is spoken of as the *mitral* valve.

The valve at the aortic orifice resembles that at the pulmonary artery in connection with the right ventricle, and consists of three semicircular flaps. It will permit of blood passing from the left ventricle into the aorta, but not back again. Behind two of the flaps or pockets are two small apertures opening from the aorta; these are the openings of two arteries which supply the substance of the heart with blood. They are known as the coronary arteries, and their corresponding veins empty themselves into the right auricle.

The heart is composed of muscular tissue of a special kind, arranged as bundles in a complicated manner. The heart muscle fibres contract just like other muscle fibres; as they contract they cause a reduction in the size of the heart cavities, and the blood which is within the cavities is driven out. The contraction of the walls of the auricles and ventricles of the heart constitutes a beat or pulsation. In the healthy human adult the heart makes about seventy-four pulsations in a minute; at birth it makes one hundred and forty pulsations, and in old age only some sixty, or even less, per minute. The rate varies in different persons; it is usually quicker in women than in men, and quicker when work is being done than during rest. The two auricles contract at the same time, and immediately after them the two ventricles contract at the same time; following this there is a slight pause, during which both the auricles and ventricles relax; then occurs again the auricular contraction, to be followed immediately by the ventricular contraction, with a pause; and so on.

Each pulsation of the heart is accompanied by two sounds; these can be distinctly heard if the ear be applied to the chest. They are well expressed by the syllables *lūb*, *dŭp*. The long sound *lūb*, or first sound, is heard during the contraction of the ventricles, and is considered to be caused partly by that action, partly by the closure of the mitral and tricuspid valves, and partly by the rush of blood through the aortic orifice. The second, or short sound *dŭp*, is heard at the end of the ventricular contraction, and is probably due to the closing of the aortic valve, and the vibration of the blood in the aorta following the sudden stoppage of the stream from the heart. Contemporary with the first sound, the impulse or apex beat of the heart is felt in the fifth intercostal space; this impulse is probably due to the sudden hardening of the heart when it contracts upon the blood within it.

The Blood Vessels are certain branched tubes which convey the blood to the various parts of the body; they are of three kinds, namely, arteries, veins, and capillaries. The arteries conduct the blood from the heart, and distribute it to the different regions of the body; the veins bring the blood back to the heart again; the capillaries are minute vessels intermediate between the smallest arteries and veins, and connect the two,—they are called capillaries because they are as fine or even finer than hairs.

The **arteries** are thick-walled vessels, which do not collapse when they are cut; they contract, and empty themselves after death, with the result that all the blood in the body is found in the veins and capillaries; it was this characteristic of arteries to empty themselves and appear empty after death, that caused them to be originally called arteries, a word really meaning an air-tube. The arteries usually occupy protected situations, and, as they proceed in their course, divide into branches; they possess considerable strength and elasticity, being extensible and retractile both in their length and width.

The majority of arteries are inclosed in a sheath of fibrous connective tissue; independently of this sheath, however, arteries (except the very smallest) are composed of three coats, named the internal, middle, and external (Fig. 11). The inner coat is a fine, transparent, colourless membrane, elastic, but easily broken; it is composed chiefly of elastic tissue, lined with an epithelial layer. The middle coat is composed partly of elastic tissue, and partly of muscular fibres; in the largest arteries the middle coat is almost entirely elastic, in the small ones almost entirely muscular. The outer coat is composed mainly of fine and closely packed bundles of connective tissue, together with some elastic fibres. Some arteries have much thinner coats than others; this is particularly so with those in the cranium and vertebral canal; the pulmonary arteries also have much thinner coats than those of the general or aortic system. The coats of arteries receive small arteries, veins, lymphatics, and nerves, and these are chiefly distributed in the outer and middle coats.

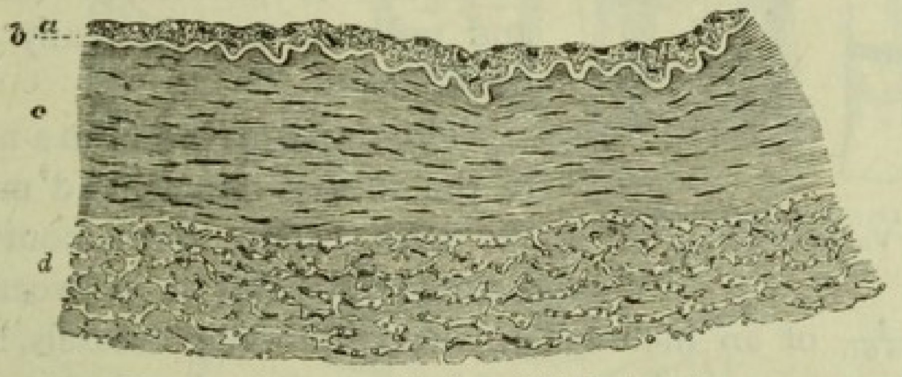

FIG. 11.—Transverse Section of Wall of an Artery.
a, epithelial layer of inner coat; *b*, elastic layer of inner coat; *c*, muscular or middle coat; *d*, outer coat.

The **veins**, like the arteries, ramify throughout the body, but in most regions are more numerous and larger, with the result that the venous system is altogether more capacious than the arterial. The walls of veins are in structure similar to those of arteries, consisting of three layers, but much thinner, there being considerably less elastic and muscular tissue in veins than in arteries; when cut across, or emptied, a vein collapses, whereas a cut artery presents an open orifice. The coats of veins are supplied with nutrient vessels in the same manner as those of arteries; nerves are distributed to them as to arteries, but in far less abundance.

Most veins are provided with valves, or mechanical contrivances for preventing the reflux of the blood from the heart to the capillaries. The valves are really formed of semilunar folds of the internal coat, strengthened by connective tissue, and projecting into the vein. These valvular folds are usually placed in pairs; but in the smaller veins the folds are often single. Many veins are destitute altogether of valves, thus the pulmonary vein and the inferior vena cava have no valves; neither has the portal vein, though some of its smaller radicles are well supplied with valves. No artery has a valve; those at the orifices of the aorta and pulmonary artery really belong to the heart.

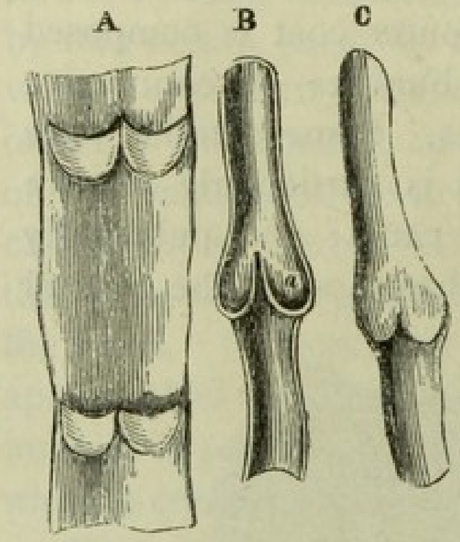

Fig. 12.—Diagram showing Valves of Veins.

The **capillaries** form a network in the various tissues, and maintain the same calibre throughout; their average diameter is between $\frac{1}{2000}$ and $\frac{1}{3000}$ of an inch. They are thin-walled vessels, usually consisting of a single layer of lozenge-shaped endothelial cells, which are practically continuous with the endothelial lining of the smallest arteries and veins. It is through the capillary walls that a constant exchange takes place between the blood and tissues of oxygen, carbonic acid, and nutrient material. The white blood corpuscles have also been seen to pass through the walls of capillaries.

Circulation of the Blood.—It will be remembered that, when describing the general arrangement of the heart, mention was made of the **aorta** leaving the left ventricle, and immediately giving off the coronary arteries for the supply of blood to the heart. Having done this, the aorta forms an arch, from which, in man at least, three large branches are given off. The first of these, or that on the right side, at once divides into two parts, which respectively go to the right arm and right side of the neck and head, while the second and third go to the left side of the neck and left arm respectively.

Continuing to arch backwards, the aorta next passes down the thorax, giving off branches to the bronchi of the lungs and

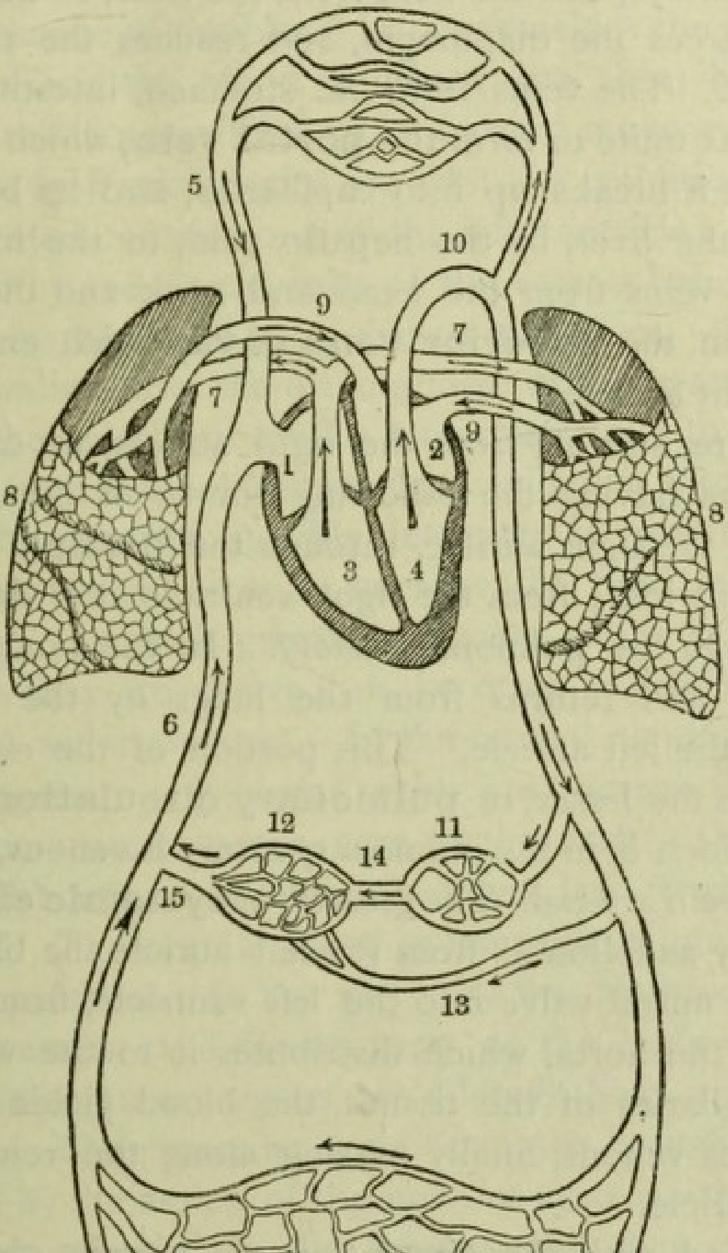

FIG. 13.—Diagram illustrating the Circulation.

1, right auricle; 2, left auricle; 3, right ventricle; 4, left ventricle; 5, vena cava superior; 6, vena cava inferior; 7, pulmonary arteries; 8, lungs; 9, pulmonary veins; 10, aorta; 11, alimentary canal; 12, liver; 13, hepatic artery; 14, portal vein; 15, hepatic vein.

walls of the chest, until, piercing the diaphragm, it enters the abdomen; here it gives branches to the various viscera, and divides, finally, into two arteries, or one for each leg.

The veins from the legs unite and pass up through the abdomen as the **inferior vena cava**; this receives the veins from the kidneys, and the vein from the liver, or hepatic vein; it finally pierces the diaphragm, and reaches the right auricle of the heart. The veins from the stomach, intestines, spleen, and pancreas unite to form the **portal vein,** which runs to the liver; there it breaks up into capillaries, and its blood finally flows from the liver, by the hepatic vein, to the inferior vena cava. The veins from the head and neck and the two arms unite to form the **superior vena cava,** which empties itself into the right auricle.

Therefore, starting from the right auricle, we can describe the blood as having the following course or circulation. It passes from the right auricle, through the tricuspid valve, into the right ventricle; from the right ventricle it is driven to the lungs, through the pulmonary artery. In the lungs the blood is oxidised, and returns from the lungs by the pulmonary veins into the left auricle. This portion of the circulation is spoken of as the lesser, or **pulmonary circulation,** and in it, the blood which is in the pulmonary artery is venous, and in the pulmonary vein arterial. The greater, or **systemic'circulation** is practically as follows: from the left auricle the blood passes through the mitral valve into the left ventricle, from there it is driven into the aorta, which distributes it to the whole body. In the capillaries of the tissues, the blood yields up oxygen, and becomes venous, finally passing along the veins back to the right auricle.

Associated with the circulation are certain physical phenomena. The primary cause of the blood circulation is the contractile action of the heart; but the movement of the blood is promoted by several other agents. Among such agencies is the aspiration of blood into the thorax, owing to the pressure in the chest being negative, or less than that of the atmosphere, both during expiration and inspiration. The circulation is further aided by the dilatation of the heart in *diastole,* and also by the compression of the veins possessing valves during muscular exertion. If a vein destitute of valves crosses a muscle, the muscle, becoming thicker on contraction, must compress the vein, and tend to drive its contained blood in both directions; but if valves are present, the backward flow is prevented, and the blood flows only in a forward direction.

The presence of the blood in the vessels is the result of the force with which the blood is driven into them by the heart, and of the resistance offered to its onward movement. Practically, all the systemic arteries are kept in a condition of tension by the repeated contractions of the left ventricle; this tension is produced by the elastic walls of the vessels being placed on the stretch by the blood being driven into them. The recoil of the vessel walls resists the driving force of the heart, and tends to propel the blood out of the larger arteries into the smaller ones, and from these through the capillaries into the veins. The **blood pressure** steadily decreases in passing from the larger to the smaller arteries, because the total sectional area of the small vessels is greatly in excess of the primary trunk from which they are derived, or, in other words, the blood is moving in a wider channel. In the normal condition of man, the blood pressure only varies within very narrow limits, as the action of the heart becomes more frequent when the resistance in the smaller arteries is diminished, and less frequent when it is increased. The normal blood pressure is maintained—when the heart's pulsations do not vary—by the reciprocal action of the small vessels in different parts of the body; thus, when those in one organ or organs are dilated, those in another are contracted. These varying conditions are brought about and maintained by the action of the nervous system—that is, by the small nerves supplied to the arteries, and thus called **vasomotor nerves.** The normal blood pressure is not apparently affected by food, drink, or exercise. Prolonged or profuse bleeding appears to lower the pressure only for a time, as fluid is rapidly absorbed from the tissues to make up the normal quantity of the blood. Any sudden relaxation of the arteries over a great portion of the body at once lowers the blood pressure, and produces faintness.

SUMMARY.

The blood consists of two parts, namely, the liquor sanguinis and the corpuscles. The liquor sanguinis is the liquid of the blood, and contains water, dissolved albumin, mineral salts, and the elements of fibrin. The corpuscles are either red or white; the former contain hæmoglobin, and have a tendency to adhere together in piles or rouleaux; the white corpuscles constantly vary in shape and resemble the amœba.

Clotted blood consists of serum, fibrin, and corpuscles. These two latter constitute the clot, which floats in the serum. The serum consists of water in which are dissolved mineral salts and albumin.

The blood consists of two kinds, namely, the arterial and the venous blood. Arterial blood is bright red, rich in oxygen, and usually contained in arteries. Venous blood is dark purple, contains less oxygen but more carbonic acid gas than arterial blood; it is usually found in veins. It is converted into arterial blood by absorption of oxygen.

The circulation of the blood is maintained by the heart and blood vessels. The heart consists of four cavities. The right auricle and right ventricle, intercommunicating by the tricuspid valve; the left auricle and left ventricle, having between them the mitral valve. The right auricle has thin walls, and receives venous blood from all parts of the body by the upper and lower venæ cavæ. The right ventricle has thick walls, and receives venous blood from the right auricle; it drives this blood into the lungs through the pulmonary arteries. The left auricle has thin irregular walls, and receives arterial blood from the lungs by the pulmonary veins. The left ventricle has very thick walls, and, after receiving arterial blood from the left auricle, drives it to all parts of the body through the aorta and its branches.

The action of the heart is that of a more or less simultaneous contraction of its four cavities, whereby blood is pumped or forced into the arteries, returning again to the heart by the veins. Each beat of the heart is accompanied by a double sound.

The blood vessels consist of arteries, veins, and capillaries. The arteries take blood from the heart, and assist in propelling blood by their elastic recoil. The capillaries connect small arteries with small veins, have thin walls, and are arranged like networks. The veins convey blood to the heart, have similar but less muscular coats than arteries, and are moreover provided with valves.

CHAPTER V.

THE RESPIRATORY SYSTEM.

The Lungs.—The respiratory apparatus of man, and of all mammals, consists of (1) certain channels by which air enters the air passages; (2) vascular sacs filled with air, known as the *alveoli* of the lungs; (3) motor or mechanical arrangements which pump air into the lungs through the air passages.

The air passages consist of the cavity of the nose, the pharynx or upper part of the gullet, the larynx, the trachea or windpipe, and its branches the bronchi. The **larynx, trachea,** and the larger **bronchi,** are tubular structures, having three coats; an outer one of connective tissue, a middle one composed of cartilage, fibrous tissue, and muscular fibres; and an inner one or mucous membrane consisting of ciliated epithelium resting on a layer of connective tissue. The trachea or windpipe extends from the larynx to the thorax; within the chest the trachea divides into two tubes, the bronchi, one going to each lung.

Each bronchus divides into smaller tubes, which again eventually divide into a cluster of short and somewhat dilated branches. These dilated blind endings of each bronchial tube are called *infundibula,* and it is these infundibula or terminal air sacs of the smaller bronchi, which, when bound together by connective tissue, form a lobule of the lung; two or more lobules form a lobe, and two or more lobes go to make up a lung. Each of the infundibula has its wall folded inwards, so as to partly divide the dilated cavity into a number of chambers. Each of these chambers is called an *alveolus.* In other words, each infundibulum consists of a cluster of alveoli, into all of which the fine bronchial tube conducts air, and the lungs themselves are formed by the ramifications of the bronchial tubes and their terminal expansions which form groups of sacculated dilatations.

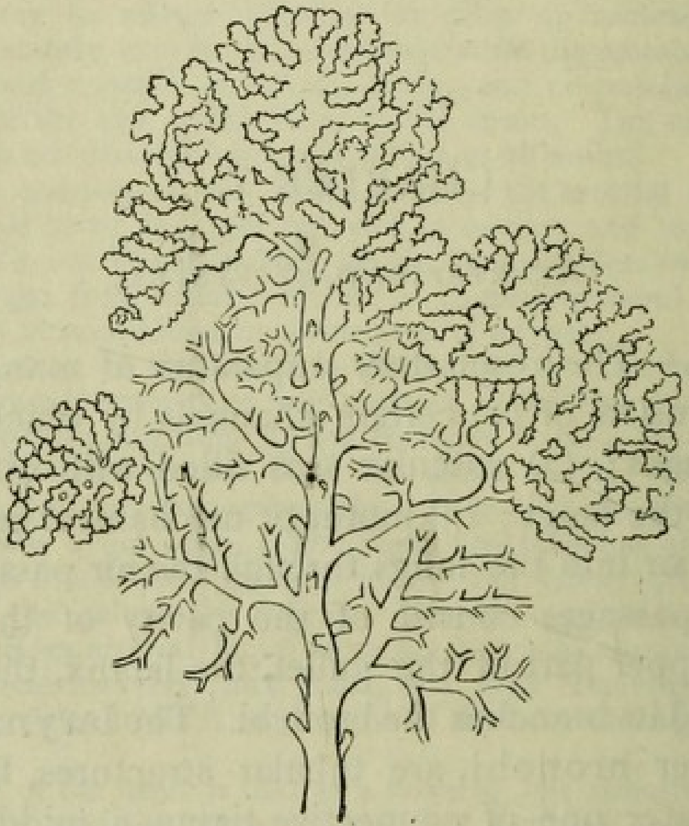

FIG. 14.—Group of Air Cells at the termination of a small Bronchial Tube.

The smallest bronchial tubes which expand into the infundibula lose the distinctness of their several layers, their walls being greatly thinned out to form the alveoli; their epithelium also is changed from the columnar and ciliated form to the cubical and non-ciliated. In the alveoli themselves, besides small groups of cubical cells, there are large irregular flattened cells, and much elastic tissue, which form a regular but extremely delicate layer separating the blood capillaries from the air within the alveoli. The network of capillaries on the alveoli is extremely close; these capillaries contain blood brought to them by branches of the pulmonary artery, and from them the blood is returned to the heart by the pulmonary veins.

Considered in relation to their structure, the lungs may be regarded as complex air sacs with very elastic walls, communicating with the external air by the bronchi and trachea, and enclosed in a distended condition within an air-tight cavity (thorax). The ingress and egress of air are effected rhythmically by the alternate enlargement and contraction of the chest cavity, which take place in the adult from sixteen to twenty-four times per minute. The act of enlargement of the thorax is called inspiration, that of its diminution, expiration. **In inspiration** the walls of the thorax are drawn apart in all directions, and its cavity enlarged by muscular action. The muscles of ordinary inspiration are the diaphragm and the various muscles attached to the ribs and sides of the thorax. The lungs expand with the thoracic cavity owing to the natural elasticity of the air in them; and following the reduction of pressure which takes place within the lungs, air enters by the larynx and trachea to restore the normal pressure. The act of ordinary **expiration** is effectual only to a small extent by muscular action; it is brought about by or results from the elasticity of the lungs and the chest walls which tend to return

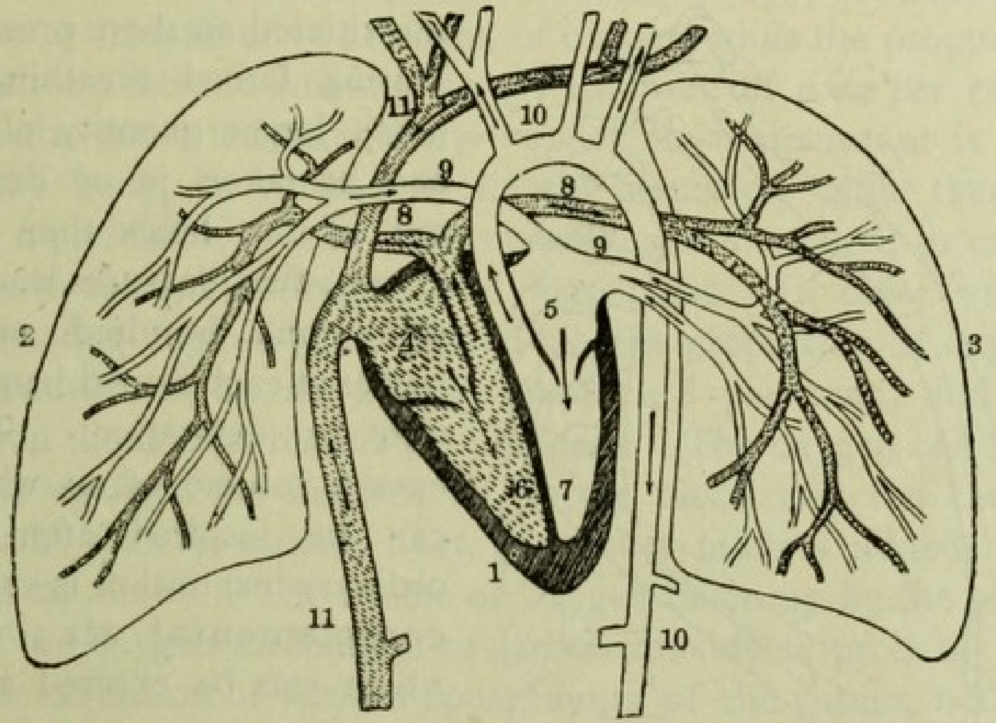

FIG. 15.—The Pulmonary Circulation.

1, the heart; 2, right lung; 3, left lung; 4, right auricle; 5, left auricle; 6, right ventricle; 7, left ventricle; 8, pulmonary arteries; 9, pulmonary veins; 10, aorta; 11, venæ cavæ. The arrows show the direction of the blood stream. The shading represents venous blood.

passively to their normal state. In laboured or forced breathing the acts of inspiration and expiration are not quite so simple as described above owing to the action of various muscles of the neck, back, flanks and abdominal walls, which are not ordinarily called into play.

At each inspiration by an adult, about thirty-five cubic inches of air enter the lungs and pass out again at the succeeding expiration; this volume of air is called the **tidal air.** Of it about twenty-nine cubic inches remain in the lung, and mix by diffusion with the vitiated air there present. During forced breathing a much larger quantity of air can be taken in or driven out of the lungs than the above; this measures usually some one hundred cubic inches at each forced inspiration or expiration. This excess volume of air which can be inspired after an ordinary inspiration is called **complemental air**; that which can be expired after an ordinary expiration is the **supplemental air,** and that which remains in the lungs after the fullest possible expiration is spoken of as the **residual air.** Thus, at the end of an ordinary expiration, there is always in the lungs about two hundred cubic inches of air which is only renewed by gradual diffusion with the tidal air in the smaller bronchial tubes; this volume of air is known as the **stationary air,** and it is this volume of so-called stationary air which is most intimately concerned in the interchange of oxygen from the air into the blood, and of carbonic acid from the blood into the air; this interchange takes place in the alveoli

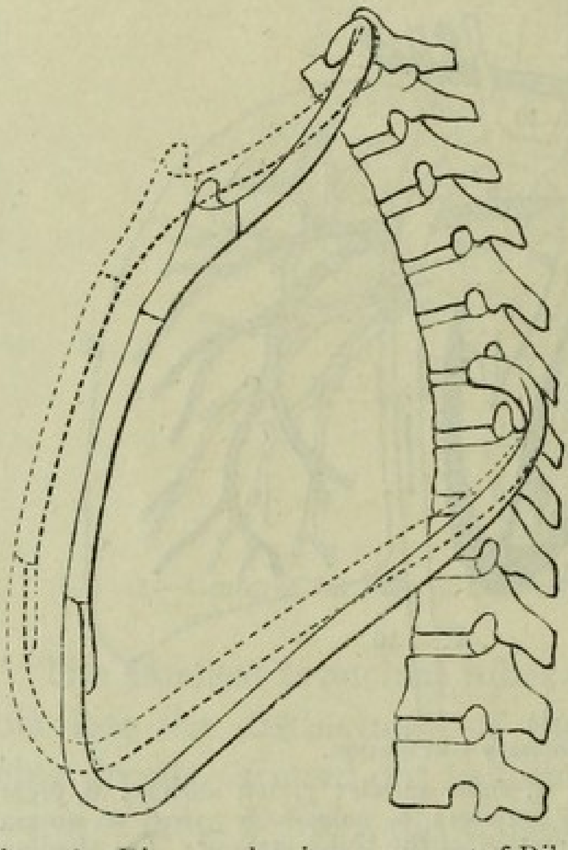

FIG. 16.—Diagram showing movement of Ribs and Sternum during respiration.

The expiratory position is shown by continuous lines, the inspiratory by dotted lines.

of the lungs, and the alveolar air in turn interchanges gases by rapid diffusion with the tidal air.

The air which is taken into the lungs during inspiration is *altered in composition*, somewhat *reduced in quantity*, and usually slightly *warmed* before it is expired. Ordinary air, as inspired, contains in every 100 volumes, 21 of oxygen and 78·96 of nitrogen, with about 0·04 of carbonic acid or carbon dioxide; there are, in addition, small quantities of water, ammonia, and other matters, which for this present purpose may be ignored. The expired air from the lungs contains only 16 to 17 instead of 21 per cent. of oxygen, while the proportion of carbon dioxide amounts to 4·3 in place of 0·04 per cent.; it is also saturated with watery vapour, its temperature is that of the body, its volume is slightly increased, while there is also an addition to it of small quantities of ammonia, so called organic matter, hydrogen, and marsh gas. In other words, contrasting expired with inspired air, the proportion of oxygen is diminished on an average about 4·8 per cent., and the carbon dioxide increased 4·3 per cent. The oxygen has been taken up from the inspired air by the blood and the carbon dioxide, watery vapour, heat, and other matters added to it from the blood. The excess of oxygen taken up by the blood over the oxygen discharged as carbon dioxide is probably lost in the oxidation of various constituents of the tissues, notably sulphur and phosphorus.

The concurrent effect upon the blood by respiration is, of course, the change of venous blood into arterial blood, or the transformation in the red corpuscles of their contained hæmoglobin from the reduced to the oxidised state.

Assuming that a man breathes 17 times a minute, he discharges from his lungs about 500 cubic inches of air containing 4 per cent. of carbon dioxide per minute. In other words, he breathes out 20 cubic inches of carbon dioxide in a minute, or 1200 cubic inches in one hour. During hard work, the amount per hour would equal 3000 cubic inches of carbon dioxide per hour. During rest, we may compute that a man gives off at least 24,000 cubic inches of carbon dioxide in twenty-four hours; the oxygen necessary for the production of this amount of carbon dioxide is supplied by the air inspired, while the necessary carbon is derived from the tissues of the body; this necessary amount of carbon thus lost from the body in the day may be placed at about eight ounces, or 3400 grains. In addition to this loss of carbon, there is a loss of hydrogen in the form of aqueous vapour, amounting to about half a pint of water in twenty-four hours. The only source of gain to the body by the lungs is the supply of oxygen to the blood from the air. This oxygen, we have already learnt, is carried to the tissues by the hæmoglobin of the red corpuscles of the blood.

SUMMARY.

The respiratory organs proper consist of the trachea or windpipe, the bronchi and the lungs. The trachea divides into the two bronchi, each of which again divides into the bronchial tubes; these bronchial tubes again break up into a number of saccular terminal dilatations, which, bound together by fibrous tissue and covered with the serous membrane called the pleura, constitute the lungs. The lungs are two in number, namely, a right and left; each occupies the corresponding half of the thorax or chest, and is nothing more than a spongy and elastic bag consisting of air-tubes, air-cells, blood vessels and elastic tissue.

Respiration is the result of the alternate expansion and contraction of the walls of the chest. It consists really of two acts, namely, inspiration and expiration. During inspiration the chest enlarges, owing to the elevation of the ribs by the intercostal muscles and the depression of the diaphragm; simultaneous with this widening and deepening of the chest, the lungs within it expand, and are filled with air, which rushes in through the trachea and bronchi. During expiration the chest becomes smaller and shallower, owing to the recoil of the elastic chest walls and elastic tissue of the lungs; at the same time air is forced out through the trachea. The air which passes in and out of the lungs in ordinary breathing is called the tidal air, and amounts to about 30 cubic inches in an adult. After each expiration, however, about 200 cubic inches still remain in the lungs, this being termed the stationary air. About half of this can be expelled on forced expiration (supplemental air), the remainder left in the lungs being known as residual air. The volume of air which can be taken into the lungs on a deep inspiration, over and above the tidal and stationary air, is termed the complemental air.

The lungs receive dark venous blood by means of the pulmonary arteries proceeding from the right ventricle of the heart. These arteries divide into a capillary network upon and surrounding the air cells. In these capillaries the venous blood becomes converted into arterial blood by exchanging carbon dioxide collected in the tissues of the body for oxygen absorbed from the air contained in the air cells. The result of these changes is that while inspired air contains about 79 per cent. of nitrogen, 21 per cent. of oxygen, with only about 0·04 per cent. of carbon dioxide, and a variable proportion of watery vapour, the expired air contains about 4·3 per cent. more carbon dioxide, 4·8 per cent. less oxygen, and an increased proportion of water vapour, the nitrogen remaining the same.

CHAPTER VI.

THE DIGESTIVE SYSTEM.

The Teeth.—There are two sets of teeth, a first, temporary or milk set, and a second or permanent set.

The **temporary** or **milk teeth** are twenty in number and consist of two incisors, one canine and two molars on each side of each jaw. Of these the earliest to appear are the central incisors of the lower jaw (sixth month), next follow the central incisors of the upper jaw and the lateral incisors of both jaws, which appear from the seventh to tenth months after birth; the front molars appear about the twelfth month, the canines from the fourteenth to the twentieth months, and, lastly, the back molars from the eighteenth to the thirty-sixth month.

The **permanent teeth** are thirty-two in number, or sixteen in each jaw, the eight on one side corresponding to the eight on the other. They consist of two incisors, one canine, two bicuspids, and three molars in each half of the jaw. These permanent teeth are heralded by the appearance of the first true molars about the seventh year, at which time the temporary teeth begin to gradually drop out. By about the fourteenth year all the permanent teeth have been cut, except the last molar on each side of each jaw; this third molar, or wisdom tooth, is usually delayed until the eighteenth or twentieth year, and, in some cases, may not appear until the twenty-fifth year.

Every tooth consists of a crown, and one or more fangs which are embedded in sockets in the jawbone. The fangs are hollow and contain a vascular marrow or pulp, to which are supplied blood vessels, also a nerve passing through a minute hole at the bottom of each fang.

A tooth consists of three calcified tissues; the enamel, the dentine and the cement. The dentine forms the main substance of a tooth, the enamel covers the crown, and the cement is a layer of bone which surrounds the root or fang.

The **enamel** is developed from the epithelium, and is a dense substance of flinty hardness consisting of hexagonal prisms set on end; these are really modified epithelial cells, but only contain about two per cent. of animal matter. The **dentine** is a substance like bone in composition, pierced by innumerable fine canals or tubules in parallel lines radiating from the pulp cavity in the centre to the surface. Filaments of protoplasm run in the dentine tubules from the cells of the pulp, and practically control the nutrition of the tooth. The pulp itself is very vascular, and well supplied with nerves. The **cement** is really a layer of bone surrounding the tooth fang or root; it is covered with periosteum, which also lines the socket, and serves to fix the tooth securely.

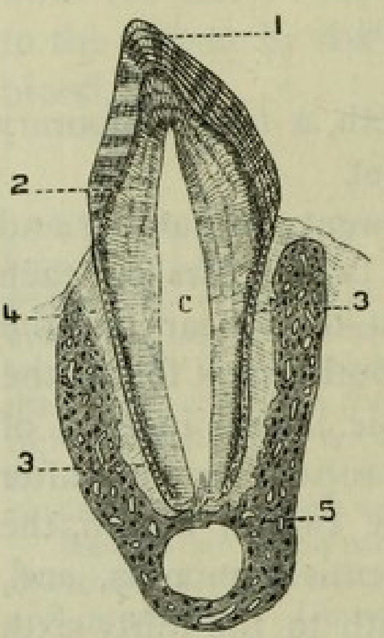

Fig. 17.—Section of a Tooth.

1, enamel; 2, dentine; 3, cement or crusta petrosa; 4, dental periosteum; 5, bone of lower jaw; *c*, pulp cavity.

The function of the teeth is purely mechanical, as in the process of mastication they grind and break up the food into a pulp, in which condition it is more readily acted upon by the saliva and the juices to which it is exposed in the stomach and intestines.

The Pharynx and Œsophagus.—When food leaves the mouth, by the act of swallowing, it passes into the pharynx which lies at the back of the mouth, and which is really the trumpet-shaped upper end of the œsophagus or gullet, or tube that leads down into the stomach. The **pharynx** consists of a mucous membrane similar to that of the mouth, except that in the upper part above the soft palate the epithelium is columnar and ciliated. Outside the mucous membrane is a fibrous aponeurosis covered by the striated fibres of the pharyngeal muscles. The **œsophagus** has a much-folded mucous membrane raised into papillæ, covered with stratified epithelium, and containing numerous mucous glands in its substance. Surrounding this mucous membrane is a muscular coat consisting of an external, longitudinal, and an internal circular layer of muscles. In its upper parts the muscular fibres are striated, but in the lower parts, or where they approach the stomach, the muscle fibres become non-striated.

The Stomach is an irregular, half moon-shaped dilatation of the alimentary canal lying crosswise across the upper part of the abdomen, immediately below the diaphragm, having its front surface in contact with the anterior abdominal wall just below the end of the sternum. The enlargement or dilatation of the stomach is greatest on the left side, forming what is known as the cardiac dilation, because it is nearest the heart. The right end of the stomach is not dilated; here it becomes continuous with the duodenum, or first part of the intestine, and is known as the **pylorus**. Owing to its peculiar shape, the stomach, along its upper border or lesser curvature,

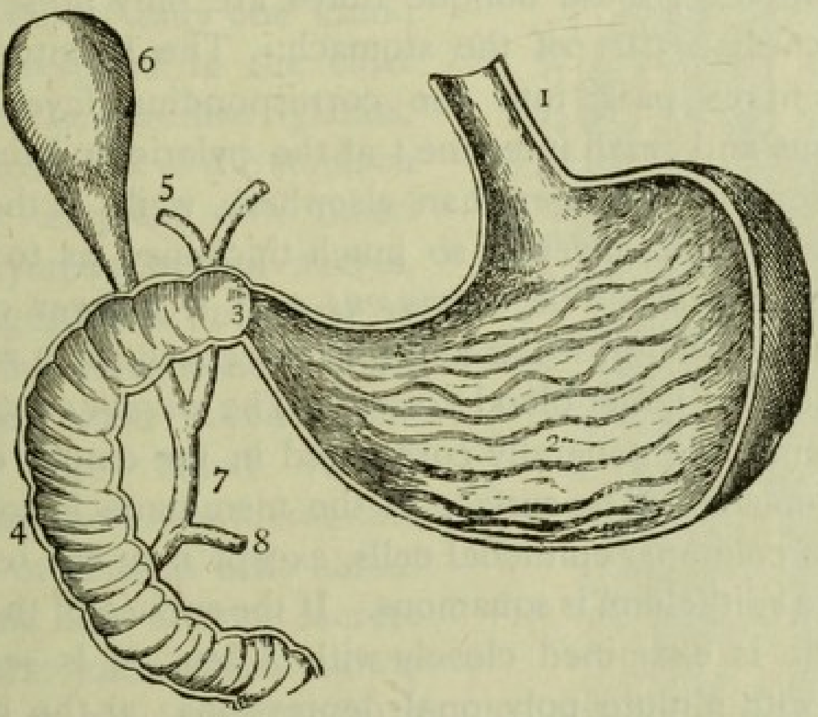

FIG. 18.—The Stomach and Duodenum laid open.

1, œsophagus; 2, stomach; 3, pylorus; 4, duodenum; 5, bile ducts; 6, gall bladder; 7, common bile duct; 8, pancreatic duct.

presents a concavity, and along its lower border or greater curvature a convexity.

The wall of the stomach consists of four coats, which, from without, are as follows, viz. : serous, muscular, areolar or submucous and mucous membrane. The *serous* coat is a layer which is derived from the peritoneum; it is deficient only along the lines of the lesser and greater curvatures. The *muscular* coat consists of three layers of non-striated muscle. Of these the bundles of the outer layer run longitudinally, those of the middle layer circularly, and those of the inner layer obliquely; these oblique fibres are only present in the left, or cardiac part of the stomach. The longitudinal and circular fibres pass into the corresponding layers of the œsophagus and small intestine; at the pyloric end these fibres are thicker and stronger than elsewhere, while at the pylorus itself the circular layer is so much thickened as to form the sphincter muscle. The *submucous* coat is a layer of areolar tissue uniting the muscular and mucous coats; in it ramify the lymphatics and larger blood vessels. The *mucous* coat is a soft, thick membrane generally corrugated in the empty condition of the stomach. The surface of the membrane is covered by a layer of columnar epithelial cells, except near the œsophagus where the epithelium is squamous. If the surface of the mucous membrane is examined closely with a lens, it is seen to be covered with minute polygonal depressions; at the bottom of each a number of orifices exist, these are the openings of the **tubular glands** which constitute the chief part of this coat. Between the glands the mucous membrane is formed of areolar tissue filled with lymphoid cells. The glands of this coat consist of a thin basement membrane lined with epithelium. Each gland consists of three or four secreting tubules, which open towards the surface into a larger common tube or duct. The epithelium lining the duct is the same as that on the surface of the membrane, but that of the secreting tubules is slightly different, and, moreover, differs in the glands of the cardiac and pyloric ends of the organ. In the cardiac glands the epithelium of the tubules is of two kinds of cells. Those of one kind are cuboid or columnar cells, called chief or central cells, because they form a continuous layer in all the glands in fresh preparations; they appear filled with granules and are believed to secrete the **pepsin** of the gastric juice; those of the other kind are larger, spheroidal, or ovoid cells which are scattered between the columnar cells and the membranous walls of the tubes; these cells are known as the parietal cells and are most abundant in the glands of the cardiac half of the stomach. In the pyloric glands, the secreting tubules possess cells of only one kind; these correspond to the chief cells of the cardiac glands. The mucous coat of the stomach is richly supplied with blood vessels, lymphatics and nerves. When digestion is not going on the mucous membrane is pale, but when food reaches the stomach the blood vessels dilate, and the whole membrane is filled or flushed with blood. The gland cells at once secrete the gastric juice which slowly oozes from the open ends of the tubes into the cavity of the stomach.

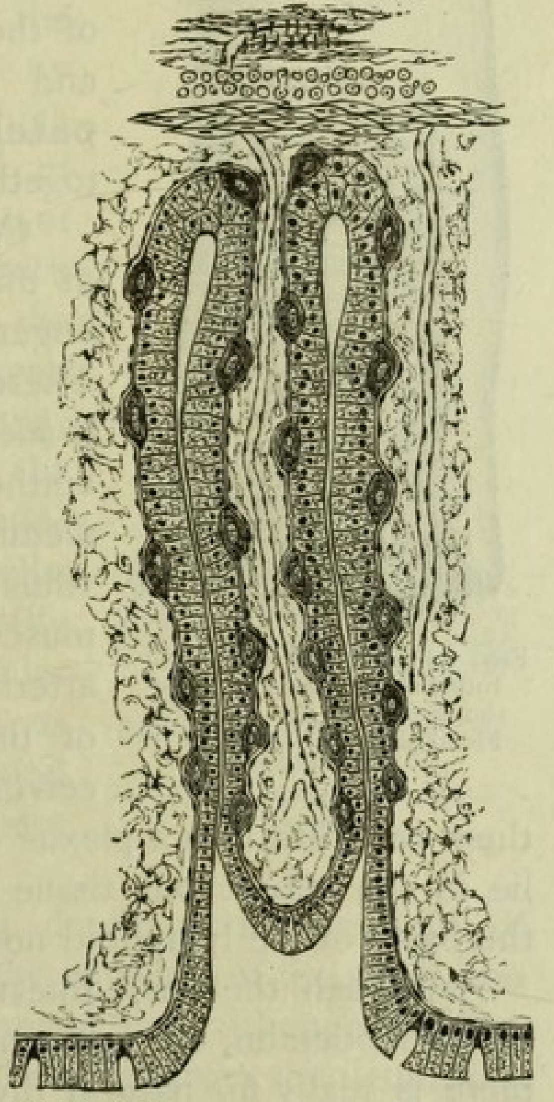

FIG. 19.—Peptic Gland from the mucous membrane of the Stomach. Highly magnified.

The Small Intestine has four coats, like the stomach. The *serous* coat is complete except over parts of the duodenum. The *muscular* coat is composed of two layers of muscular fibres—an outer longitudinal and an inner circular. Between them lies a network of lymphatic vessels and also a fine gangliated plexus of nerves. The *submucous* coat is similar to that of the stomach; in it ramify both blood vessels and lymphatics; there is also a gangliated plexus of nerve fibres The *mucous* coat is separated from the submucous by a double layer of plain muscular fibres (*muscularis mucosæ*). Pervading the whole mucous membrane are numerous simple tubular glands lined with columnar epithelium; these are the **crypts of Lieberkühn.** Between these glands the mucous membrane is mainly composed of lymphoid tissue, which is aggregated at intervals into more solid nodules known as the **solitary glands** of the intestine when they are single, and as the agminated glands or **patches of Peyer** when aggregated together.

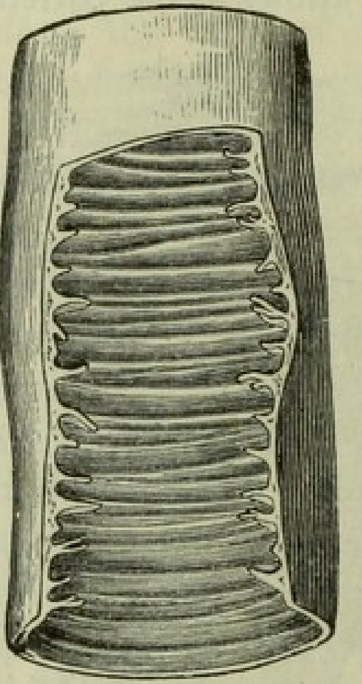

FIG. 20.—Portion of Small Intestine laid open to show the Folds of the Mucous Membrane.

Covering the whole inner surface of the small intestine are innumerable finger-shaped projections called **villi.** These villi are composed of lymphoid tissue and covered with columnar epithelium resting on a basement membrane of flattened cells. In each villus is a lacteal vessel surrounded by muscular fibres and accompanied by arteries and veins. The lymphatics of the mucous membrane, after receiving the lacteals of the villi, pour their contents into a plexus of large-valved lymphatics which lie in the submucous tissue and form dilated sinuses around the bases of the lymphoid nodules.

Although the small intestine is divided into three portions —the duodenum, the jejunum, and the ileum—by anatomists, there is really no natural division of the intestine into these parts; the most that can be said is that certain structural characters are more marked in or at least peculiar to each division, although the transition from one portion to another is gradual. Thus, the duodenum is distinguished by the presence of certain small glands resembling the salivary glands as a distinct layer beneath the glands of Lieberkühn. The duodenum, jejunum, and upper part of the ileum also are characterised on their mucous surface by **valvulæ conniventes.** These are crescentic folds of the mucous membrane extending about two-thirds round the interior of the intestine, and by which its surface is largely increased. Some of these folds are a quarter of an inch in depth.

The Large Intestine is about six feet in length, and has the usual four coats, except near its termination, where the serous coat is absent. The muscular coat is peculiar in the fact that along the cæcum and colon the longitudinal fibres are gathered up into three thickened bands which produce puckerings in the wall of the gut. The mucous membrane of the large intestine is beset with simple tubular glands resembling the crypts of Lieberkühn of the small intestine, and lined by columnar epithelium similar to that of the inner surface of the bowel, but containing many mucus-secreting cells. The mouth of each gland is usually slightly dilated. The interglandular tissue is like that of the stomach, as also is the arrangement of the blood vessels, lymphatics, and nerves; there are no villi.

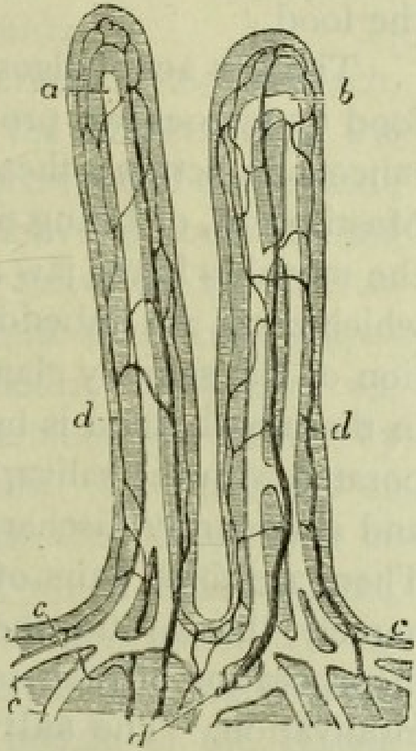

Fig. 21.—Two Intestinal Villi. Highly magnified.
a, *b* and *c*, lacteals; *d*, blood-vessels.

The **ileo-cæcal valve** is a double transverse fold of mucous membrane, which guards the entrance of the small into the large intestine, and is so arranged that although it offers no resistance to the passage of substances from the ileum into the cæcum, it entirely prevents their regurgitation. The surfaces of this valve, which look towards the small intestine, are covered with villi; those towards the cæcum are without them.

At the lower end of the rectum the circular muscular fibres of the bowel are thickened just above the anus, so as to form the internal sphincter muscle. The mucous membrane of this part contains many mucous glands, and moreover, is very movable on its muscular coat, being thrown into strongly marked folds.

Digestion and Assimilation. — By digestion and assimilation are meant those processes of preparation which the food undergoes in the alimentary canal and by which it is rendered capable of being absorbed into the blood-plasma. They consist really of certain physical and chemical changes brought about by the secretions of the alimentary canal upon the food.

The first act of digestion takes place in the mouth, where the food undergoes two processes which are inseparable and simultaneous in action; these are **mastication** and **insalivation.** Mastication, or biting of food, is effected by the movements of the movable lower jaw against the fixed upper jaw, in both of which teeth are imbedded, helped by the tongue and the secretion of the salivary glands. As a result of biting and chewing in the mouth, food is broken up into a sort of pulp and incorporated with the saliva, which is secreted by the salivary glands and abundantly discharged into the mouth during mastication. There are three pairs of salivary glands opening into the mouth, namely, the parotid, the submaxillary, and the sublingual; the incorporation of their secretion with the food is spoken of as insalivation. The **saliva** as poured out by these glands is a cloudy alkaline and watery fluid, containing epithelial cells, fragments of food, algæ, mucin, some mineral salts, and a special substance or ferment called *ptyalin.*

In connection with the digestive act, the saliva moistens the food and promotes mastication and deglutition by coating the food bolus with a viscid covering; it dissolves saline and sugary substances, and also converts starch into dextrin and grape sugar. This last action is effected through the agency of the ptyalin which acts much more quickly on boiled starch than on the raw material. The saccharifying action of ptyalin on starch takes place best in neutral or faintly alkaline solutions and is impeded or arrested by acids. Ptyalin is contained in only the saliva of the parotid glands of very young children, but at a later period of life is present in that of all the salivary glands.

During the short time occupied by the passage of food through the œsophagus, no special change takes place in it, but on entering the stomach it becomes materially affected by the action of the **gastric juice.** This is a clear, colourless fluid with a strongly acid reaction. It contains about 0·2 per cent. of free hydrochloric acid in man, some mucus, certain inorganic salts (chiefly chlorides of potassium, sodium, and calcium), and a special nitrogenous ferment called *pepsin*, which, with the above-mentioned acid, has a special action on certain portions or kinds of food called the proteids.

The first effect upon the food, after entering the stomach, by the gastric juice is the checking of the conversion by the saliva of starch into sugar, owing to the presence of a free acid; the gastric juice, however, probably converts some of the dextrin resulting from the action of the saliva on starch into glucose, and also gradually converts cane-sugar into grape-sugar. The oils and fatty matters are not acted upon by the gastric juice, except that individual oil globules are set free by the solution of the walls of the fat cells. The essential or chief action of the gastric juice is upon the nitrogenous or albuminous matters known as **proteids**, which, being colloid bodies, cannot readily pass through an animal membrane by the process called dialysis; these insoluble and indiffusible bodies are converted by the acid and pepsin of the gastric juice into soluble and diffusible substances called **peptones.** This change is not effected immediately the food enters the stomach, but gradually; as the stomach is filled, more and more gastric juice is secreted; being kept in motion in a large quantity of liquid which dissolves the cases in which the food particles are encased, the bolus or food mass slowly falls asunder, and each of its ingredients is fully exposed to the action of the stomach juice. The acid reaction of the juice neutralises the alkalinity of the saliva, so that the ptyalin is hindered and the starch remains more or less unaffected by the acid and pepsin. The heat of the stomach melts the fats, and the movements of the stomach break up the oily fluid into smaller masses. These mingle with the rest of the general liquid, which slowly becomes a turbid fluid called **chyme.** Owing to the rapidity with which peptones, as formed, are absorbed, the chyme contains but little of them. As digestion progresses the chyme leaves the stomach by the pylorus, passing into the duodenum. Any materials which resist the gastric juice or are only slowly affected by it, often remain for hours in the stomach, causing often much uneasiness, until they are finally removed by vomiting. However, many solid matters, especially unchewed vegetables, etc., pass through the stomach more or less unaffected; these usually escape through the pylorus, when it opens to let through the chyme.

On entering the duodenum, the chyme is subjected to the action of three fluids—the bile, the pancreatic juice, and the secretion of the glands of the intestinal mucous membrane.

The **bile** is a yellowish-brown or greenish fluid formed by the cells of the liver and is conducted partly to the duodenum by the common bile duct, and partly by a duct leading from the gall bladder or sac, in which it accumulates, to be discharged into the intestine in considerable quantities soon after food is taken. The bile acts upon the food as an emulsifier of the fats and oils, rendering their absorption by the intestinal mucous membrane much easier; it is also an antiseptic stimulant and lubricator to the lining membrane of the bowels.

The **pancreatic juice** is a colourless, tasteless, and alkaline fluid, secreted sparingly and usually for two hours after food by the pancreas, finding entry into the duodenum by the same orifice as the bile. Though secreted in but small quantity, the pancreatic juice is one of the most important of the digestive fluids, for it contains three ferments, namely a peptone-forming ferment, *trypsin*; a fat-splitting ferment, *steapsin*; and a starch-converting or diastatic ferment, *amylopsin*. By virtue of these three ferments, the pancreatic juice acts upon proteids or nitrogenous food-stuffs, upon fats and upon starches. It changes the proteids into peptones, emulsifies the fats, and converts starch into soluble sugar; in other words, it practically completes the work of digestion left unfinished by the saliva, gastric juice, and bile.

The **secretion of the glands of the intestines** is a thin opalescent and yellowish liquid, with a strong alkaline reaction. The observations as to its digestive properties are somewhat discordant, but in general terms it may be said to slowly affect proteids, emulsify fats, and convert starch into sugar.

The changes which the chyme undergoes in the duodenum may be summarised as follows : on meeting with the bile, the turbid chyme changes to a soft cheesy granular mass, owing to precipitation of the peptones and other proteids, and a general arrest of gastric digestion. As the alkaline pancreatic and intestinal juices meet this semi-fluid cheesy mass, a further conversion of starch into sugar takes place ; the fats are broken up and made into an emulsion, and the hitherto undigested or partially digested proteids are further acted upon by the ferments of the pancreatic and intestinal juices. The gastric chyme is, therefore, completely changed in the duodenum, with the result that we find in the succeeding portions of the small intestine a thin creamy fluid, which clings closely to the villi and valvulæ conniventes. In these situations it is slowly absorbed as **chyle** into the lacteals, and by the lymphatic system passed into the general blood current.

The coarser and undigested portions of food are hurried from the small intestine by peristaltic action into the large intestine. In this portion of the alimentary canal the secretion of the Lieberkühn follicles is the only one of importance. Its reaction is alkaline, but the contents of the colon are usually acid, owing to fermentation changes. Of the probable digestive action of the juices of the large intestine little is accurately known, but, apparently, some absorption of such materials as are still in solution, takes place as undigested matters gradually lose their fluid, and are converted into soft solid masses which, finally, are discharged by the rectum and anus as fæces.

The Liver is the largest gland in the body, weighing usually from three to four pounds. In appearance, the liver is a smooth, glistening, and fleshy mass situated in the right half of the upper portion of the abdomen, immediately beneath the lower ribs. It is covered by peritoneum, and entirely made up of innumerable little polyhedral lobules, separated from one another by connective tissue. The whole collection of lobules is surrounded by a layer of connective tissue underneath the serous or peritoneal covering of the liver; this forms the so-called capsule of the organ. As each individual lobule has the same construction and blood supply and forms in itself a minute liver, perfect in all its arrangements, a description of one of these units will suffice to give an idea of the structure of the whole gland.

The liver is divided into two parts or lobes by a large fissure or groove on its under surface called the **portal fissure**; the right lobe is further sub-divided by other fissures into three lobes, and the left lobe into two, so that the whole liver is really broken up into five lobes. At the portal fissure, three vessels pass into the liver : these are, the hepatic artery, bringing arterial blood from the aorta ; the portal vein, bringing venous blood from the stomach, intestines, pancreas, and spleen ; and the bile duct, which carries the bile from the liver to the duodenum. If these vessels be traced into the liver, they will be found to branch and divide, keeping each other company as it were, and bound together by loose connective tissue.

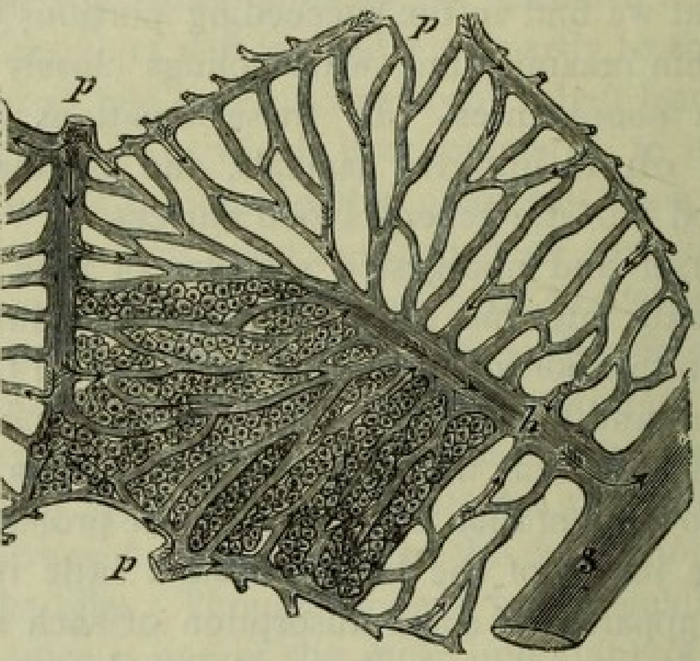

FIG. 22.—Diagram of an Hepatic Lobule.

p, inter-lobular branches of the portal vein ; *h*, intra-lobular branches of the hepatic veins ; *s*, sub-lobular vein ; *c*, capillaries.

Each lobule of the liver is about $\frac{1}{20}$ inch in diameter, and is arranged upon one of the terminal rootlets of the **hepatic vein** ; this minute vein rootlet is situated in the centre of the lobule, and is thus known as the *intra-lobular* vein. The lobules consist of minute cells cemented together by an intercellular cement substance; these cells, which are only $\frac{1}{1000}$ of an inch in diameter, are arranged in regular radiating lines around the central or intra-lobular vein. The lobular cell mass is pierced everywhere with a network of capillaries, which arise at the margin of the lobule, where they receive blood brought to them by the *inter-lobular* branches of the hepatic arteries and by the *inter-lobular* branches of the **portal vein** (Fig. 22, *p*); the capillaries of the lobule converge to the centre, where they unite to form the intra-lobular branch or rootlet of the hepatic vein; this again passes from the centre of the lobule, and opens directly into the (*sub-lobular*) branch of the hepatic vein.

The **bile ducts** commence between the hepatic cells in the form of fine canaliculi, which lie as a fine network of tubes between the adjacent sides of two cells. At the margin of the lobule, these fine canaliculi join and form inter-lobular bile ducts, which again coalesce to make the bile duct as it leaves the liver for the duodenum. All the bile secreted by the liver cells, and passing along these fine bile ducts, does not go direct into the duodenum; some passes by means of a special side tube or duct into the gall-bladder, which is a special sac or receptacle for bile situated on the under side of the anterior edge of the liver; from this **gall-bladder**, bile, we have already learnt, passes intermittently into the duodenum.

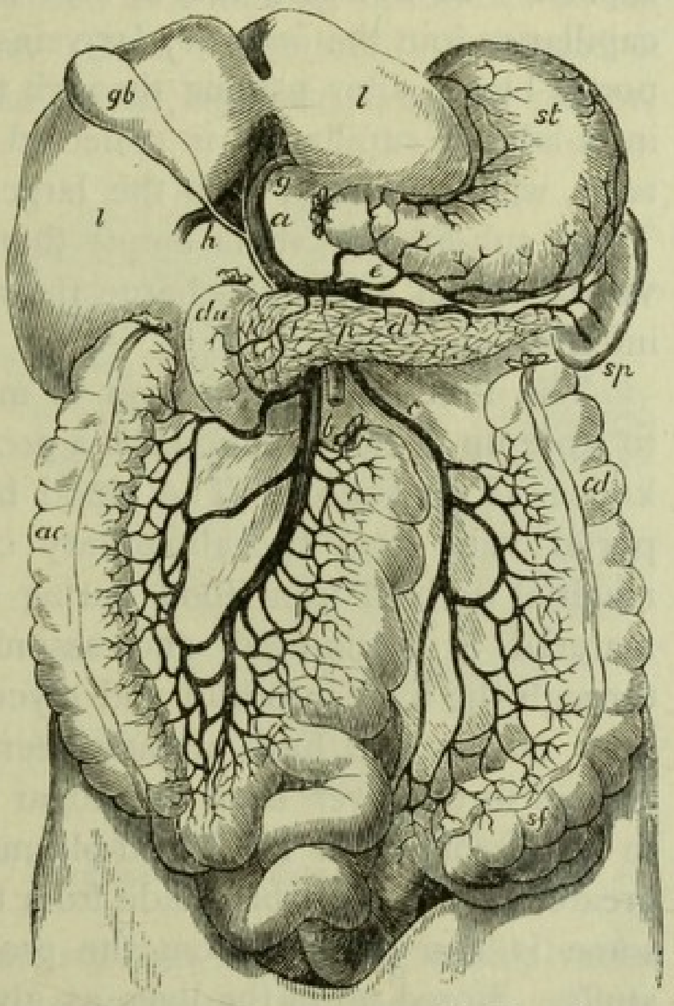

FIG. 23.—The Portal Vein and its Branches. *a, b, c, d, e,* the portal vein and its branches; *l*, liver; *gb*, gall bladder; *st*, stomach; *sp*, spleen; *p*, pancreas; *du*, duodenum; *ac*, ascending colon; *cd*, descending colon.

It will be apparent, from the foregoing statement, that the liver is peculiar in having a double blood supply. The chief supply is venous, from the portal vein, while the branches of the hepatic artery, which run with the branches of the portal vein, supply it with arterial blood. The **portal vein** divides and subdivides in the liver until it ends in the *inter-lobular* veins. The **hepatic artery** accompanies the portal vein, supplies the bile ducts, liver cells, connective tissue, and capsule with nutritive blood, with the result that its ultimate capillaries join the *inter-lobular* veins of the **portal** vein. The portal blood, after passing through the inter-lobular veins and intra-lobular capillaries, is collected in or by the *intra-lobular veins*, which, uniting, form the larger veins called *sub-lobular*. These sub-lobular veins empty themselves into the **hepatic veins**, which finally discharge their contained blood into the inferior vena cava.

The function of the liver is mainly to secrete bile and to store up in the hepatic cells a peculiar, starch-like substance known as **glycogen.** The blood brought to the liver by the portal vein from the alimentary canal is loaded with new material derived from food during digestion; and this crude material is elaborated and assimilated during its passage through the liver into bile and glycogen. The uses and purpose of the bile have already been explained. Glycogen is formed in the liver from the sugar and proteids which come to it dissolved in the blood-plasma of the portal vein; the greater part is probably made from the sugars of our food; but some is also derived from the proteids or albuminous food stuffs. Stored up in the liver as glycogen, much of the sugar absorbed from a meal is intercepted and prevented from passing too readily into the general blood circulation. The blood always contains small quantities of sugar, and is constantly supplying it to the tissues; as this circulating sugar is used up, some of the stored-up glycogen of the liver is turned into sugar again, and slowly discharged into the blood; in this way the sugar in the blood is always kept at the proper amount. This circulating sugar is ultimately converted in the tissues into water and carbon dioxide, and serves as a source of energy and heat in the body; in this sense it may be regarded as the fuel by which the activity and temperature of the body are largely maintained.

The liver stores up most glycogen after a meal rich in starch and sugar; but it can make it, though more slowly, from proteids or nitrogenous food.

The Pancreas.—The anatomical situation of this gland has been detailed on page 11. In structure it resembles the salivary glands, being composed of a number of lobules bound loosely by connective tissue. Each small lobule is formed of a group of somewhat tubular *alveoli*, from which a duct passes; and this, after uniting with other ducts to form larger and larger tubes, eventually leaves the gland to open into the duodenum. The cells which line the alveoli are columnar or polyhedral in shape, their protoplasm being in the inner two-thirds filled with small granules, while the outer third is clear. After a period of activity, the clear part of the cell becomes larger, and the granular part smaller. Enclosing each alveolus is a thin reticular basement membrane; the larger ducts have a wall of connective tissue outside the basement membrane, and also a few plain muscular cells. Blood vessels, lymphatics, and nerves are freely supplied in the form of a fine network around each alveolus.

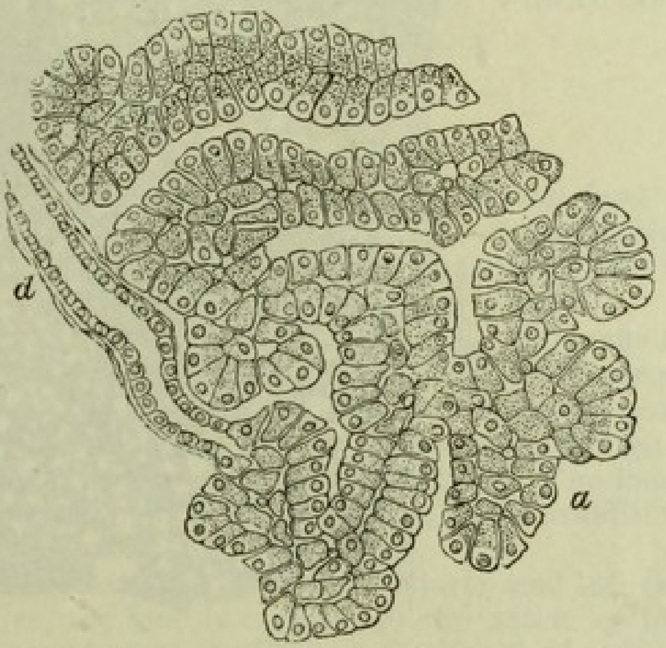

FIG. 24.—Section of the Pancreas.
d, termination of a duct in the tubular alveoli *a*.

The composition and action of the juice secreted by the pancreas have been already explained.

The Spleen is the largest of the so-called ductless glands. It is a dark red or purplish organ, some five inches in length, situated below the stomach, on the left side of the abdomen.

It is soft and spongy, and full of blood. In structure it is made up of a close branching meshwork (*trabeculæ*), consisting of fibrous, elastic, and plain muscular tissue; a layer of this same tissue invests it on the outside, constituting the so-called capsule; this, again, has a covering derived from the peritoneum.

In the interstices of the fibrous framework lies a soft pulpy substance, containing much blood, and dotted here and there

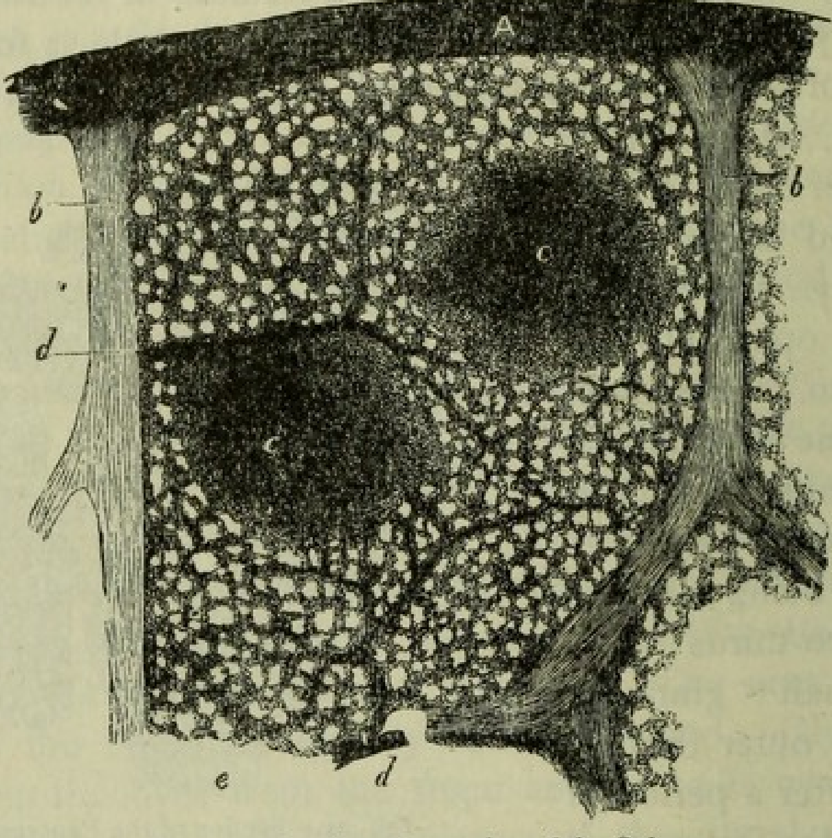

FIG. 25.—Section of a portion of the Spleen.

A, peritoneal and fibrous covering; *b*, trabeculæ; *c*, Malpighian corpuscles; *d*, injected arteries; *e*, spleen pulp.

with small whitish specks, known as the *Malpighian corpuscles*. These are composed of lymphoid tissue collected into clumps, which surround small arteries. The cellular elements which make up the spleen-pulp are of three kinds, namely, large amœboid, connective tissue cells, sometimes spoken of as splenic cells, lymph corpuscles, and the large-branched, flattened cells which form the framework. The first-named cells often contain in their interior red blood corpuscles in various stages of change into pigment.

The spleen is freely supplied with blood from the splenic artery, the smallest branches of which open directly into the pulp. From this spleen-pulp the blood is collected by small veins, which, gradually uniting, form the splenic vein, by which the blood is taken to the portal vein, and thence to the liver.

The function of the spleen is not thoroughly understood; but it appears to be intimately connected with the elaboration of the blood, white blood corpuscles being certainly formed, and the red ones probably submitted to destruction within it. The spleen varies in size, becoming largely distended with blood about five hours after a meal, then subsequently shrinking; it also constantly contracts and dilates every few minutes, apparently by virtue of the plain muscular fibres, which constitute a distinct feature of its skeletal framework.

SUMMARY.

Digestion really commences in the mouth, where, after the food is broken up by the teeth and then subjected to the action of the saliva, starch is converted into sugar. In adult life the teeth are thirty-two in number, but the milk or temporary teeth are only twenty in number.

From the mouth food passes through the pharynx and œsophagus to the stomach, which is a muscular bag, having four coats, and lying across the upper part of the abdomen. In the stomach the food is acted upon by the gastric juice, which, while having no action on starches and fats, dissolves the proteids, converting them into diffusible peptones. The food, as it leaves the stomach for the small intestine, is reduced to the condition known as chyme.

In the small intestine which extends from the pyloric end of the stomach to the ileo-cæcal valve, the food is exposed to the action of the bile, which emulsifies the fats, and to that of the pancreatic fluid, which converts starch into sugar, dissolves nitrogenous food, and further emulsifies fats. Passing into the large intestine, the food undergoes further digestion, the fluid portions are absorbed as chyle into the lymphatics and discharged into the blood, while the solid indigestible residue of food is discharged by the anus as so much excretal matter.

Closely identified with the digestive act, are the liver and pancreas. The liver is a large vascular organ lying in the abdomen, secreting bile which it pours into the duodenum to aid in the digestion of fats; the liver also elaborates a substance known as glycogen, closely resembling starch and sugar in composition. Glycogen is apparently finally oxidised in the lungs, thus producing heat. The pancreas resembles in structure and function the salivary glands, but it also has some digestive action on fats. The pancreas lies in the upper part of the abdomen beneath the stomach, and in the concavity of the duodenum.

The spleen, which is a ductless gland lying in the abdomen beneath the stomach and above the left kidney, is not, strictly speaking, associated with any digestive act, though it apparently enlarges immediately after or during the later stages of food digestion. The functions are but imperfectly understood, but appears to be concerned in the elaboration of the blood.

CHAPTER VII.

THE EXCRETORY SYSTEM.

The Structure and Functions of the Skin.—The skin consists of two layers, the outer called the cuticle or epidermis, the inner called the dermis or corium.

The **epidermis**, cuticle, or scurf-skin, forms a protective covering over every part of the dermis or true skin. The thickness of the epidermis varies in different parts of the body surface, measuring, in some places, as little as $\frac{1}{250}$, and in others as much as $\frac{1}{25}$ of an inch, or even more than this in some persons. It is usually thickest in the palms of the hands and soles of the feet, where the skin is exposed to pressure; it is not unlikely that such pressure may serve to stimulate the underlying true skin to a more active formation of epidermis.

The epidermis is made up of many layers of cells closely agglutinated together. The deepest layers consist of columnar or elongated cells placed perpendicularly on the surface of the underlying corium (Fig. 26). The layers over this consist of shorter, polygonal, or even round cells, while over these again the cells gradually become flatter and flatter, till those on the surface are mere scales. The cells of the deepest layer, or that nearest to the corium, are usually soft and often nucleated, they are known as the Malpighian layer; in the more superficial layers the nuclei disappear, and the individual cells are harder, they are here known as the corneous layer. The most superficial cells are gradually shed or worn away, and replaced by a multiplication of cells from the deeper layers. In negroes and other dark races, the colour of the skin is due to granules of pigment in the cells of the Malpighian layer. These deeper cells are closely adherent to, and fit into corresponding denticulations of the corium, but the corneous layer of the epidermis may separate from the Malpighian layer, as when a blister forms. The cells of the various layers of the epidermis have fine intercellular clefts or channels between them, and in these minute channels lymph corpuscles and leucocytes have been observed to circulate.

The **dermis,** or **corium,** or true skin, is a vascular and sentient fibrous tissue, covered and defended, as it were, by the non-vascular epidermis. Below it is attached to the parts beneath by a fine layer of areolar tissue, which, except in a few parts, contains fat; this subcutaneous connection of the skin with the deeper tissues is in parts loose and movable, in others close and firm. The corium, besides consisting of connective tissue fibres, connective tissue corpuscles, and elastic fibres, often contains muscular fibres, while blood vessels, nerves, glands and hairs are peculiarly abundant.

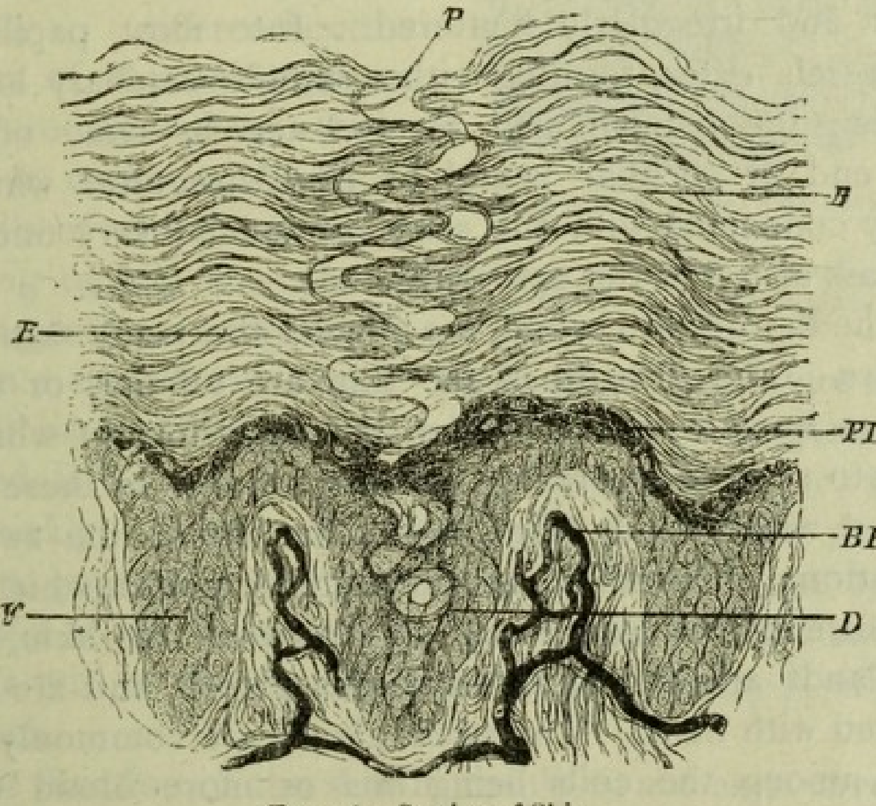

FIG. 26.—Section of Skin.

E, epidermis; P. L, stratum granulorum or layer of superficial cells belonging to the rete mucosum; V, rete mucosum; B. P, papillæ with blood vessels injected; D, sweat-gland duct, opening on the surface at *p*.

The free surface of the corium is marked by, or thrown up into small conical eminences called papillæ; these processes project up into the epidermis, and so make the lower edge of the cuticle irregular. In structure, these papillæ resemble the rest of the superficial layer of the corium, and consist of a finely fibrillated tissue with a few elastic fibres. The papillæ appear to contribute mainly to the perfection of the skin as an organ of touch, as they are highly developed wherever the sense of touch is acute. In these places they are ranged in lines or ridges, easily seen by the naked eye. In the less sensitive parts the papillæ are fewer, shorter, broader and irregularly scattered. Into most papillæ fine blood-vessels enter, forming either simple capillary loops or branches; the papillæ also receive nerves, some of which nerves end in peculiar round or oval structures which are specially connected with the sense of touch; very fine nerve fibrils pass also into the epidermis.

In the dermis or corium are placed the many skin glands and hairs. The **glands** of the skin are tubular, or sac-like structures lined with epithelium, the apertures of which are familiar to us as the pores of the skin. Some of these glands secrete a watery and saline liquid known as the sweat, or perspiration; while others secrete a greasy matter, which is the chief cause of the lustre and suppleness of the skin,—these latter glands are known as sebaceous glands, and are usually connected with hairs. The sweat glands are commonly coiled tubules, among the coils being one or more blood vessels. The perspiration is usually alkaline, but if mixed with much sebaceous matter it may be acid.

Hairs are closely associated with the structure of the skin; they are formed from the epidermis, and composed of horny cells. Each hair lies in a deep pit called the hair follicle. The hair itself consists of the root, which is fixed in the skin, and the shaft or stem. The stem is generally cylindrical, but it may be flattened; it is covered with fine imbricated scales, the edges of which project upwards, giving rise to a series of fine waved transverse lines, which are characteristic of a hair when seen under the microscope. The actual growth of a hair is dependent upon the continuous multiplication of epidermis cells which cover a small vascular papillæ which lies at the bottom of the hair follicle. The rate of growth of hair is about half an inch a month. With the exception of the bones and teeth, no tissue of the body withstands decay after death so long as the hair, for this reason it is often found preserved in graves, when nothing else remains but the skeleton.

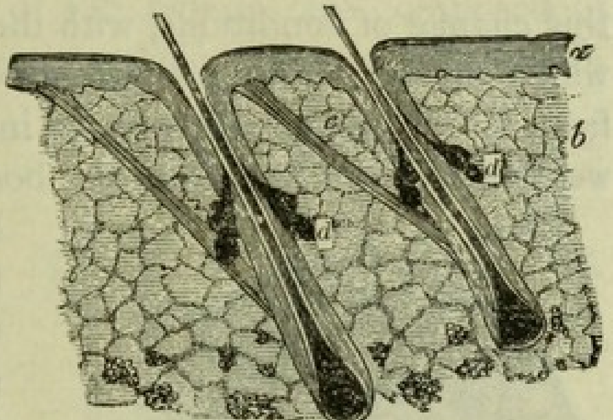

FIG. 27.—Section of the Skin, showing Hair Follicles.

a, epidermis ; *b*, dermis ; *c*, muscles of the hair follicles ; *d*, sebaceous glands.

Nails, like hairs, are specially differentiated growths of the epidermis. They are formed of the outer or corneous layers, the cells of which, instead of being rapidly shed, become agglutinated together to form a stout horny plate. The part of the corium to which the nail is attached, and by which, in fact, it is generated or secreted, is named the *matrix*. This matrix is very vascular, and thickly covered with large papillæ. Behind the matrix forms a groove, or fold, deep in the middle, but becoming shallower at the sides ; this lodges the root of the nail. The average rate of the growth of the nails is about $\frac{1}{32}$ of an inch per week.

The function of the skin is mainly to act as a covering, or defence, for the highly vascular and sensitive structures beneath. It, moreover, by virtue of the sweat glands, which are so freely distributed in it, is a source of a loss to the body of water, heat and a small quantity of carbonic acid. The watery loss varies greatly, but is usually about a pint in twenty-four hours. The activity of the sweat glands is really dependent upon certain impulses passing from the brain to the special nerves supplying the glands, but is assisted by the greater or less flow of blood to the skin as controlled by the nervous system acting through the vaso-motor nerves. An increased flow of blood to the skin is not necessarily accompanied by a profuse perspiration, though the two phenomena are usually co-existent. In what are known as "cold sweats," the glands secrete perspiration freely, although the supply of blood to the skin is small. The secretion of perspiration is intimately connected with the loss of body heat, for, as the perspiration evaporates and water passes into steam, so heat is absorbed by the water during this change of conditions, with the result that this surface from which the evaporation takes place is cooled by the heat taken from it. This explains why an increase of perspiration in hot weather removes heat from the body, and thereby prevents the body from becoming hotter than usual; conversely, in cold weather, owing to the skin receiving less blood, following constriction of the superficial vessels, the secretion of perspiration is diminished and the loss of heat from this source reduced.

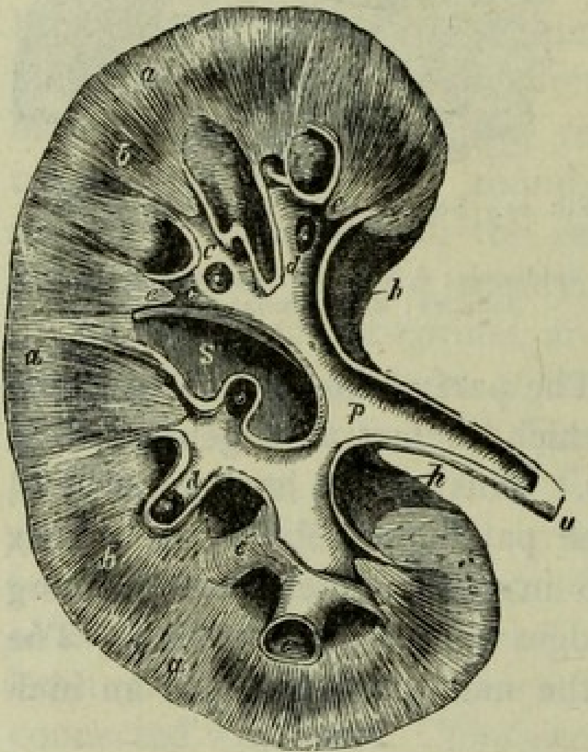

Fig. 28.—Section through a Kidney.

a, cortical substance; *b*, pyramids; *c*, calyces of the pelvis laid open; *d*, summits of pyramids projecting into the calyces; *p*, pelvis; *u*, ureter; *h*, hilus.

The Kidneys are dark red organs, some four inches long and two and a half inches wide, situated in the abdomen, one on either side of the lumbar region of the spinal column. They are somewhat flattened, being about an inch in thickness; the outer edge, or border, is convex, but the inner is concave; the depression at the middle of the inner border being known as the *hilus*, or point at which the arteries enter and the veins leave the kidneys. From this hilus also issues another tube or vessel called the **ureter**; this is a tube some fourteen inches long, which passes from the kidney to the bladder, and carries off the urine as secreted from the former to the latter.

In structure the kidney is a compound tubular gland.

When cut open, it looks to the naked eye to be formed of two portions—a *cortical* and a *medullary;* the latter being subdivided into a number of pyramidal portions, the base of each of which is surrounded by cortical substance, while the apex projects in the form of a *papilla* into the dilated commencement of the ureter known as the *pelvis* of the kidney. Both the cortex and the medulla of the kidneys are composed of **uriniferous tubules**, while the whole organ is invested in a fibrous capsule, which is continuous with the pelvis at the hilus.

The uriniferous tubules, which compose the chief portion of the kidney, are convoluted in the cortex and straight in the medulla. Each tubule commences in the cortex as a dilatation (capsule) enclosing a *glomerulus* or tuft of convoluted capillaries. After leaving the capsule, the tubules are at first convoluted, then become narrow and form loops, which dip down into the base of the medullary portion; these loops return into the cortex, and there become again convoluted, eventually, however, narrowing into a short narrow tubule. Several of these unite to form a straight tube which, passing direct through the medullary substance of the kidney, opens at the apex of the papilla projecting into the dilated pelvis of the organ.

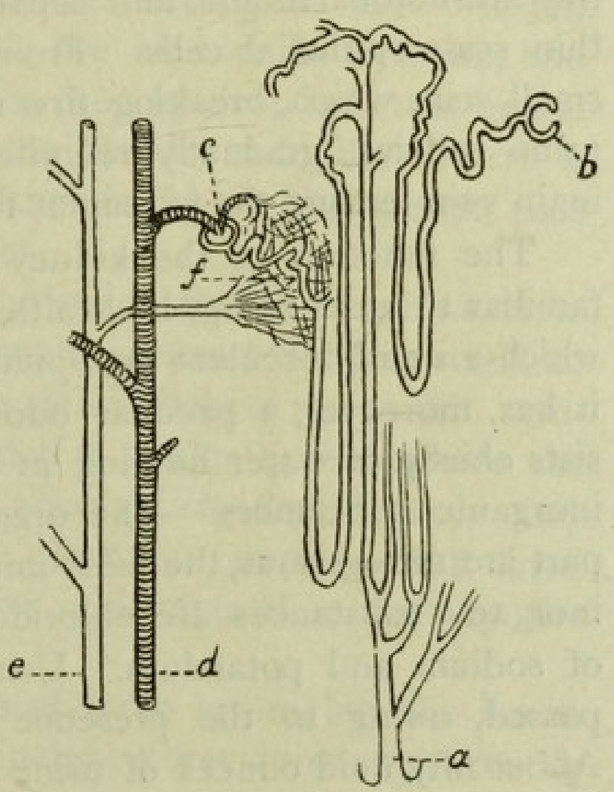

FIG. 29.—Diagram of an Uriniferous Tubule. *a*, opening into pelvis of kidney; *b*, an empty Malpighian capsule; *c*, Malpighian capsule receiving branches from *d* or renal artery; *e*, branch of renal vein; *f*, capillaries.

The uriniferous tubules consist of a fine membrane lined with epithelium; this epithelium is cubical in the convoluted portions, rather flattened in the loops, and columnar in the straight tubes of the medullary pyramids. The capsules or *Malpighian bodies* are lined by flattened epithelial cells, which also are reflected over the glomerulus or tuft of convoluted capillaries.

The blood supply of the kidney comes from the aorta by the renal artery, which, entering at the hilus, breaks up into branches and capillaries distributed between the pyramids and forming a plexus around them. From these capillaries proceeds an artery to each glomerulus, forming there a kind of tuft of fine vessels, which fills the dilated commencement of the uriniferous tubule, and separated from the urine only by thin scaly epithelial cells. From each glomerulus proceeds a small vein, which, breaking first up into capillaries around the urine tubules, gradually re-unite into veins which form the main vein leaving the kidney at the hilus as the renal vein.

The function of the kidney is to secrete **urine**; this is familiar to us as being, in health, a clear, pale yellow fluid, in which a small flocculent precipitate of mucus may be observed; it has, moreover, a peculiar odour and saline taste. It consists chiefly of water holding in solution certain organic and inorganic substances. The organic substances for the most part are nitrogenous, the most important being *urea*; the chief inorganic substances are chlorides, phosphates, and sulphates of sodium and potassium. Urine is usually acid when first passed, owing to the presence of acid sodium phosphate. About fifty fluid ounces of urine are secreted daily, containing roughly some two ounces of solids, and of these one and a quarter ounce is urea.

Urea is a compound of which nearly half its weight is nitrogen. It is the form in which nearly all the nitrogen loosed from the body passes away. About 500 grains of urea are secreted normally in the twenty-four hours, representing some 240 grains of nitrogen leaving the body in this form; the small remainder of nitrogen daily lost is excreted by the urine and other substances chiefly as uric acid.

Probably the water of the urine and some of its saline constituents in solution, are separated from the blood as it passes through the glomeruli of the kidney; this separating process must not be regarded, however, as a simple filtration, as the epithelial lining or covering of the glomerular capsules consists of living cells, "and these decide what shall pass and what shall not." As the watery urine passes from the capsules or glomeruli along the uriniferous tubules, other substances, such as urea, etc., are added to it by the epithelial cells lining the tubules; these, as it were, secrete the urinary constituents.

The Ureters and Bladder.—The urine as it is formed by the urine tubules, passes into the pelvis of the kidney or dilated commencement of the ureter. This is a muscular tube lined by mucous membrane leading to the bladder. Each kidney is connected with the bladder by a ureter, and down this tube the urine trickles drop by drop into that organ. Regurgitation of urine from the bladder into the ureters is prevented by the oblique manner in which the ureters pass through the coats of the bladder.

The **bladder** itself lies in the middle line of the pelvis, close to the anterior wall. It is usually contracted upon itself, so that it lies entirely in the true pelvis, behind the pubic symphysis. As it becomes distended it gradually rises above the brim of the pelvis, and when greatly distended, its apex may reach nearly to the umbilicus. It has a muscular wall lined by a strong mucous membrane and covered in part by the peritoneum.

The muscular coat consists of three layers, but the innermost is incomplete. The principal fibres run longitudinally and circularly; the circular fibres are collected into a layer of some thickness which immediately surrounds the aperture of exit from the bladder. The mucous membrane is lined by special stratified epithelial cells like those of the ureter.

SUMMARY.

The chief sources of loss to the body are (1) the lungs, by which it loses much water and carbon dioxide; (2) the skin, by which it loses much water, a little carbon dioxide and some urea; (3) the kidneys, by which it loses much water and urea with a little uric acid.

The skin consists of two chief parts, the epidermis composed of flattened cells, and the dermis composed of fibres of connective and elastic tissues. The epidermis is simply protective and without blood vessels or nerves. The dermis is vascular, well supplied with nerves, and also contains innumerable sweat and sebaceous glands. The sweat or perspiration is a saline watery liquid, tending by its evaporation to reduce the temperature of the body, and also serving as a means for the removal of waste matters. The secretion of the sebaceous glands serves to lubricate the skin and hairs. The nails and hairs are specialised developments of the epidermis.

The kidneys are two important glandular organs lying in the abdomen on either side of the lumbar vertebræ, and having a somewhat complicated tubular structure. Their function is to excrete urine, the daily loss by which to the body amounts to about 3 lbs. of water, 1 oz. of urea, 10 grains of uric acid, various salts and some dissolved gases. The urine passes continuously from either kidney by the ureters to the bladder, which is a strong oval muscular bag, lying in the fore part of the pelvis. The urine is retained in the bladder and discharged from it at intervals by muscular action.

CHAPTER VIII.

THE NERVOUS SYSTEM.

The Nervous System is that by which we think, desire or will, and perceive; it is also that system by means of which all the various functions of the body are kept in proper relation one with another. It is the most highly organised and complicated of any in the body, but space will not permit us to deal with it except in a most elementary manner.

The nervous system consists of two portions, called the *cerebro-spinal* and the *sympathetic* systems.

The cerebro-spinal system consists of the brain, the spinal cord, and all the nerves given off from the brain and spinal cord to the various organs of special sense (eyes, ears, nose, skin, etc.), and to the voluntary muscles. The brain occupies the cavity of the cranium, while the spinal cord occupies the spinal canal.

The sympathetic system of nerves consists of a thin greyish cord with bead-like enlargements call ganglia, situated on each side of the front of the vertebral column, and extending from the skull to the pelvis; it also includes innumerable fine nerve fibres distributed to the various internal organs, to the blood vessels, and to the involuntary muscles of the body.

The tissue or substance of which the nervous system is composed consists of either cells or fibres. Nerve cells constitute the chief part of the brain, the spinal cord and all the sympathetic ganglia. The cells are branched and united one with another by interlacing fibres. Nerve fibres are of two kinds, grey and white. The white fibres are an essential constituent of the cerebro-spinal nerves and also enter largely into the structure of the brain and cord. The grey fibres are found principally in the nerves of the sympathetic system.

Every nerve is nothing more than a bundle of either grey or white fibres bound together by a delicate sheath of connective tissue. Such a nerve has no power of starting or originating a nerve impulse; this impulse can only arise from a nerve centre, such as the brain, or one of the ganglia of the sympathetic system. The nerve centre may be compared to a galvanic battery, and the nerves to the wires which convey the electric current to and from it. "The battery, like the nerve centre, *generates*, *receives* and *transmits*; while the wires of the battery, representing the nerves, simply conduct." Nerve fibres are distributed to nearly every part of the body, and according to the places in which they terminate they have the following names—namely, motor nerves supply the muscles; the sensory nerves terminate in the skin, mucous membranes, and the organs of special sense; the vasomotor nerves end in the coats of the blood vessels, and are the means by which the amount of dilation or constriction of the vessel is regulated; the secretory nerves are distributed to the secreting glands, in the cells of which they terminate. Some of the sensory nerves of the skin terminate in a special manner, and are supposed to be intimately associated with the sense of touch.

Practically, almost all the actions of the body which depend on the nervous system are the results of what are known as **reflex actions** more or less complicated. A person pricks his finger and instinctively withdraws it; this is a simple reflex action. In this case, the terminations of the nerves in the skin, on being irritated by the prick, set up an irritation which is instantaneously conveyed by nerve trunks to the spinal cord, in the cells of which a nervous impulse is generated, passed out by other nerve trunks to appropriate muscle fibres causing a contraction and movement. More complicated actions involve more complex reflex actions, and in many cases depend primarily upon recollections of various previously received sensations stored up in the cells of our brain; these recollections give rise to thought ending in a determination to act, marked by the despatch from the brain of impulses to our muscles to carry out a definite act or series of acts. In cases where there is no consciousness, it is probable that the nerve cells of the spinal cord are sufficient to change sensory impulses into motor impulses in very simple reflex actions; but in more complicated acts, involving consciousness, it is probable that the brain cells must receive the stimulations or irritations.

In the many involuntary reflex acts connected with secretion, digestion, assimilation and the maintenance of body heat, it is the sympathetic nervous system which is employed in sending and receiving impulses to and from the various viscera. Thus, if a man drink too much water, his blood soon contains too much fluid; involuntarily, by means of the sympathetic nerves, impulses are sent to the blood vessels of the kidneys, which, by dilating, allow more blood to flow through the kidney, resulting in an increased amount of urine and an increased quantity of water filtered off from the blood. Similarly, if food be placed in the mouth, more blood is sent to the digestive organs and certain secretions poured out to digest and act upon the food.

SUMMARY.

The nervous system is divided into the cerebro-spinal and the sympathetic systems. The cerebro-spinal portion consists of the brain and the great nerves issuing from it, the spinal cord and its nerves; it also includes all nerve fibres distributed to organs of sense and voluntary muscles. The sympathetic system consists of a double chain of ganglia on each side of the vertebral column, and various disconnected ganglia. Its fibres are distributed to the internal organs and to the walls of the blood vessels.

Nerve tissue is either cellular or fibrous. The nerve cells are greyish in colour, and found mainly in nerve centres and the ganglia. Nerve fibres go to form nerves, and also enter largely into the construction of nerve centres. When fresh, nerve fibres appear as a simple semi-transparent filament, but when dead appear to be a white opaque substance.

Nerves consist of three varieties, according to their physiological function; that is, they may be afferent, efferent, or mixed nerves. An afferent nerve conveys impressions to a nerve centre only; it is sometimes called a sensory nerve. An efferent nerve conveys impressions from a centre only, and its fibres terminate in muscular fibres; it is sometimes called a motor nerve. A mixed nerve contains both afferent and efferent fibres.

The brain consists partly of nerve cells and partly of nerve fibres. It fills all the upper portion of the cranium, has gray matter on the surface, which is convoluted; the central parts of the brain consist mainly of white matter, in the form of nerve fibres, which connect the various parts together, and unite with those fibres which constitute the spinal cord.

The spinal cord occupies the vertebral canal, and consists mainly of nerve fibres on the outer surface, and of nerve cells (grey matter) in the centre. The chief functions are (1) the conduction of impressions by means of its white nerve substance or fibres, and (2) it is a centre for reflex action (grey matter). The spinal cord gives off thirty-one pairs of nerves to various parts of the body.

A reflex action is a disturbed condition of sensory nerve fibres conducted to a nerve centre, thence reflected along motor fibres to a muscle or gland, when it results in either muscular contraction or secretion.

PART II.

ELEMENTARY HYGIENE.

CHAPTER IX.

SOURCES AND VARIETIES OF DRINKING WATER.

Water is one of the first necessities of life, and is found widely diffused in nature; without it, man could only live for a few days. It enters into the structure of plants and animals as well as into nearly every tissue of our body. Water forms at least four-fifths of all the food we take, and it is due to the solvent action of water that our daily food is so changed and dissolved that the nutritive parts can be taken up by the blood, and go to renew the perpetual waste going on in our bodies. As a solid we meet with water in the form of snow and ice; as a liquid in the sea, in streams, rivers and ponds; from the sea and from the land it is raised as invisible vapour, and by separating from the air it forms the clouds, whence it falls again as rain, dew, or mist. The supply of water is a fundamental necessity, and our health largely depends upon a supply pure in quality, and sufficient in quantity.

Few people know anything of the water they drink; provided it is clear, and has no peculiar taste, they are satisfied to use it; but some of the clearest and most brilliant-looking waters are the most impure. Now we want to say something about water, and to point out some facts about water-supplies, whether it be the pump-water from a well, or rain-water, or water taken from the public main, or from a cistern.

Composition and Properties of Water.—Water is a chemical compound, consisting of two atoms of hydrogen with one of oxygen. In its purest state it is free from taste and smell, and, between 32° and 212° Fahr. under ordinary atmospheric pressure, is a transparent, tasteless, inodourous and almost colourless liquid. Water is the greatest solvent known, and for this reason is never found pure in nature.

Sources of Water.—All the water we get from springs, wells, ponds, and rivers, is derived from the rain which falls upon the ground. From the surface of the sea, and from the land, water evaporates under the influence of the sun's rays; it forms clouds by being separated from the air, and descends under changes in temperature in the form of rain, dew, mist, snow, sleet, and hail. Part of this water is again evaporated—part flows off the surface of the ground, and helps to swell the brooks and streams which, uniting, form rivers. Another part sinks in through cracks and fissures into the earth, until it reaches an impermeable stratum, when it becomes collected into the underground reservoirs which supply our wells and springs.

Rain Water varies with the purity of the atmosphere through which it has passed. If gathered in clean vessels as it falls in the open country, it would be wholesome and safe to drink; but in towns and villages it is sure to take up impurities of many kinds. As rain descends through the air it takes up from the atmosphere oxygen and carbonic acid gas, as well as nitrogen and ammonia. In addition it carries down with it suspended matters floating in the air; so that before it reaches any collecting surface, it may have added to it as much as two grains of solid matter in a gallon of water.

Rain-water is very frequently contaminated by impurities taken up from the surface on which it falls. It is best where it falls on a slate roof, but it will generally take up a little decaying vegetable matter from a tiled roof by reason of the small plants usually growing there. Rain and other soft waters have a very considerable power of dissolving metals: from a lead-covered roof it may take up a little lead, and from a galvanized iron roof a little zinc, especially if the water contains nitrates. Further, rain-water which has passed through lead pipes or been stored in leaden cisterns is apt to contain this injurious metal.

When rain-water is collected from roofs it is advisable to reject the first portion that falls, which usually is the washings of impurities off the roof and to allow such water to run to waste. This may be done by means of a rain-water separator. The separator is made of zinc upon an iron frame, the central part, or canter, being placed upon a pivot; it directs into the lower waste-pipe the first part of the rainfall which washes away the dirty substances from the roof. After a certain quantity has fallen the separator cants over and turns the clean water into the storage tank (Fig. 30).

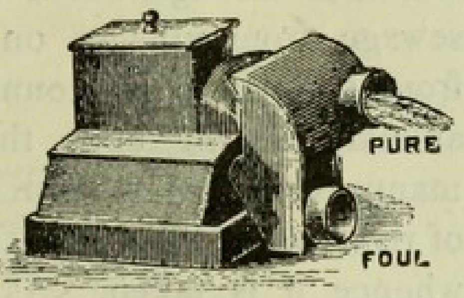

FIG. 30.—Rain Water Separator.

The average rainfall for the last two decennial periods in the United Kingdom is given in the following table:—

Rainfall.	1870–79.	1880–89.
England and Wales	35·56	33·76
Scotland	40·43	46·56
Ireland	35·86	38·54
Average of the United Kingdom	36·50	37·30
,, Great Britain	36·52	36·69

The quantity of water which can be utilised from the rainfall may be calculated if the amount of the rainfall and the receiving surface is known. The average of the three driest years is generally taken as a safe basis on which to calculate the supply. On an average, six-tenths of the rain which falls is available for storage. A simple method for calculating the amount of water given by rain is to multiply the area of the roof or receiving surface in square feet by half the rainfall in inches, the result is expressed in gallons; the error here is only about four per cent.

River Water.—Rain flowing over and through the land supplies streams and rivers. If the supply is taken from the head waters or source of the river before it reaches inhabited and cultivated lands, it is generally pure; but when rain falls upon cultivated farm lands or inhabited places it must be in any case regarded with suspicion, and is often unfit to drink. Rivers and streams form the natural drainage channels of the localities through which they pass, and therefore receive the sewage from villages on their banks and the waste liquids from factories. In country districts they are fouled by the animals feeding upon the banks and from the bones and manures applied to farm lands. The composition, therefore, of river water will vary according to the part of the river from whence it is taken. As a rule the dissolved mineral constituents in river water are in less quantity than in spring waters, but organic matters are present in greater quantity.

The use of river water for drinking purposes, unless filtered and boiled, is not to be recommended. It is especially dangerous when the river is in flood, or when there has been a prolonged drought.

Spring Water.—Springs are the outcrop or overflow of the ground water, a spring being merely a natural outlet for the underground water which is tapped when a well is sunk in the ground. They are commonly found on the side or foot of a hill, in valleys, and in the beds of rivers. When they appear flowing from artificial beds of gravel they are called "land" springs; these are derived from limited areas, are not far from the surface, and their flow and yield are uncertain. "Main" springs are found in the deeper strata, and are derived from large underground reservoirs of water; they yield a somewhat regular and constant supply.

Spring water varies in hardness according to the more or less soluble nature of the rock through which it has passed: it usually contains mineral matters, especially carbonate of lime. As a rule, spring water, although hard, is an excellent drinking water.

Wells.—There are two kinds of wells—*shallow* and *deep*. A well of fifty feet in depth, or less, is generally regarded as a shallow well; one of a hundred feet or more as a deep well. Shallow wells may yield good water, provided there is no risk of pollution from surface washings or from their proximity to drains or cesspools; but in every case it is wise to go deep enough to place an impervious stratum between the water supply and the surface of the ground. Shallow or surface wells are those which, sunk in pervious soil, tap the underground water which has percolated from the surface of the ground in the immediate vicinity of the well; while deep wells tap the water-bearing stratum beneath the impervious stratum, the water of which has percolated from the land at some distance from the well.

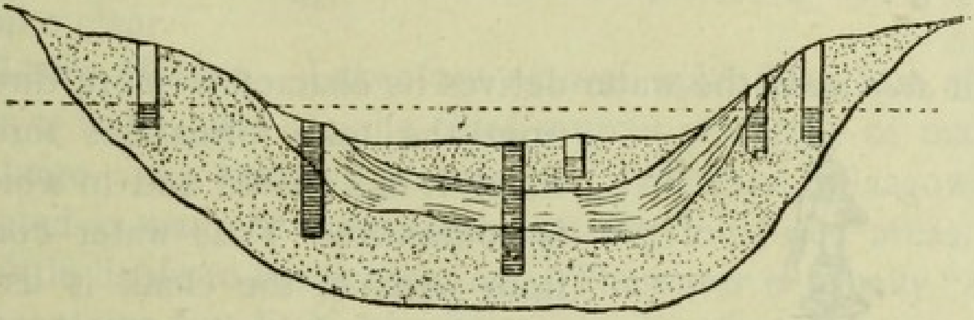

FIG. 31.—Diagram showing the tapping of the ground water above and below an impermeable stratum.

An *artesian* well (so called from the province of Artois in France where they were first used) is a well of great depth passing through a (*a*) pervious layer of soil, (*b*) an impervious layer, (*c*) water lying on the top of a deeper impervious layer.

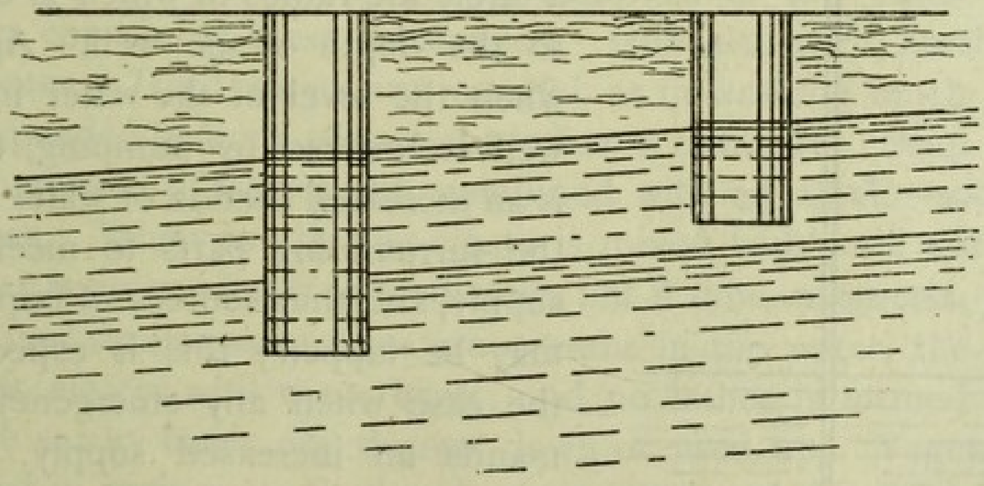

FIG. 32.

Unless great care is taken, water from a *shallow well* is liable to pollution from surface impurities, from proximity to leaky sewers, cesspits, or other receptacles of waste matters: precaution should therefore be taken to guard against such contamination by sinking the shaft as deep as possible into the water-bearing stratum, and protecting the sides by steining with brick and cement, this being carried sufficiently high above ground to prevent surface washings from entering the well.

In *deep wells* the water derives its characters more directly from the rock formations through which it has passed and in which it is contained. Thus water coming from wells in the chalk is usually pure but very hard, from the large amount of carbonate of lime it holds in solution. Sandstone also yields pure water.

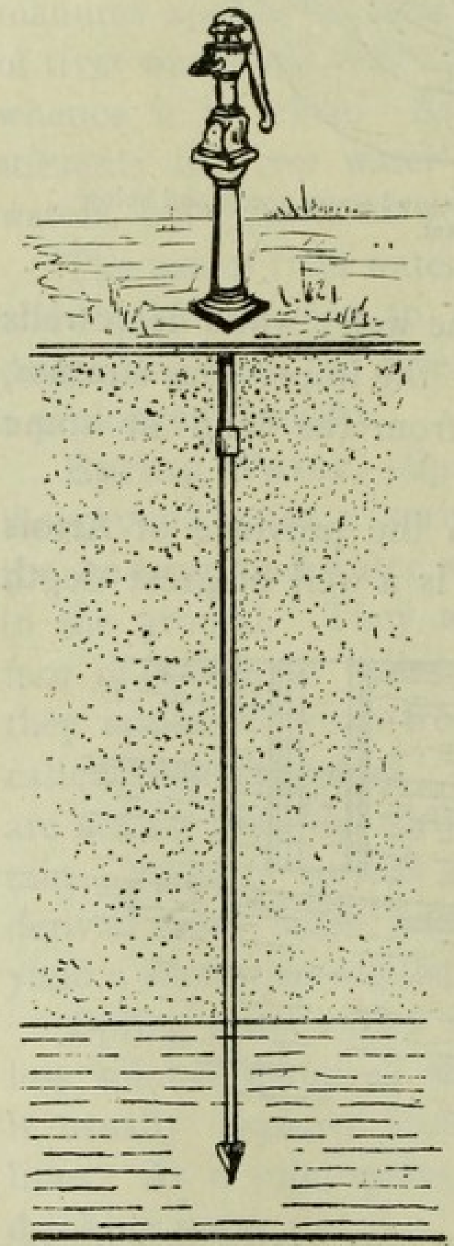

FIG. 33.

The distance drained by wells is undetermined, but in many cases no doubt large areas are affected, and the flow of water has been influenced at a distance exceeding a circle the radius of which is equal to the depth of the well. Again, when the level of the water in the well is lowered by pumping, there is an increased suction of water from the surrounding parts to meet the supply, and thus sources of impurity may be tapped; this is especially the case when any emergency demands an increased supply. To protect the water-supply from any soakage from leaky cesspools or other sources of pollution, the well should be placed above them, to windward, as it were, of all such possible sources of contamination.

Tube wells, commonly known as Norton's tube wells, are frequently used when a temporary supply is required. They are constructed by driving tubes into the soil, one length being screwed on to another, the first tube being perforated at the bottom for about two feet, its lower end being furnished with a steel point; when the subsoil water is reached, a pump is attached to the tube; the water, after pumping a short time, is quite clear.

Lake Water.—Lakes are natural upland surface collections of water, and are the chief sources of supply of many of our large cities, such as Manchester, Liverpool, Glasgow, etc. Situated as many of these are in sparsely inhabited areas, they are little liable to contamination. The water is usually "soft," and contains but little mineral matter, as the strata on which it rests are not very soluble. These waters constitute the source of our purest supplies. **Reservoirs** are artificial lakes, and are usually made by damning up the outfall of water from gathering grounds in the neighbourhood.

Hard and Soft Waters.—Water is frequently described as *hard* and *soft*. These terms are employed to express the difficulty or ease with which water forms a lather with soap, or, the soap-destroying power of a water. Hardness is due to the presence of lime and magnesia dissolved in the water from strata containing these substances. Iron also adds harshness to water. Hard waters are wasteful, as in washing much soap is expended before a permanent lather is obtained. Soap itself is composed of fatty acids, combined with an alkali—soda or potash. When an alkaline oleate is mixed with pure water, a lather is given almost immediately, but if lime, magnesia, iron, or other similar substances are present in the water, the soap forms oleates with these bases, and no lather is formed until these earthy bases are thrown down or used up. Vegetables boiled in such water tend to become hard, and the difficulty of infusing tea in hard water is well known.

The following tables show the characteristics of water from different sources (*Rivers Pollution Commissioners' Report*) :—

1. In respect of wholesomeness, palatability, and general fitness for drinking and cookery :—

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

2. Classified according to softness with regard to washing, etc.

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated land.
4. Polluted well waters.
5. Spring water.
6. Deep well water.
7. Shallow well water.

3. As regards the influence of geological formation in rendering the water sparkling, colourless, palatable, and wholesome, the following water-bearing strata are the most efficient :—

1. Chalk.
2. Oolite.
3. Greensand.
4. Hastings sand.
5. New red sandstone.

The characters of a pure and wholesome water are largely negative. It should be clear, bright and sparkling, showing that it is well aerated; free from colour and taste, and not too hard. There should be no sediment, and, if any, it should consist of a little mineral matter. When there is any marked deviation from this standard, the cause of it should be carefully inquired into.

SUMMARY.

The chief sources of water are rain, springs, rivers, lakes, and wells. The purity of water from these different sources is apt to vary acording to the circumstances under which it is gathered, the nature of the surrounding soil, and the greater or less access of men and animals to them. As a rule, springs and deep wells yield the purest and best drinking waters. Rain water is peculiarly liable to contamination by impurities taken up from the surfaces on which it falls; as a source of drinking water, rain is unreliable both in respect of quantity and quality. The composition of river water varies according to the part of the river whence it is taken; as a rule, river water, in populous districts, is an unsafe source of supply, but provided the gathering grounds are efficiently protected from pollution by animals and men, rivers may afford good supplies.

The most wholesome waters come from springs, deep wells, and upland surface gathering grounds. Stored rain water and surface water from cultivated lands are always suspicious. Shallow well water, and water from rivers to which sewage gains access, are dangerous.

Waters may be either hard or soft, according to their richness or poverty in the salts of lime and magnesia. The softest waters are rain water and surface waters; the hardest are from wells, springs, and polluted rivers. The best waters usually come from the chalk and oolite, next from the greensand and the various sandstones.

CHAPTER X.

THE STORAGE AND DISTRIBUTION OF WATER.

Quantity of Water required.—The amount of water used varies, being dependent on the condition of the place and population. An average-sized man loses, by the skin, lungs, and kidneys, about seventy-five to eighty ounces of water daily, and as this loss has to be replaced, it follows that about half a gallon of fluid must be taken daily. Of this quantity some is contained in the solid food consumed. So that for drinking purposes about fifty or sixty ounces are required; this quantity depending upon the season of the year, and the occupation of the individual. The following table gives a fairly accurate estimate of the quantities required for an ordinary household—

	Gallons daily for one Person.
Cooking	0·75
For drinking	0·33
Baths	5·0
Share of house washing	3·0
Share of laundry washing	3·0
If a general bath, add	4·0
Water-closets	6·0
Unavoidable waste	3·0
Total	25·0
For town purposes, etc.	5·0
Add for manufacturing towns	5·0
	35·0

The supply allowed per individual, in various towns, differs greatly. For example: Glasgow receives 52 gallons per head per day; Dublin, 35; Liverpool, 27; London, 35; Paris, 53;

Berlin, 22. Fifteen gallons should certainly be regarded as a minimum supply, and **twenty gallons** as a fair average; while twenty-five gallons can by no means be considered as excessive when baths and water-closet supplies are included. In hospitals an allowance of at least forty to sixty gallons per head should be made, on account of the larger amount required for baths and water-closets.

Storage and Distribution.—The water supply of a town may be on the *constant* system, in which the supply pipes are always kept full of water, or on the *intermittent* system, in which the water is only turned on at intervals for a short time during the day. The disadvantages of the intermittent system are obvious; it necessitates the storage of water in cisterns, water-butts, etc., and these are apt to get foul. Special dangers also arise from the sucking of sewer gases into the empty pipes through faulty joints, and, as the supply is a limited one, it is not always sufficient to ensure perfect cleanliness. Moreover, under the constant system the pipes last longer, as they are not so liable to rust as when filled alternately with water and air.

Cisterns.—Water which is stored in cisterns soon becomes flat and insipid, and unless periodically cleaned and carefully protected from dust, a sediment accumulates in the tank which fosters the growth of micro-organisms. Cisterns are usually made of slate, iron, galvanised iron, or lead; the latter should never be used where the stored water is taken for drinking purposes. Galvanised iron cisterns are most generally used; they have been known to give up zinc to water, but this is so exceptional that it should not prohibit their use. The cistern may also become a source of danger when the overflow pipe is led directly into a drain or soil pipe; foul air escapes directly over the surface of the water, and the water may thus become dangerously polluted; the overflow pipe should, in all cases, be carried outside, so as to discharge into the open air. For the same reason the supply pipe of any water-closet should not pass direct from the cistern, but a smaller cistern (water-waste preventer) should intervene.

To permit of cisterns being periodically cleaned they should be placed in an accessible position, and so situated that foul air, soot, dust, etc., are excluded; they should be covered with a well-fitting lid, and protected, as far as possible, from both heat and light. Cisterns should be periodically **cleaned at least twice a year.** Tanks to hold rain-water require even more constant care than cisterns, as the rain-water carries impurities with it from the roofs of buildings from which it is generally collected.

Water is usually distributed by iron pipes, called **mains,** laid about two and a half to three feet underground, the thickness of the pipe being dependent on the pressure to which it is subjected by the head of water. Cast-iron pipes, unless protected, rapidly corrode, especially when the water is soft. It is usual, therefore, to coat these pipes with a protective material before laying them down. Angus Smith's process is the one generally adopted. A varnish, distilled from coal tar until the naphtha is entirely removed, is deodorised, and a small quantity of linseed oil added; this mixture is carefully heated in a tank to about 400° F., and the pipes immersed in it. **Service pipes** communicating with houses are made of lead, wrought iron, galvanised iron, or "composition" pipe, an amalgam of lead and tin. Lead pipes should only be used when it has been proved that the water has no action on that metal, and, in any case, the water which has been remaining all night in the lead pipes should invariably be allowed to run to waste, sufficient to make certain that the water used has come direct from the street main.

Galvanised iron pipes are now very generally used; they are not liable to rust, and stand the pressure of the water well. Block-tin pipes are excellent, but very expensive. Water does not act on them, and they last a long time. Composite pipes consisting of block tin enclosed in a lead pipe are not liable to be acted on by water, but if the surface of the tin is fissured either in bending the pipe, or by frost, galvanic action takes place, and the lead is rapidly dissolved; they are, however, said to answer in places where they have been tried. A pipe coated inside with vitreous glaze, if not considered too expensive, is a perfect material, as it is not affected by any class of waters, and does not yield any unpleasant taste to water.

Action of Water on Lead Pipes.—The waters which act *most* on lead pipes are: (*a*) pure and highly oxygenated water, as distilled water, and, generally, soft waters from moorland districts; (*b*) those containing organic matter, nitrates and nitrites; (*c*) waters containing an excess of chlorides; (*d*) those containing a free acid (not CO_2), such as humic, ulmic, sulphuric, or any organic acid, the product of bacterial growth.

The waters which act *least* on lead pipes are: (*a*) hard waters, especially those containing carbonates; (*b*) waters rich in carbonic acid, provided it is not in excess; (*c*) waters containing silica, an insoluble silicate of lead being formed.

But apart from the chemical character of the water, there are other conditions which favour its solvent action on lead. These are (1) temperature: hot-water pipes yield more lead than cold-water pipes; (2) the length of time water has been in contact with the pipe, its action being more rapid within the first twenty-four hours; (3) the presence of micro-organisms in water; and (4) galvanic action, if this is set up by the juxtaposition of two metals.

A water containing as much as $\frac{1}{10}$ of a grain in a gallon, is unfit for drinking purposes, and even $\frac{1}{20}$ of a grain may be unsafe, as that amount has been known to affect some persons. Filtration removes lead from water if the filters act properly.

SUMMARY.

Each person may be said to require, on an average, twenty-five gallons of water daily. When required for towns or populous areas, water has usually to be stored in reservoirs, and distributed by gravitation. Reservoirs should be covered and ventilated; if, however, a storage reservoir is so large that it cannot be covered in, a second or service reservoir, capable of holding a few days' supply, should be provided, into which, after filtration, the water from the storage reservoir might be conveyed as required. Water collected in reservoirs is distributed on either the constant or the intermittent system. Distribution is by iron pipes, coated with some protective material on the inside. From these iron pipes or mains pass the service pipes to individual houses; these service pipes are made of iron (wrought or galvanised) or of lead. Lead pipes should not be used unless it is positively certain that the water has no action upon lead. Soft and sewage-polluted waters are most liable to act upon lead.

When the water supply is on the intermittent system, it is necessary to have cisterns in houses in which to store a sufficient supply for current needs. These may be made of slate, stone, iron, or galvanised iron. They should be so placed as to be easy of access and readily cleaned. The overflow pipe should not communicate with any drain, neither should the supply pipe of any water-closet pass direct from this cistern; in other words, the cistern for storage of drinking water must be distinct from that for storage of water for a closet.

CHAPTER XI.

IMPURE WATER, AND ITS EFFECTS.

Impurities in Water.—Water may be rendered impure (*a*) by mineral impurities; (*b*) by the presence of organic impurities. The **mineral impurities** are derived from the soil through which the water percolates. The geological formation of a district, therefore, influences the composition of the water which passes through it. The following soils generally yield a supply of pure water: granite, metamorphic rock and clay, slate soils, hard oolite and chalk. Waters from the sands, sandstones, and gravels, vary greatly in composition, and are uncertain sources of supply. The limestone and magnesium limestone waters are usually free from organic matter, but may contain the fixed hard salts—calcium sulphate and magnesium sulphate in excess; they are not, therefore, so desirable a source of supply as the chalk waters. The presence of lead in water has already been referred to.

The **organic impurities** in water may be of vegetable or animal origin, and may be either dissolved or suspended in it. Vegetable matter itself, such as peat, is probably not unwholesome, but in many cases vegetable impurities in water have been known to produce ague and diarrhœa. Stagnant water and water from marshes, especially in tropical countries, are always a dangerous source of supply.

On the other hand, organic matters of animal origin must be regarded as invariably hurtful. They are derived from sewage, and find their way into water by soakage through the soil from cesspits, sewers, etc. Surface and subsoil water should always be regarded with suspicion, unless taken from places which are far removed from possible pollution. Again, sewage is poured directly into rivers, and a mere trace of infected matter is sufficient to render a water supply unwholesome.

Effect of Drinking Impure Water.—The diseases which are usually associated with the use of impure water are, cholera, enteric fever and dysentery, dyspepsia and diarrhœa; malarial fever in tropical countries, goitre, parasitic diseases, and metallic poisoning. Waters containing an excess of fixed hard salts of lime and magnesia, frequently cause **diarrhœa** and **dyspepsia**, especially among those who are unaccustomed to use them. Diarrhœa has also been caused by suspended matters in water—probably due to mechanical irritation of the parts. **Goitre** is said to be caused by drinking water derived from limestone and dolomitic rocks; the disease has also been attributed to the presence of iron pyrites in the water. The question is one that has not been as yet definitely settled. That **dysentery** has been caused by impure water there is ample evidence; in nearly every instance the water was found to be polluted with fæcal matter, and probably with dysenteric discharges, but when the water supply was discontinued, the disease disappeared.

Enteric fever is more often spread by impure water than by any other means. It has been abundantly proved that specifically infected water does produce this disease, and that the subsequent dilution of the poison by an enormous quantity of water is no safeguard once sewage infected with the specific germ gains access to the supply. The original source of contamination is the introduction into a water supply of infected matter from the excreta of an enteric patient. Similarly **cholera** is a disease due to a specific micro-organism contained in the evacuations of those suffering from the disease, and is propagated chiefly by means of drinking water infected with the specific poison. The evidence of its spread by specifically infected water has been well demonstrated during the Hamburg epidemic of 1892, when those taking their drinking water from the Elbe, which was imperfectly filtered, and to which sewage had access, suffered severely from cholera, while those living on the outskirts of the city, and under similar conditions in every respect, except the source whence their drinking water was obtained, were not affected by the epidemic. As with enteric fever, so with cholera, if the discharges of those suffering from the disease are allowed to enter defective drains, leaky cesspools, privies, etc., the contents of these receptacles either infect the subsoil water or are poured direct into streams or rivers, from which drinking water is taken.

Malarial fever has been caused by drinking stagnant water and water from marshes in tropical countries. In such waters there is always a large amount of vegetable organic matter present. It has been observed that the character of the fever is of a more severe type under these circumstances than when its introduction into the system is through the air; in these highly malarious places, it is difficult to assign exactly the influence polluted waters play in the causation of this disease, other factors being always present.

? not.

Ova of parasitic worms are frequently found in water, and may gain access to the stomach by drinking. Small leeches may be swallowed, and have been known to lead to serious results. They are more common in the tropics than in England.

Metallic poisoning may result from the absorption by the water of the metal used in the making of service pipes, cisterns, etc., by which water is supplied, or stored. The water may also be contaminated at its source by passing through a soil in which a metal is present, as in some mining districts; or a river may be polluted with metallic refuse from trade manufactures. Copper, zinc, lead, and arsenic, are the most probable poisonous metals which may gain access to water in this way.

SUMMARY.

The impurities of water are partly the results of passing through certain geological formations, and partly the results of surface pollution by animals and men. In both cases these impurities consist mainly of certain chemical salts, the results of recent or remote contamination with sewage, and of certain forms of organic life known as bacteria or germs.

The chief effects of drinking impure water are the occurrence of such diseases as enteric fever, cholera, dysentery, and diarrhœa. In tropical countries malarial fevers follow, and in other parts goitre, parasitic diseases and metallic poisoning are not unknown, as the results of impure water. Waters containing an excess of salts of lime and magnesia frequently cause diarrhœa and dyspepsia.

CHAPTER XII.

PURIFICATION OF WATER.

Purification of Water.—This subject may be conveniently considered as applying to (*a*) purification of water on a large scale, as applicable to public water companies before distribution of the supply, and (*b*) to domestic filtration, as usually practised by the consumer in his own house.

Water is nearly always submitted to some process of purification before distribution by public companies. It is now the practice of most water companies to use **sand** and **gravel** as a filtering medium. Water is usually first passed into large reservoirs, where the suspended matter is allowed to subside by gravitation, carrying with it large numbers of micro-organisms. From thence it is led to a filter bed, made of sand and coarse gravel, the former being about three feet in thickness, and lying upon layers of gravel, fine above but coarse below, and from this the water is collected by pipes, which convey it to the reservoir. The filtration should be downward, and in order to secure satisfactory bacterial purity, the maximum rate of filtration should not exceed 4 inches, or 2·1 gallons per square foot of filter surface per hour. By these processes two means are made use of to purify the water, viz. mechanical and chemical. The mechanical process consists in allowing the heavier particles to subside, and subsequently arresting the suspended matters on the surface of the filter. Sand filtration has but slight effect on the chemical constituents of the water, but oxidation of the organic matter does to a limited extent follow, on passing water through sand filters. Recent investigations show that all that is really necessary is that mechanical filtration shall be perfect. Sand, although its effect on the organic constituents in water, as gauged by chemical analyses, is limited, is very effective in holding back micro-organisms, which, if they are not the actual cause of disease, are intimately associated with those spread by the agency of water, such as enteric fever, cholera, dysentery, etc.

The mechanical action which frees the water from micro-organisms is largely assisted by a layer of gelatinous matter which forms on the surface of the filters, and which is very retentive of microbes. The conditions stated above are, however, necessary to obtain the best results. The action of this filter is partly mechanical, partly vital; the **mechanical action** is confined to the holding back of the grosser substances which have not subsided, but remain suspended in the water; the **vital action** lies in the layer deposited on the surface of the sand which is charged with microbian life, and it is by these organisms, which are constantly increasing in number, and which penetrate the sand to a slight distance, that both the nitrification of organic matter and the arrest of other microbes is effected. From this it is evident that, in order to preserve the power of these filters, the surface layer should not be removed, with the object of cleansing it, so long as the water passes freely through it; cleansing by removing the gelatinous membrane destroys the vital action of the filter, as this does not form for at least two days after the sand filter bed has been brought newly into use.

After heavy rainfall, or in times of flood, when river water contains much suspended matters, filtration through sand is not so effectual, and special precautions should be taken to see that the water is clear and free from colour before distribution to the consumer. No water can be regarded as efficiently filtered that contains more than 100 micro-organisms in 1 cubic centimetre of the filtered water.

Water derived from the chalk undergoes a process of purification when the salts of lime are removed from the water before distribution, for the purpose of rendering the water soft. Several methods have been used, but the basis of all of them is the addition of a measured quantity of milk of lime, calculated on the degrees of hardness of the water. Carbonates of lime and magnesia are soluble in water containing free carbonic acid. When a solution of fresh lime is added to such a water in proportion to the degree of hardness present, the lime combines with the excess of carbonic acid to form carbonate of lime, which is precipitated with almost the whole of the carbonate of lime originally held in solution by the water, and falls as a sediment, carrying down with it the organic impurities held in suspension; this action of adding lime-water to remove the mineral matters (salts of lime and magnesia) from a water may be expressed as follows:—

$$CaCO_3 + CO_2 + CaH_2O_2 = 2CaCO_3 + H_2O.$$

It is necessary to know the exact degrees of hardness in the water, and to use only sufficient milk of lime as will combine with the carbonic acid holding the chalk in solution, otherwise lime passes out into the distributing pipes. If an excess has been added, a few drops of a solution of nitrate of silver added to a small quantity of the water will produce a dark yellow colour, but only a white precipitate if chlorides alone are present. In the Porter-Clark process the suspended matters are removed by allowing the lime to pass through a series of linen cloths under pressure. This has the advantage of rapidity, and removes the whole of the suspended matters effectually.

The permanent hardness of water is not touched by this process; this hardness is due to the soluble salts of lime and magnesia held in solution by the solvent properties of the water itself. Maignen's process is intended to act on this hardness; it consists in adding to the water lime, sodic carbonate, and alum; the alum causes a coagulation and precipitation of the organic matter, while the sodic carbonate attacks the salts of lime and magnesia; it is doubtful whether this process effects its object or not. It has not come into general use.

Cases will, however, frequently arise in which the purification of water for drinking purposes is necessary, but where no regular system of filtration as above described exists, or is possible, and where simpler and often ruder methods are all that can be devised. Under these circumstances **distillation** is one of the best means of water purification; this is frequently practised on board ships. The liability of such water being contaminated by lead, taken up from the pipes through which it passes, should, however, not be overlooked.

Boiling is another excellent means for purifying water; the carbonate of lime is removed, also any hydrogen sulphide, and, too, some of the organic matter. It destroys disease germs; and when water has been well boiled, it may, with safety, be drunk. Boiling the water has the disadvantage of rendering it flat and somewhat insipid.

Alum, in the proportion of five or six grains to the gallon of water, has frequently been used where there is much suspended matter present; it acts best when the water contains calcium carbonate—calcium sulphate and a bulky hydrate of alumina precipitate being formed, which mechanically carries down the suspended matters with it. It should be well stirred in the water and then set aside, to allow the suspended matters to subside.

Domestic Filtration.—*Animal charcoal* is probably the material most in use for the purposes of domestic filtration. Charcoal possesses the property of absorbing oxygen from the air, and of condensing it within its pores. Its action is to oxidise organic matter, and to thus convert it into harmless products; this it does effectually, provided that the charcoal is fresh. If this was all that was required of a filter, or what resulted from its use, it would be an excellent medium to purify water; but there are vital objections to the use of animal charcoal, for it adds to water passed through it nitrogen and phosphates, both being the nutriment on which micro-organisms grow and develop. Its action on fresh organic matter is exceedingly feeble, while the charcoal itself readily absorbs impurities from the water or air, and is more of a danger than a safeguard against disease, when it has been in use for a short time. The life of a charcoal filter is relatively short, and depends on the quantity and quality of the water passed through it.

Water cannot be kept or stored with safety after filtration by charcoal, as micro-organisms develop rapidly in it. Charcoal has the power of removing metallic salts, and in particular salts of lead, phosphate of lead being formed. For the reasons stated above, it is undesirable to use animal charcoal for the purposes of filtration of potable waters; moreover, it is expensive and not only often inefficient but dangerous.

Spongy iron, a substance obtained by roasting hæmatite ore at a low red heat with animal charcoal, is a very porous material. As a filtering medium, its action is partly mechanical and partly chemical; it arrests suspended matters and oxidises any organic substances that may be present in solution. It acts chemically on the water itself, decomposing it and setting oxygen free, which is at once seized upon and taken up by the organic products in the water; it also removes lead. Its action is, however, slow, and it adds to the water salts of iron, which must be subsequently removed, by allowing it to pass through "pyrolusite"—a mixture of black oxide of manganese, fine gravel, and sand. This material adds nothing of an organic nature to water, which may be stored after filtration; it lasts for a considerable time, provided that the material is kept constantly wet; if it is allowed to dry, the iron cakes and becomes useless, since the water flowing down at the sides between the spongy iron and the framework of the filter is not exposed to the action of the spongy iron. It has the disadvantage of allowing micro-organisms to pass through, and does not sterilise water. Its action cannot therefore be said to be efficient.

Polarite consists of the oxides of iron, with some silica, alumina, and carbonates. Its action on water is very similar to spongy iron, but it is in a more convenient form. It does not give up iron to water, nor add anything to the filtered water which interferes with its subsequent storage, but it fails to render the water sterile.

Silicated Carbon.—This filter is in the form of a block of prepared carbon, and covered by powdered silicated carbon.

It is a very inefficient form of filter; the suspended matters deposit on the surface, and, forming a slime, contaminate the water which the filter is supposed to purify. A filter which depends on a block of carbon alone is practically useless for the purposes of filtration.

Recent experiments show that the value of any filter does not so much depend on its action upon the chemical constituents of a water supply as on its power of holding back micro-organisms, and thus rendering the water sterile. Sand, which has little effect on the chemical constituents of water, has in a remarkable degree this power, and is now regarded as one of the best media for freeing water of micro-organisms which are known to be so closely connected with, if not the actual cause of, many of the specific diseases.

Following on these lines, Pasteur devised a filter tube, or "bougie," made of fine *kaolin porcelain*, through which water is forced by pressure, the resulting filtrate being sterile (Fig. 34). The pressure employed should not exceed two atmospheres. The action of this filter is purely mechanical. So fine are the pores of this porcelain, that not even the most minute of the known micro-organisms are able to pass through it. The chemical constituents of a water are in no way affected by its passage through the "bougie" or tube.

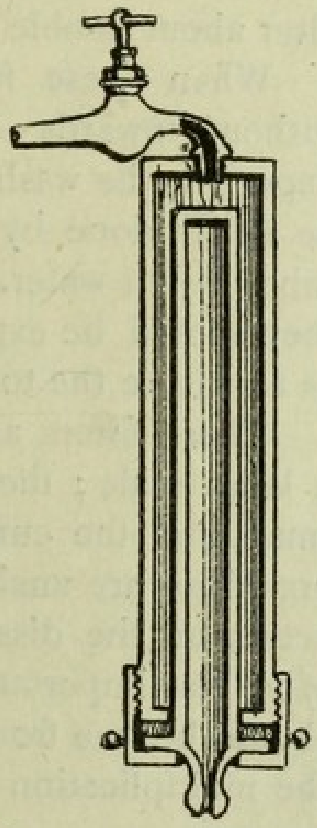

FIG. 34.—Pasteur-Chamberland Filter.

The **Berkefeld filter** is similar in form to the **Pasteur-Chamberland**; the material used is infusorial earth, and this too has considerable power in mechanically arresting any matters present in water. Its action is more rapid, and it does not require quite so much pressure, but the material being softer requires more care in cleansing. Both these filters fulfil the conditions which modern bacteriological science teaches to be necessary for purifying water; this same science also shows that the older class of filters were not only in many cases useless, but were decidedly mischievous. The objection to the use of these modern filters is that a head of water or pressure is required, and that the delivery of the filtered water is slow. The former difficulty is overcome by a simple mechanical force-pump, introduced by the inventors, by which pressure is applied to force the water through the filter; the second objection can be overcome by using several in place of one bougie only. At a pressure of one atmosphere, a Pasteur-Chamberland filter will deliver from two to three quarts per hour; a Berkefeld filter about double that amount.

When these filters are in use, the water passes from without inwards — a convenient method, as it allows the deposit to be washed from the surface of the tubes, which can be easily done by removing the screw-tap and brushing the tubes in hot water. It is also recommended that occasionally they should be exposed to direct heat over a charcoal fire, so as to ensure the total destruction of any organic matter.

These filters act on water precisely as sand filters act on a large scale; they sterilise water—that is, the pores are so small, and the current of water so finely divided, that micro-organisms are unable to pass through. These filters have no action on the dissolved organic impurities in water, but it is of no less importance that water intended for drinking purposes should be free from these, as with such, no doubt, is associated the multiplication of micro-organisms, if not their virility and potency.

SUMMARY.

Water may be purified either before or after it is supplied to the consumer; sometimes both. Chalk waters undergo a certain amount of purification when the lime salts which they contain are removed by precipitation for softening purposes. These efforts by precipitation of lime salts usually result in some considerable carrying down with them of organic impurities held in suspension.

Most public supplies of water are submitted to some process of filtration before distribution. This filtration is usually secured by passage of the water through beds of gravel and sand. The action of these filter beds is partly mechanical and partly chemical; the former is the more important, as it is the means of holding back or removing micro-organisms intimately associated with those diseases spread by the agency of water. The chemical action of filters upon water is probably due to the combined action of bacteria and air in the interstices of the sand.

Distillation and boiling are frequent means of purifying water; these methods are, however, not so general for domestic purposes as filtration. Domestic filters are made of either charcoal, manganous carbon, sand, polarite, spongy iron, infusorial earth, or porcelain. The two latter materials are the substances of which the Berkefeld and Pasteur-Chamberland filters are composed. As efficient means for sterilising water by virtue of the removal of its contained micro-organisms, these latter filters are more efficient than the earlier forms made of charcoal, etc. The action of domestic filters upon water is the same as that of sand or gravel beds when filtration is conducted on a large scale.

CHAPTER XIII.

THE COMPOSITION AND PROPERTIES OF AIR.

Composition of the Atmosphere.—Surrounding the earth on all sides is a gaseous envelope, commonly spoken of as the atmosphere or air. This air, when pure, is free from colour, taste, or smell, and is really **a mechanical mixture of gases,** possessing the properties of weight, expansion, and diffusibility. That the air we breathe is not a chemical compound, but only a mechanical mixture, is known by the facts that the gases of which the air is made up do not exist in it in their proper combining proportions, and that the relative amounts of these gases in the air cannot be expressed by any chemical formula. Moreover, on mixing the gases of which air is composed together in the same proportions as they exist in air, there is no manifestation of either heat, electricity, or change of volume, such as would result were the air a chemical combination.

The composition of pure dry air may be taken to be as follows :—

	By Volume.	By Weight.
Nitrogen	79·02	76·84
Oxygen	20·94	23·10
Carbon dioxide ...	0·04	0·06
	100·00	100·00

Besides the above gases, the air always contains a certain quantity of watery vapour, together with various impurities.

Nitrogen, which is the main constituent of our atmosphere, is a chemical element found everywhere in nature, particularly in the tissues of all animals and plants, and is essential to the existence of all forms of life. In the air, nitrogen appears to act as a diluent of the oxygen, evidently reducing its strength and rapidity of action, much as water is used to dilute spirits or wine. Pure nitrogen is a colourless, tasteless and inodorous gas; it is quite incombustible, and incapable of supporting either combustion or life. It is from this latter peculiarity that foreign chemists call it *azote*—a word derived from the Greek, meaning "no life." We English people call it nitrogen, because it is the element which gives birth, so to speak, to nitre.

The recent researches of Lord Rayleigh and Professor Ramsay indicate that some one per cent. of what has been considered to be nitrogen in the air is a remarkable elementary gas, called by them **argon**. It is the most inert body known; its atomic weight is apparently 39·6; density, 19·94; and freezing point, $-189·6°$ C.; that of nitrogen being $-214°$ C.

Although nitrogen constitutes four-fifths of the atmosphere, the most important constituent of the air is **oxygen**. This gas is clear and colourless, and necessary for nearly all forms of life; it is also needed for every kind of combustion, and for every kind of light except the electric light. Oxygen exists in the air in a free state, and is not chemically combined with the nitrogen of the atmosphere, but only mixed with it.

A modification of oxygen occurs as small traces in the atmosphere, and is known by the name of **ozone**. This gas is really a condensed form of oxygen, usually arising from the effects of electrical discharges in the atmosphere, whereby one part of oxygen condenses itself to two-thirds of the space originally filled by it. Ozone is plentiful in fresh air, but generally absent in crowded or dirty places; it is a powerful oxidising agent, and may be usually recognised by its pungent odour.

Carbon dioxide, or, as it is sometimes called, carbonic acid, exists in all samples of air, even of the purest, and this usually to the extent of from 3 to 4 volumes in 10,000 of air. It is a clear, colourless gas, produced in large quantities in all processes of combustion and by the breathing of men and animals; it also results from the numberless processes of decay or putrefaction going on upon the earth's surface, and passes constantly into the air from mines, volcanoes, and fissures in the earth. Carbon dioxide is faintly acid in taste and smell, and behaves in an exactly opposite manner to oxygen, as it can support neither life nor combustion. In small quantities, such as exist in ordinary air, carbon dioxide is not hurtful to man and animals, but when existing to any great extent, it causes headache, nausea, and general illness. The amount of this gas present in the air varies according to place and season. In pure mountain air and over the sea as little as 2·5 parts per 10,000 of air have been observed; in the streets of large towns the amount present averages from 3·5 to 4 parts for 10,000 of air; while in stables and inhabited rooms much larger quantities have been found. To the extent of 4 parts in 10,000 of air, carbonic acid gas is a normal constituent of our atmosphere, and unless it exceed that quantity it cannot be considered an impurity.

Watery vapour is always present in air. Its presence is due to the fact that water evaporates at all temperatures, so that a slow but invisible escape of water vapour is constantly taking place from the earth's surface into the air space which encircles the globe. The amount of watery vapour which the air can take up varies with the temperature of the air; the greater the temperature, the greater the amount of water vapour which can be taken up. This explains why water dries up much more quickly in warm weather than in cold. When air contains the full amount of watery vapour for any given temperature, it is said to be saturated; and in proportion as it is more or less removed from the saturation point, but not in proportion to the precise amount of water it contains, the air is said to be dry or moist. Thus, if air at any particular temperature can hold one hundred parts of moisture, but actually only holds seventy-five parts, it is said to be only three-quarters moist, or to have seventy-five per cent of humidity.

The amount of watery vapour in the air has not only a considerable effect upon the temperature of a place, but its presence is absolutely necessary for life and comfort. A perfectly dry air not only would be unbearable, but would quickly prove fatal to both plants and animals. Dry air withdraws water and heat from the body; moist air lessens evaporation, reduces the cooling action of the skin, and produces a sense of oppression. As a rule, the atmosphere contains from 1 to 1·5 per cent. of water in a state of vapour, or from 50 to 75 per cent. of the amount required for its complete saturation. If the quantity be much above or below these limits, the air is either unpleasantly moist or dry.

The physical properties of the atmosphere are those of a gas; that is to say, it has weight, it can expand or contract, and is capable of diffusion. If a glass globe of known capacity be taken and weighed, then be exhausted of all air by means of an air-pump, and re-weighed, the resulting weight will be less than it was when it had contained air. The capacity of the globe being known, the difference between the two weights is the **weight** of that volume of air.

By reason of the atmosphere having weight, it exercises **pressure.** That the existence of this atmospheric pressure is real is proved by the fact that, if a glass tube a yard in length, and having an internal diameter of a quarter of an inch, be filled with mercury, and then carefully inverted into a vessel containing mercury, the mercury in such a tube will not run out of the tube into the vessel, but remain at a variable height in the tube, according as to whether the observation is made near the sea-level or upon high ground. At the sea-level in this country, the height of such a column of mercury in a closed tube is about 29·94 inches; and it is prevented from falling any lower in the tube by the counterbalancing weight or pressure of the air. At elevated places, such as on hills or mountains, the height of the mercurial column would be less, as the weight or pressure of the air would be less. At sea-level, it is estimated from the weight of the column of mercury which the atmosphere can support, that the pressure of the air, at such a point, is equal to 14·75 pounds on each square inch of surface; this pressure being equal, or evenly distributed in all directions, is not obvious to us in our movements.

The pressure of the atmosphere is never constant, but subject to frequent changes, depending upon the temperature of the air and its degree of humidity. Like every other gas, air **expands** with heat and **contracts** with cold. The extent of this expansion and contraction is usually at the rate of $\frac{1}{491}$ or 0·002 of its volume for each degree on a Fahrenheit's thermometer, or $\frac{1}{273}$ or 0·003 for each degree on a Centigrade thermometer. For this reason, a given volume of air at 50° F. is lighter than the same volume at 40° F.; and a cubic foot of air at 0° C. would weigh just twice as much as a cubic foot of air at 273° C. Similarly, moist air is lighter than dry air. The reason of this is that the specific gravity of dry air is 14·4, while that of steam is 9; or, in other words, a volume of dry air weighs 14·4, and a similar volume of water vapour or steam only weighs 9; since moist air is dry air, *plus* water vapour, it follows that the weight of a given volume of moist air will be less than a similar volume of dry air. These variations in the weights of hot or cold, dry or moist air, are indicated by corresponding fallings or risings of the barometer or column of mercury, and explain why, in England, the barometer rises during dry easterly winds, and usually falls with the damp westerly gales.

The **diffusibility** of a gas is well and easily demonstrated by the following simple experiment; take a **U**-shaped tube some eighteen inches long, fix it at one end to a porous cell, such as is used in electric batteries, and then fill the tube nearly full with water. Next, make some hydrogen and fill with it a bell-jar. If this bell-jar containing the hydrogen be quickly placed over the porous pot, the hydrogen gas diffuses so rapidly through the pores of the cell or pot into the tube that the water is at once driven out. The rate at which this intermingling or diffusion of gases can occur is largely influenced by their weights, being really inversely as the square roots of the densities of the gases; that is to say, hydrogen with a density of 1 will diffuse into oxygen with a density of 16, in the ratio of four to one, or just four times as fast as the oxygen will diffuse into it.

These physical properties of diffusion, expansibility, and of pressure or weight, are manifested by the atmosphere, and are largely concerned in the causation of those movements of the air, over larger or smaller areas, which we call winds or draughts. Winds are produced, when, over some large tract of land the air, being warmed by the sun, expands and rises, while from adjoining regions colder and heavier masses of air rush in to take its place. Similar but smaller movements of air, due to varying degrees of heat, density and pressure, are constantly going on in and about our houses. It is the same cause which makes the warm air over a fire go up the chimney to be replaced by fresh and colder air entering by windows, doors and cracks. Whenever a room or house is inhabited by human beings, or warmed by lights and fires, a constant expansion of air is going on with an escape of the excess volume by the chimneys and doors and windows. By this means the equilibrium between one part of a dwelling and another is constantly being disturbed, and the air rarely if ever allowed to be absolutely still even over the most limited area.

From the foregoing it will be gathered that while the atmosphere has several constituents, each of them has its own particular weight; that while carbon dioxide is heavier than the oxygen, this again is heavier than the nitrogen, while the watery vapour is lighter still. If the same laws held good for gases, as regulate fluids, we should expect that these various constituents of the air would form themselves into layers, with the heavy carbonic acid near the ground, next above it the oxygen, then the nitrogen, and, above all, the watery vapour. As a matter of fact such is not the case, because of the action of diffusion which enables all these gases to mix one with the other. It is this faculty of diffusion, which is the chief cause by which the composition of the air is kept constant, and which causes the carbon dioxide, formed so freely in our large towns and cities by combustion and breathing, to be rapidly removed from where it is formed to other parts, where the processes of vegetation and sunlight can break it up into carbon for the food of plant life and oxygen for the use of men. Supplementary to the power of gaseous diffusion, we have the action of winds, which scatter and diffuse over a large area many impurities of the air which would be very hurtful if confined to any limited space. In a similar, but lesser sense, dew, rain and snow may be regarded as helping in the constant purification and dispersion of atmospheric impurities.

SUMMARY.

Pure air is free from colour, taste, or smell, and is really a mechanical mixture of gases, possessing the properties of weight, expansion and diffusibility. The chemical composition of the dry atmosphere in 100 volumes may be roughly taken as being 79 of nitrogen, and 21 of oxygen, with a small proportion of carbon dioxide. Air usually contains some watery vapour, a little ammonia and some suspended matters. Its physical properties are essentially those of a gas.

CHAPTER XIV.

THE IMPURITIES OF AIR, AND THEIR EFFECTS.

The Impurities of the Air are variable both in quantity and quality. Except at the tops of very high mountains, or at some height over mid-ocean, absolutely pure air is rarely found. The majority of samples of air betray the presence in them of various impurities, notably traces of ammonia, nitric acid, nitrous acid, some compounds of sulphur, such as sulphurous acid and sulphuretted hydrogen, various compounds of carbon, chiefly carbon monoxide, carburetted hydrogen and carbon dioxide, with a greater or less amount of suspended matter, such as soot, dust, epithelial cells, vegetable fibres, wool and silk fibres, particles of sand, chalk, or iron, and the minute forms of life. These impurities of the air are mainly the contaminations given off by manufactures and trade processes, or the emanations from sewers, marshes, etc., or the results of combustion, and the respiration of man and animals.

Although traces of **ammonia** are usually present in most air samples, it rarely exists in the atmosphere in greater amount than three parts in ten millions, and is formed in the main from the decomposition of decaying nitrogenous matter. When present, ammonia is usually in combination with some acid, such as nitric or carbonic. Chemically, ammonia represents the chief part of what is called the organic matter present in the atmosphere.

Nitric and **nitrous acids** are probably derived by the air in small quantities from decaying nitrogenous matter, while, too, a certain amount is produced in the air by the direct combination of oxygen and nitrogen during electrical disturbances, and as the products of manufactories. These acids, like ammonia, are washed down out of the air by rains into the soil, and there serve in the fertilisation of various forms of vegetation. If inhaled in any quantity these gases are irritants to both men and animals.

Sulphurous acid and **sulphuretted hydrogen** are, among other impurities, added to the air by combustion processes. The former is a constant impurity in the air of large towns, where it is one of the chief causes of the difficulty experienced in cultivating trees, shrubs and grass. Sulphuretted hydrogen is usually to be recognised in the neighbourhood of gasworks, chemical factories, sewers and marshes. In mines it often exists from the decomposition of iron pyrites, which is ferrous sulphide. As a rule this gas has no ill effects upon health, but if present to any great extent, may give rise to serious symptoms.

Carbon monoxide is a gas produced by the combustion of carbon in an atmosphere of carbonic acid, and is most frequently met with in rooms and places heated by charcoal stoves. This gas is extremely noxious, less than 5 volumes per 1000 being able to produce symptoms of poisoning, such as dizziness, headache, confusion of ideas, and a sense of constriction across the temples and forehead. The presence of carbon monoxide is always a sign of imperfect combustion, such as occurs when coke is burnt in an open grate, and is especially apt to be generated by cast-iron stoves.

Carburetted hydrogen is another product of the combustion of coal; it is, however, a comparatively harmless gas. It is often present in mines, and also over marshes, hence its name, "marsh gas;" it is also known as methane.

Carbon dioxide, we have already learnt, exists to a limited extent in pure air. This limit has usually been placed at 0·04 per cent., or 4 parts per 10,000 of air, but it is probable that this limit is too high, and that in the purest airs the natural amount of carbon dioxide does not exceed 0·3 per 1000 volumes. Any carbonic acid present in air, therefore, over and above 0·04 per cent. must be regarded strictly as an atmospheric impurity. This gas is added largely to the air by men and animals during breathing, also by all processes of combustion or putrefaction, and by certain soils; it is increased by fogs, but lessened by rain, winds, vegetation and ventilation. The amount in the air is consequently variable; in some places, notably mineral water factories, where carbonic acid is largely used in the making of aerated waters, the air often contains as much as from 2 to 5 parts per 1000; on the other hand, the air in a London street on a breezy day has been found to have as little as 0·36 per 1000. Carbon dioxide is fatal in its pure form when present to the extent of 75 parts per 1000, while 15 parts per 1000 give rise to giddiness, faintness, headache, and shortness of breath; anything below 10 parts per 1000 appears to produce no effect immediately on health. In fatal quantities the action of carbonic acid is that of a narcotic poison producing insensibility and deep sleep.

The suspended matters in the air are familiar to us as the thousands of dancing particles seen in a beam of light as it passes through a chink or crevice into a darkened room. The particles which comprise this suspended matter, or solid impurities of the air, are of the most varied nature; some are inorganic, some organic, some absolutely harmless, some truly hurtful. How far these suspended matters in the air will affect our health depends much upon their quality or nature, and not so much upon their mere quantity; but this latter, in some cases, is not a negligeable point.

The mineral matters consist largely of coal dust, rust from iron, chalk, grains of common salt, sand, etc.; they occur chiefly in and around factories, and vary with the nature of the industries carried on as well as the geology of the district.

The more common organic matters are starch cells, pollen grains, minute seeds of plants, pieces of wood, fine fragments of flax, wool, cotton, and silk, together with fatty particles, scales of hair or skin, and germs of disease in the form of bacteria, micro-cocci, and other varieties of minute life.

The Effects of Breathing Impure Air differ to some extent in accordance with the nature or source of the impurities and the size of the space.

If the impurities are of the nature of inorganic suspended matters, it is their physical conditions as to roughness, angularity or smoothness, rather than their mere nature, which influences their power for evil. Various affections of the lungs, notably **consumption**, have been traced among work-people as being due to the breathing in by them, during work, of the finer dust products of their particular trades or businesses. For instance, among tin miners **lung disease** is prevalent, owing to the fine particles of tin-dust inhaled by these workers; similarly, the fine dust from iron mechanically irritates the air passages, and gives rise to considerable ill-health among needle-makers, saw-grinders and cutlers. So too, among potters, a peculiar **asthmatic cough** is often set up in consequence of the continued breathing of the finer clay dust. The makers of cement, grindstones and certain kinds of glass, suffer in the same way. In white lead works, the lead dust gives rise to **colic** amongst the workers, while workers in copper and brass foundries are subject to a special form of **non-periodic ague,** and among match-makers the fumes and particles of phosphorus used in making matches, when inhaled, are apt to give rise to **disease of the maxillary bones.**

Most of the suspended organic impurities are comparatively harmless; but it is not so with all, for in the carding-rooms of cotton, flax, wool and silk factories, the finest dust from off the special fabrics is often so great and so irritating in nature in the atmosphere of the work-rooms that considerable ill-health results to those employed in them. How far the various kinds of bacteria and other microscopic forms suspended in the atmosphere are concerned in producing ill-health is not absolutely clear; but sufficient is known to render it certain that tuberculosis (consumption), small-pox, scarlet-fever, and some other **epidemic diseases**, are propagated by these agents through the medium of the air.

As results of breathing gaseous impurities derived from sewers, **vomiting, diarrhœa**, and **colic** are not unknown; in the same way various kinds of **sore throat, erysipelas,** and childbirth fever, have been traced to pollution of the air with sewer gas. Carbon monoxide has already been mentioned as a possible source of ill-health to those occupying rooms heated by means of coke or charcoal stoves. Sulphuretted hydrogen, if in excess, gives rise to **nausea** and **diarrhœa;** while sulphurous acid gas, nitric and nitrous acid gases by their irritating effects are a fruitful source of **bronchitis.**

The continuous breathing of an atmosphere moderately vitiated by the impurities resulting from combustion and respiration are not less hurtful to health. It induces a general **lowering of the vital processes,** with loss of strength and nutrition, to say nothing of an indirect influence towards both physical deterioration and general moral degradation. It is only too probable that to this cause, as much as to defective feeding, must be attributed the impaired vitality and health of many of the poorer inhabitants of our crowded towns and villages.

The impurities found in the air of dwelling-rooms, the products of respiration and combustion, including artificial lights, consist mainly of carbon dioxide, watery vapour, ammonia, organic matters, and minute traces of sulphurous acid; in addition, the atmosphere is heated. The effects following a prolonged stay in an atmosphere vitiated by these impurities are generally recognised to be due partly to the reduction of the oxygen in the air, and partly to the presence in the air of the so called organic and other ill-defined products given off by the skin and lungs; some further discomfort arises from the increase of carbonic acid and watery vapour. The estimation of the degree of oxygen reduction and general organic impurity of vitiated air, is much less easy than the estimation of the presence of carbon dioxide, and, as the amount of this gas appears to bear a more or less constant ratio to these other impurities, its estimation is usually accepted as the index of atmospheric purity or impurity. The precise nature of the so-called organic matter present in air fouled by human or animal respiration is undetermined.

SUMMARY.

The various impurities found in ordinary air are mainly the results of the respiration of men and animals, the products of combustion, the emanations from sewers or other collections of refuse and filth, and the contaminations given off by manufactures and trade processes. In nature,

these various impurities consist partly of chemical bodies, such as ammonia, carbonic acid, carbon monoxide, nitric acid, nitrous acid, sulphuretted hydrogen and sulphurous acid, and partly of suspended matters consisting of dust of various kinds and micro-organisms.

There is little evidence to show, except in extreme cases, that any great harm is caused to general health by atmospheric impurities other than the products of respiration and the particulate matter suspended in the air of factories and workshops. These, however, are all a constant source of ill-health, especially among those compelled by circumstances to live in ill-lighted, confined and imperfectly ventilated dwellings. Among these persons consumption and various forms of respiratory disease are peculiarly prevalent.

CHAPTER XV.

VENTILATION.

Necessity for Ventilation.—In the ordinary sense in which the term ventilation is used, we may regard it as the removal or dilution of all the impurities which can collect in the air of inhabited rooms. Wherever men or animals are crowded together, the oxygen of the air, by which they are surrounded, soon becomes exhausted and carbon dioxide takes its place; at the same time, the lungs and skin give off other waste products, chiefly organic vapour and moisture, which, though minute in quantity, still make themselves perceptible by the breath and skin, and give the peculiarly penetrating and unpleasant odour so characteristic of wherever the free access of fresh air is neglected. Over and above these sources of vitiation, we have other, or similar, impurities added to the air from the combustion of fires and light, the presence of filth, dirt, and by the escape of emanations from sewers, drains and other impurities, under or outside our houses.

In practice, we may limit the term ventilation to the dilution or removal, by a supply of pure air, of the products of respiration and combustion in ordinary dwellings, coupled, in the case of hospitals, with the additional impurities resulting from the presence of sick persons. For the removal of all other air impurities, ventilation ought not to be required, because, strictly speaking, these should be avoided by the exercise of due cleanliness, and the maintenance of a proper system of drains and sewers, combined, moreover, with a general attention to the sanitary condition of the surroundings of our houses.

Quantity of Fresh Air required.—Knowing the nature of the impurities poured into the air of our homes as the result of both respiration and artificial lighting, we have next to learn how much fresh air is required to dilute and remove those impurities, and how best this supply can be attained.

The average adult at rest exhales or gives off to the air 0·6 cubic foot of carbon dioxide per hour; during hard work, the amount evolved is considerably more, varying from 0·92 to 1·6 cubic foot per hour; but, as an average statement for men and women, the figure 0·6 cubic foot may be accepted as the amount of atmospheric vitiation from this source. In addition, some five hundred and fifty grains of watery vapour are given off from the adult body per hour; if we assume the average temperature of occupied rooms to be 60° F., this means enough moisture is given off by the human body every hour sufficient to saturate ninety cubic feet of air.

Every cubic foot of ordinary coal gas yields, on combustion, roughly, half its own volume, or 0·52 cubic foot of carbon dioxide and 1·3 cubic foot of watery vapour, and as the average consumption of gas per hour, by the ordinary burner, is not much less than four cubic feet, the air vitiation from a single gas burner, in terms of carbonic acid, is equal to at least three ordinary adults.

From these facts it is clear that we have hourly, in occupied and artificially lighted rooms, a steady vitiation of the atmosphere from respiration and illumination by both carbon dioxide and moisture, to say nothing of added organic emanations and minor chemical impurities, such as ammonia, and oxides of nitrogen, and sulphur. If we ignore these latter impurities, and take as our **index of vitiation** of the air the **amount of carbonic acid**, inasmuch as it bears a more or less constant ratio to the other impurities, we can establish a standard of permissible atmospheric impurity from which to draw conclusions as to how much fresh air is required to dilute or remove the impurities of the air.

It may be accepted as a fact, that as soon as air becomes in the slightest degree tainted, or has a distinct odour perceptible to any one entering it from the fresh air, it has become unwholesome. Experiments indicate that a feeling of closeness or stuffiness is experienced whenever the carbon dioxide in the air of inhabited rooms exceeds that in the outer air by 0·2 part per 1000, or 1 part per 5000 of air. We may therefore regard this amount as the **limit of respiratory impurity** which may be allowed. But 1000 cubic feet of air contain normally 0·4 cubic foot of carbon dioxide, therefore they can receive 0·2 cubic foot more of carbonic acid and not contain an excess over the standard limit of 0·6 cubic foot per 1000, or 6 per 10,000 of air.

Since an average adult expires 0·6 cubic foot of carbon dioxide per hour, and as it is undesirable to allow a greater excess of this gas in the air than 1 in 5000, it is manifest that every person must be supplied with 0·6 of 5000, or 3000 cubic feet of fresh air per hour if this standard is to be maintained in any occupied room. If the individual be giving off more than 0·6 cubic foot of carbonic acid per hour, say 0·95, then the amount of fresh air to be supplied hourly to keep the respiratory vitiation down to the standard limit will be 0·95 of 5000, or 4750 cubic feet of fresh air.

In rooms where large numbers are gathered together, especially when artificial illumination is employed, the standard allowance of 3000 cubic feet of fresh air per head hourly is not enough, as some must be provided to dilute and remove the impurities yielded by the gas or other illuminant. Although the contaminations from lights, especially coal gas, are very great, it is estimated that for their proper dilution the amount of fresh air supply, in relation to the carbon dioxide evolved, need not be so great as for respiratory impurities, a supply of 1000 cubic feet of fresh air for every cubic foot of carbonic acid per hour evolved by the light being deemed sufficient; and as every cubic foot of coal gas, when burnt from an ordinary fish-tail burner, evolves 0·52 cubic foot of carbon dioxide, it results that, for every cubic foot of coal gas burned, something like 500 cubic feet of fresh air should be supplied per hour in addition to those needed to dilute the respiratory impurities.

To recapitulate, we may say that if we wish to keep the air of our homes at the standard degree of purity, it should not contain more than 0·6 part of carbon dioxide in 1000, or 0·2 part in 1000 over the average present in samples of ordinary air; the maintenance of this standard means an hourly supply of at least 3000 cubic feet of fresh air per head. In mines, as much as 6000 cubic feet per hour have been delivered to ensure maximum energy in those working below ground. In hospitals, and for the sick generally, the maximum supply of fresh air ought to be at least one-half more than that allowed in health. If 3000 cubic feet per hour be accepted as a general average supply for health, we may admit the needs of the sick to be at least 4500 cubic feet per hour.

As regards the amount of fresh air required for animals, it may be laid down as a rule that at least 25 cubic feet per pound of body weight ought to be supplied, as, like human beings, all animals thrive best in well-ventilated places.

Cubic Air Space required.—Although theoretical considerations may indicate that certain quantites of fresh air are needed per hour per head in order to maintain the atmosphere at a degree of sweetness compatible with health, yet, when it comes to actual practice, certain difficulties are met with. Experience shows that, under the ordinary climatic conditions of this country, the air of a room cannot be changed more than three times an hour without causing much inconvenience by draught. This means that if we are to have 3000 cubic feet of fresh air each hour, we must each have a cubic air space of at least 1000 cubic feet. If it be less than this, say, 100 cubic feet of space, then, in order to deliver 3000 cubic feet of air hourly, the renewal of air will have to be thirty times in that period of time, and this we know, owing to the formation of draughts, would be unbearable unless the incoming air be warmed. At 60° F., air, moving at the rate of two feet per second, is barely perceptible; at three feet it is more so, and above this it becomes a draught. At 70° F. the velocity of the air current can be even greater without being noticed. The question arises: What, then, is the least amount of cubic space through which the standard quantity of fresh air can be passed without causing inconvenience from draught? Theory and experience indicate that the least amount of air-space which ought to be given to each adult should not be less than 1000 cubic feet; but this is, undoubtedly, much in excess of what most people are able to obtain. In the majority of rooms occupied by the poorer classes, the cubic space available for each occupant is rarely more than 250 cubic feet, while in the lodging houses of the larger towns the allowance is not more than 300 cubic feet. In Board Schools the regulation minimum allowance is 100 cubic feet per head. In factories and workshops, 250 cubic feet of air space are required per head during the day, and 400 cubic feet during overtime. For soldiers in barracks, 600 cubic feet is the least space allowed. In hospitals, the cubic space ought to be quite 1500 cubic feet, if not nearly 2000; and the minimum floor space 100 square feet.

The question of **floor space** is as equally essential as cubic space, especially in the case of rooms occupied by more than one person; the object being to allow currents of air to circulate for the removal of emanations from one individual without interfering with his neighbour. For this reason, it is a good rule in all cases to secure as the lowest limit of floor space an area of not less than one-twelfth of the cubic space. It cannot be too well understood that cubic space is of no value when it is principally obtained by means of lofty ceilings. The space at the bottom of a well, if crowded, would speedily become unwholesome, although the air space above is unlimited: similarly, people have been known to die of suffocation in a crowd, though in the open air. The same supply of fresh air is needed in the largest as in the smallest room, the only real difference being, that in the former the moment of permissible impurity is longer delayed; but, ultimately, the same volume of fresh air per head must be supplied hourly. Thus, 1000 cubic feet of space for one adult would be sufficient if the air in it were changed three times an hour, but in the absence of any renewal, 1000 cubic feet of air would only be sufficient for one person for twenty minutes; in a similar way, 10,000 cubic feet would suffice for four occupants for only fifty minutes. Large rooms possess this advantage over small ones, that the change of air is effected with less draught. The difficulties in adequately changing or renewing the air in small rooms arise not only from the actual movement of the general mass of air, but from the velocity with which the air enters at the openings, and the nearness or relative positions of these to the persons occupying the space.

Practically the best height for a room is 12 feet; no great advantage is gained by exceeding 14 feet, though there is no real objection to a greater height, provided the increased height is not made a pretext for omitting means of supplying fresh air. Assuming 12 feet to be the limit, a room to afford 1000 cubic feet of air space would have a floor space measuring 10·5 feet long and 8 feet wide, or an area of 84 square feet. If we allow only 500 cubic feet for each person, then the floor-space should be 42 square feet, represented by a room 8 feet long and 5·25 feet wide, or about the absolute minimum permissible. Soldiers in barracks are allowed 50 square feet of floor-area, children in board schools are allowed 8 square feet each, but in many of the newer schools the area available is from 12 to 15 square feet. As a rule, hospitals should have from 100 to 150 square feet of floor-space per patient; in many it is really more.

SUMMARY.

Ventilation means the dilution or removal, by a supply of pure air, of the products of respiration and combustion in ordinary dwellings, coupled, in the case of hospitals and factories, with the additional impurities resulting from the presence of the sick, and trade processes. The standard index as to the state of efficiency, or inefficiency, of ventilation is the amount of carbon dioxide in excess of that normally present in the atmosphere. Assuming that this normal amount is 0·4 in 1000 volumes of air, the permissible quantity of carbon dioxide in a well-ventilated space should not exceed 0·6 per 1000 of air, or 0·2 parts per thousand over that normally present. On the further assumption that an average person gives off hourly 0·6 cubic foot of carbon dioxide, to maintain the standard degree of atmospheric purity, at least 3000 cubic feet of fresh air should be delivered hourly to each person. In special cases, this amount of fresh air needs to be increased. To secure this ideal delivery of fresh air per hour, under ordinary circumstances, an air-space of close upon 1000 cubic feet per individual is necessary. In actual life, however, this amount of cubic space is rarely secured or attainable. Similarly, the theoretically ideal floor space of at least 80 square feet per head can be rarely obtained.

CHAPTER XVI.

VENTILATION METHODS.

Ventilation Methods are generally divided into two kinds—the natural and the artificial. There is no very sharp line of distinction between these two methods, but by natural ventilation is nominally understood any plan which does not involve the use of elaborate contrivances for the renewal of air, the natural forces which set air in motion being mainly depended upon; artificial ventilation, on the other hand, implies the supply of fresh air by means of pumps, fans, bellows, and various other mechanical means, for setting air in motion.

Whatever method is employed, the essentials of a good system of ventilation are—a complete and continuous change of air, so that at no time the amount of respiratory impurity shall exceed the standard; the change of air must be so controlled that at no time shall there be a current or draught perceptible to the occupants of the space being ventilated. Equally, it must not be overlooked that the source, from which supplies of fresh air are drawn, is pure and clean. In a similar way attention needs to be directed to the actual temperature and degree of humidity of the air within or entering a chamber; in summer it may need to be cooled and moistened as much as it may require to be heated and dried in winter, the reason being that the actual temperature and humidity of an air current is the main factor in our appreciation of its velocity. Whenever the temperature of the air within an occupied room exceeds that of air coming in by 10° F. a draught is experienced. A temperature of 60° F.

and a humidity of 60 per cent. may be deemed to be the most agreeable conditions for the air of occupied rooms in this country.

Natural Ventilation is carried on by the natural agencies of gaseous diffusion, winds, and the movements of air caused by changes in density produced by heat and moisture. We know that a gas diffuses at a rate inversely proportional to the square root of its density; for this reason, the air of rooms, being usually warmer than that outside, diffuses with rapidity through cracks and openings, and even through porous materials, such as sandstone, bricks, mortar and mud. The extent of this **diffusion** through the walls of ordinary houses, in spite of papering, plastering, and painting, is often much greater than many persons imagine. The interchange between the inside and outside airs of rooms rapidly lessens, the more the temperatures of the inside and outside approximate to each other; this explains why a room is often better ventilated in winter during a frost, with all its windows and doors shut but with a good fire in the grate, than in summer, with the windows wide open, and the inside and outside temperatures nearly identical.

The action of **wind**, as an agent in the production of natural ventilation, is partly by what is called perflation and partly by aspiration. The wind is said to perflate if it pass freely through open doors and windows into a room; its ventilating action then is immense, but much less so if a thorough current cannot be obtained, as in narrow courts and alleys, or when furniture, curtains, etc., block the way. The aspirating power of the wind is illustrated by the draughts of chimneys, caused by wind blowing over their tops; a partial vacuum is produced on either side of the wind's path, towards which the surrounding air rushes in to restore the equilibrium. As a result, the wind lessens the pressure of the air in the chimney over

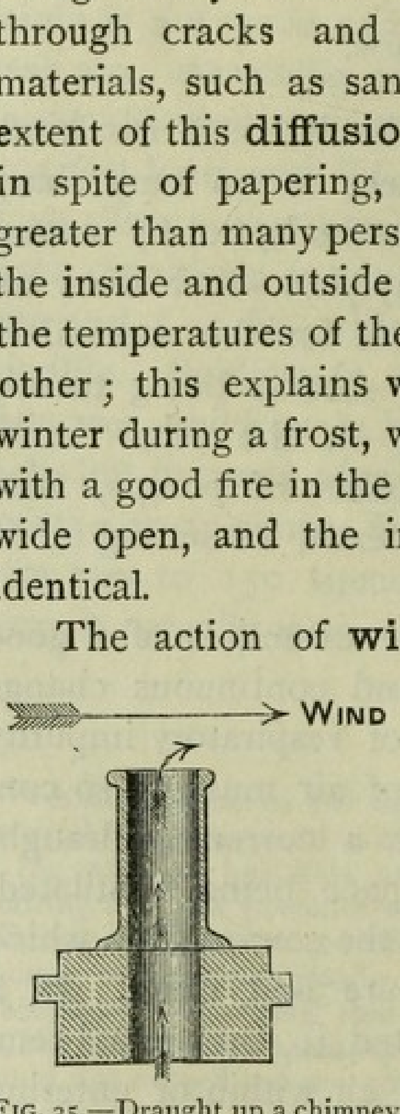

Fig. 35.—Draught up a chimney caused by wind blowing over its top.

which it blows, producing an up-draught in the chimney, so that the air of the room below is gradually withdrawn, the outer air taking its place.

The primary force which produces not only winds but the movements of all bodies of air, is the **difference in their weights or densities** due to irregularities of temperature. If air, or any gas, is heated, it expands, and, becoming lighter, endeavours to ascend; if there be any outlet, some will escape, and the air outside, being colder and heavier, will force itself in through any opening there may be to take its place. That this actually does occur is familiar to most of us who have sat near the crevice of a closed door or window of a room in which a large fire is burning.

All ventilation methods aim at providing, in the first place, inlets or means of entrance for the fresh air, and outlets, or means of escape for the foul or impure air. To avoid the production of draughts, all **inlets** or orifices by which cold fresh air is admitted should be above the level of the heads of those occupying a room, say nine feet, and directed upwards to the ceiling, while the actual current itself should be as much broken up or dispersed as possible by means of trumpet-shaped openings, the smallest apertures of which are towards the outer air and the wider towards the room. If the inlets be intended for delivering previously warmed air, then they may discharge near the floor. The heating of air previous to its entering a room by an inlet is conveniently done, either by the use of an air chamber placed behind a grate or stove, as in Galton's stove, or by passage of it over hot-water pipes.

As to **outlets**, since the escaping or impure air is invariably warmer than the incoming or fresh supply, the right place for them is the top of the room, and in cases where the foul air is specially heated, as over ventilating gaslights, the connection of the outlet tube with the chimney constitutes the best arrangement. In all cases, these structural devices, whether as inlets or outlets, should permit of their being kept free from dirt or otherwise being blocked up.

Of all the methods of natural ventilation, the simplest and most obvious is that of open windows; but this arrangement, except in the finest weather, is inconvenient. All windows, however, ought to be made to open, particularly at the top. Among the many devices for inlets of fresh air, especially by utilising the windows, one of the simplest is that suggested by Hinckes Bird. It consists in raising the lower sash of a window by an accurately fitting block of wood, whereby a corresponding space is left between the meeting-rails in the middle of the window, through which entering currents of fresh air are directed up towards the ceiling (Fig. 36).

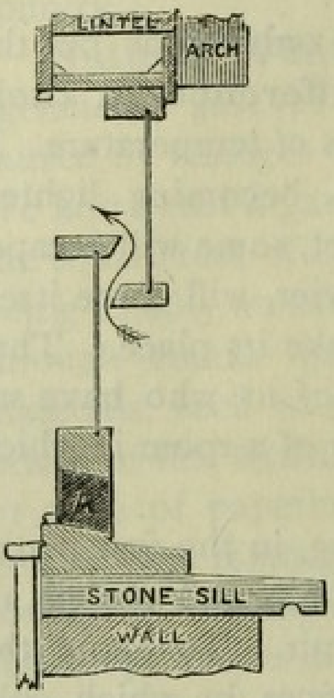

Fig. 36.—Hinckes Bird's plan of window ventilation.

With the same idea, others have proposed double panes of glass, an open space being left at the bottom of the outer and at the top of the inner one. Similarly a pane may be louvred, that is, strips of glass lying one over the other, and fixed on to a frame, which, by means of a lever, can be opened or shut at will (Fig. 37). Windows can also be made that, when they open, they slope into the room, or they can have part of a pane to open or shut by a revolving disc of glass, on the hit or miss principle. Cooper's ventilator is one of this kind (Fig. 38). Double windows are another device for improvising inlets. Rooms, provided with them, may be easily ventilated by raising the lower sash of the outer window, and

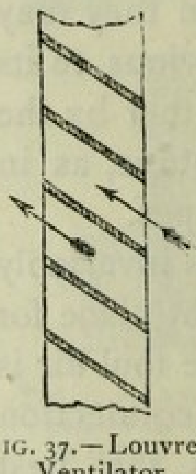

Fig. 37.—Louvre Ventilator.

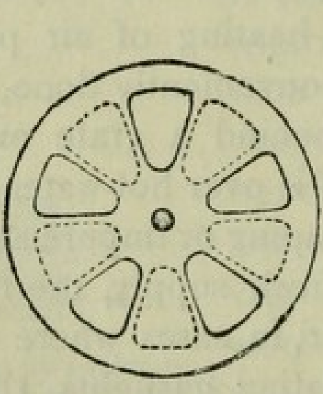

Fig. 38.—Cooper's Ventilator.

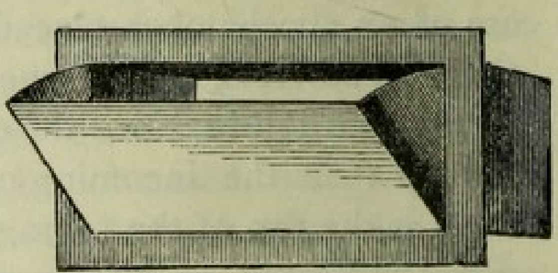

Fig. 39.—Sherringham Valve.

lowering the upper sash of the inner one. Fresh air passes in between the two, as in Hinckes Bird's method, and as in the case of double panes above mentioned.

An excellent form of inlet is that known as Sherringham's valve (Fig. 39), which consists of an iron box so made that the air enters from outside through a perforated brick or grating, and is directed upwards to the ceiling through a valve which can be opened or closed by means of a balanced weight. The inside aperture of the ventilator is larger than the outer, consequently the air enters the room at a less velocity than at which it passed through the outer wall or grating.

Another plan, advocated originally by Tobin of Leeds, is that of introducing the air through horizontal shafts under the floor, and then delivering it into the room by vertical tubes at different heights, varying from six to nine feet from the floor. The currents of air issuing from these tubes ascend and then curve imperceptibly downwards. For public buildings, like churches or halls, the columns which support galleries may, on this principle, form convenient inlet tubes. For ordinary houses, these Tobin tubes are not very suitable, as they are difficult to keep clean, and often become clogged up by cobwebs, dirt, and dust. They, moreover, do not readily become or act as outlets when occasion requires, which being a conspicuous feature of the Sherringham valve, renders that form of ventilating agent practically the most convenient for every day application.

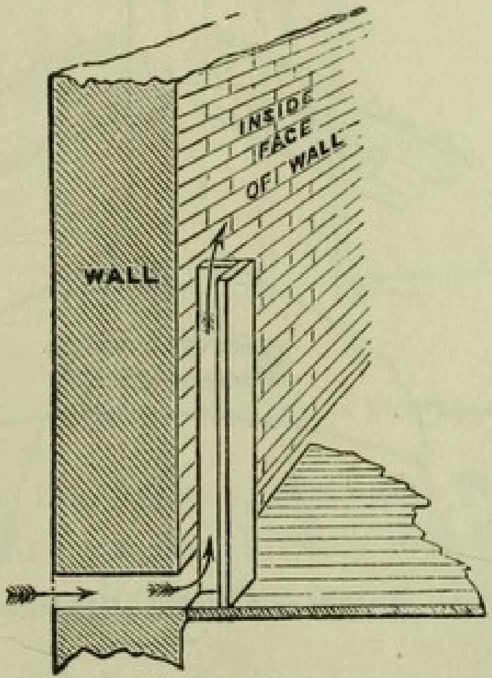

FIG. 40.—Tobin's Tube.

Suitable inlets can be provided by what are known as air-bricks, of which probably the best types are those of Ellison and of Jennings. They are merely specially prepared bricks perforated with a number of holes, so cut that the inner aspects of the perforations have a larger diameter than the outer, whereby the velocity of the entering air-current is lessened. The wind blows through them, but with a variable movement. In Jennings' air-brick, the perforations are directed upwards, so that the entering air-current flows rather towards the ceiling than towards the floor.

With all, or any of these simple ways of letting fresh air into rooms, it is presumed that equal facilities are offered for the escape of foul air. In most rooms, particularly if a fire be alight, this will be done largely by means of the chimney connected with it, but in its absence may need to be accomplished by special outlets. The simplest form of outlet, other than a chimney, is a special shaft from the ceiling to above the roof; the movement of air up such an outlet shaft will largely depend upon the aspirating action of the wind over its top, and upon the particular temperature inside it as compared with that of the outer air. Owing to the uncertain and disturbing action of these influences, these shafts do not always act as outlets, but in any case facilitate a continuous change of air, whichever way they may happen to act. Down currents in such shafts can usually be obviated by placing a cowl or valve on its upper orifice, or by leading it up inside a chimney.

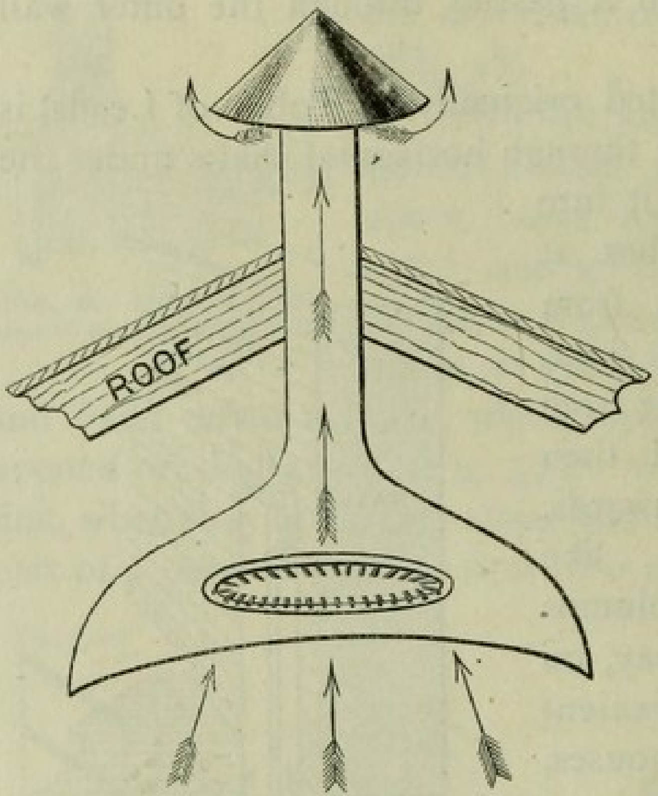

FIG. 41.—Sunlight Gas-burner.

Frequently so-called ventilating gaslights are used as outlets in which the products of combustion, after being collected by means of a cover or bell-glass, are carried off by a tube which is itself often contained in a larger one. Owing to the heating of the inner tube, the space surrounding it and between it and the outer one acts as an extracting shaft for the impure air. In theatres and public buildings, advantage is taken of this method by using the Sunlight gas-burners (Fig. 41), which, in addition to giving light, act as extracting agents for removing the polluted air.

Another arrangement, known as Arnott's valve (Fig. 42), is designed to act as an outlet for foul air. It is usually placed in the wall of a room near the ceiling, so as to open into the chimney. The valve is so arranged as to swing towards the chimney when the pressure or draught of the air is from the room to the chimney; but when the pressure is greater from the chimney to the room the valve closes, and thus prevents the escape of smoke or air from the chimney into the room. These valves are sometimes objectionable owing to the noise they make.

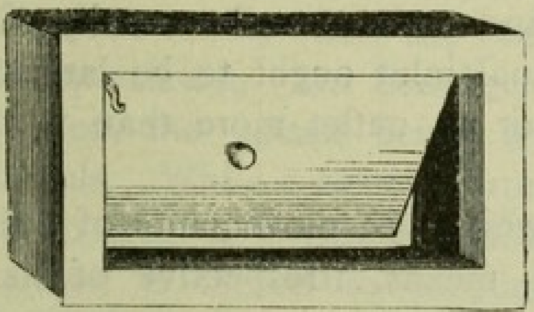

FIG. 42.—Arnott's Valve.

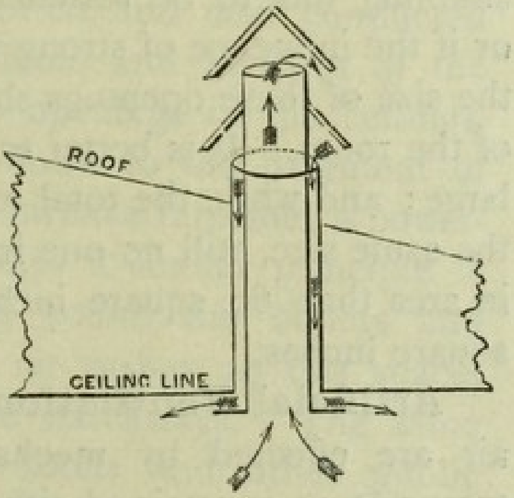

FIG. 43.—McKinnell's Ventilator.

For small rooms having no other rooms above them, a suitable form of ventilator is McKinnell's (Fig. 43). It consists of two tubes, one inside the other, both opening at their lower ends in the ceiling of the room to be ventilated; fresh air passes down in between the tubes, and by a flange on the inner tube is dispersed. The inner or outlet tube, which is always made sufficiently large to equal in area the inlet, projects well beyond the other, both above and below, and effectively carries off foul or impure air. On much the same principle, ventilating cornices are made, which consist of a double channel of perforated metal; by the lower channel, cold fresh air is brought into a room, while by the upper one the foul air is carried to the chimney or other outlet. Analogous to this plan is that of carrying along the cornice of a room, on three sides, a perforated inlet tube, while on the fourth side is a similarly perforated outlet tube.

As regards the **size of inlets and outlets**, the conditions of temperature are so variable that it would be impossible to fix on a size that should be universally applicable. As an average for this country, a size of twenty-four square inches per head for inlets, and the same for outlets, seems calculated to meet common conditions; but arrangements should be made for enabling this to be lessened or closed in very cold weather, or if the influence of strong winds is too much felt. As a rule, the size of these openings should be in proportion to the size of the room. It is better to have openings too small than too large; and while the total inlets and outlets can be usually of the same size, still no one individual inlet ought to be larger in area than 60 square inches, nor an outlet more than 144 square inches.

Artificial Ventilation, in which the movements of the air are effected by mechanical means, irrespective of its temperature, is attained either by the **extraction** or aspiration of foul air from a room, or by the **propulsion** of fresh air into it; the entrance of the fresh air in the first case, and the escape of the foul air in the second, being left to chance. As a rule, either method is sufficient, because doors and windows are never absolutely air-tight. In actual practice, ventilation by propulsion alone is not always quite satisfactory, especially in buildings of complicated arrangement, because the products of respiration tend to collect in and hang about corners or recesses. It usually has to be supplemented by some means of extraction to get rid of foul air. Ventilation by propulsion has this advantage, that the movements of the air are under considerable control; the chief mechanical agencies for propelling air along conduits into buildings are a system of metal vanes, called **fans**, driven by stationary engines. The same mechanical arrangements can be applied in a reverse manner, that is, to extract or aspirate air out of rooms or buildings. This method is especially useful in factories or workshops, where much dust is produced. Mines are largely ventilated by means of a **furnace** at the foot of the upcast shaft, its supply of air being drawn down another shaft, and then made to pass through all the workings on its way to the upcast by an ingenious arrangement of doors and partitions.

As typical of the various methods proposed for ventilating artificially large buildings by means of heat extraction, may be mentioned the system employed in the Houses of Parliament. There the fresh air enters the basement, where it is washed or filtered through screens of moistened canvas, then passed over steam-pipes, by which it is heated, and next conducted by shafts to spaces beneath the floors and benches of the rooms. The vitiated air ascends to openings in the ceilings, and is thence conducted by a shaft down to the basement of the clock tower, where the flue of a furnace furnishes a powerful up-exhaust. On board steamships a similar principle is applied, the upcast being a space round the boilers and funnels. While a strong current of air rushes up this space, air to feed it is directed down the hatchways. The same method is turned to account in hotels and other public buildings by the utilisation of hot-water pipes to cause currents of air in suitable extraction shafts.

Owing to the absence of control over the sources from which air is sucked in extraction methods, due to the readiness with which air rushes in at all available apertures, the supplies of air under these circumstances are occasionally drawn from objectionable places. With care, however, provision can be made to either warm, cool, wash, or filter the air at suitable points. On the whole, the advantages of artificial ventilation are great, being mainly due to its facility of management and constancy under varying conditions. For factories, workshops, ships, and wherever there is machinery, artificial ventilation, whether on the principle of propulsion or extraction, is certainly the most economical and convenient. On the other hand, theatres, hotels, and prisons, commonly require to be ventilated by some mechanical arrangement, based upon the utilisation of all fires and gas jets to work an exhaust or aspirating shaft. In private houses, the use of ventilating grates and stoves, or some of the simpler plans of ventilation, should suffice to keep the air pure; but no hard and fast rule can be laid down, each case requiring to be considered intelligently on its merits.

SUMMARY.

Ventilation is maintained by either natural or artificial means. The natural means of ventilation are gaseous diffusion, the action of winds, and the influence of heat and moisture upon density. Artificial ventilation is effected by mechanical means, such as by fans, or by the effects of furnaces. The former may act either as propellers or as extractors of air, the latter act only as a means of extraction. Artificial ventilation is particularly well suited for public buildings and workshops.

In all systems of ventilation, inlets for fresh air, and outlets for foul air, must be provided; the average size for both these should be 24 square inches per head, but no individual inlet should be larger in area than 60 square inches, nor any outlet more than 144 square inches.

CHAPTER XVII.

THE NATURE AND USES OF FOOD.

Necessity for Food.—If we remember that the body never rests, and that, even when we are asleep, our body is doing some work, we shall readily understand why we require food. The work of the body really consists of two kinds, namely, internal and external work. The **internal work** consists of the maintenance of the heat of the body, the continuance of the beating of the heart, and our breathing, as well as the various actions and processes constantly going on within us, and of which we are unconscious. The **external work** consists of all our voluntary acts, such as standing, walking, running, thinking, talking, etc. It is to make good the continuous losses which the body undergoes every day, to warm it and to supply the energy necessary for the performance of both the external and internal work of our bodies that we take food. The human body has been appropriately compared to a steam engine. Just as there is in the engine the metal framework and the coal or wood, which heats the water placed in the engine boiler into steam, which again sets the metal machine into motion; so there are in the body the skeleton or bony framework moved by muscles, which in turn are set in action by the brain and nerves, which themselves obtain their energy from the food eaten. In both mechanisms, carbon and hydrogen are burnt; in both, water is heated and turned into vapour; in both, stored up or potential energy is converted into actual energy and heat. From both engine and body, carbonic acid and steam escape, and unburnt or unused waste is thrown out. Food, in its relation to the human body, however, differs in one thing from the fuel supplied to an engine, and it is this; coal or wood does not have to supply the repair or building up of the engine itself, whereas, the food we eat goes largely towards those processes, besides providing warmth and energy. For these reasons, our food becomes a very important point in our daily life, and the more we understand the workings of our own bodies, the more apparent is the necessity that we should receive and consume not only sufficient quantities of food, but also that such food should be of sufficient quality, and in proper proportion. Experience in the main teaches men to eat enough; but a knowledge of the principles which underlie and govern our choice of food is necessary to every educated citizen.

The Classification and Uses of Food Stuffs.—The various substances which constitute food may be conveniently classified as follows:—

- Water.
- Organic.
  - Nitrogenous, such as the proteids or albuminous bodies.
  - Non-nitrogenous
    - Fats or hydrocarbons.
    - Starches, sugars, or carbohydrates.
    - Vegetable acids.
- Inorganic. Mineral salts.

In the case of man's food, we must add to the above another group, which includes the so-called "food accessories," such as tea, coffee, alcohol, etc.

If we remember that something like sixty-four per cent. of the body consists of **water**, the need of this elementary substance is not difficult to understand. Though a portion of it is obtained by the oxidation of the hydrogen in the tissues, still, the greater part is derived from that taken in as food. In the body itself, water serves chiefly for the solution and conveyance of food to different parts of the system, for the excretion of effete products, for the equalisation of heat by evaporation, both from the lungs and skin, as well as for the regulation of all the chemical and mechanical functions of the body.

Just as the greater part of the atmosphere is made up of nitrogen, so is the greater part of our body (bone excepted) made up of proteid or nitrogen-containing substances. A large amount of nitrogen in the form of urea, uric acid, and other substances is daily lost from our bodies by the urine; and, to repair this loss, a daily intake of nitrogenous food is required. The only form of nitrogen food which the body can make use of is that of proteids or albuminoids. A plant equally needs nitrogen, but this it obtains from the ammonia and nitrates of the soil, which are much simpler bodies than proteids.

All **proteids** are composed of carbon, hydrogen, oxygen, nitrogen and sulphur, with occasionally a little phosphorus. When regarded as food-stuffs, the proteids are divisible into two great groups, according to their nutritive value. The more nutritious one is the group of true proteids, consisting of albumin in white of egg, serum albumin, serum globulin and fibrin in blood, myosin and syntonin in muscle, casein or curd of milk and cheese, legumin of peas and beans, and the various peptones and albumoses present in some vegetables and the products of the digestion of proteids. The other, or less nutritious group, is sometimes called the albuminoid group; its members include substances obtained only from animals, such as gelatin, chondrin, ossein, and keratin. Though allied to the true proteids, these albuminoid substances cannot replace them in a dietary.

The old idea as to the functions of the proteids or nitrogenous food-stuffs, was that they were converted within the body directly into flesh or muscle, and that when the muscles acted and work was done, the muscles wasted and were, as it were, used up. To a large extent, this view is now known to be incorrect, it being rather considered that the nitrogenous food-stuffs are the substances which construct and form the body, enabling it both to grow and be repaired; they are also a source of some of the fat of the body and of the glycogen found in the liver and muscles, as well as serving to regulate the absorption and use of oxygen in the body. The proper supply of the proteid food-stuffs is of the first importance, though an excess of proteid food throws an excess of work upon the nitrogenous tissues. The natural law seems to be that to preserve health the nitrogen taken in as food must equal that destroyed in the body and lost by the urine.

The **fats**, or hydrocarbons, are compounds of glycerine with the fatty acids, oleic, stearic and palmitic acid, etc. They all contain carbon, hydrogen and oxygen, but no nitrogen. The proportion of oxygen in them, however, is insufficient to combine with all the hydrogen present so as to form water. When taken as food, the fats not only repair or renew the fatty tissues, but yield energy and heat, owing to their oxidation into carbonic acid and water. In addition to this, they help in the proper digestion of the other foods, possibly owing to their influence in promoting the flow of bile and the pancreatic juice. Fats are found in the majority of diets of all nations, and by those living in very cold countries the amount consumed is very large. When hard work is being performed, an increase of fatty food is demanded.

The **carbohydrates** are a large group, and embrace all the various starches and sugars, also cellulose and gum. Like the fats, they contain no nitrogen, but only carbon, hydrogen and oxygen; these two latter elements exist in sufficient proportion to pure water, hence their name, "carbohydrates." In the main, the carbohydrates are derived from the vegetable world, though lactose, a kind of sugar, is found in milk, and glycogen, a form of starch, exists in the liver.

In their physiological uses the carbohydrates closely resemble the fats, being directly used in contributing to the maintenance of animal heat and the production of force or energy as well as the formation of fat. They, however, differ from the fats in that the amount of them consumed as food is proportional to the quantity of carbonic acid excreted; with the fats this is not so. Performing, as they do in the body, similar functions, it has been surmised that fats and carbohydrates might be mutually interchangeable as articles of diet. On this point, although the evidence is not very precise, the general consensus of opinion is that they are not wholly interchangeable, though perhaps practically so, as instanced by the fact that, owing to their relative cheapness, carbohydrates largely replace, but not completely, the fats in the diets of the poor. A certain degree of health can be maintained on a diet of proteids, fats, salts, and water; but the absolute withdrawal of fats and a bare substitution of carbohydrates for them rapidly lead to a loss of vigour and health. The truth probably lies in the acceptance of an admixture of both fats and carbohydrates in the daily diet.

The **vegetable acids**, though not, strictly speaking, foods, play so important a part in preserving the health of man, that they demand some notice. The chief among them are tartaric (from grape juice), citric (from lemons), malic (from apples), oxalic (from rhubarb), and acetic acid (as in vinegar). These acids exist mainly in fresh fruits and vegetables, either as free acids, or in combination with alkalies as alkaline salts, and in the body form carbonates, which exercise a controlling influence in preserving the alkalinity not only of the blood, but of other fluids; they also furnish a small amount of energy and heat by oxidation. Their absence for any length of time from any dietary leads to a peculiar lowering or weakening of the blood, resulting in the disease called "scurvy."

The **mineral salts** comprise chlorides of sodium and potassium, phosphates of potassium, calcium, and magnesium, various salts of iron, and some sulphates. These, in their various and respective ways, are essential for the repair and growth of all parts of the body. The uses of the chlorides, as typified by common salt, are very important. The complete withholding of common salt (chloride of sodium) from foods leads to rapid disease, and even death. The chlorides generally keep in solution the globulins of the blood and other fluids, while at the same time they are the source of the hydrochloric acid of the gastric juice, and materially aid in the solution of albumin. The phosphates of lime, potash, and magnesium contribute, especially in the young, to the formation of bone; while iron forms an important part of the hæmoglobin of the red blood corpuscles.

The **accessory foods** constitute a class by themselves, inasmuch as they include certain articles which experience shows to be very useful, but without which we could probably do very well. They are mainly luxuries, and include such articles as tea, coffee, pepper, mustard, and alcohol. It cannot be said that any of these are necessary to the life of man; but they act as important stimulants to digestion and of the nervous system, and are of value in aiding recovery from exhaustion, whether caused by mental or bodily exertion.

Nutritive Value of Food-stuffs.—We are all familiar with the fact that if we lift a weight by our hands, muscular force is employed in the act, and the **energy** involved in this or any other muscular action must have its origin or source in something. As a matter of fact, the energy so evolved has its source in the material which has been supplied to the body in the form of food. This being the case, any expression of the nutritive value of the food-stuffs becomes identical with the expression of their value as force-producers.

For comparing the values of food-stuffs as **force-producers**, it is necessary to reduce all force evinced or work done to one common standard; in other words, to convert the various kinds of labour, such as walking, running, pulling, carrying loads, etc., into the same expression of work. The standard of work or labour is always expressed as lifting a known weight. Thus, suppose one lift a hundredweight exactly one foot off the ground and let it fall again, and do this twenty times in a day, the day's work of external labour will be accurately expressed by saying that one has lifted one ton, one foot high, or one foot-ton; and the standard used, in this country at least, for expressing work is so many tons lifted one foot, or so many **foot-tons**. On the Continent, and in most foreign countries, the standard expression for work done is so many **kilogrammetres**, or so many kilogrammes lifted one metre high; as the kilogramme equals 2·2 lbs. in weight, and the metre equals 3·28 feet, then the expression of one foot-ton is the equivalent of 310 kilogrammetres.

The external work performed by individuals naturally varies; thus a postman, weighing 10 stone, and walking 10 miles a day at the average rate of three and a quarter miles an hour, does work equal to about 200 foot-tons, while an Indian hill coolie engaged in carrying loads up the hills often does as much as 400 foot-tons of external labour in the day: this is a very hard day's work for most men. Clerks in offices who have to sit still while writing nearly all the day, do not do much more than 50 foot-tons of external work daily.

The simplest measure of the amount of power or energy which can be obtained from a given weight of matter, is the heat produced during its combustion. As a standard measure of heat, we have the **heat unit**; this unit being in this country the amount of energy required to raise the temperature of a pound of water one degree on Fahrenheit's scale of a thermometer; in foreign countries, using the metric system of weights and measures, the heat unit is the amount of energy required to raise the temperature of one gramme of water one degree Centigrade. The British heat unit, if manifested as a mechanical force, will raise 772 lbs. a foot high, or corresponds to 772 foot-pounds, or 0·344 foot-ton of work. The metric heat unit would raise 425·5 grammes of weight to the height of one metre, or corresponds to 0·4255 kilogrammetres of work.

Applying this principle that as heat production is related to the amount of chemical action ensuing, so likewise is mechanical power production, we find that as a measure of the utility of food, the nutritive value of the various food-stuffs as mechanical power producers will correspond with their value as heat producers. Further, since the carbon and hydrogen taken in the food is more or less burnt up in our bodies into so much carbonic acid and water, and since during this combustion heat is produced, it follows that those foods which give rise to the greatest amount of heat will, of course, theoretically have the greatest capacity for the production of working power; that is, will possess the greatest potential energy. This theoretical potential energy is not only different in the case of each class of food-stuff, such as proteid, fat and carbohydrate, but differs also in different foods of each of these classes. In the case of many food-stuffs, their actual value in respect of capacity for heat production has been determined experimentally, and expressed in relation to the performance of work; thus, it has been calculated that the substances given below, on complete combustion, yield energy as follows :—

1 oz. of	dry proteid matter	173	foot-tons of work.
,,	lean beef	197	,, ,,
,,	fat	378	,, ,,
,,	milk	188	,, ,,
,,	starch	138	,, ,,
,,	potatoes	164	,, ,,
,,	cane sugar	131	,, ,,
,,	bread	169	,, ,,
,,	carbon	317	,, ,,

However, we must remember that just as in a steam engine the theoretical amount of steam is never obtained from a given weight of coal, so in the human body this theoretical amount of force is never realised; the reason being that part of the carbon, nitrogen and hydrogen passes away unconsumed; also the food has to be digested, and its energy applied in the proper place. In the body it is practically only the fats and carbohydrates which are completely burnt; the proteids are not metabolised beyond the stage of urea, which we know escapes in the urine. If, therefore, we wish to express the available energy of the proteid foods, we must subtract the unused energy of urea. A given quantity of proteid gives rise to about one-third of its weight of urea, and one ounce of urea yields 85 foot-tons of energy; therefore the true available energy from one ounce of a proteid food, such as dried lean beef, will be 197 less 28, or 169 foot-tons.

Therefore, if we know how much fat, proteid, starch and sugar, etc., any diet contains on analysis, we can calculate how many foot-tons of work it is capable of producing when consumed in the body. Just as the stoker of an engine has to supply an excess of coal or wood over and above that required theoretically to start and keep the mechanism in motion, so have we to eat an excess of food over and above that which, if the digestive organs were perfect extractors of food, would nourish the body. Of the total energy developed by oxidation of the food in the body, it has been estimated that the animal economy is capable of turning only from one-seventh to one-fifth to the account of external work, after allowing for the internal work of the body. The internal work is reckoned to be equal to 2800 foot-tons daily; therefore, to get an ordinary day's work done (say 300 foot-tons), we require five times that amount of energy (1500) in addition to the quantity needed for the body's internal work; or 1500 + 2800 = 4300 foot-tons to be available from the material taken in as food. For a harder day's work, say, of 450 foot-tons, we need 2550, that is, five times the first 300, and seven times the next 150, in addition to the internal work, or 2550 + 2800 = 5350 foot-tons. The following estimates have been made as to man's work:—

Light work, from 150 to 200 foot-tons each day.
Average ,, ,, 300 ,, 350 ,, ,,
Hard ,, ,, 450 ,, 500 ,, ,,
Laborious ,, 500 ,, 600 ,, ,,

SUMMARY.

Food is necessary in order to repair the waste which is constantly going on in our bodies, and to keep in health it is necessary that the food taken in exactly counterbalances the loss incurred by waste of tissues and work done. Food-stuffs are divisible into the following classes, namely, proteids, fats, carbohydrates, mineral salts and vegetable acids. Of these only the proteids are nitrogenous. The proteids are required mainly for the repair of the tissues and their growth; they are also a partial source of fat and glycogen. The fats and carbohydrates are chiefly concerned in the maintenance of body heat, and the production of energy. The mineral salts are intimately concerned in the nutrition of the tissues, while the vegetable acids preserve the alkalinity of the blood, and furnish a small amount of energy and heat by oxidation.

The nutritive value of these various foodstuffs is practically identical with their value as force-producers.

CHAPTER XVIII.

THE PRINCIPLES OF DIET.

General Principles of Diet.—In the preceding sections, we have learnt the nature, uses and nutritive values of the food-stuffs individually; it is necessary now to briefly discuss them collectively in reference to their powers of maintaining life—whether any one group of them is capable of supporting vitality, or what combinations, and what quantity of them, experience and experiment teach us are useful in the food of man. There is abundant evidence to prove that no one group of the alimentary substances is alone sufficient to sustain life for any length of time, but that a mixed diet is necessary. Such evidence is derived from instinctive proclivities, from considerations of the comparative anatomy of our digestive organs, from experience and experiment. That man cannot live on any one group of the food-stuffs is further shown by an examination of the needs of the body, as demonstrated by the daily loss by the kidneys, bowels, skin and lungs.

Various experiments have shown that an average adult gives off 307 grains of **nitrogen** and 4700 grains of **carbon** daily. If he wishes to keep in health, this daily loss of nitrogen and carbon must be made up by a corresponding intake of these elements with his food. If such an adult subsisted only on a carbohydrate food-stuff—say, for instance, bread, which contains 116 grains of carbon and 5·5 grains of nitrogen in each ounce—he would, in order to obtain the 307 grains of nitrogen needed by him, have to consume 3·1 lbs. of bread, while, at the same time, the necessary quantity of carbon is contained in 2·5 lbs. Or, to take the supposititious case of a man wishing to live on beef (representing the proteids), and having a composition of 60 grains of carbon and 10 grains of nitrogen in each ounce, he would, in order to obtain his 4700 grains of carbon, have to eat daily no less than 4·7 lbs. of that substance, while the required 307 grains of nitrogen are contained in little more than 1 lb.

Similar defects and inconsistencies occur if a man lives only on potatoes, rice, or maize. For these reasons men eat a mixture of foods, that is, a man eats a mixture, say, of beef, bread and salt, or he eats rice, beans and oil, with salt, so proportioned that he gets the proper quantities of proteid, fats, starches, sugars and salt, and not too much of one group and none of the others. It is with a due regard to these principles that dietaries or rations are constructed; though, in ordinary life, when living is plain and simple, and the calls of nature are followed, there is no need of weights and measures. As a matter of fact, the researches of Playfair, Smith and others, show that the usual range, in the diets of adult men, is of daily nitrogen from 250 to 350 grains; the extremes being 180 grains in a minimum or bare subsistence diet to 500 grains taken during very great exertion. Of carbon, the daily consumption seems to be from 3500 to 6500 grains. It is curious to note how closely these figures, derived from amounts of food actually consumed by different persons, agree with what we know to be the real average daily losses from the body in terms of nitrogen and carbon. In other words, the intake more or less balances the output.

The amounts of carbon and nitrogen taken daily in food are of the highest importance, since these are the chief elements which undergo metabolism in the body. The following table shows the quantity of carbon, nitrogen, etc., in each ounce of the various dried food-stuffs :—

One ounce (dried).	Nitrogen.	Carbon.	Hydrogen.	Sulphur.
Proteids	70 grains	212 grains	8 grains	6 grains
Fat	—	336 ,,	48 ,,	—
Carbohydrates :—				
1. Starch ..	—	194 ,,	—	—
2. Cane sugar ..	—	184 ,,	—	—
3. Grape sugar	—	175 ,,	—	—
4. Milk sugar ..	—	175 ,,	—	—

The total carbon in an ounce of proteid is 233 grains, but of this 30 grains are only metabolised as far as urea, and oxidised as carbon monoxide; making allowance for this, we have a nett total equal to 212 grains of carbon fully oxidised from each ounce of dry proteid.

Assuming these compositions in terms of nitrogen and carbon of the various food-stuffs, and accepting that the daily need of an average adult man to keep in health is equal to 307 grains of nitrogen, and 4700 grains of carbon, certain **standard diets** have been compiled. Adopting an average of the statements of various authorities, the following amounts express the standard diets for an adult weighing 150 lbs., under varying conditions, in terms of dry or water-free food-stuffs.

Kind of work.	Proteids.	Fats.	Carbo-hydrates.	Salts.	Such dieting equalling—		
					Nitrogen.	Carbon.	Potential energy.
	Ozs.	Ozs.	Ozs.	Ozs.	Grains.	Grains.	Foot-tons.
Subsistence ..	2·00	0·50	12·00	0·50	140	2872	2160
Idleness ..	2·50	1·00	12·00	0·50	175	3150	2370
Ordinary work	4·50	2·90	14·26	1·06	320	4700	4000
Hard work ..	6·00	3·50	16·00	1·50	420	5488	4441

These amounts are, of course, theoretical standards, and, as such, are only approximate. The need of so great an increase of proteids during hard work is doubtful, while, on the other hand, the need of carbon under the same conditions is possibly greater than given in the above table. As already stated, all the constituents are reckoned as being quite free from water, but would, in actual practice, be combined with quite their own weight of water, making the total weight of solid food taken to be from twenty to forty ounces. In addition, too, some sixty to eighty fluid ounces of water would be taken as drink. As a general rule, it may be accepted that a man consumes daily about $\frac{1}{100}$th of his own weight of dry food, and some $\frac{3}{100}$th of water, or, in other words, each pound of his body receives in twenty-four hours 0·15 oz. dry food and 0·5 oz. of water.

It will be readily understood that, though the above-named amounts are accepted as standards, in actual life there are very great individual differences in diets, and that no single standard will meet all cases, because no two persons eat exactly the same. The chief influences which affect the amount of food and drink taken are sex, age, work and climate.

As regards **sex**, women are said to require ten per cent. less food than men; while, in reference to **age**, during young life nitrogenous and fatty food are particularly needful to provide for the growth of tissues; in old age, proportionate reductions are demanded, as there is not only lessened labour, but actually lessened tissue change. If people are doing great **work**, there is a natural need of more food, especially for proteids and fats; also in a less degree for water. The influence of **climate** on diet is not very defined. In cold countries more fat is consumed than in hot, but how far this increase is due to greater need for energy and body warmth, or increased exertion, is not quite clear.

In all good and well-considered diets there is a definite proportion between the nitrogenous and non-nitrogenous foodstuffs—usually in the ratio of 1 to 3·5; and the nitrogen should be to the carbon as 1 is to 15. The ratio between fats and carbohydrates, which should be aimed at in all diets, is roughly as 1 is to 9, but, for economical reasons, the proportion varies constantly in different practical dietaries. The great diversity which exists, as regards the food consumed by the human race in all parts of the world, is the most remarkable feature of the study of dietaries. Some people live upon a wholly vegetable, others on a wholly animal, and others on a mixed diet. The mixed diet may be regarded as that which, in Nature's plan, is designed for man's sustenance. However, where custom and habit have given certain races a peculiar suitability for a purely vegetable diet, the arguments in favour of a mixed diet are not sufficiently strong for the reversal of the customs of many ages.

Calculation of the Value of a Diet.—We have now established a series of dietetic standards, and a knowledge of the chief points to which attention must be directed in regard to food; it is of importance, further, to be able to examine any given diet in the light of these facts, and to be able to construct a dietary. To do this, however, it is necessary to have some knowledge of the mean composition of the various articles of diet. The following table shows the percentage composition of some of the more ordinary articles of food:—

Articles of food.	In 100 Parts.						
	Proteids.	Fat.	Carbo-hydrates.	Salts.	Water.	Nitrogen.	Carbon.
Uncooked medium beef	20·50	8·40	—	1·60	69·50	3 28	15·37
Cooked medium beef	27·60	15·45	—	2·95	54·00	4·41	25·10
Fat pork ..	14·54	37·34	—	0·80	47·32	2·32	35·27
Dried bacon ..	8·80	73·30	—	2·90	15·00	1·40	59·40
Herring ..	14·55	9·00	—	1·78	74·67	2·32	11·25
Cod (salt) ..	27·00	0·36	—	22·00	52·64	4·32	13·77
Chicken ..	21·00	3·80	—	1·20	74·00	3·36	13·35
Bread	8·00	1·50	49·20	1·30	40·00	1·28	27·25
Oatmeal ..	12·60	5·60	63·00	3·00	15·80	2·01	38·35
Rice	5·00	0·80	83·20	0·50	10·50	0·80	40·50
Potatoes ..	2·00	0·16	21·00	1·00	75·84	0·32	10·57
Arrowroot ..	0·80	—	83·50	0·30	15·40	0·12	38·00
Peas	22·00	2·00	53·00	2·40	20·60	3·52	36·35
Macaroni ..	9·00	0·30	76·80	0·80	13·10	1·44	39·87
Eggs	13·50	11·60	—	1·00	73·90	2·16	15·45
Milk (cow's) ..	3·90	3·70	4·50	0·70	87·20	0·67	6·67
Cheese ..	28·00	23·00	1·00	7·00	41·00	4·48	31·50
Chocolate ..	6·18	20·00	54·00	2·20	17·62	0·98	39·69
Butter (salt) ..	—	80·00	—	3·00	17·00	—	60·00
Sugar (cane) ..	—	—	96·50	0·50	3·00	—	40·70

The application of this table is best shown by an example. Suppose a man eats for his dinner 2 ozs. of beef, 4 ozs. of potatoes, and 5 ozs. of bread; it is required to know how much that meal represents in terms of proteid, fat, carbohydrates, salts, nitrogen and carbon. The table shows that 100 parts of beef have a certain composition, and we have only to multiply the amounts given by $\frac{2}{100}$, that is, by 0·02 to know the several amounts of each constituent in 2 ozs., which will be—proteids, 0·552 oz.; fat, 0·3 oz.; salts, 0·05 oz.;

water, 1·08 oz.; nitrogen, 0·08 oz., or 38 grs.; and carbon, 0·5 oz., or 218 grs. In like manner the components of the potato have to be multiplied by $\frac{4}{100}$, or by 0·04, giving proteids, 0·08 oz.; fat, 0·006; salts, 0·04 oz.; carbohydrates, 0·84 oz.; water, 3·03 ozs.; nitrogen, 5·2 grs.; and carbon, 185 grs. Similarly the bread constituents multiplied by $\frac{5}{100}$, or 0·05, gives proteids, 0·4 oz.; fat, 0·075 oz.; carbohydrates, 2·5 ozs.; salts, 0·06 oz.; water, 2 ozs.; nitrogen, 28 grs.; and carbon, 595 grs. Or, the whole 11 ozs. of food consumed yield—1·032 oz. of proteid, 0·38 oz. of fat, 3·34 ozs. of carbohydrate, 0·15 oz. of salts, 6 ozs. of water, 71 grs. of nitrogen, 998 grs. of carbon.

In attempting to change the elements of a diet into terms of the elementary food-stuffs, or *vice versâ*, as a means of estimating their value, it is important to remember that no mere calculation on these lines alone can properly measure the efficiency of any particular diet, but that other conditions must also be considered; the chief of these will be relative to the hours and arrangements of meals, the digestibility of the food and its cooking.

When and How to Eat.—In addition to the quantity and quality of food, attention must be given to the method of taking it. Food should be taken with regularity and at proper periods. Long intervals between meals are specially hurtful. The prevailing custom, which has doubtless arisen from instinct and from what has been found by experience to be best suited for our requirements, is for three meals to be taken during the day at intervals of about five or six hours' duration. Children should have not less than four meals a day. Observation has shown that an ordinary meal is digested and passed on from the stomach in about four hours' time, and thus, according to the above precept, the stomach is allowed to remain for a short period in a state of rest before it is filled with food again. It is difficult to give exact periods of time in which different kinds of food digest, as the circumstances vary so much; but on this point it may be said that the proteids and fats derived from animals are more readily digested than those obtained from vegetables. As to the carbohydrates, no general rule can be laid down beyond that white bread and properly cooked rice are the most digestible.

The habit of going to bed or to sleep on a full stomach after a meal is particularly injurious. A hearty meal should neither immediately follow nor precede violent exertion. In each case the stomach is rendered unfit for the vigorous discharge of its functions. All persons should endeavour always to take a little food with either a cup of hot tea or coffee in the early morning before going out to work. Such a practice strengthens the body and digestion at a time when its powers are at their lowest, and, too, in malarious countries has a marked influence in keeping off fever.

During the course of a meal, it is of the utmost importance to eat slowly and chew the food well; disregard of this rule is one of the most common causes of indigestion; the food is too often imperfectly masticated and bolted down the throat before the teeth and saliva have been able to do what nature requires of them. Large quantities of water or other fluids should not be drunk at meals; they retard digestion by diluting the digestive juices. Tea should be taken rather at the end of a meal than sipped from time to time during its progress. The habit of reading or attempting to learn lessons while eating should be discouraged; it produces mental preoccupation, which materially interferes with digestion; it is far preferable to talk during meals.

The **feeding of infants** is a matter of the utmost importance, since much of the subsequent ill-health of adult life is directly traceable to errors committed in the matter of feeding during infancy and the early years of life. It may be laid down as a good rule that until an infant is eight months old it should only be fed upon human milk, or if this cannot be done, then upon cow's milk more or less specially prepared; on no account should starchy food be given to an infant under this age, the reason being that, owing to imperfect development, its saliva and pancreatic juice cannot digest starch. At about nine months of age, a child may be gradually "weaned" from its mother's breast; but up to that period it should be allowed to suckle from every two to four hours. At nine months of age some other food may be gradually given with the milk, such as Mellin's, Benger's or Nestle's foods, perhaps a little broth, bread crumbs soaked in gravy, or a custard pudding; but the chief dietary at this period should be boiled cow's milk.

If good cow's milk cannot be obtained for infants, then condensed milk of a good kind, such as the "Milkmaid" brand of the Anglo-Swiss Milk Co., should be mixed with fifteen parts of water, and as the child grows older, less and less water should be added, until at about nine months the child is getting one part of milk with seven of water. All hand-fed infants should be fed from what is called a "lamb-feeder;" these are readily kept clean and sweet. The use of feeding-bottles with glass or indiarubber tubes should be forbidden, as they are difficult to keep sweet and clean, with the result that the milk rapidly turns sour and the child becomes ill. Two or more bottles of the lamb-feeder type should be in use, so that as soon as one has been used it may be thoroughly washed in hot water, and a fresh one ready for the next meal.

SUMMARY.

A variety of reasons indicate that a mixed diet is the best for man. The amount of this diet to be consumed daily is proportionate to the needs of the body, as indicated by its daily losses in terms of nitrogen and carbon. An average adult loses daily 307 grains of nitrogen, and 4700 grains of carbon; if therefore he wishes to keep in health, this daily loss must be made up by a corresponding intake with the food. These daily needs vary according to the work being done, and on these data certain standard diets have been formulated. In all good and well-arranged dietaries there is a definite proportion between the nitrogenous and non-nitrogenous food-stuffs, usually in the ratio of 1 to 3·5; similarly the nitrogen should be to the carbon as 1 is to 15.

CHAPTER XIX.

THE COOKING OF FOOD.

Principles of Cooking.—By cooking, our food is rendered more pleasing to the eye, agreeable to the palate, and digestible by the stomach. Apart from its power of removing any obnoxious property in a food by killing any disease germs or parasites existing in it, cooking so alters the texture of a food as to render it more easy of mastication and subsequent digestion. Thus, a piece of meat before cooking is tough and stringy, but when cooked the muscular fibres are given a firmness from the coagulation of their albumin, and the connective tissue which binds the muscle fibres together is made into a soft and jelly-like mass. The result of all this is, the meat is rendered less coherent and more digestible, also more capable of being broken down by the teeth and the digestive juices. In the same way, cooking makes vegetables and grains softer in consistence, loosens their structure, and enables the digestive juices to penetrate into their substance. It also aids digestion by its action of breaking up the starch granules, which exist largely in vegetables and cereals; if not so broken up, starch offers considerable resistance to digestive action. The warmth imparted to food in cooking helps digestion, and exerts a reviving effect on the system.

We may say that there are six common methods of cooking: namely, boiling, roasting, broiling or grilling, baking, frying, and stewing.

Boiling has for its object either the extraction from the food of its nutritive principles, or their retention in it. If we wish to extract all the goodness of meat into the surrounding liquid, as when we make a soup or broth, the article should be finely cut up and placed in cold water. After it has thus soaked for a while, heat should be applied slowly; if a broth is to be made, no actual boiling should be allowed; by this means the albumin of the meat is not solidified, but with the other natural juices flows out into the surrounding water; in the making of a soup, the same procedure is adopted, with this difference, however, that boiling is maintained for a short while, whereby more of the albumin and juices of the meat are extracted, and the actual meat itself, owing to the more complete deprivation of its constituent juices, is rendered still more tasteless and less nutritious. Thus treated, the nutritive principles of the meat pass out into the surrounding liquid, which gains in flavour and nutritive properties, while the meat itself is left as a hard, fibrous and tasteless residue. The essential difference between a broth and a soup is merely one of degree.

If, on the other hand, the object of boiling is not to extract from, but rather to retain in meat all its flavour and nutriment, then it should not be cut up, but left as a large piece, plunged suddenly into boiling water, and the boiling briskly maintained for five minutes. The application of sudden heat in this manner coagulates the albuminous matter on the surface of the meat, and makes an impermeable external coat which stops the escape of the juices from the inside of the meat. To complete the cooking, boiling should not be long continued, but the water only allowed just to simmer. Cooked in this way, the central part of a joint of meat remains juicy and tender. The usual fault in cooking meat in this manner is made by allowing the water in which it is boiled to remain at too high a temperature after the first dipping in to coagulate the surface. The actual period of boiling need not and should not exceed five minutes; after that the temperature required for the surrounding water is not greater than 160° Fahr., actual boiling being 212° Fahr. The former temperature is the true cooking point of meat, while the latter is the boiling point of water.

The same principles should guide us in boiling a fish, but with this reservation—namely, that fish being relatively fragile as compared with red meat, many kinds would break down if suddenly plunged into boiling water. To avoid this, water just below the boiling point must be used for fish, and the whole process of cooking the fish be completed without actually boiling the water at all. Similar principles of trying to retain the soluble constituents of a food within it are involved when potatoes are boiled in their skins; but in the case of a vegetable like the potato, we retain its constituents within it, not by coagulating any surface albumin, because there is none, but by boiling them in their skins or jackets, or by steaming them. Speaking generally, boiled food is less tasty, but more digestible than when cooked in any other way.

Roasting is conducted on the same principles as boiling, namely, the retention of the nutritive juices of meat by the formation of a coagulated layer on the surface. After a short exposure to a sharp heat, the meat should be removed to a greater distance from the fire; in this way the albumin is coagulated without the fibrin being hardened. In all roasting processes, to hasten its course and prevent burning of the superficial parts, the joint is *basted*, or kept constantly enveloped in a varnish of hot melted fat, which, while assisting in the communication of heat, checks the undue evaporation of the juices, or, in other words, during roasting heat convection is established by the medium of a fat bath, while in stewing or, boiling it is supplied by a water bath. Roast meat is usually more savoury, but less digestible than boiled.

Broiling or **grilling** is the same in principle as roasting, but the scorching of the surface is greater owing to the larger surface exposed to heat.

Baking is similar to roasting, except that the operation is carried on in a confined space, such as an oven. Owing to the confined space and the want of ventilation in the chamber or oven in which baking is carried on, the condensed vapour from the article being cooked and the fatty acids, if it be meat, are prevented from escaping, rendering the food so cooked richer and stronger for the stomach. For these reasons baked food is unsuitable for the sick or delicate.

Frying, as a rule, is an indifferent method of cooking, as owing to the heat being applied through the medium of fat, the article so cooked is penetrated with oily matter, and often highly indigestible. Frying is practically nothing more than boiling a food in fat instead of in water.

Stewing is really a modification of boiling for extracting from the food more or less of its juices, but if properly carried out the water should never boil, but remain at about 160° Fahr. or so. Stewing is best conducted by means of a water bath or *bain-marie*. The ordinary glue-pot is a familiar form of water bath, being simply a vessel immersed in an outer vessel of water. The water in the outer vessel may boil, but that in the inner one never does, because evaporation from its surface keeps its temperature lower than that of the water from which it gets its heat. A water bath can be readily improvised by performing the stewing in an earthenware jar or glass placed within an ordinary saucepan containing water. Stewing places food in a very favourable state for digestion; if properly stewed, a large part of the nutritive matter passes into the surrounding fluid, but owing to this fluid never having reached the boiling point, the residual meat is left soft and eatable, not tough, hard and curled up as when allowed to boil for any time; it as well as the water in which it has been cooked are usually consumed together. Hashing is the same thing as stewing, only the meat has been previously cooked instead of being fresh.

In cooking, meat loses about one-fourth of its weight; this loss is due to the evaporation of water and the melting or escape of fat. From articles which contain much water the loss is usually much more than this.

It is needless, perhaps, to say that all things used in cooking should be scrupulously clean, and carefully scalded and cleansed after each time of use.

SUMMARY.

The aim of all cooking processes is to render food more palatable, and more digestible, also to destroy in it parasites, or any other hurtful matters which may be present. The principles which govern all processes of cooking are either to retain within the article to be cooked its essential nutritive constituents, by forming on its surface a layer of coagulated albumin, or to extract from the food more or less of its nutriment. This latter intention underlies the cooking procedures of stewing and hashing. The best temperature for cooking articles of food is one of about 160° F.; it is rarely necessary to allow the water in which any article is being cooked to boil. All food-stuffs lose weight on being cooked.

CHAPTER XX.

DISEASES DUE TO FOOD.

Diseases due to Food.—These are many and various, and may be due to bad dieting or cooking, though the food itself is good, or they may arise from decayed or diseased food.

An excess of food, due to too large or too frequent meals, usually leads to an oppressed stomach, bad digestion, a dirty tongue, disordered action of the bowels, fatness, a sluggish mind, and troubled sleep. The excess of food may, in some cases, be absorbed, but more usually large quantities pass away by the bowels more or less undigested. Excess in animal food leads to an increase of tissue change in the body, causing the person to become thin; it is a not infrequent cause of gout and diseased conditions of the kidneys and arteries. Excess in vegetable foods, particularly starches and sugar, gives rise to flatulence, indigestion and commonly fatness.

Insufficiency of food produces the well-known phenomena of starvation, as evidenced by gradual loss of flesh and general inanition or weakness.

Faulty dieting, due to either bad cooking, bad arrangements of meals, or bad proportions of the various food-stuffs, gives rise to a variety of dyspeptic troubles. Where an insufficiency of fresh meat, of vegetables, or, rather, the vegetable acids, is the chief dietetic error, the disease called **scurvy** manifests itself by the occurrence of sore and bleeding gums, and the appearance of blood under the skin like small bruises. This condition was formerly common on ships, and is not altogether unknown in large towns among the badly fed, particularly those living almost entirely on bread, butter and tea, with perhaps meat and fresh vegetables once in the week. The same disease is sometimes met with in children who are badly fed; but the chief affection arising from faulty dieting among the young is **rickets**. The main cause of this affection is the giving of an excess of starch or other farinaceous food to infants when they are unable to digest it. The disease manifests itself by enlargements of the bones near the wrists and ankles, deformities of the limbs, enlargement and excessive perspiration of the head.

Putrid food, or that which is in a state of decomposition, usually gives rise to unpleasant symptoms, such as vomiting, diarrhœa, collapse, and even death. Such cases more commonly occur after eating sausages, hams, and meat pies of doubtful antecedents. Bad fish and rotten fruit occasionally produce similar troubles. On the other hand, high game and ripe cheese can usually be eaten with impunity, though some people cannot eat them without being ill.

Diseased meat derived from diseased animals is a fruitful source of illness. Thus so-called "measly" pork or beef, or that flesh of pigs and cattle containing bladder-worms, when eaten imperfectly cooked, gives rise to tape-worms. In a similar way, pork infested with small muscle worms, called "trichinæ," will set up a similar condition in man, called "trichinosis," and is marked by diarrhœa, fever, muscular pains, and even death. These trichinæ are minute worms living in the muscles of the pig, and, if the pork be eaten insufficiently cooked, can breed within the intestines of man, passing eventually into his tissues. The flesh of cattle infected with infectious inflammation of the lungs, with cattle plague, with consumption or tuberculosis, also the flesh of sheep having small-pox, and the flesh of pigs suffering from swine fever or trichinosis, should never be used as food, as these diseases are more or less capable of being communicated in this way to man. The milk of cows suffering from tuberculosis and foot and mouth disease should be forbidden as food. In a similar way oysters and water-cress which have been allowed to grow in sewage-polluted water have been the cause of enteric or typhoid fever when eaten uncooked.

Of all foods, milk is perhaps the most common vehicle of disease germs. Whole districts supplied by one source of milk have been affected with such diseases as diphtheria, scarlet fever and enteric fever, the germs of which affections have been found, on inquiry, to have gained access to the milk either from the air, from sewer gas, or more often from dirty and polluted water used either as an adulteration to the milk, or for washing out the milk-cans. The only remedy for these dangers, and for the possible transmission of tuberculosis from tuberculous cows, is the systematic boiling of the milk for at least three or four minutes before use. In the case of milk used for the feeding of children, this is a precaution which should never be neglected, no matter how apparently pure the supply may be.

SUMMARY.

The chief diseases which can be traced to food as their origin are due either to bad or diseased food, to indifferent cooking, or to faulty dieting in respect of excess or insufficiency. Setting aside such symptoms as vomiting and diarrhœa, the chief diseases which result from food are various forms of parasitic affections due to diseased conditions of the original food. If the cooking be adequately carried out, these effects can be largely guarded against. The effects of excess or insufficiency of food are respectively various disorders of digestion and the production of scurvy or rickets. Both these latter diseases are definitely traceable to the absence of certain elementary substances in the food. Tuberculosis, diphtheria, scarlet fever and enteric fever appear to be frequently associated with impure milk, or with milk from diseased animals. The only reliable remedy for this contingency is the systematic boiling of all milk of doubtful origin.

CHAPTER XXI.

ARTICLES OF FOOD.

Meat, or the flesh of animals in some form or other, supplies us with the chief portion of our proteid food. The flesh of animals may be divided into red meat and white meat; of red meats, beef, mutton, pork and game are the chief examples; the white meats include chicken, turkey, goose, and rabbits. Speaking generally, the white meats are more digestible than the red.

As an article of diet, meat furnishes proteid, fat and salts. The proteids are chiefly myosin, a globulin, alkali and serum albumin; of the total proteids in ordinary meats, some thirteen per cent. are made use of in the body. The amount of fat in meat of course varies; in good ox-flesh about one-third is fat, in pork about half is fat. The salts of meat are chiefly phosphate of potassium, with small quantities of magnesium, lime, and chloride of sodium. Besides these, meat yields certain nitrogenous extractive or crystalline bodies. These are derived from the changes in the proteid of muscle, and constitute the stimulating principles of broth and beef-tea. The chief extractives of meat are kreatin, kreatinin, xanthin, taurin, sarkin and urea.

The muscle of all meat should be firm and elastic to the touch, of a bright, glistening, uniform colour, and slightly mottled from the interspersion of fine lines of fat with the lean. Its odour should be faint but pleasant, the juice reddish, and the fat firm, yellowish in colour, and free from blood-stains.

Beef usually contains less fat, but weight for weight is more nutritious than either mutton or pork. Some people find it indigestible; but its quality depends on the age, sex, breed, and feeding of the animal. Usually the best beef comes from the carcase of a four-year-old ox.

Mutton and lamb are often more watery than beef, but they are usually very digestible.

Veal is less nutritious and less digestible than either beef or mutton; it is generally poor in fat, hence has to be served with bacon; it, further, is deficient in salts, owing to the objectionable custom of gradually bleeding the calf in order to make the flesh or meat a delicate white colour.

Pork is the most indigestible of all meats, though usually rich in fat. It needs to be specially well cooked, owing to the frequency with which the pig suffers from parasitic worms.

In estimating the dietetic value of meat, some allowance must always be made for bone, which, as usually sold, equals at least one-fifth of the whole; but this is a much less variable item than the fat. In the uncooked state, the daily allowance of meat for an adult may be said to be about one pound, representing when cooked from ten to twelve ounces.

Owing to the rapidity with which meat, under ordinary conditions, decomposes and becomes unfit for food, various processes are employed to **preserve** it in a more or less fresh condition. The chief methods are drying, salting, freezing, the injection of preservative solutions, and the exclusion of air, whether by covering it with an impervious coating or by hermetically sealing in tins. The chief objections to all these methods are, first, the danger depending upon possible original defects in the meat, and secondly, the risks of decomposition and putrefaction if the preservation has been imperfectly carried out. Where meat has been frozen, unless the freezing had been commenced before rigor-mortis set in, such preserved meat rapidly decomposes so soon as thawing is allowed. Experience shows that it is better to keep the meat at a temperature just short of freezing—say 35° Fahr.—rather than allow it to actually freeze. Salted meat is generally hard and very indigestible. In the case of tinned meats, not infrequently ill-effects have followed their consumption, even when the original material has been above suspicion, and no signs of putrefaction have been present in the tin contents; the only unusual character being the presence of salts of tin, lead, or zinc in the meat and jelly, due possibly to the action of variable organic acids upon the solder or tin. Fortunately such events are rare, and this mode of preserving meat is probably the best.

Fish, as a class, vary much in digestibility, this depending practically on the amounts of fat they contain. The fatter a fish is, the more digestible is its flesh. Of the fat group of fishes, the best are salmon, eels, herrings, mackerel, and sprats; of the non-fatty, the cod is the most commonly consumed specimen. Of the various shell-fish, oysters eaten raw are almost self-digestive, but lobsters and crabs are not only foul feeders, and as such liable to give rise to ill effects when eaten, but they are also notoriously indigestible. The same may be said of mussels, these fish in particular being at times extremely liable to cause poisonous symptoms, especially when taken from stagnant water to which sewage has had access.

To be at their best, fish should be in season, and when eaten should be fresh. A fresh fish is firm and stiff, and should be clean, unbruised and unbroken. If the scales are dull or damaged, it is very suggestive of either ill usage or staleness, often of both; softening in places indicates the same.

Fish are sometimes affected with a parasite in the form of a bladder-worm; this, when imperfectly cooked, gives rise to a tape-worm. These diseased fish are rare in this country, but are common in Russia, Poland, and Sweden. The processes of drying, pickling, salting, and smoking are employed for the preservation of fish. Each process considerably lessens its digestibility, and therefore unsuits it for either the dyspeptic or the invalid.

Eggs.—From the fact that the young chick is developed from it, an egg necessarily contains all that is required for the construction of the body. On this account, eggs are often spoken of as typical animal foods. Proteid matter is largely present, in the form of albumin, both in the white and yolk. Fat exists as an oil in the yolk. Carbohydrates exist in the form of minute quantities of a saccharine matter, and salts, chiefly in the form of phosphate of lime, complete the list. The hen's egg usually weighs two ounces, but those of ducks and some sea-fowl weigh more. The shell of an egg usually constitutes some ten per cent. of the total weight, the white sixty per cent., and the yolk thirty per cent. The white of an egg consists chiefly of albumin, with traces of fat and salt; the yolk consists largely of fat and salts, with a small amount of globulin. Duck's eggs contain generally more fat than those of fowls.

Eggs offer a convenient and concentrated article of diet, rich in fat and proteid, but are at times indigestible, particularly if over-cooked. They are conveniently preserved by exclusion of their contents from the air, either by coating the shell with oil, wax or gum. Their condition as to freshness is readily determined by dissolving two ounces of common salt in a pint of water; in this saline solution a good egg will sink, while a stale or bad one floats.

Milk may be regarded as nothing more than an emulsion of fat containing proteids, salts, and carbohydrates in solution in water. It is the sole nourishment provided by nature for the young of all animals which suckle their young, and because it contains all the four elementary classes of food necessary for health and growth during the early period of life, it may be regarded as **a typical food.** The average composition of milk per hundred parts, from the chief sources as used by man, is shown in the following table :—

Kind of milk.	Specific Gravity.	Water.	Total Solids.	Proteids.	Fat.	Carbo-hydrates.	Salts.
Human ..	1·027	87·40	12·60	2·29	3·81	6·20	0·30
Cow's ..	1·032	87·20	12·80	3·90	3·70	4·50	0·70
Ass's ..	1·026	89·60	10·40	2·25	1·65	6·00	0·50
Buffalo's ..	1·032	81·40	18·60	6·11	7·45	4·17	0·87
Goat's ..	1·032	85·71	14·30	4·30	4·78	4·46	0·76
Mare's ..	1·035	90·79	9·21	2·00	1·20	5·65	0·36

Although all the above are used at times by man for food, the most important kinds undoubtedly are human milk and cow's milk; these differ from each other in some essential particulars. As seen by the preceding table, while there is more carbohydrate in human milk than in cow's, the reverse is the case with the proteids and salts, the fat being much the same in them both. Ass's milk, except in regard to its fat, is most like human milk; but mare's milk contains even less fat and proteid than the ass's, while, on the other hand, milk from both the goat and buffalo are very rich in fat.

All the constituents of a perfect diet are in milk. The proteids are represented by the curd or casein, with some albumin; the fats are present as oil globules, forming cream; the carbohydrates have their representative in lactose or milk sugar; and the salts are both numerous and various, chiefly in the form of phosphates of lime, potash, and magnesium. These different constituents are partly in solution and partly in suspension. Those in solution are albumin, some of the casein, the milk sugar, and the greater part of the salts. The rest of the casein and salts, and the fat in the form of little globules are in suspension. It is owing to its peculiar composition that milk makes such a perfect food for children; but, owing to its relative poverty in carbohydrates, it is unfitted for adults, except as an adjunct to other foods.

Boiling of milk produces coagulation of the albumin, some obscure changes in the sugar, and greater coalescence of the fat globules. Micro-organisms and ferments are at the same time destroyed, a fact which explains the better keeping qualities of boiled milk. Hot weather tends to hasten fermentation and decomposition in milk.

When milk is left undisturbed for a few hours, the fat rises to the surface, constituting cream; there is no definite relation between the amount of fat and the cream, but usually the proportion of cream yielded by a pure milk is ten per cent. If the cream be removed from the surface of milk, the fluid left is called **skim-milk**, and consists of water in which are dissolved the milk-sugar and the salts. On the addition of rennet or any weak acid, skim milk is separated into a solid called **curds** and a liquid called **whey**. This whey contains the soluble salts and the lactose.

The chief **adulterations** or sophistications of milk are the addition of water and the removal of cream. These can only be absolutely determined by analysis. Added water can be sometimes detected by taking the specific gravity of the milk by means of a lactometer, which consists of a glass stem with a bulb at one end weighted with mercury to keep it upright; on the stem is a graduated scale, and the mark on the scale to which the instrument sinks in the milk is read off as the gravity. If the specific gravity of water be taken as 1, that of good milk may vary from 1·027 to 1·034. The gravity is really the result of three things—(1) the amount of fat in the milk, which tends to lower the gravity—that is, make it nearer to that of water, because fat is lighter than water; for this reason a pure milk which happens to be rich in fat shows often a lower gravity than one which has been skimmed or deprived of its cream and fat. (2) The quantity of water in a milk, which tends to lower the gravity. (3) The amount of milk sugar and salts, which increase the gravity by adding to its weight as compared with water. The most common procedure in respect of milk sophistication is to remove part of the cream, which would naturally raise the specific gravity, and then, by adding water, to bring the specific gravity down to the normal. The use of the lactometer alone will not detect this fraud; reliance must be placed upon exact methods of analysis.

The dangers and possibilities of disease being conveyed from animals and men to men by milk has already been referred to at page 147.

Preserved milk, or rather concentrated or condensed milk, with or without sugar, is such a common article in daily use as to merit short reference. Those without sugar keep less well than those with sugar, once the tin in which they are sold is opened. The added sugar in condensed milk tends to make it rather fattening; but on the whole its nutritive value is below that of fresh milk, because, being made chiefly from skimmed or separated milk, it is poor in fats. This deficiency in fats, so constantly noticed in samples of condensed and preserved milks, renders them faulty articles of diet for young children, and indirectly accounts for the excessive prevalence of rickets and scrofula among children reared upon these fatless milks. In using the various kinds of condensed milk, care should be taken to see that only those are employed which have been prepared from whole milk; those made from skim milk should be avoided as being practically valueless as substitutes for the fresh article.

Cheese is made from milk by the action of rennet, which is commonly obtained from the fourth stomach of the calf. Cheese consists of coagulated casein, with varying proportions of fat and salts. The different qualities of cheese depend mainly upon whether they are made from pure milk, from skimmed milk, or from a mixture of skimmed and whole milk. Thus Cheddar, double Gloucester, Cheshire, and some American cheeses are made from whole milk, while Stilton is made from whole milk to which cream is added. Dutch, Parmesan, Suffolk, and Somersetshire cheeses are made from skimmed milk. Cream cheese consists of the fresh curd which has been moderately pressed; it is eaten without being allowed to ripen. When a cheese is kept, it undergoes a change known as "ripening," which is essentially a decomposition, whereby the casein undergoes a fatty change, including the formation of lime-salts of the fatty acids and the production of a soluble compound of phosphoric acid with casein from the phosphate of lime usually present in milk.

As an article of diet cheese is very useful, being particularly rich in both proteid and fat, the only objection to it being its occasional indigestibility. Its adulterations are unimportant, the chief being starch, to give weight. The blue and green mould seen on old ripe cheeses is due to a fungus or low form of vegetable life; the cheese mites are produced from the eggs of an insect; while the maggots so often met with in old and ripe cheeses are the larvæ of the cheesefly.

Butter.—We have already learnt that in milk there is a certain quantity of fat, and that, if the milk be allowed to rest quiet, some considerable portion of the fat rises in the form of cream; it is from this fat, by means of shaking and beating, that butter is made. Besides the fat of milk, butter contains some of the water, casein, and mineral matter of milk. Common salt is often added to butter to preserve it, but, if fresh, butter contains very little salt.

More than eighty per cent. of butter is fat, and this fat is really a mixture of seven different fats, namely, butyric, caproic, caprylic, rutic, oleic, stearic and palmitic. Of these the first four are very soluble, the last three less so; and it is owing to the larger proportion in it of the soluble fats that makes butter differ from animal fats and from artificial butters, and to be proportionately more easy of digestion than these latter. It is probable, however, that there is very little difference in nutritive value between butter fat, beef fat, or mutton fat.

Of artificial butters there are several; but in their manufacture they are very similar, consisting really of a certain amount of genuine butter mixed up with animal or vegetable fats, such as lard, rapeseed oil, etc. By the law of 1881 all these artificial butters are ordered to be called and sold as **margarine**; in the United States they are termed *oleo-margarine.* Artificial colouring matters are often present in butter, notably *annatto*, but it is harmless; occasionally starch is added to give weight.

Vegetable Foods constitute a large group, which includes a great number of articles of diet whose chief dietetic value is the supply of carbohydrates, vegetable acids, and salts to the organism; a small number yield a certain quantity of proteid and fat.

The proteids of vegetables are mainly in the form of globulins and albumoses; the most important of them being **glutin**, which is largely present in wheat-flour. Glutin does not exist as such in wheat-flour, but is formed from the globulin and albumose naturally present, by the action of water. Glutin forms a very valuable proteid food, and can be obtained also from rye-flour, but less easily than from wheat. **Legumin** and **conglutin** are other proteids formed chiefly in the pulses or peas and beans. The fats yielded by vegetable food are very small in quantity, and from a nutritive point of view are quite unimportant.

The carbohydrates, either as starches, gums (*dextrin*), or sugars, constitute the chief part of all vegetable foods. The minerals are chiefly in the form of phosphates and various salts of potash, with occasionally small traces of iron.

The vegetable foods may be divided into six great classes, namely, the cereals, the pulses, the roots or tubers, ordinary green vegetables, fruits, and the eatable fungi. The **cereals** include wheat, barley, oats, rye, maize, and rice. They yield from five to fourteen per cent. of proteid, and about seventy per cent. of carbohydrates, chiefly as starch, and much mineral matter, such as lime, magnesia, potash, soda, silica, potash, and iron. Their seeds are usually ground down into a meal or flour, and the outer hard and more or less indigestible shell or covering separated as bran. As this bran contains an appreciable amount of proteid, the whole meal is really more nutritious than the separated or white flour; but the presence of much bran in flour often acts as an irritant, causing a slight diarrhœa. Of all the cereals, wheat is undoubtedly the most valuable, as from its flour the best forms of bread can be made.

Oats are rich in fat and mineral salts, but yield little glutin, consequently are ill-adapted for bread-making; they are principally used in the form of oatmeal. Barley and rye both yield less proteid than either wheat or oats, and are ill-suited for bread-making, owing to the imperfect formation of glutin; they are correspondingly less nutritious. Maize is particularly rich in fats or oil; it also contains considerable proteid matter, but not in the form to yield glutin. Cornflour and hominy are familiar preparations of maize. Rice consists almost exclusively of starch, with but little proteid.

The **pulses** include peas, beans, lentils, etc. They are chiefly remarkable for the large amount of proteid which they contain in the form of legumin. These food grains need to be well cooked, otherwise they are extremely difficult of digestion; if combined with fatty foods they are most important articles of diet, especially in the form of soups.

The **roots and tubers** include potatoes, artichokes, arrowroot, tapioca, sago, carrots, parsnips, beet-roots, and turnips. None of these yield much proteid, but contain large quantities of starch and water; while beet-roots, carrots and parsnips, also contain cane-sugar. All this group are in extensive use as foods, their dietetic value depending mainly upon their contained starch and salts.

The **green vegetables** as represented by cabbages, cauliflowers, tomatoes, etc., have but a subsidiary dietetic value, since they contain little or no starch or sugar, but much indigestible material known as cellulose. Their great value lies in the salts which they possess, for their continued absence from a dietary, unless replaced by an equivalent, invariably leads to the diseased state of the body known as scurvy. They all agree in possessing a large amount of water, while some, such as the onion, leek, shallot, etc., possess peculiar and essential oils, which render them valuable flavouring agents.

The **fruits** are chiefly esteemed for their taste; though being, as they are, rich in water, vegetable acids and salts, they are distinctly of service as preventatives of scurvy. Some fruits, such as grapes, contain sugar; while others, like dates and bananas, contain not only sugar, but starch. When eaten, fruit should not only be ripe, but quite free from decomposition. Some few, like dates and figs, can be dried, but the softer and more perishable varieties cannot be too fresh when eaten.

Sic

The **edible fungi**, as represented by several varieties of mushroom, contain over ninety per cent. of water and a little nitrogen; they are not easy of digestion, and of very doubtful value as food.

Bread is usually made from white wheat flour, but brown and whole meal breads are made from flours which contain more or less of the bran or wheat-grain coats.

Bread is made by mixing flour with water and kneading it so as to form dough by the cohesion of the glutin which results. To this dough is added a ferment or leaven, usually consisting of a mixture of potato, flour and brewer's yeast. The addition of this leaven gives rise to a ferment action on the starch, whereby alcohol and carbonic acid gas are formed in the dough, resulting in the latter becoming broken up and perforated by innumerable holes. During baking, a certain quantity of sugar and dextrin is formed from the starch, while too, in consequence of the full aeration of the dough, the bread mass becomes light and digestible. In some bakeries, in place of using leaven or yeast, powders containing tartaric acid and bicarbonate of soda are added in order to generate the necessary carbonic acid. In another system, known as Dauglish's, the carbonic acid is generated separately by the action of sulphuric acid on marble, and the resulting carbonic acid gas forced into the dough by pressure. It is claimed for these unfermented, or aerated breads, that they have the advantage of containing no alcohol, acetic acid, and other bodies, the products of yeast action. This may be the case, but, on the other hand, the action of yeast is largely a digestive one, by which the starch is changed into maltose and dextrin, and some of the proteids of the flour into albumoses, or even peptones.

A good bread should be white in colour; any yellowness is suggestive of either an old flour, bad yeast, or a mixture of rye or bran. Although bread differs somewhat in composition from flour, its disadvantages as a food are more or less the same, namely, too little fat, and too little sodium chloride or salt. In daily life, the deficiency of fat is made up by eating butter, dripping, or bacon with bread, while in the baking, half an ounce of salt is added for each 4 lbs. of dough.

Several special kinds of bread are now in the market, notably those sold as "Hovis," "Bermaline," and "Germ" bread. These are all made from special or patented flours, the essential point in the preparation of which is some manipulation of the germ of the wheat grain. The "germ" of wheat is a special central part of the grain which is particularly rich in fat, and which, when largely present in flour, tends to cause it to keep badly. Under modern methods of milling, this can be separated from the rest of the grain. For making Hovis bread, the separated germ is acted upon by superheated steam, whereby it is partly cooked, and given good keeping qualities; it is at the same time given a flavour similar to that of malt. One part of this prepared germ, together with salt in about the same quantity used in ordinary bread-making, is mixed in with three parts of white flour, and constitutes Hovis flour or meal. In ordinary flour from which bread is usually made, no germ is present, it having been discarded in the milling. Germ bread and Bermaline bread are modifications of the above employment of the germ of wheat grains. These special breads have a high nutritive value, and usually a very agreeable flavour.

Biscuits are nothing more than well-baked mixtures of flour and water; though the more fancy varieties often contain milk, butter and eggs. Owing to the absence of yeast in their preparation, biscuits do not contain the products of its action upon the carbohydrates and proteids of flour. Taking weight for weight, biscuits contain more nourishment than bread, but are apt to be indigestible and monotonous if consumed for long periods.

Macaroni and **vermicelli** are both preparations of flour, being made chiefly from the flours of the hard wheats of France and Italy, which are particularly rich in glutin. Both preparations have a high dietetic value.

Sugar is of great importance in the nourishment of the human body, and, as already explained, constitutes a large proportion of the carbohydrate group; its special dietetic value depends on the fact that it is absorbed directly into the body as a nutritive substance, and is not—like nearly all other food-stuffs—separated by the agency of the digestive organs.

Sugar is met with chiefly in two forms, namely, grape sugar and cane sugar. Grape sugar exists largely in the juice of fruits, but is, however, mainly derived not from fruit or grape juice, but from potato starch by the action of dilute sulphuric acid, when it is often spoken of as starch sugar. However, neither grape nor starch sugar is suitable for ordinary requirements, but the kind of sugar known as cane or beet sugar is the sweetening article in daily use. This sugar was originally prepared from the juice of the sugar cane, but at present it is largely obtained from the juice of the beet-root; according to its purity and colour, it is called refined sugar, loaf-sugar, or brown sugar. Honey is closely allied to sugar, and consists chiefly of grape sugar, albumin, prussic acid, salts, and water.

Saccharin, which has, of late years, come into general use as a sweetening agent, demands a short notice. This body is an artificially prepared substance, quite without nutritive value, but some three hundred times sweeter than cane sugar itself. Two grains of it are sufficient to give a thousand grains of starch sugar the same sweetening power as a thousand grains of cane sugar. There is no evidence to show that saccharin is in any way hurtful, but since it has no nutritive power, its substitution in food for a carbohydrate is objectionable as tending to reduce nutritive value.

The Condiments include a variety of substances which are added to our food for the purpose of either making it more palatable, or of assisting digestion by stimulating the digestive organs to increased action. They are in no sense true foods, but rather stimulants. The more common condiments in general use are ordinary table salt, mustard, pepper, horse-radish, ginger, nutmegs, cinnamon, cloves, allspice, mint, parsley, vinegar, lime juice, and lemon juice. With the exception of the three last, the greater number of ordinary condiments do not demand special notice.

Vinegar is nothing more than dilute acetic acid, obtained either by the oxidation of alcohol, following the fermentation of grape juice (wine vinegar) and malt-wort (malt vinegar), or it is obtained by the destructive distillation of wood (wood vinegar, or pyroligneous acid). Vinegar is rarely used alone, but chiefly in combination with pickles or sauces. Taken in moderation, it will allay thirst and helps digestion, but if taken in large quantities it interferes with the proper nutrition of the body, and is distinctly injurious.

Lime juice and **lemon juice** are chiefly of value for their powers of warding off scurvy, due to their containing citric acid. Apart from their value in this respect, both these juices furnish agreeable and refreshing beverages; they allay thirst and sickness, and, too, are of special value as antidotes in poisoning by the alkalies.

SUMMARY.

The various kinds of meat, fish and eggs are the chief sources of our nitrogenous food, they also supply some fat. Milk, which should be the chief food of the young, constitutes a typical food-stuff, as it yields all the alimentary elements necessary in a perfect diet. It, however, is peculiarly liable to adulteration and decomposition, and needs special care to be observed both in respect of its selection for use and storage. Cheese, which is prepared from milk, is remarkably rich in proteids ; it has the great disadvantage of being somewhat indigestible. Butter, another milk product, is the chief source of the fats of our food.

The vegetable foods owe their dietetic value mainly to the starches, sugars, vegetable acids and salts, which they contain ; a small number yield a certain quantity of proteid and fat. The chief vegetable foods are cereals, the pulses, the roots, green vegetables, the fruits, and the edible fungi. Bread, biscuits, macaroni and vermicelli, are the chief products from these food-stuffs. The sugars and the various condiments also belong to this class.

CHAPTER XXII.

BEVERAGES.

Tea consists of the dried leaves of a shrub which grows in India, Ceylon, China, and Japan. As met with in everyday life, tea leaves are curled, but they uncurl on being placed in hot water, and when so treated, are found to be ovate in shape, pointed, and with a margin toothed like a saw, almost to the stalk. The size of the leaves varies, and usually mixed with them is some stalk. Practically all tea in the market is grown from the same species of shrub, the various names given as indicating different kinds are only trade names, and do not indicate really different varieties of tea so much as different qualities dependent upon mixing or blending, and on the age of the leaves, or on the soil upon which the plant has been grown. The best teas are those composed of the smaller top leaves of the twigs and the buds. The buds and small top leaves go to make Orange Pekoe, the two or three larger leaves growing on the same twig a little lower down are Suchong, and below that the still larger leaves become Congou.

The simplest division of teas is into the green and the black; both are from the same plant, the only difference is their colour. Green tea is now little used, in consequence of the disrepute into which it fell as the result of the artificial colouring it received some years back; but real green tea owes its colouration to being dried over wood fires when fresh. Black teas owe their colour to the leaves having been allowed to lie in damp heaps for twelve hours or so, during which they undergo a process of fermentation, and are afterwards dried slowly over charcoal fires.

In selecting a tea, one should not be guided by any trade name, but determine, by pouring a little boiling water over the leaves and examining them, whether the leaf was a whole leaf, and not a large leaf cut into small pieces. The larger the leaves, the weaker will be the infusion, and the less its value.

The average percentage composition of tea leaves is: water, 8; theine, 2·6; tannin, 14; oily matter, 0·4; starch and gum, 15; insoluble organic matter, 54; ash, 6; consisting of potash, iron, silica, alumina, and magnesia. Formerly, the chief adulteration of tea was by mixing with it other leaves, such as those of the willow and sloe, which bear a superficial resemblance to real tea leaves. At the present time, the chief adulteration of tea is the admixture of old and exhausted tea leaves, that is, those which have been used and dried again, while, in the very inferior kinds, there is often clay, lime, or ferruginous sand.

The value of tea as a beverage depends upon its contained **theine**, which is a nitrogenous, crystalline principle, possessed of considerable powers of stimulating and invigorating the nervous system, the muscular activity, and the circulation. The most essential points in making good tea, and with the least waste, are to have actually boiling water, and tea leaves so crushed and subdivided that the largest possible surface is rapidly exposed to the boiling water in making the infusion. The water should be a soft one, if possible, but when hard water is used, it should be boiled for some time to soften it, or a pinch of bicarbonate of soda added to it.

Tea is in no way a food, but, if used in moderation, undoubtedly serves a useful purpose among our daily wants. It is essentially a stimulant of the brain and nervous system, producing no subsequent depression; but, if taken in excess, it induces indigestion, loss of appetite, with constipation; in some persons, these bad effects are produced even when only small quantities are consumed. The excessive drinking of tea, especially when fasting, is distinctly injurious, so also are old or stale tea infusions which have been made some time, and often re-warmed. In the best cups of tea there is absolutely no nutriment beyond that of the milk and sugar added.

Coffee is the seed or berry of a plant growing in most parts of the tropics, but chiefly in Arabia, Abyssinia, Ceylon, and the West Indies. After the seeds have been roasted to a chocolate brown, they are ground to a powder in a mill, and then used in the form of a decoction or infusion.

The percentage composition of unroasted coffee may be expressed as follows: water, 11·23; nitrogenous matter, 12; caffeine, 1·3; fat or oil, 12·25; sugar or dextrin, 8·55; tannin, 32·8; cellulose, 18·16; salts, 3·7. The chief properties of coffee depend upon the caffeine and its aromatic oil. **Caffeine** itself is a nitrogenous crystalline alkaloid, identical with theine; in the roasting of the coffee berry, this body is not destroyed, but dissociated, as it were, from its previously existing combination with tannin. During the same process, the sugar and dextrin are changed into caramel, and the gas and water of the berry driven off.

The adulterations of coffee are chiefly chicory, but at times dates, beans, maize and even acorns have been added. **Chicory** is a legal addition to coffee, provided such admixture be stated, no limit being fixed as to their relative proportions; as a rule, it amounts to about thirty per. cent. The addition of chicory to coffee is considered, by some people, to add to its flavour, but how or why, is not apparent.

Chicory itself is the dried and powdered root of the wild endive. In composition it differs much from coffee, containing no caffeine, less oil or fat, but more sugar.

The effects of coffee are due to its contained caffeine, and, like tea, it is not a true food, but merely a stimulant of the nervous and muscular systems, and indirectly increasing the flow of urine and actions of the bowels. As an adjunct to other foods, coffee is of great value, and, if properly made, is probably a relatively better nerve stimulant than tea.

Cocoa is the roasted seed of a tree growing chiefly in the West Indies. Cocoa nibs are the seeds or beans roughly broken; flake cocoa is the same, completely ground and crushed; soluble cocoa is the same, freed from cellulose; while prepared cocoa is the same after half or more of its contained oil or fat has been removed, and, in most cases, starch and sugar added. The percentage composition of cocoa beans may be said to be as follows: water, 6; cellulose, 21; starch, 10; theobromine, 1·5; fat or oil, 50; gum, 8; salts, 3·5.

Theobromine is a nitrogenous body closely resembling theine and caffeine, not only in its nature, but in its action. The adulteration of cocoa is chiefly by adding sugar and starch; while, in some cases, much of its contained fat or oil is removed. Apart from cocoa, by nature, containing nitrogenous and fatty matter, in its commercial forms it contains so much starch and sugar that it is rightly regarded, to some extent, not only as a proteid and fatty food, but also as a carbohydrate one. Cocoa differs much from both tea and coffee in having but little stimulant action, but it does possess some nutritive value, and, as such, may, in a limited sense, be regarded as a true food.

Chocolate is a preparation of cocoa, from which the greater part of the fat has been removed, and which, after being mixed with sugar, starch, and various flavouring substances, is made into a paste with water, and then pressed into moulds.

Aerated Waters.—In addition to the large number of natural waters rich in carbonic acid, there are many artificial aerated waters which have come into general use of late years. The peculiar feature of them all is that they are prepared by forcing carbonic acid gas into ordinary water, and adding to it either some saline or a flavouring agent. Much of what is known and largely sold as "soda water," really contains no soda at all, but is merely an ordinary water highly aerated, and charged with carbon dioxide. The chief sources of danger to health in these beverages lie in the possible employment of originally impure water; the making of the carbonic acid from impure materials; the presence of either lead, copper, or tin, as the result of imperfect washing of the gas, or derived from the plant used in the manufacture. These dangers can only be obviated by the exercise of care in the selection of the water and the materials used. It is questionable whether any real danger to the public health exists under this heading.

Beer is a fermented saccharine infusion to which has been added any wholesome bitter. Modern beers may be divided into two great groups, namely, the non-malt beers, and the malt beers. What are called non-malt beers are those made by a yeast fermentation of an infusion of sugar, mainly derived from starch, chemically or artificially converted, as by the action of dilute sulphuric acid. Malt beers are the result of a similar yeast fermentation of an infusion of sugar, only in this case the sugar is derived from the natural conversion of grain starch by means of germination or malting. In both instances, the resulting liquor is an alcoholic one, due to the splitting up of the sugar into alcohol and carbonic acid; a portion of the alcohol becomes subsequently transformed into aldehyd, and by a further oxidation changed into acetic acid.

The actual preparation of malt, and the subsequent brewing of beer, is easy to understand. The maltster first soaks his barley in a cistern, then transfers it to floors, on which it is spread out; here he leaves it for ten days or so, during which time germination takes place, and the grain sprouts. When this germination has proceeded far enough, it is arrested by drying the grain over a kiln. It is now malt, and if tasted is distinctly sweet, owing to the conversion of grain starch into grape sugar by the action of a peculiar ferment present in grain called **diastase**. After the dried malt has been sifted so as to break off the sproutings, it passes into the hands of the brewer, who, after crushing it, places it in his mash-tub with water heated to about 160° F. This water completes the transformation of the starch into grape sugar, and dissolves it, causing the resulting liquor or *wort*, as it is called, to have a decidedly sweet taste. In the case of a brewer using chemically converted starch, or a mixture of it, with malt, a similar treatment with warm water would be followed with the production of a sweet liquor, or wort. When the conversion of the starch into sugar is sufficiently complete, all chance of further conversion is checked by boiling the wort, which also acts in coagulating the albumin which the water has dissolved out of the grain; advantage is also taken of the boiling to add hops, which aid further in clearing the wort by coagulating the remaining albuminous matter, besides imparting to it their characteristic bitterness. Both the length of the boiling and the quantity of hops added vary according to the richness of the wort in sugar, and the quality of beer it is intended to make.

The next step in brewing is to run off the boiled liquid into shallow vessels, in which it is cooled to the best temperature for fermentation. If "top" yeast is going to be used, this temperature is 60° F., but if what is called "bottom," or sedimentary yeast, as used in German breweries, a much lower temperature is preferable. When at the required temperature, the liquid is run into the fermenting tin, and a sufficient quantity of yeast added. It is usual to use a yeast obtained from a kind of beer different from that which it is proposed to make; the whole is allowed to ferment slowly for six or eight days. During this time, under the influence of the yeast fungus, the sugar dissolved in the wort splits up into alcohol, which remains in the beer, and into carbonic acid gas, which, for the most part, escapes into the air.

The most essential points in brewing are the facts that the quantity of yeast to be added, and the temperature at which fermentation is allowed to take place, vary with different kinds of beer; also that yeast works better when transferred from one kind of beer to another; and that the fermentation must be so regulated that the whole of the sugar contained in the wort is not transformed into alcohol, as, if it is all so transformed, the beer is more heady, less nourishing, and has no keeping power; that is, it readily turns sour in the casks, owing mainly to the passage of the alcohol into aldehyd, and the subsequent oxidation of this into acetic acid.

There are many varieties of ales and beers, the distinctions really being dependent on whether they have been fermented at low temperatures, like the light German or lager beers, or at higher temperatures, like the stronger British beers; also the quality depends on the manner of cooling, the length of the fermentation, and on the composition of the original wort. The colour generally depends on the degree of heat to which the malt has been kilned, and whether caramel or burnt sugar has been added.

The chief constituents of beer, stout and porter are alcohol, dextrin, sugar, hop resin or oil, glutin, acetic, and lactic acids, carbonic acid gas, phosphoric salts and water. The alcohol in beer varies from one to ten per cent. in volume. The lighter German beers contain three or four per cent., pale ale about two or three per cent., and the stronger British ales, stouts, porters, etc., as much as six to eight per cent. The malt extract, which consists mainly of sugar, dextrin and cellulose, varies from four to twelve per cent.

Regarded as a food, the nutritive value of beer is small, though, of course, higher than any other alcoholic drinks, owing to the large amount of maltose, dextrin, and other saccharine substances which it contains in the form of malt extract. In the main, its dietetic effects are those of alcohol, modified by the associated action of other ingredients. Beer appears to have some action peculiarly its own; this is generally attributed to *lupulin*, which is the active principle in hops. On some people, beer acts as a depressant, and, if taken in excess, it undoubtedly is a stupor producer and intoxicant. Beer also seems to exercise slight but continuous interference with tissue change, with a tendency to fatten and engender gout and rheumatism. When drunk to any excess, beer appears to have a retarding influence upon digestion, and produces the same injuries to health as excessive indulgence in alcoholic liquors; taken in moderation, however, particularly the lighter varieties, beer is an invigorating and refreshing beverage.

Wine is the fermented juice of the grape, with such additions only as are essential for its proper keeping. This definition permits us to admit as wines those beverages which, made from grape juice, require for their preservation the addition of spirit or alcohol, as in the case of the ports and sherries; but it excludes the so-called British wines, which are not made from grape juice at all, and also those other so-called wines from other countries, which are fortified with spirit when they require no such addition.

When the sugary juice of a fruit, such as a grape, is left to itself at a moderate temperature, fermentation takes place from the influence and action of germs present in the air; this process differs, therefore, somewhat from that of beer-making, when the starchy or sugary liquid or wort is boiled, and then the germ or yeast added deliberately to make it ferment. During the fermentation of a fruit juice, a part or whole of the sugar is converted into alcohol; at the same time various ethers which give the characteristic flavour to wine are formed, as well as acetic, tartaric, malic and other acids. The essential acid of wine is tartaric acid; much of this crystallizes in the casks as cream of tartar or tartrate of potash. The newer wines contain aldehyd, which is very intoxicating. Later on this becomes oxidised into acetic acid, and if the wine be left exposed to the air long enough, all the alcohol in the wine will be converted into this acid, so as to practically become ordinary wine vinegar. Much of the colour, taste and character of wines depends upon how far they are made from the grape juice only, or how much this is mixed with the seeds or skins of the fruit. The seeds are rich in tannin and a bitter principle, while the skins yield a colouring matter, some flavouring principle and tannin.

There is no constancy as to the amount of alcohol contained in wine; the natural, or light French and German wines, such as clarets, burgundies, hocks, moselles and champagnes contain from six to thirteen per cent., by weight of alcohol, while the ports and sherries, which are really fortified wines, or wines to which alcohol has been added to make them keep better, contain from fourteen to twenty-two per cent. of alcohol.

The sugar in wine varies much, being for the most part in the form of grape sugar. Sherries contain about 8 grs. to the ounce, in Madeira it varies from 6 to 66 grs. per ounce, in port from 12 to 28 grs., in champagnes the average quantity is about 24 grs., but many of the dry champagnes contain little or none. Wine is acid from the presence of pure acid, and acid salts, such as tartrate of potash. The usual acidity of wines, in terms of tartaric acid, is about 2 grs. per ounce in sherry, 3 grs. in champagne, 4 grs. in port and the better kinds of claret or Burgundy, and 6 grs. or more in the inferior clarets.

The colour of wines is derived mainly from the grape skins; by nature it is greenish or blue, but becomes violet or red by the action of the wine acids. As wine ages, changes occur, resulting in a precipitated combination of the organic bodies with tannic acid, whereby the wine becomes paler, and less astringent. Occasionally, in the inferior wines, artificial colouring matter is added in the form of the many varieties of aniline dyes, logwood, cochineal, etc. The adulterations of wine are mainly in the direction of added spirit, artificial colouring, and sulphate of lime to give it a bright, clear appearance and to reduce its excessive sweetness.

In the manufacture of other vinous beverages, such as the so-called British wines, gooseberries, currants, raisins, bilberries, apples and pears are chiefly used; the juice of these fruits is allowed to ferment with sugar and alcohol, and water added; they, as previously explained, are not to be considered as true wines.

The nutritive value of the wines is small, and in the main subsidiary to the stimulating properties of their contained alcohol. The clarets and lighter wines are more or less anti-scorbutic, owing to the presence of the organic acids. Port and sherry appear to predispose to gout. The presence of some albuminous principle in wine may give it a slight nourishing value, but in favour of such a view the evidence is small. The artificial products, or British wines, cannot serve as substitutes for real wine in regard to its stimulating or health-giving effects; but, on the contrary, unless exceptionally well prepared, may prove distinctly injurious to health on account of their ingredients.

Spirits.—Of all the alcoholic beverages, spirits contain the largest amount of alcohol. They are all made by the distillation of alcohol from the fermentation of various saccharine or starchy materials. The more common spirits in this country are brandy, whisky, rum, and gin. The basis of them all is ethylic alcohol, which is a neutral compound of oxygen, carbon and hydrogen; but they all contain other alcohols, usually classed together under the name of fusel oil, various compound ethers and fragrant bodies produced during distillation. It is the varying proportions of these latter which give the respective spirits their characteristic taste and aroma. After being kept for some years, spirits become mellowed, or softened down; this was formerly supposed to be due to the diminution of the so-called fusel oil, but it is now more generally regarded as due to a lessening both in quantity and quality of the flavouring substances.

Brandy is made by the distillation of fermented grape juice. When first distilled it is colourless, but gradually darkens with age, though too often artificially coloured by means of burnt sugar. Pure brandy consists of water, alcohol, acetic acid, acetic and œnanthic ethers, a volatile oil, colouring matter, and tannin. It usually contains from forty-six to fifty-five per cent of alcohol volume in volume. The best kinds come from France, the more inferior from Spain, Portugal, and Italy.

The chief adulterations of brandy are water, cayenne pepper, burnt sugar, and acetic ether. Some of the cheaper brandies are not made from grape juice at all, but are mere imitations, made from corn or potato spirit, flavoured and coloured.

Whisky is really one of the corn spirits, being made from malted grain. The more inferior kinds are prepared from oats, barley, or rye, or from potatoes mashed up with malted barley, and then roughly distilled and burnt in order to give it the peculiar smoky flavour characteristic of some varieties. Whisky usually contains from forty to fifty per cent. of alcohol volume in volume. The adulterations are much the same as those of brandy.

Rum is a spirit obtained by distillation from the fermented skimmings of sugar-boilers, or the drainings of sugar-barrels (molasses). Like brandy, it is colourless when first distilled, but it is later on artificially coloured with burnt sugar. Rum is chiefly made in Jamaica; its peculiar flavour is due to butyric ether and a flavouring oil; the amount of alcohol present in rum is from fifty to sixty per cent volume in volume.

Gin in this country is usually made from a mixture of malt and barley, flavoured not only with juniper berries, but with oil of turpentine, orange peel and several other aromatic substances. In Holland, it is made from unmalted rye and barley malt, with juniper berries. In consequence of the juniper and turpentine contained in it, gin is a direct stimulant to the kidneys. It usually contains from forty-nine to sixty per cent. of alcohol volume in volume. Its chief adulteration is water, which makes it turbid; to remove this, alum and acetate of lead are employed, followed by the addition of sugar and cayenne pepper to sweeten it and give it pungency.

Dietetic Value of Alcohol.—This is an important but somewhat difficult question. In attempting to understand the nutritive value of alcohol, one must bear in mind that there is a distinction between the effects of alcohol taken in dietetic doses and when taken in excess, and too, that the physiological action of pure alcohol is not quite the same as that of many alcoholic beverages, because many of these contain other bodies besides alcohol, and which have a distinct action of their own. Moreover, it must not be forgotten that what is a dietetic dose for one person is an excess for another. The amount of pure or absolute alcohol which can be taken daily by the average adult without doing harm appears to be about one and a half fluid ounces. This is contained in about three ounces of ordinary brandy or whisky, in three-fourths of a pint of the light wines, such as claret or Burgundy, and in about two pints of the ordinary ales or beers.

When alcohol is swallowed, it passes from the stomach into the blood, but what becomes of it, and how it is passed off from the system is undetermined. The probable truth is that alcohol is oxidised in the tissues, the products being excreted in the urine. In small doses, alcohol stimulates the nervous system, reddens the lining membrane of the stomach, increasing the secretion of the gastric juices, and may indirectly promote the appetite. When carried into the circulation, it increases the heart's action, and, at the same time, causes the smaller blood vessels to dilate.

It is a popular idea that alcohol tends to make one feel warmer, on this point there is no evidence to show that it does anything of the kind; on the contrary, there is much to indicate that, if anything, when taken to excess, it really lowers the body temperature; moreover, it is beyond question that the systematic consumption of alcohol tends to lower the natural resisting power of the body against cold, and for this reason alcohol is unsuited for those exposed to great cold. If taken too often, even in small doses, or taken in any large quantity at one time, alcohol, instead of stimulating the nervous system, actually depresses and paralyses it, as evidenced by the condition of intoxication. In these circumstances, the perceptive power of the brain is depressed or paralysed, correct judgment is impossible, while speech is disordered, and the emotions out of all control.

If repeatedly taken to excess, alcohol delays digestion, causes catarrh of the stomach and bowels, accompanied by degenerated conditions of both the liver and kidneys sufficient to result in death. It is beyond question that, when taken in sufficient quantities to produce these effects upon the brain and the nervous system, alcohol causes an immensity of harm. The physical, moral, and social evils of intemperance are only too familiar to us all.

How far alcohol is beneficial or not, when taken in small or dietetic doses; is still a matter of controversy between the teetotallers and those who advocate moderation. Of this, however, we are certain, that only under exceptional circumstances can alcohol be regarded as a food; also that a person can do quite as hard, if not harder, work without alcohol than with it. On the other hand, it must be borne in mind that, in ordinary life, to many the cares and worries of business and existence are such that to them, after the labours of the day, a moderate amount of alcohol, in some form or other, is not only an advantage, but almost a necessity. To the old and feeble, the use of alcohol is not less valuable. In all cases, however, it should be remembered that alcohol should never be given to children, except under medical direction, that it should never be taken during working hours with the idea that the body and brain are likely to do more work after it than before; the only time when it can be advantageously used is after the day's work is done; so taken, its influence is often to check tissue change and waste, to soothe and stimulate an exhausted brain with a removal of the sense of fatigue, and to promote digestion. Alcohol should never be taken fasting, its best effects are secured when taken with food, and at no meal more so than at the late dinner or supper. While we may say that, to the robust and healthy, alcohol is quite unnecessary, still, in many forms of disease, it is undoubtedly of very great value.

SUMMARY.

If we set aside ordinary water and the artificially aërated waters, the chief beverages are the alkaloidal and the alcoholic. To the first group belong such beverages as tea, coffee and cocoa, all of which contain more or less of certain alkaloidal bodies, such as theine, caffeine and theobromine. All these beverages have distinct stimulating and restorative effects upon the nervous and muscular systems. Among the alcoholic beverages are beer, wine, and the spirits. Their dietetic value is practically identical with that of their contained alcohol. Alcohol is not a necessity as part of man's diet. It is a stimulant in small doses, but a depressant in large doses. If taken at all, alcohol should only be taken with food, and preferably after work is done. Except for medicinal purposes, alcohol should never be given to children.

CHAPTER XXIII.

SOILS AND SITES.

Soils.—There is every reason to believe that originally our earth was in a molten state, and that, in the course of ages, it gradually cooled down, forming a sort of crust round a liquid core. After this crust of the earth, as it were, had solidified, and become what geologists call *igneous rock*, or rock produced by the action of fire, it was subjected, through long periods of time, to the wearing action of rain, frost and wind, with the result that much of it was worn down into fine particles, which, collecting together, contributed to the formation of another class, called secondary, or *sedimentary rocks*.

Now, it is of these two kinds of rocks that the great mass of the earth is composed in the present day, examples of the igneous rocks being granite, basalt and volcanic lava, while representing the sedimentary rocks are the various sandstones, greensands, limestone, chalk, gravel, and clays. The surface of the earth, or soil, is really only the result of the gradual wearing or breaking up, as it were, through many years, of these various rocks of which our globe is mainly constituted. It is convenient to divide the soil into two parts, namely, a deeper portion, or **subsoil**, consisting chiefly of inorganic materials, the direct result of the breaking up of the rock under various agencies; and an upper portion, or **surface soil**, which, again, is derived partly from the inorganic subsoil, and partly from the products of the decomposition of vegetable and animal matter.

Sites.—Although the choice of sites for our houses in towns and villages is usually sacrificed to expediency or necessity, and more often than not fixed upon regardless of the advice of any one, still, some knowledge of the chief considerations which should rule the selection of a building site is none the less necessary, because, if we ever do have a choice in the matter, it is as well that we should know how to choose or, at least, to understand what to avoid in making our selection.

This question involves the following considerations—*dryness*, *warmth*, *light* and *air;* as a rule, dryness and warmth go together, as also do light and air.

The **dryness of a site** depends mainly upon the readiness with which rain can pass off, or through the soil, coupled with the consideration of how far below the surface lies the great underground sheet of water, known as the subsoil or ground water. Common sense indicates that a flat and non-porous soil, or a soil which, though porous, has an impermeable layer underneath it, must be damp, and consequently undesirable as a building site. As a rule, the best sites for houses are on slate rocks, or what is known as millstone grit; these formations allow no water to pass through them, and readily allow rain to run off. Equally good are gravels, chalk and sandstone; these all permit water to run through them, but they should be of some considerable depth. If, on the other hand, the beds of sandstone, gravel, or chalk be not of any great thickness, and, moreover, have immediately beneath them clay, or some other impervious layer, the upper stratum of gravel, chalk or sandstone, simply acts as a sponge, and absorbs, or holds the water, which cannot get away owing to the impervious bed beneath; these situations are obviously unfavourable, unless adequately improved by carefully arranged subsoil drainage.

The impermeable rocks, although theoretically good sites for houses owing to their general dryness, are often objectionable owing to the difficulty of obtaining water near or on them. Gravels and chalk are usually both dry and healthy; so also is sandstone, provided that, like gravel and chalk, it is of considerable thickness or depth, and not underlaid with clay. Marls and clays, for obvious reasons, are unsuitable sites, being usually damp, unless well drained. The same objection applies to peat-land. **Made soils** or artificial sites prepared by shooting rubbish and other objectionable matter into pits or holes should be avoided as sites for houses. They usually contain much organic matter in varying stages of putrefaction, and, unless very carefully prepared, are a fruitful source of ill-health to those living upon them. If, however, there is no other available site for necessary buildings, than such a "made soil," it should be carefully drained, and the whole of the ground covered by the houses carefully protected by an air-proof basement of concrete, or some impermeable material. If this arrangement cannot be adopted, a space of at least a foot should be left between the under side of the lowest floor and the ground surface; this serves as a means of disconnection between the soil air and the air of the house, it also, as a means of ventilation, acts as a preservative against dry rot.

In order that a house may get plenty of light and air, we should endeavour to secure for it a situation with a southerly or south-western aspect, and a site well removed from other buildings, and not closely surrounded by trees. It is not always possible to secure these advantages in towns, so readily as in the country, but wherever the building may be, it is obvious that the greater the open space around and about it the better. To secure these important essentials of light and air, commendable efforts are now made in towns by means of bye-laws for defining the precise limits, beyond which buildings shall not extend, and for maintaining a due proportion between the heights of buildings and the widths of the roads or streets upon which they abut.

In all sites intended to be built upon, it is important to notice the distance of the **ground water** from the surface. If this ground water be too near the ground level, the spot will be damp and cold; it ought never to be nearer the surface than ten feet, and, if possible should be at least fifteen or twenty feet below the ground line. There is good reason to believe that frequent, sudden and extensive changes of water level are specially unhealthy; therefore a place where the level of the water in a well is apt to rise and fall a good deal is not a good site. Statistics show that where the ground-water level has been lowered, and the soil made drier by means of drainage, there the public health has improved. This improvement in health has been chiefly in the lessening of such diseases as consumption, bronchitis, catarrhs, sore throats, rheumatism, and ague.

Summing up the facts in regard to a choice of site for building purposes, the most essential points to be sought for are as follows :—

1. A moderately elevated spot, with the ground falling away from it on all sides, sheltered from the north and east, but not so shut in as to impede the free circulation of air round and over it.

2. The site should, if possible, be upon a porous soil, such as gravel or sand, care being taken, however, to see that the subsoil is sufficiently permeable to secure thorough drainage, either naturally or artificially.

3. The ground water should not be nearer the surface than ten feet, and not subject to either great or sudden fluctuations in level.

4. The surface soil and subsoil, no matter what their nature, should be clean, and not fouled by either sewage or refuse.

SUMMARY.

Soils are the result of the wearing away and breaking down of the rocks of which the crust of our earth originally consisted. As bearing upon their suitability as sites for dwellings, the most important features of all soils are (1) their freedom from decomposing organic matter, (2) their permeability, and (3) their dryness. Made soils are specially objectionable as sites for buildings.

The ideal site for a dwelling is a moderately elevated spot, sheltered from the cold north and east winds, located upon a porous soil, free from sewage or refuse pollution, and in which the ground water does not reach nearer to the surface than ten feet, and is free from sudden or great fluctuations in level.

CHAPTER XXIV.

THE HABITATION.

EVERY inhabited building should be so constructed that it shall be firm, dry, warm, well ventilated, well lighted, and with no possibility of ground air entering it. These essentials can only be secured by paying attention to the manner of building of the foundations, walls, roof, floors and general arrangement of the rooms with their attendant facilities for heating and lighting.

The foundations ought to be sufficiently solid and deep enough to give firmness to the building. When the ground is soft, or a solid foundation cannot be reached, the walls should be built upon a solid platform of concrete or stone, which should be at least four times as broad as the walls. The bases of the walls themselves should be expanded into what are called *footings,* the lowest course of which should be at least twice the breadth of the wall. The height of the footings ought to be not less than two-thirds of the wall thickness.

Damp-proof Course.—The situation and nature of the soil upon which a house is built may need measures to be taken to prevent damp rising in the walls by capillary attraction, and in order to do this it is necessary to lay a damp-proof course along the full thickness of the wall above the highest point at which the wall is in contact with the earth, and below the lowest timbers or floor supports. This course is made of either glazed tiles, slate, sheet lead, asphalte, or other impervious material. The walls of no room or cellar should be in direct contact with the soil. This can usually be secured by digging away the earth on the outside to below the level of the floor, so as to form a "dry area." As an alternative plan to this, the wall may be made hollow up to a point above the ground level, and then inserting two damp proof courses, one at the bottom of the hollow and below the floor-level, the other at the top of the hollow and therefore above the outside ground level. By this means the inner wall is quite shut off from the soil. Both these arrangements are shown in the diagram (Fig. 44).

Whichever plan is adopted, it is necessary to provide drainage from the bottom of the area or cavity, and, both in the case of the dry area and the hollow wall, sufficient openings must be provided for ventilation.

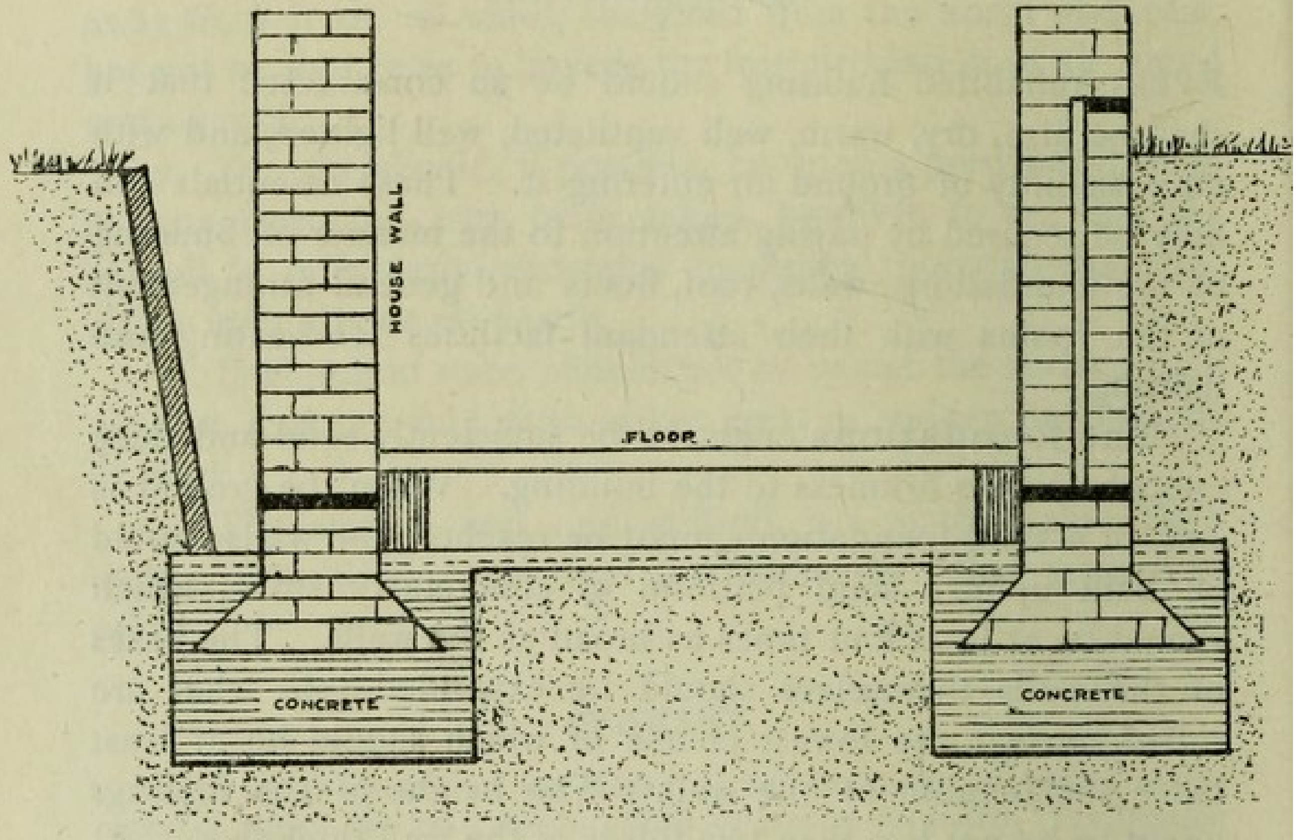

FIG. 44.

Walls.—The materials ordinarily used for the construction of the walls of dwelling houses are bricks, stones and wood. In many tropical countries crude or sun-dried bricks are employed, but these are unsuited for this climate, and we have therefore to use baked or kiln-dried bricks. **Bricks** are made of clay, and if of good quality should be heavy and hard, and when knocked against one another, they ought to give a clear ringing sound. The quality of bricks constantly varies, owing to the variability of the clay employed. Bricks are very porous, readily absorbing water and permitting the passage of air through them; in fact, so much is this the case that it is desirable in all dwellings that the outer walls should, if of brickwork, be at least a brick and a half thick (fourteen inches), so that in addition to the bricks, there may be in the structure of the wall itself a vertical layer of mortar. **Mortar** is a compound of one part of slaked lime with three parts of fine clean sand, made up with fresh water. If the sand be dirty and contain clay, or if salt water be used, the mortar will not "set," but crumbles to pieces.

Two classes of **stone** are ordinarily employed for house building; they are sandstone and limestone. Sandstone has been described as sand made into a cake with clay, lime and oxide of iron. It is the varying amount of this latter which gives the various colours to it, such as red, yellow, and grey sandstone. Limestone is a rock composed mainly of carbonate of lime. Like bricks, stone is both porous and absorbent of water, but in a less degree.

Wood is only occasionally used in the external walls of houses in this country, but enters largely into the construction of the inner fittings of all dwellings. In its natural state it is extremely absorbent, and the unavoidable cracks and crevices admit both air and water. The chief kinds used are ash, beech, oak, elm, pine and larch. The first four differ from the two latter in being free from turpentine. Good timber should be close and straight grained, free from cracks and dead knots, and well seasoned.

In all houses of one or more stories, the walls should not be of less thickness than nine inches, while a fourteen-inch wall is preferable. If built of brick, the bricks should be bonded together, by being laid lengthways and crossways alternately, and only whole bricks used. If broken bricks are used, the stability of the structure is much weakened. When special strength is desired, or if there is any doubt as to the foundations, *hoop-iron bonds* may be introduced. Walls built of cut stone need to be no thicker than those of brick, but if of rough stone or flint and boulders, they should be at least one-third thicker. Combination walls made of both bricks and stone need to have the two elements carefully bonded together. Wood is at times used in making the upper part of the outer walls of houses; when so employed, it needs to be backed with at least 4·5 inches of brickwork and well bonded together.

Walls above the ground level should be more or less impervious, otherwise driving rain will penetrate into them. To prevent this, slates or tiles may be fastened to battens on the face of the wall. A surface of mortar sprinkled with small stones is occasionally employed for the same purpose. All these are effective, provided they are applied when the bricks are dry, as otherwise the moisture is kept in the bricks. Pitch or paint, if regularly renewed, will also protect the walls from damp, but interferes with the insensible ventilation or diffusion of air which so constantly goes on through the walls of most inhabited buildings. Probably the best plan to keep damp from coming through outer walls, is to build them double, with a cavity or space of two or three inches between them; the double walls are tied together at intervals by bonding-ties of non-absorbent material, such as iron or glazed stone ware. These kinds of wall, in addition to being impervious to wet, are bad conductors of heat, consequently, in houses so constructed, a uniform temperature is more easily maintained than in those built with solid walls of equal thickness. It is essential that ample means for the ventilation of the wall cavity should be provided.

A damp-proof course is needed at the top of exposed walls, such as parapets and chimneys; this is usually provided by finishing the top either with a stone and letting it project an inch or two over the side, or by having an impervious damp-course laid in the wall or chimney at its junction with the roof. Window-sills also cause damp, unless they are built beyond the face of the wall and are grooved longitudinally on the under projecting surface. Defective spouting is also a frequent and serious cause of damp house walls. Another weak point is often where the roof joins a parapet wall. Cement is often used to render this junction impermeable, but sooner or later it separates from the brickwork and causes leakage; lead is far preferable.

During the building of house walls, care should be taken that chimney flues are properly constructed. They should all be made as straight as possible, and separate one from another. They should contain no woodwork, and, if possible, be lined with pipes, an arrangement which not only disconnects the flue from the house structure, but favours cleansing and the maintenance of an up-draught.

Roofs need at all times to be closely considered, as defects in them are a frequent source of dampness. The more common materials used in making roofs are slates and tiles, or less often thatch, wood, zinc, and corrugated iron. Slates, when good, should be hard, free from streaks or flaws, and give a metallic ring when struck; if of poor quality, they are apt to scale and break away. Tiles, like bricks, are made from clay, but need more careful drying and burning. Thatch forms a good roof, being both warm and dry, but is apt to catch on fire, and, unless well looked after, is rapidly infested with birds and vermin. Wood, covered with tarred felt, makes an excellent roofing, but, like zinc and galvanised iron, is practically only suited for temporary buildings. Lead is too costly to be used other than for special parts of the roof.

In all roofings it is important that there be a framework, sufficiently strong to bear the weight of the material, plus a certain amount of snow. The framework is usually made of wood. If the covering is to be of slates, the slope of the roof should be 25° with the horizon, if of tiles, at least 30°; metal roofs may be made flatter.

House roofs should always be covered with boarding laid at right angles to the rafters of the framework, and, if possible, with a layer of some good non-conducting material such as felt, which not only makes the house cooler in summer, but warmer in winter. Slates are often laid on laths, but the practice is objectionable; boarding is far better, as it forms a solid support, and offers a greater resistance to changes in temperature. Slating should be laid with a three inch lap, otherwise the rain or snow will be driven through.

In all cases the eaves of a roof ought to project some distance beyond the walls, and be provided with a good gutter, so as to throw off the rain well away from the house. These gutters should be of iron, and at least two inches from the wall, discharging into rain pipes, which should be also of iron, and placed well outside and away from the house wall. These rain-water pipes should either discharge into properly ventilated rain-water tanks, or over a drain covered by a grating. They should never be connected directly with drains or sewers, neither should they be placed with their heads just below bedroom windows, more particularly when they empty into a tank.

So far we have considered how to keep the outside walls of the house dry, or at least how to prevent the damp reaching the inside. It is now necessary to consider the inside walls and floors.

The inner walls of a house need to be protected and covered in some way, though the practice is not free from the objection that it interferes with the porosity of the wall, and thereby impedes ventilation. In this climate, however, some wall covering is more or less of a necessity. The simplest plan is white-washing, but at best of times it is crude and leaves a comparatively rough surface on which dirt lodges and collects. If walls are white-washed, the wash must be frequently renewed.

For all inside wall surfaces, we should endeavour to secure not only an impervious material, but one which has a smooth surface and can be readily cleaned. For this purpose, two plans can be employed; either cover the walls with glazed tiles, or plaster them and then paint over with some form of washing paint. Papering walls is very common, but it has the disadvantage that, unless the paper be varnished, it cannot be washed and much dirt sticks. The various flock papers and their cheap imitations are particular offenders in these respects. Lime-washing is preferable to common unglazed or flock papers; but it must be borne in mind that the mere putting on of a fresh coat of lime-wash over an old and dirty one is not cleanliness; the wall should be first scraped, and the old coat thoroughly removed. Similar objections exist to the too frequent habit of pasting new wall-papers over old. This often goes on for times together, until half a dozen or more papers are found one under the other. Each of these will have taken up its share of dirt, and each will have been laid on with a fresh supply of paste, so that, on the slightest dampness, the whole has every facility for rotting and fermenting. In all cases, the old paper should be scraped off before the new one is put on.

Floors, like wall coverings, are best made of impervious materials, which can be washed. Wood, stone, or tile constitute the chief. Stone or tiles are very good for passages and sculleries, but are apt to be cold for kitchens and living-rooms. Wood makes the best flooring, particularly if of hard wood, or made of wood-bricks. In the majority of cases, floors are badly constructed, ill-seasoned wood being used, which soon shrinks and gapes. Even if made of a soft wood, such as deal, a floor can be well laid down, if care be taken to tongue and groove the planks which constitute it, or if this be not done, to caulk the seams with tow and then varnish the whole over. This will permit of its being cleaned by dry scrubbing or sweeping, and, even if washed of being quickly dried. Too often, owing to the cracks and crevices in floors, the enclosed space below becomes a receptacle for dirt of all kinds; moreover, if the floor be a basement one and unprotected by concrete or other impermeable layer, or be over an unventilated cellar, foul gases and air find a ready entrance into the room. The necessity for the free ventilation of all closed spaces has been previously explained, and nowhere is it more needed than in those below basement floors. If the ventilation is insufficient, the air becomes damp and a fungus growth called dry rot is liable to set in and destroy the wood flooring. In the upper stories, however, the ventilation through the boards and ceiling is usually sufficient, unless constantly covered with oil cloths or some other air-tight material. If floors were made better, so as to insure a more or less uniform and impervious surface free from cracks through which draughts can enter and dust collect, there would be less inducement to cover the whole floor area with a carpet or drugget as is so commonly done. If carpets are used, they should be sufficiently limited in size, as to leave a border of bare flooring round the room. This arrangement does not allow dust to accumulate readily in corners, and at the same time simplifies the taking up and beating of the carpet.

General Arrangement of the Dwelling.—In all efforts to plan a house, the great object is to make every use of the whole space, in order to get as much accommodation and comfort as possible. When we have to consider small cottages there is seldom much choice in the matter. In no case, however, should privies, middens, or pigsties, etc., abut upon or form part of a dwelling house; neither ought houses to be built back to back. If possible, rows of houses should run north and south, and all square buildings should have their angles in those directions so as to get some sunlight in every room, during some period of the day.

In dealing with houses of the better class, there are several points which call for notice. One of the most frequent errors is the cramped space allowed for halls and staircase. Plenty of space should be given for them, as with ventilating windows at the top they constitute the central ventilation of the house. All the rooms ought to be so placed as to get light and air directly from the outside; and if there be any passages or lobbies they should be similarly lighted and aired. No room or chamber which has, so to speak, a borrowed light, and which is not in direct communication with the outer air, ought to be used as a sleeping-room. Equally, it is undesirable to use a kitchen or room in which food is prepared or kept as a sleeping-room.

The size and allotment of rooms in a dwelling will of course depend upon questions of cost, convenience, and the purpose for which they are intended. The kitchens and larder ought to be on the cool side of the house, which in this country is on the northern aspect. It has been suggested that the kitchen should be placed at the top of the house, so as to allow smells and vapours of cooking to rise into the air instead of into the house, as when the kitchen is in the basement. Theoretically, this is a very good plan, but practically only possible in a very limited number of houses. Its general adoption, particularly in small houses, would be impossible.

The height of rooms should not be less than nine feet, and need rarely exceed twelve feet. Every room should have at least one window in it which opens to the outer air direct. If possible, it should open half its size, extending nearly to the top of the room, and equal in area to at least one-tenth of the floor-space. Among other requirements in a good window, it should be so made as to permit of being cleaned by a person standing inside the room, whereby the risk and expense of cleaning from without are avoided. This involves the abandonment of the sash window, and the adoption of one so divided that one-half vertically—or, in large windows, one-third, may open inwards on hinges, the other half, or two-thirds, being fixed and wind-tight, the breadth of each division to be such that a servant's arm can reach out and clean the outer side of the fixed window when standing inside the room. The use of skylights in the place of proper windows is not permissible. In addition, every habitable room must have either a fire-place or some special ventilating aperture or air-shaft, the sectional area of which should be not less than a hundred square inches.

Every artisan dwelling should at least comprise a living-room with small scullery attached, and sufficient bedroom accommodation—say, one room for the parents and one or two for the children. The most economical arrangement for this amount of accommodation is in a two-storeyed building, the height of the lower story of which should be 9 feet, and that of the upper not less than 8 feet. The living-room ought to have a minimum floor area of 150 square feet, and be fitted with a cupboard for storing food, lighted and ventilated by a separate window. The scullery adjoining the living-room should be at least 10 feet by 7·5 feet, and if possible, a pantry, entered through the scullery, also provided. The parents' bedroom ought to have about 80 feet of floor area, and those for the children 50 feet. All the rooms should have fire-places in them. The water-closet accommodation and places for the deposit of refuse in these small houses are best placed in a shed out-of-doors. The distance at which this is placed should not be excessive, neither should groups of closets common to two or more houses be placed in yards in which children play, women hang out washing, or men and boys loiter. Such arrangements are objectionable not only on account of decency and morals, but also as tending to deter inhabitants from using these sanitary conveniences as freely as might be desired. Apart from these objections, unnecessary facilities are afforded for the spread of infectious disease present in any one dwelling to the inhabitants of the others through the medium of the privies and ashpits.

In towns, the dwellings of the poorer classes offer great difficulties in arrangement, because it is usually necessary to place them upon sites where land is expensive and limited in extent. The separate houses, as usually built in rows, should differ little from the minimum standard just given; but the modern blocks of artisan dwellings occasionally present unnecessarily objectionable features. Some of the earlier-built dwellings of this class were arranged on both sides of the main corridor, eight feet wide in each story. This corridor arrangement, besides conducing to want of privacy and independence, involves often difficulty in regard to both light and ventilation. A further defect in some of these blocks is the provision of a water-closet as an integral part of each dwelling; and too often the same is so placed as to be a source of danger to health. The corridors should be dispensed with, and each dwelling be made independent of its neighbour for air by having vertical series of dwellings only on each side of one or more staircases, the other side of the dwellings being open to the outer air. The water-closet accommodation should be improved by rendering it accessible from each dwelling from the external air by means of some sort of covered way or balcony; while by wholly detaching the blocks of buildings, confined angles and stagnant corners will be obviated.

In the better class of house, one of the most frequent errors is the position of the water-closet, which is often close to the bedrooms or even kitchens, and not in the least disassociated from them. Sometimes the water-closet opens out of a bedroom, often with no communication with the outer air, or at most, ventilated into a passage or hall. The proper situation for a water-closet is in a separate or outstanding part of the house, and where there are several water-closets these ought to be built one over the other, and quite confined to one part of the building.

Each closet ought to have at least one window of a minimum superficial area of two square feet opening direct into the outer air, also have a second opening, such as either a Tobin tube or a ventilating brick, so as to secure a circulation of the air independently of the house. The closet walls ought to be covered with glazed tiles, painted plaster, varnished paper, or at least limewashed. The floor may be of tile or cement, or if of wood, well caulked and varnished.

The details relating to the removal of both liquid and solid refuse and excreta from houses are discussed in the next chapter; similarly the theory and practice of ventilation has been discussed already in an earlier chapter; there remains therefore but the consideration of the chief points connected with the heating of the dwelling.

Heating of Rooms and Houses.—In many ways this question is closely connected with that of ventilation, and like it, is a branch of domestic economy upon which much ignorance exists. Among the poorer classes especially, this ignorance, combined with apathy and carelessness, is responsible for not only a reckless waste of coal, but also for much unnecessary discomfort. It is to be feared that the people are not alone to blame for this waste, but that builders and others are equally if not really more culpable, as they practically oblige people to live in houses with fire-places so constructed as to afford a minimum amount of heat from a maximum consumption of coal.

Heat is distributed in three ways : these are by radiation, by conduction, and by convection.

Radiation of heat is not only the most common but the most wasteful. This kind of heat is propagated in straight lines in all directions with equal intensity, the effect lessening according to the square of the distance ; thus, if the heat at one foot distance from a fire be one, then at ten feet it will be one hundred times less. The open fire-place is an example of heat communicated by radiation, and in the case of long rooms, an open fireplace is an imperfect method of warming, because the distribution of warmth and heat is not uniform, moreover, draught is likely to be felt in the neighbourhood of the fire, owing to the inrush of cold air from distant parts of the room and from ventilation apertures, etc., towards the fire-place.

Conduction is the term applied to the passage of heat from one particle to another. The best conductors of heat are the metals, then stone, next wood, and least of all wool or silk. Bodies which are good conductors rapidly give off heat to the surrounding air or to anything in contact with them; in like manner, if colder, they withdraw heat from other bodies. Porous materials, like felt, are extremely bad conductors of heat.

Convection of heat is that mode in which heat is propagated in liquids and gases, and is dependent upon that characteristic of those bodies which allows the portions of them which have been heated to expand and rise, their place being taken at once by colder parts. A sort of circulation of the water or air is set up, and the whole mass soon heated.

Disregarding any particular variations in the source of heat, that is, whether from coal, coke, wood, etc., we can say that the principal methods of warming and heating rooms or houses may be classed as either open fires, closed fires or stoves, and pipes containing either heated air, hot water, or steam.

Open Fires.—As usually constructed, open fire-places are extravagant and imperfect means of heating a given space, inasmuch as they render available only thirteen per cent. of the total heat capable of being yielded by coal or coke, and only six per cent. of that by wood, the rest being lost in the air or escaping as unconsumed carbon up the chimney. Their chief advantages are that they ensure a certain amount of ventilation and emit a cheerful light or glow.

The majority of open fire-places present the following important faults: (1) the grate is too far back under the flue, so that the greater part of the heat escapes up the chimney;

(2) the back and sides of the grate are constructed of iron, and there is a large space behind, which causes needless loss of heat by radiation ; (3) the bottom and front bars are too wide apart, so that the coal either falls out unconsumed or the combustion is needlessly rapid and therefore wasteful.

Following the principles laid down by Teale, the chief practical points to be aimed at in making open fire-places may be summarised as follows : (1) use as little iron but as much fire-brick as possible ; (2) the fire-place should be brought into the room as much as possible, so that the heat may have a chance of radiating in all directions, and not nearly all go up the chimney : (3) that the front and underneath bars should be so close together as only to admit of the smaller ash passing through ; (4) that no air ought to be allowed to pass under the fire, the space between the lower bar and the hearth being closed by a movable box for receiving the ashes. These essential points are practically all secured in the Teale fire-place (Fig. 45). That this type of fire-place is a very great improvement on the old and ordinary cast-iron grate is beyond question. Its great feature is the construction of the back. By its being made to project forward over the fire, heat, which would otherwise be lost largely up the chimney, is reflected back upon the fire as well as into the room ; and, moreover, the consumption of smoke rendered much more perfect.

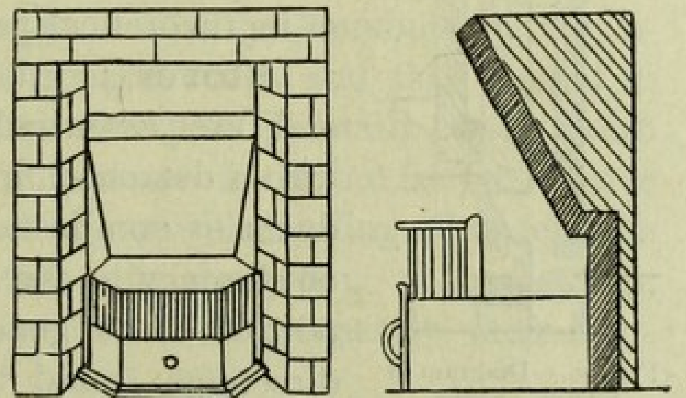

FIG. 45.—Teale's Fire-place.

There are various modifications of this class of grate, notably the Staffordshire fire-place and the Leamington grate. Both are satisfactory heat givers, and fairly economic of fuel. Their chief characteristic is the relatively great distance which separates the fire from the flue. In cases where fire-grates are constructed on the above principles, it must be borne in mind that a considerable amount of heat is accumulated on or about the hearth, consequently, special care must be taken that there are no wooden beams under the hearth or behind the fire back.

What is known as the Galton grate is shown in Fig. 46. Externally, it has the appearance of an ordinary grate; but behind the fire is an air-chamber, in which the air is heated by the iron back, upon which several broad flanges are cast, so as to obtain a large surface of metal to give off heat. Cold, fresh air passes into this air chamber by means of an inlet flue from the outside, and, after being heated, is passed into the room, near the ceiling, by the opening shown in the illustration. This grate combines, theoretically, heating and ventilation in an excellent way; but, unless well constructed, is apt, in practice, to fall short of its theoretical promises.

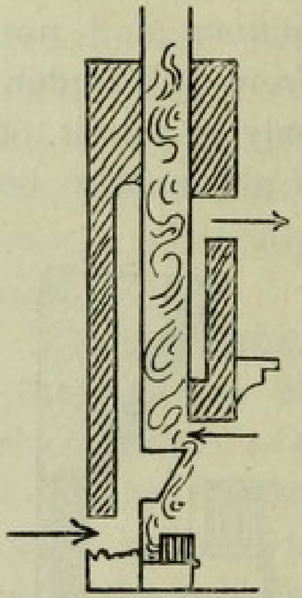

Fig. 46.—Diagram of Galton's Stove.

Stoves, as usually made, are of cast iron, and are essentially apparatus for heating with a detached fire, so placed that the products of combustion escape by an iron flue or chimney to the outer air, while the main portion of the generated heat radiates in all directions round the stove. At the lower part is usually a draught hole, by which the air necessary for combustion enters. Owing to the less waste of heat by these means of warming than by open grates, this mode of heating is more economical, but by no means so healthy as that by ordinary fire-places, because their ventilating power is less. Stoves are often objectionable, owing to their making the air hot and dry; but this can be obviated, usually, by placing vessels of water upon them. They often, too, emit a bad smell, due, generally, to the decomposition of organic matter present in the air, by contact with the heated sides of the stove and chimneys, or, occasionally, from the diffusion of carbon monoxide and other gases through the heated sides of the stove. These objections can, in great measure, be obviated by the use of wrought iron, or the stoves may be lined with fire-brick and covered with tiles.

Gas Stoves, or **Fires**, are now in very general use both for heating and cooking. Cleanliness and economy in servants' time are the chief arguments in their favour. In all cases, they should be provided with means of ventilation, by a pipe carried into a flue or direct to the outside. Speaking generally, there may be said to be four common forms of gas stove in general use; these are (1) reflector stoves, (2) condensing stoves, (3) asbestos, or refractory fuel stoves, (4) ventilating stoves.

The reflector stove has usually a naked gas flame, backed by a mirror or metal reflector. It is bright and cheerful looking, but gives out little heat; and, unless provided with a flue —which, more often than not, is wanting—adds very considerably to the vitiation of the air.

Condensing stoves are those so constructed that the water vapour, which is one of the products of gas combustion, is condensed by passing through upright tubes, and then caught in a tray beneath. This condensed vapour naturally carries down with it some, if not all, the sulphur products, but fails to remove any of the carbon dioxide which, notwithstanding all statements to the contrary, really escapes into the room. These stoves, consequently, always require a flue; unfortunately, their heating powers are small.

Stoves fitted with asbestos or refractory fuel, and lighted by Bunsen or Argand burners, are popular, owing to the fact that the fuel is rendered incandescent, with the close resemblance to the glow of an ordinary coal fire. These stoves yield radiant heat only, as a rule, though a few are made with attached hot-air chambers, to give off heated currents of air. These are, in the main, good stoves, but somewhat extravagant as gas-consumers; they always need a flue to carry off products of combustion; this usually takes off much of the heat which they produce as so much waste.

The essential defects of all the three preceding forms of gas stoves are a disproportionately low amount of heat gained as compared with the high expenditure of gas, due mainly to a failure to rob the products of combustion of their heat before they escape out of the stove in as large a degree as is consistent with ensuring their escape from it. As obviating these objections, the so-called ventilating gas stoves may be regarded as a great improvement upon the preceding types. They are so constructed that fresh air is discharged into the room after it has been heated by passing through a tube which is enclosed in a chamber in which the gas burns. The outer or gas-chamber is connected with the chimney by a pipe which carries off the foul products of combustion. Figs. 47 and 48, which show diagrammatically George's "Calorigen" and Bond's "Euthermic" stoves, illustrate the general arrangement and principle upon which stoves of this class are constructed.

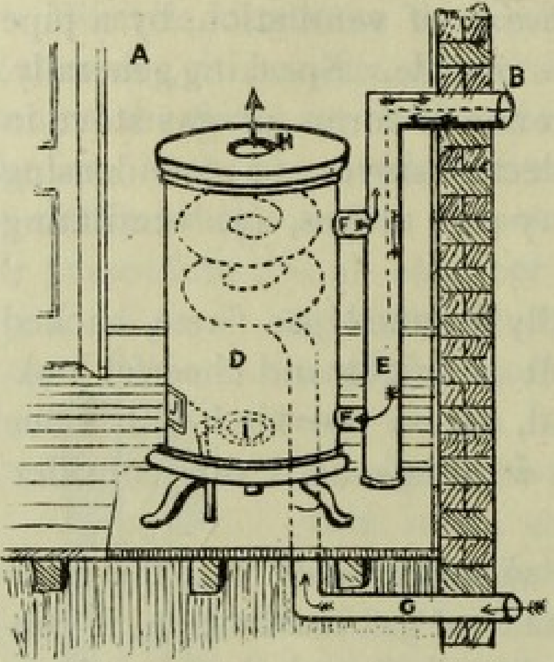

FIG. 47.—Calorigen Stove.

Hot Air, obtained by driving air over hot bricks or pipes, is occasionally introduced into rooms and public buildings for heating purposes by means of mechanical arrangements, such as fans or exhausts, as used in artificial ventilation methods.

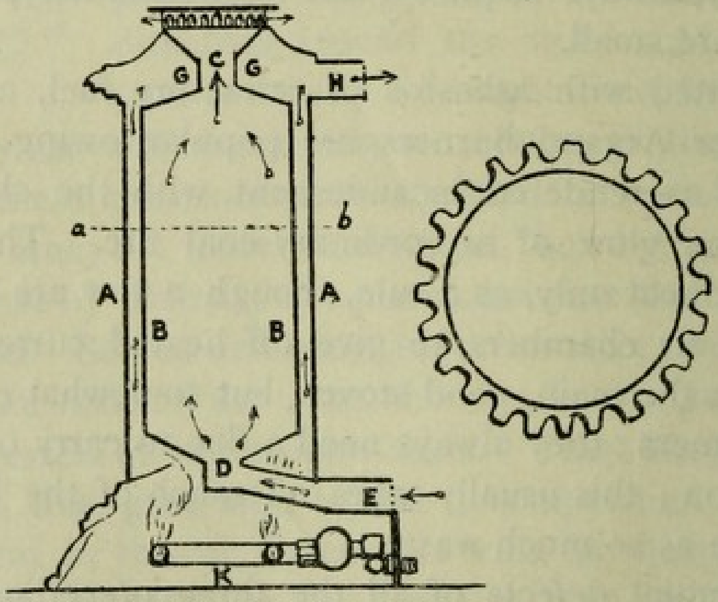

FIG. 48.—Euthermic Stove.

This is very efficient as a way of combining heating with ventilation, but is very costly.

The chief objection to the use of hot air as a general means of warming a dwelling or room lies in the fact that heated air is often unpleasantly dry, and, when so employed, should be moistened, or, if need be, purified by filtration through canvas screens moistened with water.

Steam or **Hot Water** is closely allied to hot air for heating purposes. The ease with which all parts of a building can be heated by pipes containing steam or hot water is obvious, and, as applied to the needs of hotels, hospitals, churches, etc., is practically supplanting all other methods of warming. This system, if properly applied, is an excellent one, but quite inadmissible unless both inlets and outlets are provided for ventilation.

In the present day, in this country, steam is only used for heating purposes in the case of factories, where it is necessarily on the spot as a motive power. For public buildings, water at either high or low pressure is much more convenient and cheaper. In a low-pressure water system the pipes are about four inches in diameter, and are always in a double row, to allow of the water circulating. The boiler in connection with it is commonly placed in the basement of the building, and from its upper part runs a main pipe, ending in branches which extend to the furthest end of the building; these then return underneath the others, unite into another single pipe, and then re-enter the boiler at its bottom. The circulation in the pipes is dependent upon the water, after being heated, being lighter than when cold, and as such, tending to rise to a higher level; this, having given up its heat to the various rooms, returns, cooled, by the lower pipe. The heat of the pipes is controlled by a valve which can be opened and closed at will. A feed-pipe from a supply cistern enters the return pipe near the boiler, while an escape for air is provided at the highest point of the system. In the high-pressure system, water is heated to about 300° Fahr. in a portion of the pipes which pass through the kitchen fire. This system secures a greater heat, but requires very careful management, as any failure in the circulation would at once result in an explosion. It has other objections owing to the liability to overheat the air.

Under the low-pressure system, five feet of a four-inch pipe will heat one thousand feet of air to 55° Fahr., and twelve feet will heat the same to 65°; but under the high-pressure, in which the heating power is something like two-thirds more, a proportionately less length of piping is required. The introduction of radiators, in which as large a surface of metal as possible is exposed for radiation, is gradually reducing the need of extensive coils or lengths of pipe. The radiators are hollow and in direct connection with the supply of heated water.

SUMMARY.

Every dwelling should be so constructed that it rests upon firm foundations, is dry, warm, well ventilated, well lighted, and so built or arranged that emanations from the ground on which it stands cannot enter it. These essentials can be secured only by directing care as to the manner of building the foundations, walls, roof, floors, and general arrangement of the rooms, with their attendant facilities for heating and lighting.

Heat is distributed either by radiation, by convection, or by conduction. Practically heat is provided in dwellings by open fires, by stoves, or by means of pipes containing either hot air, hot water or steam. Though, as ordinarily constructed, open fire-places are extravagant and imperfect means of heating rooms, still, if certain scientific principles be observed in their construction, they constitute perhaps the most useful and convenient mode of heating for houses and rooms in this country. The great advantage of an open fire-place is the fact that it is an important ventilating agent. Stoves, when constructed on rational lines, are eminently useful where cleanliness and economy of fuel are a desideratum. The use of hot air, hot water, or steam pipes, is only practicable in dwellings of the rich, or in buildings of a large size.

CHAPTER XXV.

REMOVAL AND DISPOSAL OF REFUSE AND EXCRETA.

In order to maintain health it is essential that all refuse matters which are liable to decay should be removed as speedily as possible from the vicinity of dwellings. Domestic refuse is of a very complex nature, and consists of excretal matter—fæces and urine, the waste and slop waters from kitchen sinks, containing much organic matter and fat, scraps of food, etc., also the ashes, dust, refuse or rubbish, which, if not disposed of, rapidly accumulate.

In towns and in many parts of the country the excretal matters, together with the slop and waste waters, are carried away by the sewers and drains by means of water. Where this is not available, pails, tubs or cesspits are resorted to, in which these effete matters are retained, and decomposing are extremely liable to create a nuisance. The dry refuse, such as ashes and cinders, is indestructible, except by burning.

On an average 4 ozs. by weight of solid and 50 ozs. by measure of liquid excreta are passed daily by an adult person. Vegetable feeders, as a rule, pass more, owing to the larger proportion of water in their food. In a mixed population the daily average amount per head may be taken at 2·5 ozs. of solid and 40 ozs. of liquid excreta. In a year, therefore, 1000 persons pass 25 tons of fæces and 91,250 gallons of urine.

Fæces are acid when first passed, and remain so for a considerable time, if unmixed with urine and dry. When fæces and urine are mixed together, decomposition of urea with the formation of ammonium carbonate rapidly takes place, and fœtid organic matters are given off.

Urea is rapidly decomposed into carbonic acid and carbonate of ammonia. The following table gives the average composition of excrementitious matter passed by a male adult daily :—

	Fresh Excrements, ounces.	Dry Substances, ounces.	Mineral Matters, ounces.
Fæces	4·17	1·041	0·116
Urine	46·01	1·735	0·527
Total. . . .	50·18	2·776	0·643

Composition of Sewage.—Sewer water varies very much in composition, being sometimes very turbid and highly impure; in other instances being less impure than water from surface wells. The Rivers Pollution Commissioners gave the following table to show the average composition of sewage from towns sewered on the water-closet system and from towns using middens :—

AVERAGE COMPOSITION OF SEWAGE, IN PARTS PER 100,000.

	Total Solids in Solution.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Total Combined Nitrogen.	Chlorine.	Suspended Matters.		
							Mineral.	Organic.	Total.
Midden towns	82·4	4·181	1·975	5·435	6·451	11·54	17·81	21·30	39·11
Water-closet towns . .	72·2	4·696	2·205	6·703	7·728	10·66	24·18	20·51	44·69

The question whether the solid excreta ought to be passed into the sewers has been the subject of much controversy; in all cases urine has been found to enter, and the inclusion or exclusion of solid matters appears to make little difference.

One ton of average London sewage contains only from 2 to 3 lbs. of solid matters.

The waste waters from houses, factories, also the rainfall, and the water used in cleansing and watering streets are, as regards their composition, almost as foul as ordinary sewage.

In some cases the sewage as measured at the outlet is greater in amount than the water supplied to the town and the rainfall together; in this case probably the subsoil water gains access to the sewers.

Removal of Excreta by Water.—This is the cleanest, the readiest, the quickest, and in many cases the least expensive method. The water supplied for domestic purposes, which has possibly been raised some height by steam or horse power, gives at once a motive force at the cheapest rate; while as channels must necessarily be made for the conveyance away of waste and dirty water which has been used for domestic purposes, they can be used, with little alteration, for excreta also. It would be a waste of economy to allow this water to pass off without applying the force which has been accumulated in it for other purposes. The success of this method depends on there being a good supply of water, properly constructed sewers with good ventilation and proper outfall; also means of disposal of the sewer water.

Water-Closets.—There is probably nothing more satisfactory in a house than a good water-closet; if placed in a well-ventilated and convenient apartment, with ample light and being constantly flushed with air, it should be devoid of smell. Too little consideration has hitherto been given to this question, and it is not uncommon to find the water-closet placed in a damp, dark and ill-ventilated apartment.

The essential feature of a good water-closet is a basin of some non-absorbent material, and of such a shape as will contain sufficient water as to allow the excreta to fall direct into the water without touching the sides.

There may be said to be four distinct types of water-closets now in general use. They are: (1) the *pan*, or *container closet;* (2) the *long hopper;* (3) the *valve*, or *plug closet;* and (4) the *short hopper*, or *wash-down closet.* The first two of these, now generally recognised as being distinctly bad forms of water-closet, are giving way gradually to less complicated and much safer types of closet. The pan, or container closet, is the

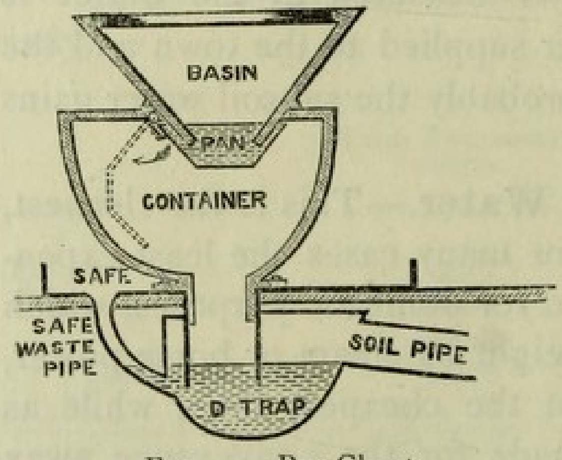

FIG. 49.—Pan Closet.

most objectionable, and is now prohibited by the Model Byelaws of the Local Government Board to be fixed in any new water-closet. Its peculiar feature is the presence of a metal container or pan, which not only rapidly fouls and wears out, but which each time the basin is emptied allows foul air to escape. Very commonly associated with this kind of closet is a D trap, a contrivance primarily intended by means of the water which remains in it to prevent the return and escape of sewer gas back into the house, but which more often becomes filthy by the retention of a large amount of offensive matter. A diagram of this closet is shown in Fig. 49.

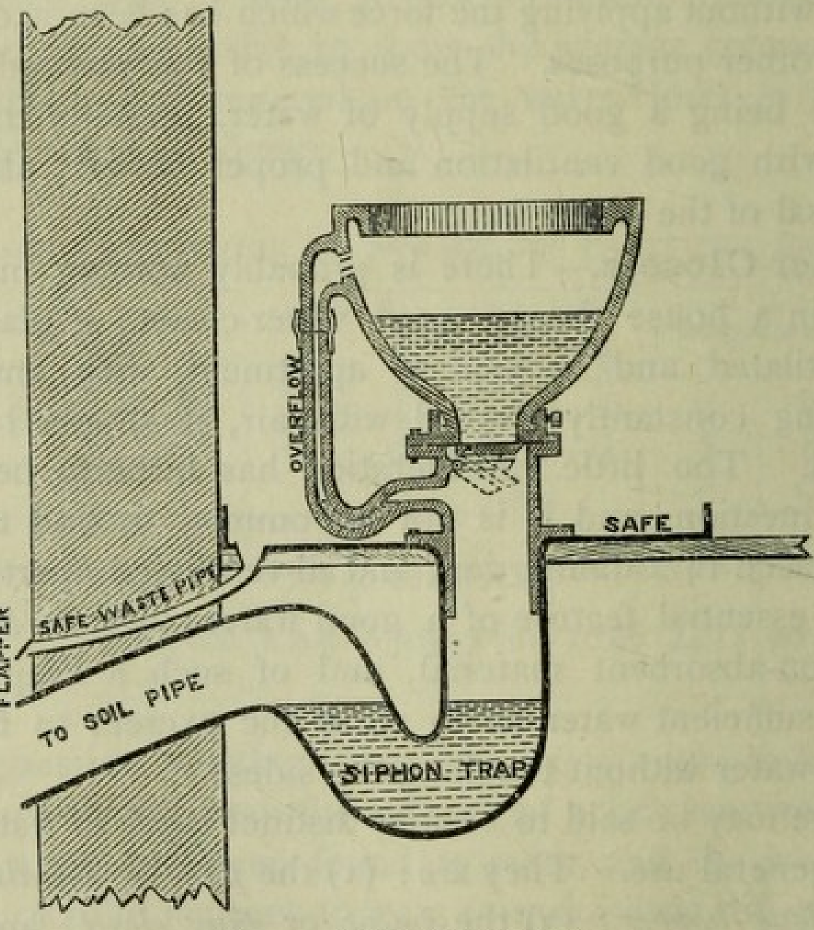

FIG. 50.—Valve Water-closet.

The long hopper is nothing more than a deep conical basin, ending in a bent tube or siphon-trap, and is decidedly objectionable, by reason of it becoming easily fouled, and being imperfectly flushed.

The valve, or plug-closet (Fig. 50) was a distinct improvement on the two preceding forms, but in recent years has been quite superseded by other and better kinds. Its chief faults were that it was complicated, its plug or valve often leaked, and failed to keep a supply of water always in the basin, while, at the same time, it was difficult to keep clean. Another defect was that, if by chance the siphon-trap became unsealed, foul air could escape into the house from the soil-pipe through the overflow pipe.

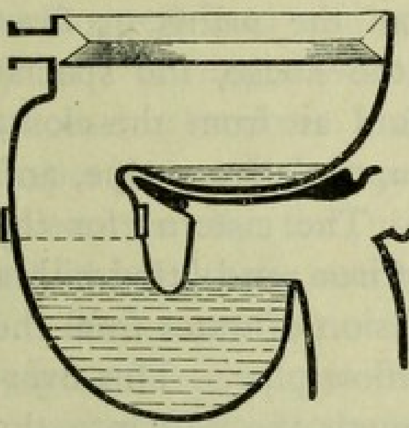

FIG. 51.—Wash-out Closet.

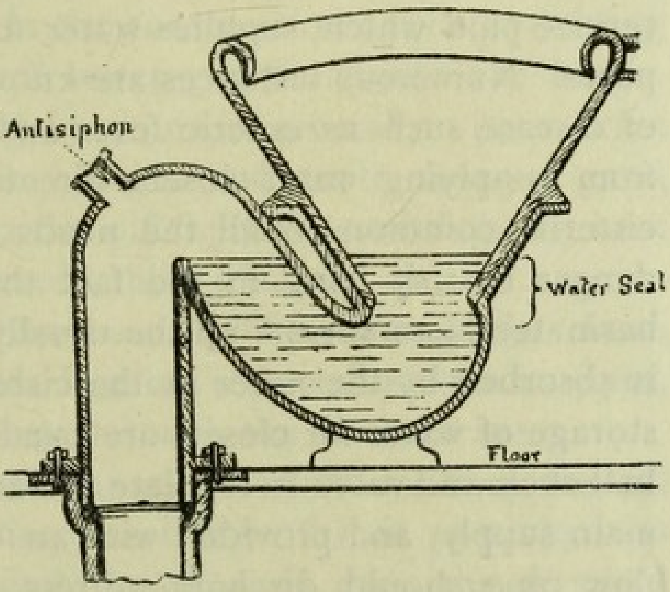

FIG. 52.—Wash-down Closet.

Of the modern forms of water-closet the two most frequently to be seen are the wash-out and the wash-down, or short-hopper closets. Both are made pedestal in shape, and of one single piece of earthenware, composing both closet and trap. In the wash-out closet (Fig. 51) a certain amount of water is kept in the basin by means of a dam or ridge, over which the excreta are carried by a flush of water. Much of the force of the water-flush is lost in dislodging the contents of the basin, and there is a liability for the contents to be swept into the trap only, and not through it. Of the short hopper, or wash-down class (Fig. 52), one of the best is the "Deluge," which, like all good closets, should be and is provided with a flushing-rim from which the water flows in such a manner and direction that the basin is kept constantly clean. These closets are generally made with the addition of a hinged seat, so as to allow of their being used as slop-closets. They have no valves or other mechanism liable to be put out of order.

The quantity of flush-water available should be at least 3 gallons, and, to avoid waste, should not exceed 3·5 gallons. It should be delivered by a 1·5 inch pipe from a height of 5 or 6 feet, to secure sufficient force for properly washing out the basin. This flushing-water for the closets should be supplied from its own separate cistern, and not from a cistern or service-pipe which supplies water for general household purposes. Numerous instances are known, showing that outbreaks of disease such as enteric fever and sore throats have resulted from supplying water-closets direct from the mains or from cisterns common to all the needs of the house, the special danger or risk lying in the fact that foul air from the closet basin tends to escape up the usually empty delivery pipe, and is absorbed by the water in the cistern. The cisterns for the storage of water for closets are usually of iron, and fitted with a ball-cock and valve to regulate the admission of water from the main supply, and provided with an overflow pipe. This overflow pipe should discharge direct through the wall into the outer air a few inches from the brickwork; it should under no circumstances be allowed to discharge into any pipe connected with closets. The advantages of the "intercepting" cistern are, that a regular supply of water each time the closets are used is secured. It should, however, be so constructed as to fill rapidly, and with such a head or pressure of water as to forcibly dislodge the contents in the basin.

In cases where water-closets are placed in the upper floors of houses, a lead tray is frequently found placed underneath the apparatus to prevent any drip or overflow from the closet, in case of leakage, from soaking into the floor and through the ceiling below. This tray is commonly called a "safe," and is provided with a waste or overflow pipe carried straight through the wall to end in the open air and in no way connected with any part of the water-closet apparatus. The placing of a "safe" beneath a closet was frequently needed, when the closets used to have the old pan and valve water-closets. With the more modern and simpler arrangements the need does not exist, while, too, the old custom of boxing in the apparatus by means of woodwork is now regarded as unnecessary and more or less uncleanly.

The contents of a water-closet should be at once conveyed in a suitable pipe called the **soil pipe,** not less than 4 inches in diameter, in as direct a manner possible through the house wall to the outside. The junction of the earthenware closet and soil pipe is usually made by a short lead pipe, and is frequently the weak point in the construction; a faulty joining will admit of the entrance of sewer gas direct into the house. The joint itself has hitherto been made generally with a brass collar, red lead and gaskin being relied on to secure a good joint. Owing, however, to the different expansibilities by heat of the substances connected, this joint is apt to become imperfect, and soon crumbles away. This difficulty has been overcome by the use of Doulton's metallo-keramic joint, which effectually unites the metal with the earthenware.

To prevent air or gas returning into the house from the soil pipe, and to completely disconnect it so far as possible, it is usual and necessary to bend the pipe, or even the terminal portion of the closet basin, in the form of an **S**, an arrangement which retains water and thereby prevents gas from passing back. The essential point about this "trap" is that the bend should be sufficiently great as to place some portion of the roof of the pipe below the water level, and the difference between the water level and the pipe-roof constitutes the *seal* of the trap; to be at all effectual a water-seal in a trap should not be less than 1·5 inches deep. Though there are various other forms of traps, as will be seen later, practically the most useful form in connection with water closets is the **S** or siphon trap. Now, like traps in other situations, those belonging to water-closets are liable to become unsealed by a great rush or volume of water passing into them and emptying them of their safety water by what is known as siphon action. This is particularly liable to take place when two or more water-closets discharge into the same soil pipe, with the result that the discharge from one sucks out water from the traps of the others. This accident is best prevented by causing the ventilating pipe from the trap of the lowest water-closet to join the ventilating pipe above, so as to form an anti-siphon vent, and the whole to be finally connected with the soil pipe above the highest closet.

Soil pipes are generally made of drawn lead or iron, coated with Angus Smith's preservative. When necessity obliges them to be placed within the house, drawn-lead pipes are the best material, as jointing can be made perfect by means of the form known as a "wiped joint;" but the rule should be that they should always be on the outside of an outer wall of the house. They should extend from a point at least three feet above the eaves, clear of all windows, to a point below the level of the ground; a few yards from the house they should be led into an intercepting trap, which disconnects them from the house drain. Inspection of the soil pipe ought to be made periodically, to see that the joints are secure, with no tendency to leak. The size should be four inches in diameter, the shape being circular.

The various conduits or pipes within a house, and which run from either sinks or closets to the drain outside the house, are conveniently called "house-pipes." These house-pipes are made of either lead, iron, zinc or composition; those made of drawn lead are the best, and should be so laid that an inspection of them can be easily made.

No pipe conveying sewage should be allowed to pass under a building, unless no other means of construction is possible, in which case it must be laid in as direct and straight line as can be obtained; and, moreover, be embedded in concrete six inches thick all round, laid at a depth below the surface at least equal to its own diameter, and, finally, ventilated at each end of the portion beneath the building. The habit of concealing pipes in inside walls and under floors is extremely risky, in case of leakage. In all cases it is best to run pipes at once, by the nearest way, through the wall to the outside of the house, when it can join the proper drain.

The majority of houses now built for the upper and middle classes contain baths and bath-rooms. No bath-room should open out of a bedroom, unless used exclusively by that bedroom's occupants. The best place for a bath-room is at the side of the house, so that its waste water can be readily carried away outside. The custom of placing a water-closet in a bathroom is bad, as it not only makes the water-closet useless to the rest of the household when the bath is occupied, but it further causes the bather to breathe foul air if any imperfection exist in the closet fittings. Like closets, bath-rooms need to be well lighted and ventilated, and their walls and floors covered with some impervious material; for these floors, ordinary oilcloth or linoleum is as good as anything.

Although the shape and material of which a sink is made are not of great moment, still the construction and destination of its waste-pipe are of importance. Formerly the plan was simply to carry all sink-pipes directly into the soil pipe. The consequence was, that foul smells and gases often came up through them, rendering houses both offensive and unhealthy.

It is now recognised that the only proper and safe plan is to take care that no pipes whatever join the drain, except the soil pipe of the water-closet and the slop-sink—where one exists. All other pipes carrying waste water ought to deliver freely into the open air, on a channel leading to a grating, which covers a trap communicating with the drain.

All sink-pipes need to be provided with a trap to collect the grease, which forms so large a part of the refuse water sent down from scullery or kitchen sinks. This may be combined with the trap leading to the drain.

Slop-Closets.—In some towns, particularly in Lancashire and Yorkshire, where a sufficient water supply is not available, or precluded by financial reasons from being utilised for flushing and washing out water-closets, advantage is taken of the house waste water to do the necessary cleansing. Closets from which the contents are removed by the slops or refuse liquids of the household, instead of by clean water supplied for the purpose, are called "slop-closets." Of these there are two kinds, namely, those in which the waste is allowed to run directly into the basin or is poured down by hand, and those in which, with a view to give a better flush, the waste liquid is held up or collected in a suitable contrivance, and then discharged from time to time in a sudden forcible stream. These latter are distinguished by the name of "automatic flush closets." Of the former variety perhaps the best type is that known as Fowler's closet, largely in use in Newcastle, Salford, and Hanley. The general arrangement of these closets is shown in Fig. 53.

The objection to these closets is that the force or stream of water is often insufficient to keep them clean; also that the closet basin is apt to get fouled at the back and sides by the excrement falling against it, besides which, improper substances are readily thrown down it and block the pipes. To get these closets to work well, a fall of at least five feet to the sewer is necessary.

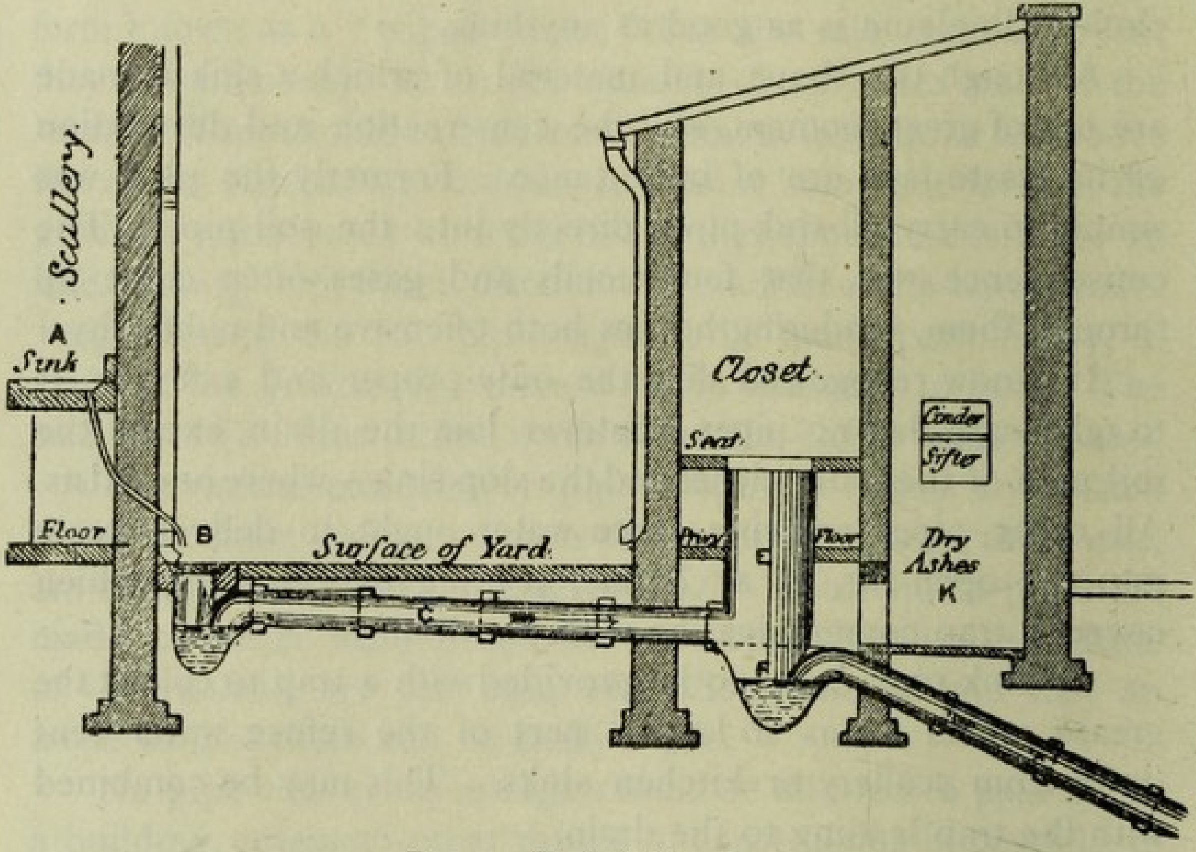

FIG. 53.—Fowler's Slop-closet.

Another form of slop-closet is that of Hill, in use in Birmingham, in which either a siphon cistern or tipper is used to collect the slop water, and then discharge it in a sudden flush (Fig. 54). Experience indicates that the tipper is preferable to the siphon tank, as the latter will not act owing to clogging with greasy water. A number of closets can be placed on one drain, a single trap serving for the whole, this being placed at the bottom of the man-hole for convenience of access.

An improvement and development of these closets are the various kinds of automatic slop-closet, in which the slow and uncertain trickle of the slop waters from the sinks is replaced by a sudden gush of the slop water after storage in either a siphon, cistern, or a tipper. The tipper is merely a metal vessel, so shaped and balanced on pivots that, when full, the weight of the contained liquid overbalances it and causes its contents to be suddenly poured down the pipe. As already stated, siphon cisterns are unsuited for the storage of dirty or greasy water; so that practically the tipper is the best contrivance for this purpose.

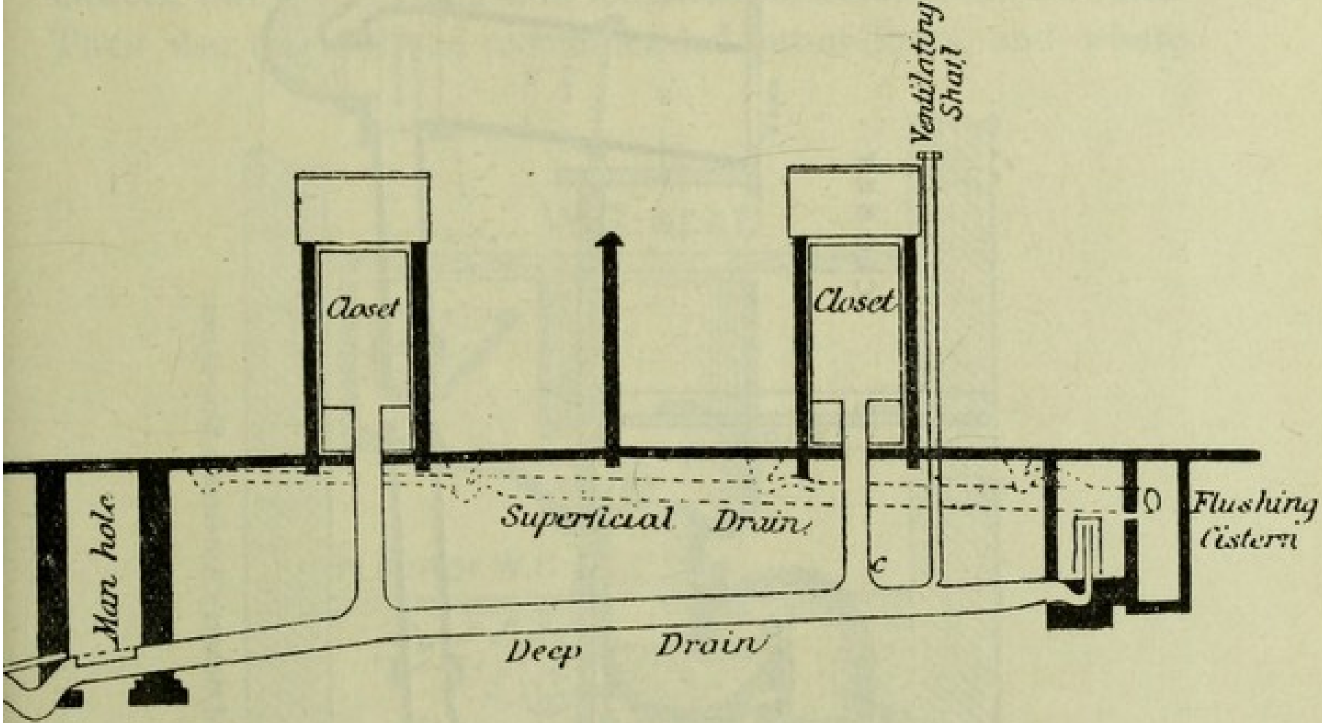

FIG. 54.—Hill's Automatic Slop-closets.

There are several varieties of these automatic slop-closets; in some the tipper is placed close to the sink discharge pipe (top flushing), in others the tipper is placed well away from the slop stone, and more or less in a piece with the lowest section of the closet shaft (bottom flushing). The best forms of these closets appear to be Duckett's of Burnley.

The device as to these closets is mainly a question of suitability to any particular place. The tippers, to be effectual, must contain at least three gallons of water for single closets,

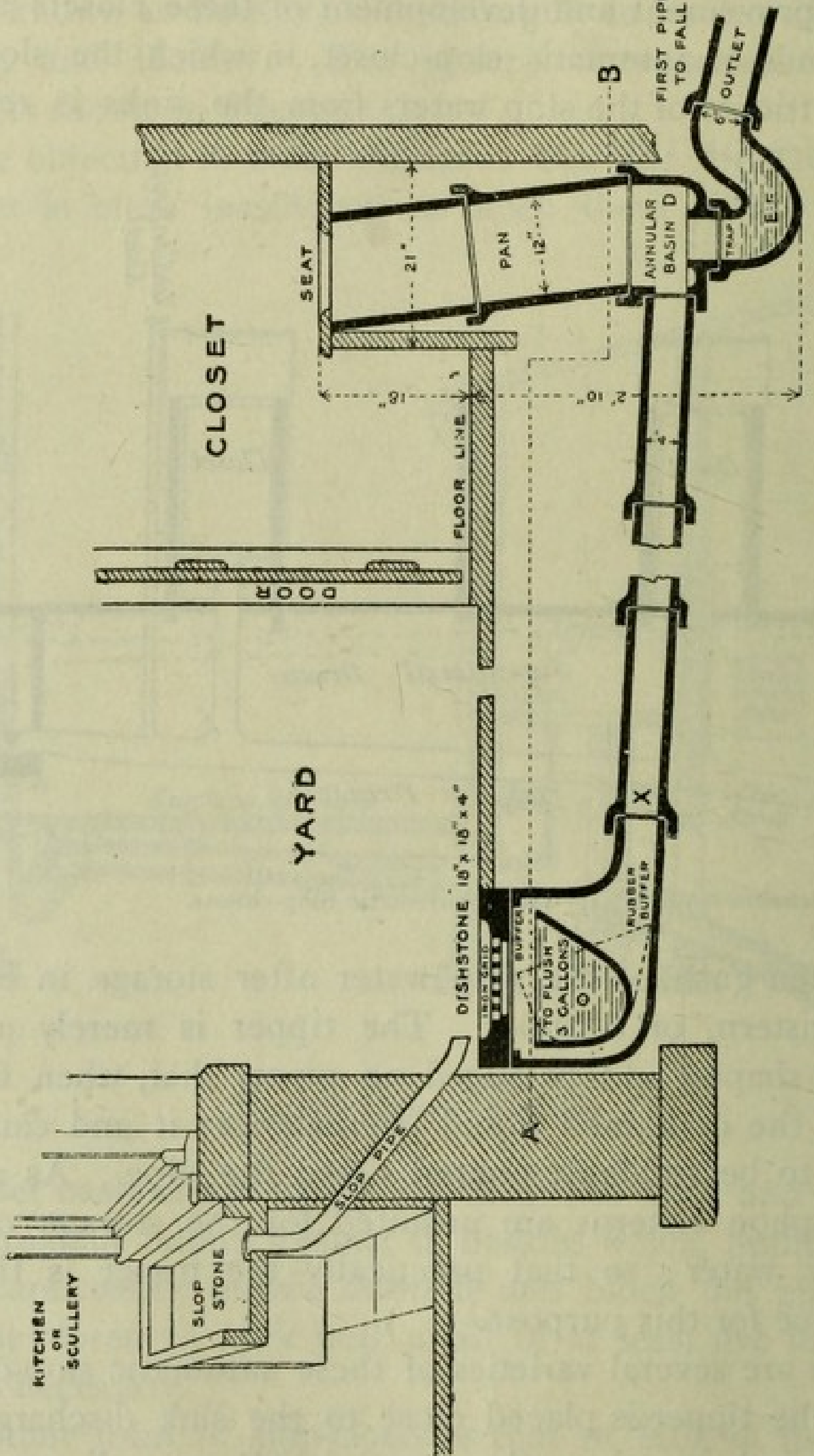

FIG. 55.—Duckett's Automatic Slop-closet.

and five gallons if flushing two or more closets in a row. Some kinds, such as Whalley's, do not have a self-acting tipper, but one discharged by pulling up a handle. Others have the tipper situated at the side or back of the closet basin (Fig. 56).

The various automatic slop-closets appear to be advantageous in that their original cost is small, they consume less water, produce less sewage, and are less liable to frost or to get out of order than the ordinary water-closets; against them are the facts that they are unsightly, less cleanly than water-closets, owing to fouling and lodgment of excreta on the sides. Their use can only be recommended out-of-doors, and where the sewers have a good fall and a public service of water is laid on to each house. Each house should have a separate closet. Subject to these conditions, these slop-closets may be of great use and value in towns and suburbs, especially when it is desirable to economise the water.

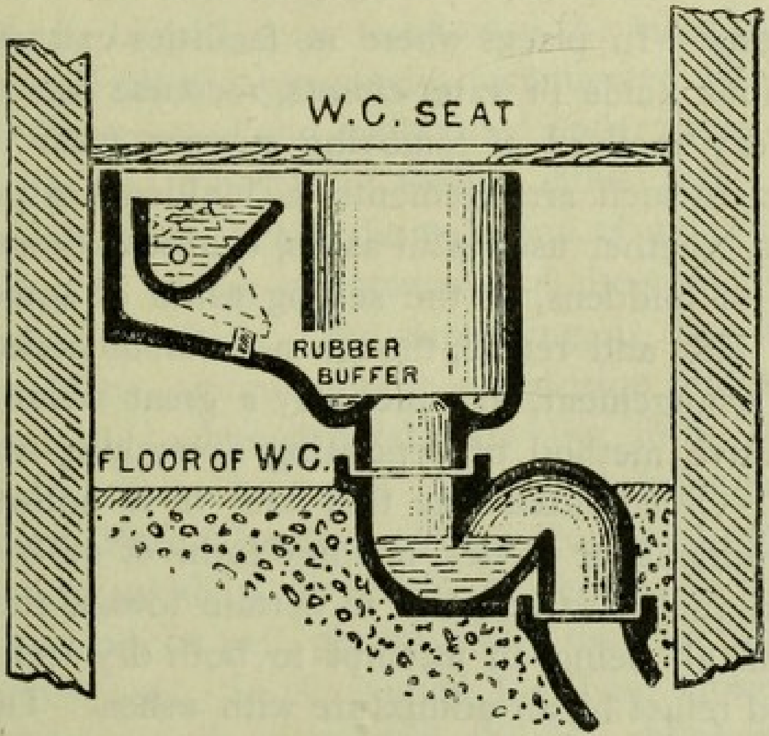

FIG. 56.—Duckett's Blackburn Closet.

Trough Closets are those in which a long metal trough filled with water passes beneath the seats of a number of closets side by side, and receives the excreta from them. From time to time these troughs are flushed out by the discharge of a volume of water, either by an attendant or automatically, by a siphon-cistern or tilting receiver, and the contents carried away to the sewer through a trap at the end of the trough.

These closets are adapted for schools, factories, and groups of artisans' houses, being little liable to get damaged by rough usage or to get out of order; the only desideratum being a good large drain well jointed with cement and plenty of water. Their drawbacks are original cost, the large quantity of water used, and the alarming noise and splashing which results if the flushing happens to take place when the seat is in use. Trough closets, whether automatic or otherwise, can only be used where good drains exist and a supply of water is laid on.

Middens.—In places where no facilities exist for the use of the various kinds of water-closets, recourse has to be had to some dry method of removing excreta from the house. This embraces such arrangements as middens, or privies, and pail closets, whether used with ashes, charcoal or earth. The institution of middens, or the setting aside of some spot for depositing filth and refuse, though a most objectionable and insanitary arrangement, was probably a great advance on the more primitive method of depositing everything anyhow and anywhere. Objectionable as they are, it is unfortunately a fact that middens, or privies, in some form or other exist still, not only in rural districts, but in certain towns, the essential principle in all being an attempt to both dry and deodorise excreta and refuse by an admixture with ashes. The original midden, if not a heap of decomposing filth, was at best but a hole dug in the ground more or less full of rotting matter, and giving rise to most offensive gases and liquids, which only too readily polluted the soil around houses and the wells near them. In the present day, in towns where middens do remain their existence is subject to certain definite rules and conditions. These are briefly as follows: (1) the midden, or privy, must be at least six feet away from any dwelling, and fifty feet away from any well, spring, or stream; (2) ready means of access must be provided for the scavenger, so that the contents need not be carried through a dwelling; (3) the privy must be roofed to keep out the rain, and be provided with a ventilating apparatus as near the roof as possible; (4) that part of the floor which is under the seat must not be less than six inches above the level of the adjoining ground, and, moreover, be flagged or paved with hard tiles having an inclination towards the door of the privy of one-half inch to the foot, so that liquids spilled upon it may run down outside and not find their way into the receptacle under the seat; (5) the size or capacity of this receptacle may not exceed eight cubic feet, by which limitation a weekly removal of its contents is necessitated; (6) the sides and floor of this receptacle must be of some impermeable material, the floor being at least three inches above the adjoining ground level; (7) the seat of the privy should be hinged, so as to allow of the ashes to be readily thrown in; and (8) the receptacle unconnected with any drain or sewer. Constructed and maintained under these conditions, it is probable that the risks of fouling either soils or wells are reduced considerably; while the pollution of air is safeguarded to a large degree by the maintenance of the contents in a dry and inodorous condition. But depending, as does the success of these middens, upon sanitary supervision and scavenging, it is universally acknowledged that any form of them is inadvisable, no matter how well constructed and supervised.

Tub and Pail Closets.—These are really nothing more than miniature middens, in which the receptacle is a movable one, such as a tub or pail, placed under the seat for the reception of the excreta. It is claimed for these closets that the filth removal is much easier and the air pollution less than when midden contents are removed. The pails, whether of wood or galvanised iron, should have close-fitting lids and be both air and watertight. The structure of the closet in which the pails are used should be similar to that proposed for middens. The pail or tub should be removed at least once a week and a clean one substituted for it. To avoid smells, it is most important that the contents of the pail (urine or fæces) should be kept as dry as possible. This can only be effected by adding to the contents some dry and absorbent material such as ashes, charcoal, earth, or even lining the pail with some absorbent substance such as sawdust or peat. If the mixed urine and fæces be left to themselves in the pails, they rapidly undergo decomposition, and in this case may have a higher commercial value as manure than if mixed with ashes, charcoal or earth. The presence of the urine tends to increase decomposition, but its separation is not only practically difficult, but an actual loss of fertilising material if intended for manure.

In Manchester only the fine ashes, after sifting, are allowed to fall into the pails; while in Halifax, what is called the Goux system is in use, the pail being lined with a layer of peat or a mixture of tan, sawdust and soot, substances which render the contents drier and less offensive. Sifted cinders and ashes also form very efficient deodorisers and desiccators—and being always available are more readily usable than either charcoal or earth. Both these latter substances are also used in pail-closets. In Stanford's closet the charcoal used is prepared from seaweed, about half a pound being used each time. Neither ashes nor charcoal have the same beneficial and disintegrating action on the excreta that dry earth has. For this reason, earth-closets have had in one place and another a very extensive trial, about one and a half pound of clean dry earth is thrown upon the pail contents, either automatically from a hopper or by hand every time the closet is used. The best kinds of earth for the purpose are loamy surface soil, vegetable mould, dry clay or brick earth. Chalk, gravel and sand are not suitable. Care has to be taken that the earth stored is sifted and dry, and that each particular stool is covered at once with the earth, and no slop water added to the pail contents. It is not safe to allow pail, earth or ash-closets to be placed inside houses, as when so situated they are frequently made receptacles for slop waters and then become an intolerable nuisance. Even under the most careful supervision they at times give off odours: they should be placed outside the dwellings where they are likely to be least productive of nuisance. If a pail-closet has to be used, from a sanitary point of view, the earth closet is the best form, as, if properly managed, the closet is free from smell and the process of removing the contents not offensive. In addition to this the earth is readily obtainable, and not without value as an application to both fields and gardens.

Ashpits and Dustbins.—These receptacles are intended to contain the solid refuse of the house until such times as it can be taken away. Inasmuch as these substances can only be removed at intervals, it is important that they be so stored as to remain free from offence while still on the premises. Nothing except ashes, soot and inorganic *débris* should be consigned to the ashpit. The articles most likely to become offensive are organic matters, particularly kitchen refuse, such as bones, fat and waste food. As far as possible these matters should be invariably burnt in the kitchen fire, and what cannot be disposed of in that way, should be placed in a galvanised iron receptacle with a lid and taken away daily. Formerly the receptacles for ashes and house refuse were dustbins, constructed of brickwork, leaning upon a yard wall or against the side of a house, with a wooden cover and a door at the side or front for the removal of the contents. This faulty arrangement rendered the contents of the dustbin extremely liable to become wet from rain, resulting in steady decomposition of the organic refuse with the production of much offensive gas and smell. So glaring were the defects of this system, that it has become largely replaced by the provision to each house of galvanised pails placed in an outhouse and regularly emptied at short intervals: the advantages of this plan are, the small capacity of the pail, the non-absorbent character of the material of which it is made and the ease with which it is kept covered. It can be removed with its contents to be emptied at a distance, and afterwards can be thoroughly cleansed. In towns ashpits are subject to certain definite rules and conditions, which are briefly as follows:—(1) The ashpit must be at least six feet from the dwelling-house; (2) ready means of access for removing the contents must be provided, so that these need not be carried through the dwelling; (3) its capacity shall not exceed six cubic feet, or of such less capacity as may be necessary to contain all the dust, etc., during a period not exceeding one week; (4) it must be constructed of impervious material, and if of brick, this must be nine inches thick and hardened inside with good cement and asphalted; the floor shall be raised at least three inches above the surface of the adjoining ground and flagged or asphalted; it must be roofed over and ventilated, and furnished with a suitable door, so constructed as to admit of the convenient removal of the contents, and to admit of being securely closed and fastened to prevent the escape of any refuse; (5) there must be no connection of an ashpit with any drain.

The ultimate disposal of the contents of any dustbin or ashpit should certainly be destruction by fire: cremation is the only safe means, and the practice of mixing it with or utilising it as manure should be abandoned; this method has led to outbreaks of diphtheria and sore throat among village populations in the vicinity of London where this mode of refuse disposal is frequently resorted to.

Traps and Gullies.—The object of traps is to act as a barrier so as to completely cut off the atmosphere of the house drain and sewer from the interior of the house. A good trap should completely disconnect the air in one pipe from that in another; this is secured by means of a water-seal, which should not be less than to allow the water to stand an inch above the openings.

The trap itself should be of such a form as to allow of its being completely washed out with every flush of water passed through it.

Traps are almost of infinite variety, but they may be conveniently divided into (1) the *siphon*, (2) the *mid-feather*, (3) the *flap trap*, (4) the *ball trap*.

The simplest form of **siphon trap** for use in the course of a drain is an ordinary pipe with a bend in it, but this is faulty for several reasons: it has no base attached to it, and it is difficult to fix it level, the dip is not sufficient, and there is no provision for the ventilation of the drain, or of access to admit of the trap or the drain beyond the trap being cleaned out in case of stoppage. The best form of siphon trap is shown in Fig. 57. This trap has a deeper seal and the drain inlet is well above the outlet, thus affording a better flush. The

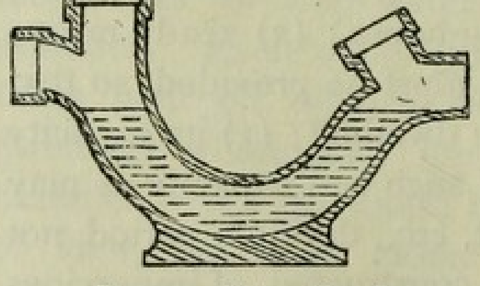

Fig. 57.—Siphon Bend.

trap should stand on a flat bottom, which makes it easy to lay. The opening at the top may be carried up by means of pipes to the surface of the ground, and, if covered by a grating, acts as an air inlet, while the opening beyond the seal may be used for cleaning the drain between the trap and the sewer. It is always advisable to trap the soil pipe at its juncture with the drain, and, if possible, there should be an air-disconnecting trap at this point, so that its union with the drain may be broken both by water and air. Buchan's disconnecting and ventilating trap (Fig. 58), or the form of manhole, designed by Rogers Field, secures this action. These traps secure the upward current of air through the soil pipe; and if the trap of the closet should fail, the air drawn into the house would be practically free from sewer gas. The siphon trap, or, as it is sometimes called, the **S** trap (Fig. 59), is the only kind of trap admissible inside a house for waste pipes. To allow of cleansing and removing stoppages an access screw plug should be fixed at the bottom of the lower bend.

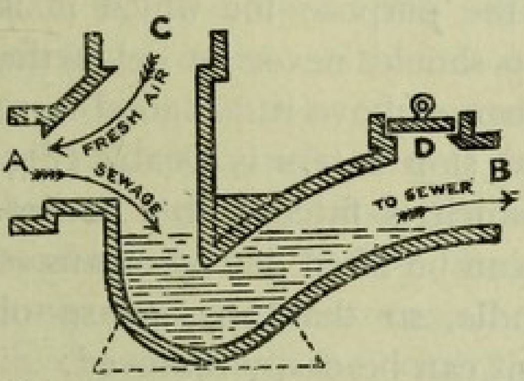

FIG. 58.—Buchan's Disconnecting and Ventilating Drain Trap.

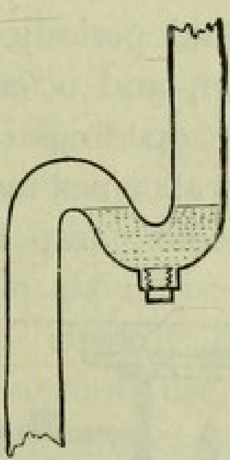

FIG. 59.—Siphon Sink Trap with movable screw for cleaning.

The **bell trap**, which is a modification of the mid-feather trap, was until very recently fixed over sink outlet pipes in houses: it is one of the worst forms of trap; the bell portion is removable, and when taken off, the water-seal is done away with (Fig. 60) and direct connection with the drain established.

Gully Traps are used for disconnecting the various waste pipes of the house and rain-water pipes from the drain. Whenever any connection is made with the drain apart from the soil pipe, one or other form of gully trap is used. Fig. 61 shows the ordinary form of gully trap as is used in yard drainage and frequently also for drain pipes: it is essential that it should periodically be cleaned out. It is simple in its construction, and is efficient for the purpose for which it is used. The openings into the trap should never be below the grating, but all pipes made to discharge above it. A good form of disconnecting trap for sink and slop waters is Dean's (Fig. 62), which is fitted with a bucket. This can be lifted out by means of a handle, so that any grease or deposit can be easily removed.

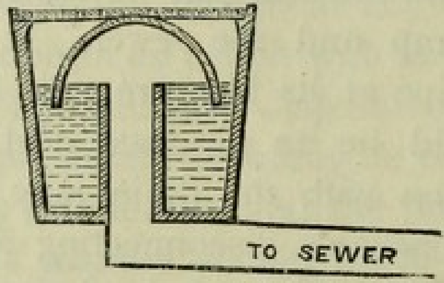

FIG. 60.—Bell Trap.

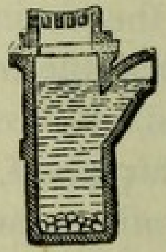

FIG. 61.—Gully Trap.

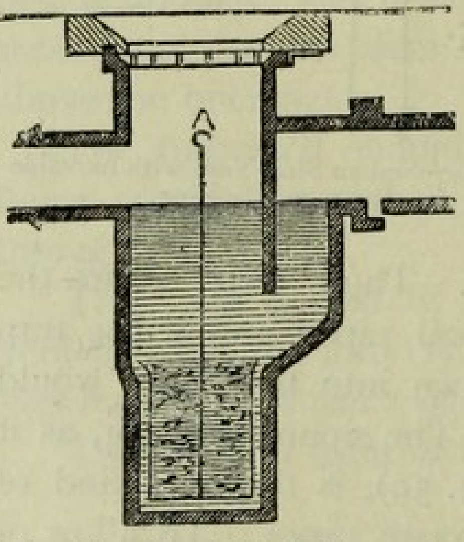

FIG. 62.—Dean's Gully Trap. A, Handle of movable bucket.

The bye-laws of the Local Government Board require that "the waste-pipe from any bath, sink (not being a slop-sink constructed or adapted to be used for receiving any solid or liquid filth) or lavatory, the overflow pipe from any cistern or from any safe under any bath or water-closet, and every pipe in such building for carrying off waste water, to be taken through an external wall and to discharge in the open air over a channel leading to a trapped gully at least eighteen inches distant."

The **Mid-feather Trap** is in principle a siphon; it is merely a round or square box, with the entry at one side, at the top, and the discharge pipe at a corresponding height on the opposite side, and between them a partition reaching below the lower margin of both pipes. It is a bad form of trap, as it favours the collection of deposit and is not self-cleansing; it is liable to leak under the cover, and to allow foul gas to escape.

The **Flap Trap** is used to prevent the reflux of water into the secondary drains. It is merely a hinged valve, which allows water to pass in one direction, but which is so hung as to close afterwards by its own weight, and is supposed to prevent the passage of sewer gas. It is a very imperfect safeguard.

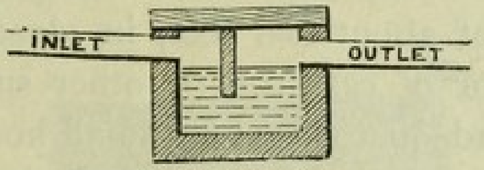

FIG. 63.—Mid-feather Trap.

The **Ball Trap** is used in some special cases only. A ball is lifted up as the water rises until it impinges on and closes an orifice. It is not a desirable kind of trap.

The essentials of a good trap are, that the water stand at least an inch above the openings, that the trap itself be self-cleansing, and that every portion should be effectually washed out by every flush. A trap is only efficient so long as it contains water. If not in constant use, especially in dry weather, the water evaporates and direct communication is established with the drain. In dry weather frequent flushing is therefore necessary.

Drains and Sewers.—*Drain* means any drain of, and used for the ordinary drainage of *one* building only, or premises within the same curtilage, and made merely for communicating therefrom with a cesspool or like receptacle for drainage or with a sewer.

Sewers include sewers and drains of every description except drains to which the word "drain," as above defined, applies. In other words, a sewer is a drain receiving the drainage of two or more buildings, and may be an open channel, such as a polluted watercourse, as well as an underground culvert.

The function of a drain is to carry away, as rapidly as possible, to the sewer or cesspit the waste products that are capable of being removed by the agency of water. In order to do this it must be made of such a form as will cause the least resistance to the free passage of its contents, and be constructed of materials that will permit of no leakage of surface waters into the drain or of sewage into the ground; the joints between the different sections must be also made impervious, so that the whole drain is both air and water-tight throughout its entire length, except at those exits which are provided for ventilation.

The usual form of drain is a circular pipe made in lengths of about two feet, in glazed earthenware, semi-vitrified ware, or of cast-iron or other suitable material. They must be of adequate size; for small houses four or five inches in diameter; for larger houses six-inch pipes will be necessary; and for hospitals and other large institutions nine-inch pipes. They should be well glazed internally, and quite smooth.

Laying of Drains.—They should be laid carefully on concrete on all sides, and if the ground on which the pipe has to be laid is not solid, it is advisable to lay a foundation of concrete of sufficient thickness; also to support the pipes in their length, and not at the sockets only.

Each length of an earthenware pipe is provided at one end with a socket into which the spigot of the next pipe fits. This space between the spigot and the socket is generally filled in with cement to make the joint water-tight, but care must be taken that this does not penetrate to the inside of the pipe and afterwards obstruct the flow of sewage. Stanford's joint is composed of one part of boiled tar, one part of clean sand, and one and a half parts of sulphur. It forms an excellent cement. Clay luting should never be permitted, as it is washed out of the joints in a short time. To avoid deposition of sediment, drains should be laid in as straight lines as possible and with a regular fall. Junctions should be made oblique, so that the sewage may enter the drain in the direction of the flow. The junction of drains is effected by a special form of pipe, which may be either single or double. (Fig. 64.)

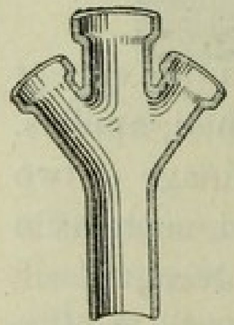

FIG. 64.—Junction Pipe.

The square junctions are undesirable, as blockage will always occur; oblique junctions should be insisted upon.

Fall of Drains.—The amount of the fall or inclination given to a drain must depend on the circumstances of the case, but it may be taken as a general rule, that a house drain should have a fall of 1 in 50. A convenient rule is to multiply the diameter of the drain in inches by 10; thus a 4-inch drain should have a fall of 1 in 40; a 6-inch drain 1 in 60. The fall should be such that the scouring of the drains can be effectually accomplished without the use of special flushing; on the other hand, the inclination must not be too great, or the liquid portion flows away too rapidly, leaving the solid matters behind. When the current is feeble and where deposits are liable to occur, automatic flushing-tanks may be placed at the upper end of the drain. Field's automatic flush is well adapted for this purpose; it acts by siphonage, and by regulating the flow of water, it may be made to empty itself as often as necessary.

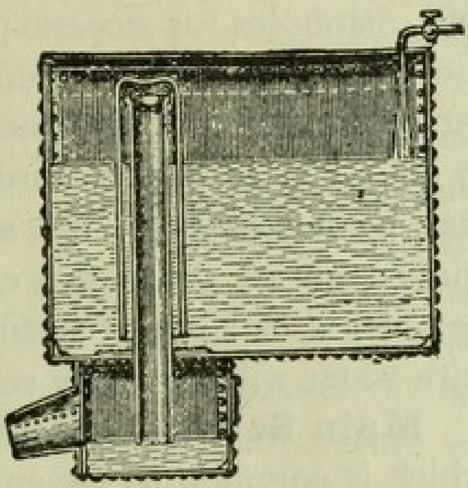

FIG. 65.—Field's Flush Tank.

To Examine and Test Drains.—Pour water down the pipe and notice whether there is any smell indicating want of ventilation in the pipe. The simplest method, perhaps, is to pour down the pipe, at its highest part, one ounce of oil of peppermint with a few gallons of hot water; as this is a very volatile oil, there is no difficulty in tracing the place whence the odour is emitted and so detecting the leak. This is all that can be done inside the house, but the pipe may be inspected from the outside, and, if necessary, the drain opened up; in that case, pour water mixed with lime down the house-pipe; if the whitened water is long in appearing and then runs in a dribble merely, the drain wants flushing; if it is much discoloured it indicates a foul state of the drain. It may be desirable to test whether the drain is water-tight. If the lower end of the drain is plugged and the pipe then filled with water, any leak will be observed by the sinking of the water in the top of the pipe; this test is a severe one, and few old pipes will bear the pressure. Or the drain may be filled with smoke by exploding a smoke-rocket at the manhole or opening, when any leak will be detected by the passage of the smoke through faulty connections, traps or joints. The smoke test, although convenient for testing traps and fittings above ground, is of no value in testing underground pipes. A drain below the surface of the ground may be leaking at every point, and yet appears perfectly sound on the application of the smoke test. If stoppage of the drain occurs, and manholes or access pipes are provided, the spot where the obstruction takes place can be easily localised; but if no such arrangement exist, the drain or pipe will have to be broken in one or more places, until the point of stoppage is found. It may be necessary to use a drain-cleansing machine—a sort of wire brush set on to the end of a bamboo rod, which, being flexible, is capable of getting round the bends. Brisk flushing with water will generally remove any obstruction.

Main Sewers.—House drains end in a channel or sewer, which is common to several drains, and is of larger size. These sewers, up to eighteen inches in diameter, are generally made of well-glazed earthenware pipes; for larger sewers well burnt impervious brick is used, moulded in proper shape, and set in Portland cement or concrete. The shape now almost universally given to sewers, except in the largest outfall part, is that of an egg with the small end downwards, so that the invert is the narrowest part (Fig. 66).

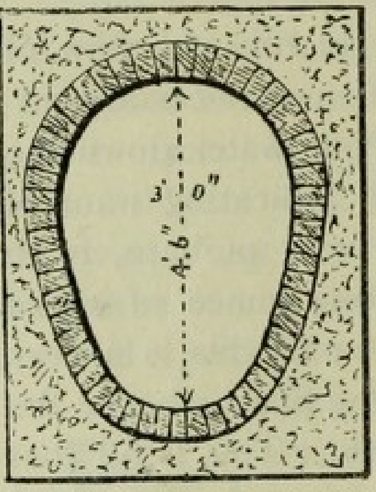

Fig. 66.—Oval Sewer.

The object of this is to secure the maximum scouring effect with a small quantity of water. When the quantity of sewage is small, the lesser diameter of the invert of the egg-shaped sewer affords a better scouring power than the larger diameter of an equivalent circular sewer, while the increased flow of the former conduit affords the requisite space for an increasing outflow.

Sewers should be laid in as straight lines as possible, with a regular fall—from 1 in 244 to 1 in 784, according to size; tributary sewers should not enter at right angles, but obliquely, and if the sewer curves, the radius of the curve should not be less than ten times the cross sectional diameter of the sewer.

Sewers of unequal sectional diameter should not join with level inverts, but the lesser or tributary sewer should have a fall into the main sewer at least equal to the difference in the sectional diameter. If a manhole is used for a junction, the bottom can always be constructed so as to give the required curve in the direction of the flow of the current.

Ventilation of Sewers.—Sewers cannot be constructed air tight, on account of the very numerous openings into them. The tension of the air is generally not very different from that of the atmosphere outside, while the movement of the air is usually in the direction of the flow of the current. Certain conditions, however, are present which produce movement of the air in sewers, the chief being the differences in temperature in the sewer and in the external air, barometric pressure, the passage of hot water and steam from houses and manufactories, causing a rise of temperature in the sewage and consequent expansion of the air in the sewer; the blowing off of steam, which increases the temperature and pressure suddenly; and the sudden increase of water flowing into the sewers.

Any of these conditions may expel air from the sewer or draw air in from the external atmosphere. Tidal water in sewers is not liable to affect the air in them to any extent, as the rise of the tide, with its accompanying increase of pressure, is gradual.

The simplest plan for ventilating sewers is by means of a shaft from the crown of the sewer to the surface of the street or road above, preferably in the middle of the roadway, where it is covered by an iron grid. The mud and gravel which may fall through the grid is caught in a tray placed beneath the grating, which catches the mud, but allows the free passage of air around it. One such opening should be placed at every hundred yards.

A sewer which stinks at its open gratings is giving evidence of its unsuccess, and for this reason it has been suggested that street gullies should never be trapped. To trap gullies, in any such case, would greatly increase the danger of sewer gas being sucked into houses. The remedy lies rather in providing better ventilation and preventing deposits by intrinsic flushing at due intervals. It has also been proposed to use the columns of street lamps to carry away the sewer air, and to convey the escaping gases through a flame which is kept constantly burning in the lower part of the column. This plan may relieve any pressure of sewer air in the sewer.

Shafts in connection with factory chimneys have also been tried, but have not proved satisfactory; they only influence a very short section of the sewer, as air rushes in from the nearest openings. In all sewers some of the openings will act as inlets, others as outlets; but, if properly ventilated and no deposits take place, the sewer air will be so diluted as to render it inoffensive, if not innocuous. Our aim should always be to have such free communications between the internal and external air that there never can be sufficient pressure to force the traps of houses.

Manholes must be provided for the purpose of inspection of sewers; they should be fitted with iron steps, and with a groove for a sluice if required.

When sewers are properly laid they should be self-cleansing. It will, however, sometimes be necessary to provide special arrangements for flushing and cleansing, as the volume of sewage may be at times so small, compared with the size, or the gradiant so slight, that the velocity will be so reduced as to cause deposit. Automatic flush tanks, placed at the head of sewers, are most useful for this purpose. Flushing is effected better by water than by backing up the sewage and then suddenly releasing it.

SUMMARY.

In a mixed population, the daily average amount of excreta passed per head may be taken to be 2·5 ozs. of solid and 40 ozs. of liquid excreta. One ton of average sewage contains about 3 lbs. of solid matter.

Where an abundant water supply exists, the removal of excreta by water is the best plan. All water closets should be placed in a well-ventilated and convenient apartment. Their contents should be at once conveyed direct through the house wall to the outside, by a suitable soil-pipe, not less than 4 inches in diameter. There should be a trap disconnection between the basin of the water-closet and the soil-pipe; this latter should be ventilated. All supplies of water to a water-closet should be distinct from and independent of the supply of water for ordinary domestic purposes. No pipe conveying sewage should be allowed to pass under a building, unless no other means of construction is possible.

Where no facilities exist for the use of water-closets, recourse must be had to some dry method of removing excreta from the house. Probably the best dry method is that of earth-closets; dry earth being an excellent deodoriser.

Ash-pits and dust-bins, intended for the storage of the solid refuse of a house until such times as it can be taken away, should be erected some little distance from the dwelling, and so constructed that their contents may be kept dry. The contents of all ash-pits should be removed at least once a week.

All drains should be disconnected from the house by means of traps, the water seal of which should not be of less depth than one inch. All drains should be laid upon a solid bed, and with sufficient fall to ensure an adequate flowing away of their contents towards the sewer. If necessary, automatic flush-tanks should be arranged to flush them. Drains and sewers should be laid in as straight lines as possible. Every sewer should be adequately ventilated, and so laid that no accumulations can collect to give rise to smells and gaseous emanations.

CHAPTER XXVI.

DISPOSAL OF SEWAGE.

Storage in Tanks—Cess-pits.—This system must be regarded only as temporary and partial; it provides for the immediate removal from the house of the excreta and foul waters, but only to a short distance, when it is received into a cesspit, which has to be emptied from time to time. Cesspits are generally constructed of brick; and in the majority of cases the solid matters only are retained, the liquids passing into the surrounding soil, and infiltrating it for some distance around. The cesspit should always be constructed of good brickwork and lined with cement, so as to render the bottom and sides impervious; but in this case an overflow pipe must always be provided. The cesspit, or dead well, is really the only method available in a country place. It should be placed at least fifty feet distant from any dwelling, and a hundred feet from well, spring or stream. It should be properly covered over, provided with adequate means of ventilation, and emptied at regular intervals.

Complete disconnection, by proper traps, from the house drains and efficient ventilation are necessary to make this a sanitary method.

Discharge into Rivers, etc.—This is now prohibited by the Rivers Pollution Acts of 1876 and 1890. It is illegal to pollute any stream or river by allowing crude sewage to flow into it.

Discharge into the Sea.—When sewers discharge into the sea, the outlet should always be under water; care must be taken to carry the sewage well out to sea, so that it may not return with the tide and be deposited on the foreshore. Tidal currents should be taken advantage of to prevent this. There should be a tide-flap opening outwards, to prevent ingress of tide and wind blowing up the sewer. The tide will block sewage at certain times; this, in the case of low-lying towns, necessitates a "tank sewer," to store the sewage that flows down during this period; but with this method decomposition and evolution of gas and ammonia compounds are very liable to take place; it needs attention to prevent its becoming a nuisance.

Purification of Sewage.—This presents great difficulties. At the present moment the ultimate disposal of sewage is the sanitary problem of the day, and it is impossible to be certain which of the many plans may be finally adopted. The methods generally employed are—(1) precipitation; (2) electrical methods; (3) intermittent downward filtration; (4) irrigation; (5) the septic tank system.

Precipitation.—This process consists in collecting the sewage in tanks, thus allowing a large volume to remain comparatively quiescent, so that the solid particles may subside. In order to produce greater purification, the sewage in the subsiding tanks is mixed with some chemical agent or precipitant. The solids formed in settling take down with them the suspended matters of the sewage, together with some of the dissolved organic impurities. Lime is one of the principal substances used for precipitating; the quantity varies from three to twenty-five grains for each gallon of sewage. If the sewage is made alkaline by the addition of too much lime it undergoes putrefaction rapidly; it has been attempted to prevent this by adding chloride of iron to the quicklime, by which means putrefaction is delayed but not prevented.

Another process is the A.B.C. process (Sellar's patent), in which alumina salts clarify the sewage, but do not deodorise it, while clay and charcoal deodorise it but do not clarify. In many towns where this process has been tried it has not succeeded. The ferrozone and polarite processes of the International Sewage Company is used at Acton and Hendon. Ferrozone consists of proto-sulphate of iron. The larger part of the impurities is removed partly by subsidence and partly by the ferrous sulphate in the ferrozone.

All these chemical processes do, to a certain extent, purify sewage, chiefly by removal of the suspended matters; but they leave a large amount of putrescible matter in the effluent, certainly all the ammonia (sometimes adding to it); the greater part of the phosphoric acid is precipitated by some of them, while they increase the hardness of river water.

Disposal of Sludge.—This is always a great difficulty. Efforts have been made, in connection with the chemical processes, to utilise the sludge as manure, but they have more or less failed, as the product is inferior, owing to the ammonia being lost in the effluent. Another method of disposal is to burn the sludge in a "destructor," the mass being reduced to clinker. Scott proposed to make cement from sludge by adding to it lime and clay; the process has not succeeded. In London the sludge is pumped into a specially designed steamship and discharged into the sea far from land. The composition of pressed sewage sludge at Crossness is stated by Dibden to be—water 58 per cent., organic matter 17 per cent., mineral matters 25 per cent.

Disposal of the Effluent Water.—The effluent water from all these processes is merely clarified sewage; it contains ammonia, together with some soluble organic matter, and it would appear that nearly the whole of the fertilising compounds remain in the effluent. If passed into a fairly rapid river, where the ordinary volume of water is much greater than the effluent, it is not likely to cause a nuisance. The clear fluid is well adapted for market gardens.

The Electrical Processes.—Webster proposed to purify sewage by electrolysis. The chemical change that takes place in sewage when it is electrolysed is that the water as well as the chlorides of sodium and magnesium are split up by the electric current into their constituent parts, chlorine and oxygen being set free at the positive pole and uniting to form hypochlorous acid. This being intensely active and liberated in a nascent state oxidises the organic matter in the sewage into innocuous compounds. The effluent produced by this process is subsequently filtered through beds of sand and coke, and passed on to land, if this is convenient, as it has a certain manurial value. The sludge is dug into waste land or shipped out to sea.

The Hermite process has been tested at Havre, Worthing, and other places. This system is based upon the electrolysis of sea water; the resulting liquid is a disinfectant, containing a hypochlorite which is almost odourless and inoffensive. It is claimed for this process that the solid matter in sewage is at once consumed in this solution as well as all organic matter. Experiments, however, show that although a remarkable reduction in the number of living micro-organisms has been effected in the sewage, nothing like sterilisation takes place, since a considerable number of bacteria survive the process. The fluid has also a destructive action on metal pipes and fittings.

Intermittent Downward Filtration is defined by the Metropolitan Sewage Commission as "the concentration of sewage at short intervals on an area of specially chosen porous ground, as small as will absorb and cleanse it, not excluding vegetation, but making the product of secondary importance."

The process of purification by filtration is essentially one of oxidation; hence continued aeration of the filter is necessary. This is best secured by the downward passage of the sewage. As regards the soil itself, the physical characters—that is, its porosity and fineness of division—have more to do with its cleansing power than its chemical composition. The best soil seems to be a loose marl containing hydrated iron oxide and alumina.

The conditions necessary for the successful filtration of sewage are: (1) a porous soil; (2) an effluent drain not less than six feet from the surface: (3) proper fall of land to allow the sewage to spread over the whole land; and (4) division of the filtering area into four parts, each part to receive the sewage for six hours, and to have an interval of eighteen hours.

The quantity of land required is about one acre to purify the sewage of one thousand persons. The larger solid bodies should be removed by straining before allowing the sewage to flow on to the land.

When the amount of available land is limited, the sewage should be first treated by one of the precipitation processes already described; but this will deprive it of much of its manurial value.

This process produces an excellent effluent, if the details are carefully carried out, and the effluent is quite fit to be discharged into any river or stream. The solids form a fine cake on the surface, and can readily be broken up and mixed with the soil. Generally, all crops grow well on these sewage farms; but Italian rye grass and green vegetables do best.

Irrigation is defined as "the distribution of sewage over a large surface of ordinary agricultural ground, having in view a maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied."

It is essential that the sewage should not merely run over but through the soil before passing out as an effluent.

The quantity of land required is large—about one acre to every hundred persons.

To ensure success, the area must be sufficient, the land well drained, and, when necessary, broken up and mixed with ashes, lime, etc., the sewage to be passed on at intervals so as to permit of aeration of the soil. A succession of growing crops is needed, the ground being laid out in hills and furrows, while the sewage should reach the ground in as fresh a state as possible. If the land is suitable and the process well conducted, this method for the purification of liquid refuse is excellent.

Simple mechanical straining is sometimes necessary in order to arrest the most offensive matter which, with the street sweepings, can be sold or destroyed in an incinerator.

The Septic Tank System.—This method, which has recently been devised by Mr. Cameron, may be considered as yet in the experimental stage. It is based on the principle that organic changes in sewage are brought about mainly by bacterial action, and aims at fostering and assisting the process by placing the sewage under the most favourable conditions to undergo disintegration and oxidation by means of micro-organic life. The sewage is led into a close-fitting and dark tank, light and air being excluded as far as possible. Changes take place in this tank by the bacteria which are present in the raw sewage, whose growth is favoured by darkness, the absence of air and the comparative absence of movement.

Much of the solid matter is rendered soluble and dissolved. The sewage, after remaining twenty-four hours in this tank, is drawn by a pipe from the septic tank, without disturbing the surface, in a thin stream over an "aerator" or trough, over the edge of which it flows, finely divided, into a receptacle communicating with the filters. During this process it takes up oxygen from the air.

The filter beds consist of (1) clinkers and (2) coke breeze, in which nitrifying organisms attack and complete the work done in the septic tank. The result is a remarkably clear, odourless and inoffensive liquid, which, it is stated, can be discharged into a river or stream without danger.

This system is now being experimented on at Exeter; but although it promises well, no opinion on its utility or suitability to large sewage works can yet be given. It has not as yet passed out of the experimental stage of inquiry.

Comparison of the Different Methods.—Considering all the conditions involved, it appears impossible for all places to adopt the same plan, and the local circumstances of each place must be taken into account in determining the best method for the removal of and disposal of excreta. The principle to be aimed at is the complete and immediate removal of all kinds of refuse from the vicinity of habitations in the most expeditious manner.

There can be no doubt about the main principle of sewage disposal, that animal waste products should be as quickly as possible submitted to the disintegrating action of growing plants, and thus converted from dangerous impurities into wholesome food. The difficulty lies in its application.

The dry methods do not answer this requirement, as the excreta is only removed at intervals, and although deodorisation may be complete, disinfection is not attempted. For a large population, therefore, some system of water-carriage is necessary.

Having, therefore, sewage to deal with, we must get rid of it in the least objectionable manner. It must not be sent into rivers; therefore, when land is available, immediate application to the land either by intermittent downward filtration or irrigation is indicated.

By intermittent downward filtration sewage can be purified, so that the effluent water may be permitted to run into any stream or river, the water of which is not required for drinking purposes. Little, however, of the manurial value is saved; the greater part passes away in the effluent. Irrigation, on the other hand, accomplishes all that is done by filtration with the further advantage that the whole of the manurial constituents are returned to the soil, which is fertilised by them.

Disposal of House and Town Refuse.—The simplest method in the case of isolated houses in the country is to burn the contents of dustbins and ashpits, which consists of dry refuse, paper and combustible material, and subsequently to bury it in trenches in the ground. Animal refuse may also be dealt with in this way, and, if covered with ashes, combustion proceeds slowly, without any offensive odours being given off. The usual plan for the disposal of dry refuse and street sweepings in towns is by some kind of "destructor." The refuse is discharged into a furnace, which destroys all combustible material, leaving as a residuum a mass of hard material, called "clinkers," which may subsequently be used for road making, or ground down and mixed with lime to form cement.

In Fryer's destructor the street sweepings and refuse containing organic matter are received into a "carbonizer" which converts these matters into a kind of charcoal, which has some deodorising properties; the "concretor" is used for excretal matters, the residue from which has a certain manurial value, being concentrated by drying. Special means are adopted to prevent noxious vapours and fine particles of dust from being given off during the processes. By these methods not only is the disposal of refuse, but their actual destruction, provided for in a perfectly safe and inoffensive way.

SUMMARY.

Crude sewage may be discharged into a cesspit or dead well, from which it must be subsequently removed and buried in land, or it may be discharged direct into the sea. No crude sewage may be allowed to flow into a river or stream. Crude sewage may be purified by treatment with chemicals, whereby its solids are precipitated, and the resulting liquid effluent, after filtration, passed either into a flowing river or upon land. Other methods proposed are by electrolysis and by bacterial action; in both cases the resulting effluents need to be filtered before being discharged into a stream.

Apart from purification, sewage may be disposed of by passage direct upon the soil, either on the principle of intermittent downward filtration or of irrigation.

House and town dry refuse should be burnt.

CHAPTER XXVII.

PERSONAL HYGIENE.

The general principles of hygiene and sanitary legislation may do much to give us healthy homes to live in, pure air to breathe, pure water to drink, and good or sufficient food to eat, but even these will not suffice to keep us in health unless attention be paid equally to matters which relate essentially to the individual. These matters include the influence of temperament and inherited qualities, the practice of personal cleanliness and wholesome habits, the judicious combination of exercise with rest and clothing.

Temperament and Heredity.—The older physicians were in the habit of dividing healthy people into groups or classes according to their so-called temperaments, and we still speak of persons having a sanguine, a nervous, or lymphatic temperament. Persons of a *sanguine* temperament are robust, strong, and usually possessed of great animal spirits. Such people are typically healthy, rarely become diseased, and, when they do, usually soon get well. In those with a *nervous* temperament, the nervous system has too marked a predominance over the rest of the body. Such people are peculiarly liable to develop nervous diseases, are excitable and unreliable. As a class they may be looked upon as individuals with a marked tendency to brain disease or insanity. Children of a nervous temperament need judicious restraint and supervision both at work and at play, and require frequent changes of occupation and study. The *lymphatic* temperament is accompanied by an undue predominance of the lymphatic or absorbent system, and is characterised by a listlessness and inactivity which form a strong contrast to those of the nervous temperament. The lymphatic temperament is a condition of strong predisposition to scrofula and consumption. Children of this type need to be stimulated and encouraged to work, and even to play; moreover, it is especially important that they get good food, fresh air, good clothing, and not live in damp unwholesome houses.

The development of these types or temperaments is mainly the result of inherited qualities. We all know how like his father or mother a child often is, and how external resemblances descend in families. In the same way do resemblances occur in the construction and physiological working of internal organs, with the result that tendencies toward certain kinds of disease are frequently hereditary. The tendency or predisposition to nervous diseases, such as many forms of insanity and epilepsy, is undoubtedly hereditary, so too is consumption, though often persons get consumption who do not belong to a consumptive family, but contract it either from those already affected, or get it from being placed in conditions suitable for its development, especially living in bad air and damp houses. Gout and cancer are other examples of hereditary tendencies.

It is clearly necessary that persons who have an hereditary tendency to a particular form of disease should be placed as far as possible in conditions unfavourable for the development of that disease, in order to overcome the inherited taint or defect. Thus, those of consumptive families should avoid living in close or impure atmospheres, but rather have an abundance of fresh air and exercise, and be encouraged to eat fats, and avoid damp, overcrowded or badly drained districts; those with an inclination to gout should be very moderate both in eating and drinking; children belonging to families with histories of insanity or epilepsy need more exercise of the body than the brain, especially in their earlier years; if there is a history of intemperance in the parents, the only safe and logical training for the children is one of total abstinence from alcohol. In connection with this question, we must remember, too, that the tendency to an hereditary disease is much increased if this disease is common to both father and mother; consequently a person belonging to a family in which a definite disease taint exists should not marry into a family similarly affected. This is at all times a difficult question, and too often ignored when the idea of marriage arises, but unless attention is directed to the matter, we shall go on perpetuating families born with disease tendencies. The remedy for these evils rests with the younger generations, and it is only by the intelligent action of every man and woman that we can hope for the inherited tendency to disease to be stamped out, and a tendency to long life be made hereditary.

Habits.—Our personal habits may be either important aids to the promotion of health and prolongation of life, or they may be powerful predisposing causes of disease. The question of food has already been discussed, but it is of the greatest importance that all young people be trained to chew their food carefully and eat slowly, as the habit of eating quickly or hastily inevitably ends in indigestion; the excessive use of condiments and spices is also a habit to be discouraged. The evils of intemperate habits and excess in alcoholic drinks have been detailed in a previous chapter as incalculable; besides rendering man's capabilities for work less, alcohol deadens the activity of the mind, interferes with the oxidation of waste matters in the blood, and so alters the character and nature of his internal organs, particularly the liver and kidneys, that disease and death therefrom are the certain results in middle or later life for those who habitually take alcohol in any excess.

Smoking, too, is another doubtful habit, and one for which there is not the slightest reason or excuse under twenty-one years of age. Even among adults, it is more than doubtful whether the use of tobacco is defensible. Smoking, to some extent, interferes with appetite and impairs the bodily activity; if indulged in, smoking should be kept within very moderate limits.

The regular removal of waste substances from the body is most necessary for the preservation of health; since the organs by which waste matters are removed from the body, are the lungs, the skin, the kidneys and intestines, it is important that all should early acquire habits suitable for keeping them in proper action. The chief agents in regulating the action of the first three are cleanliness and exercise; with regard to the last the formation of a regular habit early in life is essential. Neglect in this important particular leads to constipation, indigestion, hæmorrhoids or piles, and occasionally to inflammation of the bowels. Every young person should be taught to secure a free evacuation of the bowels at least once every day, and no better habit can be encouraged to secure this than that of visiting the water-closet at a certain hour every day. Aperients should be avoided as much as possible; efficient substitutes for them can usually be found by regular exercise, daily washing of the body, the use of brown bread, oatmeal, vegetables, and fruit.

Another good and important habit is the cleansing of the teeth. This should be done at least twice a day with water in which a little salt has been dissolved, or even with Castille soap; the routine use of tooth powders is unsound. After meals, particularly when meat has been eaten, the mouth should be rinsed out with water, and, if possible, the teeth lightly brushed. The teeth should not be used for biting or cracking hard substances such as nuts. Apart from their value as an aid to good looks, sound and healthy teeth are the first aid to a good digestion and its attendant advantages. When the teeth show any signs of decay they should be immediately stopped or plugged by a dentist; the routine examination by a dentist of the teeth of the young, once a year, should be as much a domestic routine as the cutting of the hair once a month or oftener.

Cleanliness.—The structure of the skin and the importance of its functions have already been pointed out. If the skin is not kept thoroughly clean, the dead scales from its epidermis, which ought to be removed, collect upon the surface, and, with dirt, block up and check the proper action of the many glands contained in it. If the skin does not do its work properly, more has to be done by the lungs and kidneys, and these, if over-worked, are liable themselves to get diseased. The only reliable stimulant and tonic for the skin, is the free use of water;

but to remove dirt and grease, and for purposes of real cleanliness, bathing or washing without the use of soap and friction is useless.

Soap is either a potassium or sodium salt of one of the fatty acids, produced by the action of potash or soda upon the fats. As the result of this action of these alkalis upon the fatty acids, not only is an alkaline salt of the fatty acid formed, that is a soap, but also glycerine is set free. Potash soaps are very deliquescent, retaining so much water as to form often a soft jelly; of this kind is *soft soap*. Soda soap retains little water, and readily hardens when exposed to the air, constituting *hard soap*. Ordinary soft soap is largely made from whale or seal oil; ordinary hard soaps are commonly made from tallow. *Yellow soap* is made by a mixture of resin with tallow and palm oil, or with a grease stock consisting of kitchen and bone fat. It is very firm, somewhat rough, and often translucent. *Toilet soaps* are commonly made from lard, beef-marrow, or sweet almond oil, and after repeated refinings, finally scented with some perfume and coloured by special pigments. *Glycerine soap* is merely ordinary soap, to which glycerine has been added. *Silicated soaps* are ordinary soaps mixed with solutions o glass or silicate of soda. Soap is soluble in water, especially hot water, and the solution is always alkaline. When a person washes with soap, this alkaline solution, particularly if a warm solution, acts upon the grease which is on the surface of the skin, by saponifying and emulsifying it, with the result that it is easily removed by the water.

To keep the body sweet and clean, it should be frequently, if not daily, washed; to wash the hands and face only is not enough. This frequent washing of the whole body is not readily managed, except in the larger kind of houses; but even in the smallest homes this ought to be possible, and actually carried out, once a week. For actual cleansing purposes, warm water is better than cold. The warm bath has usually a temperature of 100° F., and should be taken the last thing at night, because it renders the skin very susceptible to changes of temperature, and the chances of taking cold are much less if one goes at once to bed than if one moves about the house or in the open. After washing, all traces of soap should be carefully removed with plenty of clean water, and the body rapidly dried with a rough towel. The hands, face, and neck should be washed twice daily at the very least, and when the employment is dirty the hands should be invariably well washed before taking food, otherwise dirty or poisonous particles from them may gain access to the food. Children should always be washed in warm water, and care taken to see that the water is not too hot before any part of the child is plunged into it. As they advance in years, children should be encouraged to use cold water, but the change should be very gradual, and allowances made for the season of the year.

The use of cold water is an excellent tonic and stimulant for all persons except the very feeble. The cold bath should only be taken by persons in robust health; it is best taken early in the day, immediately after getting up, and should be of short duration, the body being rapidly dried by rubbing with a rough towel. The average temperature of the cold bath should be about 60° F. The cold bath is usually followed by a sense of warmth and well-being, due to the increased activity of, and removal of waste products by, the internal organs, consequent on the contraction of the superficial or cutaneous blood-vessels. If in place of the feeling of warmth after a bath there is a chilly feeling or blueness of the fingers and toes, it indicates that the bath has been either too prolonged, or has been taken by an unsuitable subject.

Bathing in the open sea should never be performed either fasting or immediately after taking a full meal, or when greatly exhausted by fatigue. The best time for such a bath is either early in the morning after a cup of tea or coffee and a biscuit, or an hour or so after breakfast. Persons advanced in years, and those in whom the circulation is weak, should neither attempt outdoor bathing, nor indulge in very cold baths at home; in them the resisting and rallying powers are often low, and reaction correspondingly difficult to secure.

Exercise and Rest.—A perfect state of health implies that every organ of the body has its proper share of exercise, and if this be either in excess or insufficient, the body suffers. As usually understood, the term exercise means the use of the voluntary muscles. The effects of proper exercise, particularly walking, running, gymnastics, etc., are an increased removal of carbon dioxide and water by the lungs, and an increased absorption of oxygen through them by the blood. The heart is made to beat more strongly, and the blood to flow through the arteries and veins vigorously; the skin acts more freely, perspiration is established, and by the numberless pores in the skin, waste and foul matter removed from the body. The muscles themselves become harder and firmer; the nervous system gets exhilarated, while the digestion and appetite are both increased. In addition to all these effects, the body is warmed, and the action of both the kidneys and bowels in removing waste substances helped. If exercise is taken to excess, all these beneficial results do not follow, but, on the contrary, the body rapidly thins and deteriorates.

As to the amount of exercise necessary, experience is perhaps the best guide; but at all times the quantity of work and exercise performed by the body must and should be in proportion to the force-producing value of each individual's diet. Very few of us lead absolutely idle lives, without any exercise; but many of us do not take proper exercise, owing to the nature of our occupations. In some cases the chief work is performed by the brain, and little by the muscles; in other cases, those who exercise the muscles do not exercise the brain; while, in many other instances, when muscular work is done, only certain groups of muscles are really exercised. Although but few of us can so alter our employments or occupations as to secure an ideal scheme of exercise for all parts of our bodies, still, the greater number can so arrange their affairs that during spare time those parts of our brains and bodies which are not worked during business hours may receive exercise in recreation hours. Thus the office man or brain-worker should take regular exercise out-of-doors, either by walking, bicycling, football, cricket, or lawn tennis. These forms of physical exercise need to be intelligently followed in a regular manner, not performed spasmodically and irregularly, otherwise, owing to lack of training, the muscles will soon get tired and fail. In a similar way, the individual engaged during working hours in purely physical or muscular work should, in his spare time, devote himself to mental studies, such as reading, music, etc., in order to exercise faculties as different as possible from those chiefly employed in the usual occupation. These remarks as to the need of regular and varied exercise are as applicable to women and children as to men; in fact, possibly more so, as upon the well-being of women and children really depends the future of the race.

Although regular and varied exercise is essential for the maintenance of a high standard of health, it must not be overlooked that regular rest is equally necessary, in order that the fatigued muscular and nervous systems may be repaired and renewed. This rest can only be absolutely obtained by sleep. It is practically impossible to lay down a general rule as to the amount of sleep necessary, as this depends on a variety of conditions—particularly age, temperament, and occupation; but, speaking generally, an infant needs sixteen hours' sleep a day, a child of five years twelve hours, of twelve years ten hours, of sixteen years nine hours; a healthy adult needs eight hours' sound sleep; in old age this may be increased to ten or twelve hours.

Night is the natural time for sleep. The sleeping-room should be quiet and dark, warm and well ventilated. If possible, all persons should sleep upon beds and bedsteads; to sleep upon the floor and ground is unhealthy, as it interferes with the free circulation of air under and around the sleeper, and, moreover, favours the inhalation from the floors and ground of dust and gases, which are best avoided if possible. The bed should be a hair mattress rather than a feather bed, the pillows should be made of feathers, the sheets of cotton, and the other coverings light, but warm.

Sleep should not be sought either immediately after a meal nor after much mental labour. For those with weak circulations, or persons who suffer from cold feet when in bed, sleep is much encouraged by either a hot foot-bath at bedtime, or a hot bottle in the bed, or by wearing bed-socks. Infants and young children should not sleep with their parents or other adults: if so allowed the risks of suffocation from "overlaying" are very great; they should invariably sleep in separate beds, or in improvised cots, which can be readily constructed out of ordinary clothes'-baskets or packing-cases. The use of bed-curtains and other hangings around beds and in bedrooms should be discouraged, as they not only impede ventilation, but harbour dirt and dust.

Clothing is required to protect the body from cold, heat, wind or rain, to maintain its warmth, protect it from injury, and also to adorn it. The chief materials used for clothing are derived from animals and vegetables. From the animal world we get wool, fur, leather, feathers and silk; while from vegetable life we draw cotton, flax, jute, hemp, coir, indiarubber and gutta-percha.

Warmth and coolness, or the power of maintaining the body heat at its normal height, being the most important property of all dress materials, it follows that our choice of clothing will depend largely upon this feature. If the object of clothing is to keep in the heat of the body—that is, keep it warm—we must employ something which is a bad conductor of heat and also one which at the same time will readily absorb perspiration into its texture without feeling wet, as the body is largely cooled by the evaporation of the sweat. Fur, perhaps, is the best non-conductor of heat, hence makes the best clothing material in cold countries; it is, however, very expensive. Next to fur comes wool, then silk, cotton and linen; the two latter, being good conductors of heat, rapidly take heat away from the body, hence always feel cold. In the same order these same materials best absorb perspiration into their texture. Fur and wool are particularly endowed with this property; linen and cotton readily take up moisture, but at the same time become quite wet, and as evaporation at once proceeds, a rapid cooling of the body follows. This explains the reason why flannel is the best material to wear during times of great exertion, or when the body is streaming with moisture. Under similar conditions linen or cotton clothing would be at once wet through, and evaporation resulting, a chill would probably follow.

The heat-conducting property of a material is further proportionate to the closeness with which it is woven—that is, as to how little or how much air it contains. Since air is a bad conductor of heat, it follows that any dress material which contains much air in its interstices—that is, a loosely woven stuff—is warmer than a closely woven material, or one which contains little air. On this account, all soft, furry fabrics, no matter whether of wool or cotton, always feel warmer than the closely woven, smooth-surfaced silks and linens. In the same way several layers of clothing, which naturally have several layers of air, are warmer than a very thick but single layer of clothing; similarly, loosely fitting clothes are warmer than those which fit closely.

The influence of colour is dependent upon the heat-absorbing powers of that colour. White absorbs heat the least, and is consequently the coolest; then comes yellow, red, green, blue, and black. It is obvious that this effect of colour can only be of influence when outside, and that the popular idea that red flannel, when worn next the skin or as part of an under-garment, is warmer than white is imaginary. It is a mistake to wear coloured clothing next to the skin, as not unfrequently the dyes are poisonous, and, coming off, give rise to irritation.

When possible, underclothing should be of wool in this country; in the tropics this is too heavy a material, and linen or cotton shirting is more generally suitable. All clothing should be porous, so as to permit of a certain amount of evaporation, and allow the skin to ventilate, as it were. For this reason, the habitual and indiscriminate use of water-proof materials, such as oilskins, mackintoshes, and tarred cloths, or cloths covered with layers of indiarubber, are objectionable. As a protection against rain, garments of these latter materials are necessary at times, but care should be taken to see that they are constructed rationally, that is, fairly loose and ventilated, also that they are not worn too long.

While affording warmth, protection from cold, wet and injury, clothing should always be so made as not in any way to impede natural movements, nor unduly constrict any part of the body, nor be needlessly heavy, and also not afford unnatural support. The more we analyse the common forms of clothing, the more we see that their main faults are in the direction of impediment, constriction and weight. This is particularly emphasised in the case of long and close-fitting skirts, tight sleeves, stays or corsets, garters, bands round the waist and neck, ill-fitting gloves, hats and boots. Many of these defects and faults might be obviated if people would remember that (1) no article of clothing should be either so tight as to interfere with the circulation, or so shaped as to change the natural outline of any part of the body; (2) no garment should contain more material than is actually necessary; (3) all garments requiring suspension should be suspended directly or indirectly from the shoulders or hips.

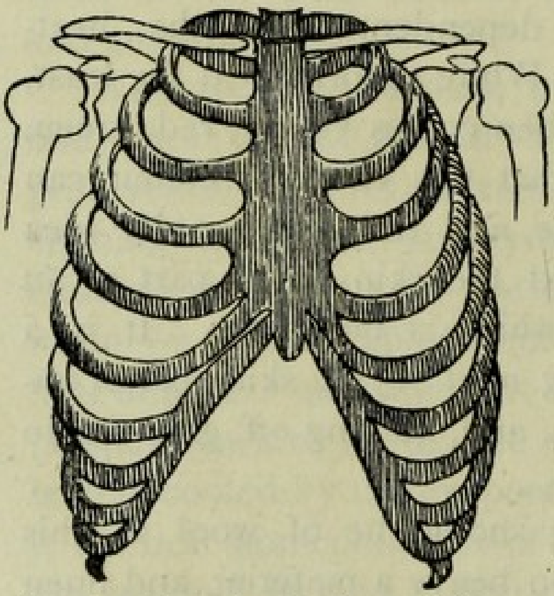

FIG. 67.—Normal or Undistorted Thorax.

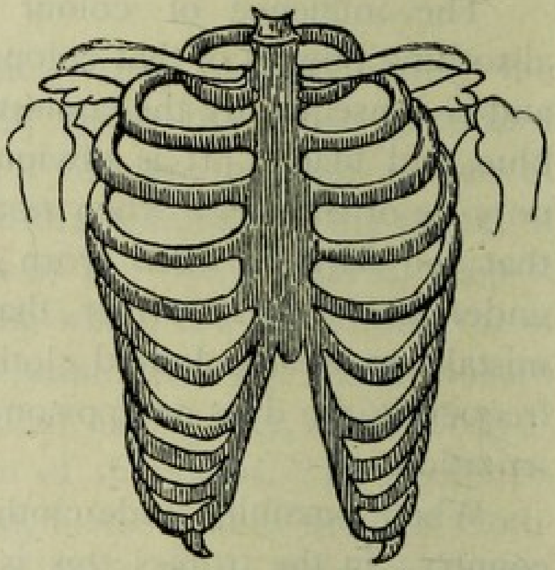

FIG. 68.—Abnormal or Distorted Thorax, the result of tight lacing.

It is in women's clothing that the chief faults are made. In them the body is rarely evenly clothed; usually the abdomen is too much covered, while the legs, arms and upper part of the chest are insufficiently so; the result is that while the body is too hot, the hands and feet are too cold. Another constant error is the habitual compression of the lower part of the chest and upper part of the abdomen by stays or corsets, which not only embarrass in the performance of their natural functions, but actually displace the lungs, heart, liver, stomach and intestines. How this distortion affects the thoracic skeleton is shown in Figs. 67 and 68. The woman's natural waist is not over the ribs, but below them, and above the hips.

The same fundamental error of misapplied constriction is apparent in the fashionable boot or shoe of the present day, both of men and women. A properly made boot should fit the foot accurately; the great toe should be in a straight line with the inside of the foot; the outer side of a toe of a boot should slant outwards and backwards in conformity with the natural slant of the toes. Fig. 69 shows the enormous distortion which usually occurs when a foot is made to fit the boot, instead of the boot fitting the foot. The inevitable result of such misshapen feet and boots is an impediment to walking and the presence of both corns, bunions, and in-growing toe-nails. The widest part of the sole of a boot should correspond with the widest part of the sole of the foot, which is at the base of the toes; the heel should be made broad and low so as to give a firm and stable support. Even when new, the wearer ought to be able to move all the toes with freedom in the boot; the actual sole of the boot should be flexible and slightly arched so as to fit into the natural arch of the under side of the foot. The upper leather of a boot must be equally flexible, so as to conform readily to the foot. The stocking or sock should, whenever possible, be of woolly material or of a mixed material in which wool predominates. If no sock be worn, the boot needs to be high and close-fitting round the ankle, so as to prevent dust and stones getting into the boot. As to whether boots are preferable to shoes is rather a question of circumstance. In fine or dry weather, shoes are perhaps better than boots, as they permit of ventilation, and by allowing free play to the ankle tend to

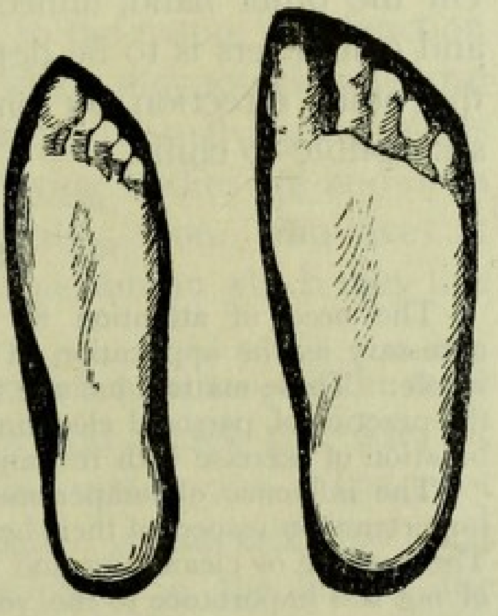

FIG. 69.—An Abnormal and Normal shaped foot.

strengthen the muscles and ligaments connected with that joint. In wet weather or when the nature of the ground is rough, boots should be worn.

No persons need more careful clothing than infants and children. In them the body surface is relatively large and their heat producing powers are feeble. For this reason they need to be covered up as much as possible, with loose light clothing, so that the natural movements of their bodies may have full play. When possible, the under garments should be of wool; the prevalent idea that children should be thinly clothed with more or less bare limbs, so that they may become "hardened," is contrary to all physiological teaching and absolutely cruel. On the other hand, unnecessary swathing of children in wraps and comforters is to be deprecated, and it does equal harm in the other direction by rendering them tender and peculiarly susceptible to chills.

SUMMARY.

The need of attention to matters of individual hygiene is just as necessary as the application of sanitary methods to the community as a whole. These matters include the influence of temperament and heredity, the practice of personal cleanliness, wholesome habits, the judicious combination of exercise with rest and clothing.

The influence of temperament and inherited qualities are chiefly of importance in respect of their bearing upon the early training of the young. The practice of cleanliness and the development of wholesome habits are of not less importance to the young than to the old. Regular and varied exercise combined with regular rest is as vital to the preservation in health of the mind as of the body. Apart from its value as a protection from cold, heat, wind and rain, clothing is of importance as a means of maintaining warmth, protection from injury and also of adornment. These advantages can only be attained, provided that not only is the material of which clothing is made suitably chosen, but also that the same is rationally constructed. The chief errors committed in the planning and construction of clothing are in the direction of impediment to natural movements, constriction of vital organs, and excessive weight. These faults are as important to the man as to the woman, to the child as to the adult. They can only be corrected by a practical appreciation of the elementary facts and teaching of anatomy and physiology.

CHAPTER XXVIII.

PARASITIC AND INFECTIVE DISEASES.

THE human body is liable, both without and within, to the attacks of various living organisms. These organisms are both animal and vegetable, and, according to the nature and function of the respective parts of the body which they attack, give rise to diseased conditions of varying severity. These living organisms which exist at the expense of other living bodies are known as *parasites*, from a Greek word, meaning, "one who lives at another's expense;" and the thing or person on which they live and grow is called the "host."

The **Animal Parasites** which attack man are, for the most part, either insects which burrow in and attack the skin, or worms which infest the blood and internal organs. The most remarkable feature in animal parasites is the fact that their parasitism only represents a single phase in the life of the animal; and that while a few parasites, notably the parasitic insects, do not attain to sexual maturity until they have commenced to lead a free existence, the greater number of them, especially the worms, attain sexual maturity while in their parasitic stage, and therefore reproduce themselves in the body of their host.

The commonest animal parasites attack the external parts; examples, such as fleas, bugs, mosquitoes, lice and itch insects, are well known.

The itch insect is very minute, and burrows into the skin, exciting much itching and some rash. It is only the female insect which thus burrows; she lays her eggs under the skin, where they hatch, and from there the young insects themselves commence to burrow afresh in other directions. Owing to the ready means by which the itch insect can pass from one person to another, itch is eminently contagious and the greatest care is needed to separate those affected with the parasite from those who are free. The only safeguard against this objectionable disease is absolute cleanliness, maintained by liberal washing of the hands and other exposed parts with soap and hot water.

The louse may infest either the hair of the head or the body, in both of which parts it gives rise to characteristic irritation. The constant use of warm water, soap and combing of the hair, with scrupulous cleanliness of all parts of the body, are the only sure means of keeping away lice.

Ordinary fleas and bugs are, in a sense, parasitic, as they practically feed upon the blood of their host. The female of a tropical variety of flea actually burrows into the skin and there matures her eggs, giving rise in the process to considerable irritation; this flea is, of course, a true parasite.

Among the animal parasites which attack the internal parts of the body, the commonest are tape-worms, which gain access to the body by means of diseased meat from the cow or pig, and cause much irritation by their presence in the small intestine; other parasites of this kind are thread or seat worms, which cause so much itching round the anus and in the rectum, also the round worm, which so much resembles the common ground worm and which occasionally infests the small intestine. These various worms can usually be expelled by suitable medicines, and any trouble which they may have caused be removed. It is otherwise, however, with a minute worm called the trichina, which gets into the intestines of man from similarly diseased pork, and from there burrows into the muscles, from which situation they are not easily expelled.

Less common than some of the preceding animal parasites is the bladder form of the tape-worm of the dog, which gains access to man's stomach as minute eggs attached to uncooked and imperfectly washed vegetables, such as lettuce or water-cress. On the eggs developing, the animal burrows, usually to the liver, where it forms a bladder, known as an hydatid cyst;

this cyst gradually enlarges, and unless treated by means of a surgical operation may eventually cause death.

Besides the foregoing, there are many other forms of animal parasites which infest either the blood or tissues of man; fortunately many are relatively uncommon, certainly in this country, though less so in the tropics; to give an account of only a few would take up too much space, but in respect of most of them, the chief means by which they gain access to man's body, are dirty water, impure food, and general uncleanliness.

The **Vegetable Parasites** are for the most part microscopic, and their presence in or on the body only suspected from the diseases to which they give rise. They may be all included under the one head of *microbes* or *germs*, and the diseases to which they give rise are commonly spoken of as *infective diseases.*

Microbes vary considerably in form, being either round, oval, rod-shaped, spiral, or filamentous. The round or oval-shaped ones are termed *micrococci;* the rod-shaped, *bacteria* or *bacilli;* the spiral forms, *spirilla;* while the filamentous forms are generally termed *leptothrix* when straight, and *spirochæta* when wavy. Some microbes are very mobile, while others are just the reverse; their size is, of course, minute, but varies from $\frac{1}{50,000}$ to $\frac{1}{500}$ inch.

Microbes, or germs, multiply or propagate by one of three methods. Some, such as the yeast plant, grow and multiply by giving off buds; others, such as the moulds or fungi, increase by branching and by small eggs or spores; a third group, such as the *oidium lactis*, or milk-souring germ, multiply by fission or division, also by means of eggs or spores. Practically, all the vegetable parasites which attack man belong to one or other of these two latter groups, that is, they multiply either by branchings and spores, or by fission and spores. Among the branching microbes or germs, which attack the human body, we find the so-called ringworm which, as minute branching cells, attacks the hair of the head, and sometimes the skin of other parts of the body, causing the breaking and falling out of the hair, accompanied by a ring-shaped eruption. This parasitic affection is most readily passed from one person to another and therefore highly infectious. Various other skin diseases are caused by other minute vegetable organisms of a similar nature; so also are the white sore patches found in the mouths of young children, and known as "thrush."

The third group of microbes, or those germs which multiply by fission and spore formation, are the most important as affecting the human body, for they appear to be most intimately associated with that class of communicable diseases called "fevers." These diseases are caused and spread by a process resembling the sowing of seed upon a suitable soil, in which, by reproduction of the seed, it, in its turn, becomes a new centre, or focus, of material, whence it may spread to others. A good example of this sequence of events is seen if we sow a little yeast into a solution of sugar. Yeast, we know, consists of minute vegetable cells; these, on being placed in the sugar, set up fermentation, by which the sugar is split up into carbonic acid and alcohol, while at the same time an enormous increase has taken place in the number of yeast cells. If we substitute for the sugar solution the human body, and for the yeast cell the microbe of an infective disease, such as diphtheria, enteric fever, cholera, or small-pox, we can readily appreciate the analogy between the process of fermentation and infective disease production, and, too, understand that as fresh yeast cells are produced in the sugar solution, so are new disease germs formed in the body, ever ready, in their turn, to reproduce, on gaining access into another, all the features and peculiar characteristics of their own disease. The close likeness between fermentation and infective disease processes, has led to the term **zymotic** (from a Greek word, meaning leaven or ferment) being applied to them.

If the above conception as to the nature of infective diseases be correct—and every year that passes brings more evidence in support of this belief—that infection matter is a living body, preying upon our bodies, and, as a parasite, in most cases dependent upon our bodies for its own existence and multiplication, we can say that the course of an infective disease is truly the life history, so to speak, of a lower plant, and as such has a period of development (incubation), during which the germ is, as it were, brewing in the body, without showing its presence by any bad effects; a period of its greatest vigour, and a period of decline or death.

How these germs have originated in the first case we cannot tell; but it is as difficult to deny that every germ has arisen from some previous germ, as it is to question that the growth of a plant must have resulted from the seed or cutting of some previous and similar plant; further, we may think, though it is not absolutely proved, that from scarlet fever, scarlet fever alone results; from small-pox, small-pox; from measles or whooping-cough, only measles or whooping-cough, and so on.

These minute enemies of man are present nearly everywhere; we breathe them in the dust of the air, we eat them with our food, and we drink them in our water. In fact, the mystery is how we ever escape their attacks. Several theories have been suggested in explanation of this, but the one which is most intelligible and plausible is that there are in our bodies a number of cells, somewhat like the white blood-cells, whose duty and *rôle* is to attack, destroy and remove all harmful or foreign matters which enter the tissues. If these protective cells are in sufficient numbers and robust enough, they gain the upper hand of the invading germs; if they are few in number and weak, the germs overcome them, attack the body tissues and thereby set up the phenomena of disease. There are some difficulties, which we need not here discuss, in the way of accepting this theory as an absolute and adequate explanation of the fact that our bodies are able to protect themselves against the attacks of disease germs; still the theory agrees in a curious way with the practical fact which is familiar to most of us, that persons in good health stand a better chance of resisting disease in periods of general sickness than do those in bad condition, be it from cold, insufficient food, fatigue or dissipation.

A person who, though exposed to, and perhaps actually invaded by certain disease-producing germs, successfully resists the attack of the infective disease agents, is said to possess an **immunity** to that particular affection. This immunity may be due merely to the fact that his tissues are rich in the special protective cells above mentioned; but it may also arise from the circumstance that he has already had the particular disease, or has been inoculated with a protective chemical substance which is hostile to the germs of that special affection. On what this protection depends in these latter cases is uncertain, but a possible explanation is that in the course of each of these diseases or following some protective inoculation, the blood or tissues undergo such a change that they no longer afford, and never will afford possibly, the conditions necessary for the development of the particular causative microbe. Whether this change is a removal of some chemical substance necessary for the germ's growth, or the production and leaving behind of some direct or indirect product which prevents any further multiplication, or whether the cells and tissues are in some way modified during an attack so as to be able to resist future attacks of the same microbe, is by no means clear. Whatever may be the explanation, the essential fact remains, that one attack of an infectious disease usually protects the sufferer from a second attack of the same affection. Of course this is not always the case, neither is the duration of the protective action at all constant.

The practical value of the above facts is that, in the prevention of the extension of infective diseases we must allow only those who are protected from, or immune to a given disease, to come in contact with the sick; accordingly, prevention depends largely upon avoidance of infection by susceptible people, or the production of as many insusceptible or protected persons as possible. If we can bring about this condition of insusceptibility by means of protective inoculations, the strength or virulence of which we know, or by such procedures as vaccination, well and good; but we must not endeavour to attain the same end by wilfully exposing children to mild cases of the infectious diseases, such as scarlet fever or measles, on the supposition that they are certain sooner or later to get the disease, and that a mild attack will protect them in the future. Such a practice is almost criminal and quite indefensible, simply because it is by no means certain that a child will have one of these diseases at all, especially if ordinary precautions are adopted; moreover, a mild attack can never be ensured simply because some one else has a mild attack; what is really a mild attack in one often gives rise to a very severe attack in another, or *vice versâ.* Apart from this, we must not forget that one attack does not necessarily protect from a second one at some future time; further, the risks of death attending attacks during childhood from all diseases of this kind are much greater than in later years, so that so far from encouraging the occurrence of these infective diseases among the young, the greatest efforts should be made to prevent them.

The channel by which infective diseases are communicated to susceptible or other people is mainly one of three ways. They may be conveyed by the air and taken in by the breath. This is perhaps the most common method, and constantly occurs in such diseases, as whooping-cough, scarlet fever, measles, consumption or tubercle, diphtheria, small-pox, chicken-pox, and ague or marsh fever. They may be carried by means of water into the stomach and intestines, as with enteric fever (typhoid), cholera, dysentery and ague; or by means of food, notably milk, as with tubercle or consumption, enteric fever, diphtheria, scarlet fever, and foot-and-mouth disease. They may be communicated by actual contact (contagion), as occurs so frequently with itch, ringworm, small-pox, hydrophobia, erysipelas, and ophthalmia or an infectious inflammation of the eyes often met with in children. Lastly, they may be spread by means of infected articles, such as clothes, and so pass into the air; this is not uncommon in respect of scarlet fever and small-pox. Perhaps the only one of the above-named diseases which is not communicated from one person to another is ague. The germ of this disease probably lives in marshy ground, and by getting into the air and water of marshy or so-called malarial districts, only affects those persons living in those places.

Having explained the general nature and cause of the infective diseases, we may now pass to a brief consideration of the more common affections of this group, limiting our remarks to so much about them as every person should know.

Chicken-pox is usually a mild disease, but undoubtedly infective. The germ is probably inhaled from the air, and derived from the scabs or crusts which fall off from the little vesicles or water-blisters, which are characteristic of the eruption of this disease. The incubation period is about a fortnight, and the disease is infectious for about a month, or until all the scabs have fallen off.

Cholera does not often occur in this country; but a thorough recognition of its nature and the methods by which it is spread is of the greatest importance to all of us, as it is not infrequently introduced by people coming from India and other places abroad, where it is a common and fatal disease. Cholera is characterised by violent diarrhœa, vomiting and collapse, the sick person often sinking so rapidly that he dies within six or ten hours of being first attacked. The germ of the disease exists largely, and probably solely, in the bowels of those ill with the affection, and is thrown off in the discharges or excreta of those suffering; and when so cast off, unless promptly and efficiently destroyed either by fire or chemical agents, these germs possess untold powers and capabilities for spreading and giving cholera to others. This extension of the disease by these microbes or germs is dependent upon two conditions; they are: human intercourse and pollution of either air, food, or water by the excretal discharges of the cholera-stricken.

Besides human intercourse, certain conditions as to time, place, and individual susceptibility aid in causing the spread of cholera; human intercourse acts solely by furnishing the vehicle by which the poison is carried from one place to another, and in various places contaminating either air, water, or food. The conditions of time and place which aid in cholera-diffusion are warmth, moisture and general want of sanitation; the two former are dependent upon nature and climate, and cannot be affected by man, but the latter is completely under man's control. By general want of sanitation is meant fouling of the air, water and food by collections of dirt and faulty sewage removal. If the drinking-water, all water used either in bathing or washing cooking utensils and all food supplies, be kept unpolluted with cholera discharges, no outbreak of cholera will arise.

Inasmuch as certain personal conditions are predisposing to attacks of cholera, it must be borne in mind during the prevalence of this disease in any district that fear renders people doubly liable to attack. At such times increased care should be given to cleanliness in all things—doubtful water boiled, all indigestible food, raw fruit, and purgations avoided; the abdomen kept warm by means of a broad flannel belt, to guard against chills of the intestines; similarly, any looseness of the bowels should be at once checked by suitable remedies. If care be directed to these points, and the precautions given be intelligently adopted, combined with general sanitation of both people and places, it is absolutely certain that there is little likelihood of cholera spreading.

Should an actual case of the disease come under notice, all the bowel discharges and vomited matters must be carefully disinfected as soon as they have passed; when poured down drains, these must immediately be flushed with disinfectants. There is probably no danger of being in the same room as the patient, provided that the discharges are properly dealt with and any soiled sheets or clothing immediately removed and disinfected. If this cannot be done, far better burn them. On no account should discharges of any kind be allowed to pass into cesspools or streams. As an invariable rule all clothing and linen, which has been in contact with or used by the sick person, should be boiled for one hour in carbolised or other disinfected water, and on no account, until thoroughly purified, be washed with, or in any way mixed among, other and uncontaminated clothing.

Diphtheria is, unfortunately, a very common disease, very fatal among young children and eminently infectious. The disease is transmitted by kissing, by inhaling the breath of those affected, by milk and possibly by some other kinds of food or drink, and by clothing. Those living in damp or badly drained localities are peculiarly liable to attacks from this affection, and there is some reason to think also that sewer gas may give rise to sore throats which closely resemble diphtheria, if they are not actually that disease. The incubation period of diphtheria is about two days, and the earliest symptoms are sore throat, much weakness and swelling of the glands in the neck. A yellowish-white skin soon forms in the throat, which, extending to the larynx and windpipe, may cause suffocation unless a surgical operation be performed. Later on the kidneys may become affected, and possibly transient forms of paralysis follow. During the progress of the disease there is often great weakness of the heart, which, unless great care is taken to guard against the patient sitting up or making other sudden muscular efforts, may result in fatal syncope or fainting.

The total time of infectivity in diphtheria usually lasts about a month, but no very hard-and-fast rule can be laid down about this, as the germ is very tenacious of vitality and often remains in the throat and air-passages long after the patient has apparently recovered. Most cases of so-called croup are really cases of unrecognised diphtheria, so also are many apparently mild cases of ordinary sore throat. So strong is the evidence in support of this latter point, that it is advisable, as a precautionary measure, to treat even the mildest cases of sore throat among children as serious affections, and not permit those affected to either attend school or otherwise mix with other children.

Enteric Fever.—This disease is often called typhoid fever and is most prevalent in youth and adolescence, the cases becoming fewer and fewer after the age of thirty. The microbe or germ of this affection is almost entirely found in the discharges from the bowels, having originally gained access to the body through the mouth either by water, milk, food, by sewer gas, or perhaps directly from the fingers of those attending cases of the disease and who have not been careful to keep the hands perfectly clean. The incubation period of enteric fever is about fourteen days, and the infectious period lasts all the time there is any diarrhœa—that is, usually for three weeks or a month. Few diseases repay careful nursing so much as enteric fever, as throughout the attack the patient must be kept constantly in bed, and only the blandest and most simple kinds of food given; no solid food should be given except under instructions from the doctor.

From the foregoing brief statement of the nature of the infection, cause, and mode of propagation of enteric fever, it will readily be understood that the risks of infection from the enteric sick to others is greatest in small and crowded homes, where careful nursing, scrupulous cleanliness as to the attendant's hands and soiled bedding or clothing, cannot be secured. When such can be obtained, as in the large hospitals, the enteric sick can be treated side by side with other cases with little risk to the latter, the chief precautions needed as preventive measures being disinfection of all clothing and articles which have been soiled by the sick, no matter how slightly, scrupulous cleanliness of the attendant's hands, and the exercise of the greatest care to disinfect all excretal discharges, even the urine, and so dispose of them as not in any way to contaminate sources of water, milk or food-supply.

Measles, Mumps, and Whooping-cough.—These diseases have their infective germ contained almost exclusively in the mucus of the nose, mouth and throat, or in the breath. They are all apparently very infectious, even in the earliest stages, the contagion or germ being capable of spreading, not only by the air, but by clothing, such as handkerchiefs, pillows and bed-linen. What is known as German measles is a malady seemingly different from scarlet fever and measles, but having some of the characters of both. It is regarded as an entirely distinct disease, inasmuch as it occurs in epidemics, is able to protect against itself, but not against either scarlet fever or measles; nor do attacks of either of these diseases protect against it. Like measles and whooping-cough, German measles is contagious even before the rash comes out; fortunately, it has little or no mortality, and its power of infection is less active and less persistent than those of either measles or scarlet fever. Owing to their early infectiveness, all these diseases spread largely by the attendance of children at schools and other places of public gathering who are merely sickening for them, and have not so far manifested the characteristic symptoms. There is no evidence that these diseases are ever disseminated by the agency of water, milk, or even by domestic animals. In all these diseases there is a great liability to bronchitis and inflammation of the lungs, consequently children and others suffering from them need to be kept in the house, or even in bed, to guard against chills.

Scarlet Fever.—In this disease, sometimes called "scarlatina," the infection reaches the air in the early stages, even before the rash appears, chiefly by the breath and mucus secretions of the nose, mouth and throat. Later on it is given off by the skin as well as the breath, particularly in the form of fine bran-like scales of skin. Fortunately, these do not appear to spread infection any great distance through the air; but, on the other hand, they lend themselves so readily to attachment to clothing, that infection is retained for months, long after the original case existed. On this account, too great care cannot be exercised in burning, or at least adequately disinfecting, all handkerchiefs soiled by the nose and throat secretions, as well as all bedding and clothing which has been exposed to infection. Not infrequently milk becomes infected with the germ of scarlet fever, either from human sources or, possibly, from some obscure but similar disease in the cow. This fact is another illustration of the need for boiling milk before use. There is no evidence of scarlet fever being conveyed by water, nor of its being carried any great distance by air currents.

It must not be overlooked that the peeling stage of this disease is always a time of some danger to the sick person, as, if exposed to cold, the kidneys are liable to become affected, resulting in dropsy and possibly death. The ears, too, may become involved with inflammation and discharge matter which contains germs. Scarlet fever is always most infectious during the stage of peeling from the skin, and every patient must be kept separate from other people until all peeling of the skin and discharge from the throat, ears and nose have ceased.

Small-pox is infectious from the very commencement of the disease, the infection gaining intensity as the eruption advances, even up to and including the scabbing stage. The microbes or germs of the disease are contained in the secretions of the nose, mouth and ear passages, as well as in the contents of the pustules or pocks which form on the skin. They are given off most freely when these latter dry up and scab, diffusing themselves to great distances in the form of a fine dust. Owing to the great resisting power or vitality of these microbes, the spread of small-pox by means of infected clothing is even greater than that of scarlet fever. Small-pox is highly infectious throughout the whole duration of the attack, and the patient must be kept separate from others until every scab has fallen off and all the sores have healed—a period of about five weeks. Small-pox is one of the most loathsome diseases known, and amongst the unprotected very fatal, and, if not fatal, productive of great disfigurement.

Individual protection against an attack of small-pox can be obtained in three ways—by natural small-pox, by inoculated small-pox and by vaccination. In former years protection, once acquired, was looked on as permanent and absolute; but later experience shows that, from whatever cause obtained, the amount of protection varies according to the thoroughness of the productive procedure. Severe small-pox gives more lasting protection than mild small-pox; small-pox inoculation gives most protection when followed by an eruption; and a complete, thorough and multiple vaccination gives more lasting protection than does a vaccination in which only a single small vesicle has been produced.

Vaccination is the inoculation of man with the small-pox of the cow, by which man contracts the affection called "vaccinia" or "cow-pox," which is really small-pox in a very mild and harmless form. By the English law all children must be vaccinated before they are three months old, in order that they may be protected from true small-pox. Vaccination is performed by making a few scratches on the arm, and then spreading on it a clear fluid called *vaccine*, taken either from the vesicles on the arm of a child who has been similarly vaccinated seven days before, or the vaccine may be taken from a vaccinated calf (calf-lymph). To secure adequate protection, at least three marks should be made on the arm. The operation is practically painless, and, if performed carefully, is absolutely free from danger. Some eight days after the arm has been vaccinated, vesicles filled with a clear fluid are developed. These, later on, turn to pus with the formation of a scab. During this stage the places should be kept protected from dirt and friction by clothes or scratching by means of a clean piece of linen spread over with vaseline. It is owing to want of care on the part of mothers and others to guard against fouling of these simple sores with dirt and other matter that so largely contributes to many of the alleged dangers and accidents following vaccination.

This vaccination in early life, if adequately performed in three or four places, will protect against small-pox for about twelve years; at this age it is advisable to be re-vaccinated, when protection for the rest of life is practically assured. Following the introduction of vaccination, there has resulted a remarkable decline in the prevalence of small-pox, not only in England but in various countries; nowhere more so than in Germany, where both primary vaccination during infancy and re-vaccination at the age of twelve years are compulsory; in that country small-pox is practically unknown. On the other hand, where vaccination has been neglected, as in Gloucester, small-pox tends to occur as an epidemic, resulting in an enormous loss of life and the production of much suffering and disfigurement.

Tuberculosis is a diseased condition which occurs in man in a variety of different forms, the most familiar being phthisis or consumption, scrofula, and inflammation of the membrane covering the brain. It is causally related to the action of a particular bacillus or germ, and the existence of this germ in the expectoration of those afflicted with consumption or tuberculosis of the lungs, suggests the communicability of this disease from one person to another, particularly by means of the air. That this is true has been shown by the occurrence of infection of whole groups of people, free from hereditary taint, by mere residence in rooms or houses which had been previously occupied by persons suffering from tuberculosis. The infective microbes of consumption are probably not given off by the breath of those suffering from this disease, but exist only in the expectoration; and once the expectoration becomes dry, then the germs are easily scattered about as dust, in which form they gain access to the lungs. This sequence of events is very liable to occur when consumptive persons are allowed to spit on the floor or pavements, but can be readily obviated by insisting upon all such affected persons spitting into spittoons which contain carbolised water, the contents afterwards being either burnt or buried. The mouth should not be wiped with a handkerchief but with a piece of rag, to be afterwards burnt. In the same way, all spoons and crockery used by a consumptive person should be used by him only and always cleaned with boiling water after use. No other person should sleep in the same room as a tuberculous or phthisical person, and bedrooms which have been so occupied need thorough disinfection before occupation by others.

Phthisis or consumption and other forms of tuberculosis is much influenced by hereditary predisposition, that is, a special weakness for resisting the germ is passed on from parents to children. Where such exists, care needs to be taken that those hereditarily tainted do not live in damp houses, or in places where there is imperfect ventilation and absence of fresh air and sunlight. Inability to carry out these precautions explains why this disease is so much more prevalent among the poor than among the rich, and in the slums or crowded courts and alleys of towns than in the villages of the country.

Tuberculosis occurs among oxen and cows as a disease known as "grapes," it also affects pigs, as well as fowls, rabbits and guinea pigs. The occurrence of this disease among animals from whom we draw some of our food indicates that grave risks of infection occur from these sources, particularly if food be imperfectly cooked. Milk from tuberculous cows can undoubtedly convey tuberculosis to young children; therefore, the precaution of boiling it before use is of paramount importance to guard against possible infection; for the same reasons the careful inspection of carcases by experts before being sold for meat, and its thorough cooking afterwards, are safeguards which should not be neglected if the ravages of this infective disease are to be checked.

Typhus Fever was formerly much more prevalent than now. It is at present rarely met with except in the poorest, dirtiest and most overcrowded parts of towns. Its diminution is largely due to the removal of personal filth and overcrowding. The infection of typhus is mainly communicated by air, though only when close to the sick person, possibly by the breath; it is occasionally transmitted by clothing. The germ appears to be rapidly killed by fresh air, therefore the chief preventive measures to be adopted are adequate ventilation and the maintenance of great personal cleanliness.

Isolation of the Infected Sick.—By isolation is meant the separation of the sick from the healthy, so long as the sick person is capable of giving his disease to another; and to be of the greatest value it must be thorough and carried out before the sick person has infected others. In the interest of the greater number of persons, the best method of isolation is accomplished by the removal of the sick to an infectious disease hospital, where he will obtain the best treatment, the most careful nursing, and be the least danger to the rest of the community. If removal to the hospital be impossible, it is necessary to isolate the sufferer as completely as can be done at home. He should be placed in a room or part of the house as much detached as can be from the rest of the building; in most cases this will be at the top of the house. The room should be provided with a fire and capable of free ventilation; from it all unnecessary carpets or curtains and furniture should be removed. The nurse or attendant upon the sick should, if possible, be selected from those who have previously passed through an attack of the disease she is called upon to nurse, and therefore be less liable to contract it again. The nurse should be prevented from mixing with other people in the house; she should wear a simple linen dress (not of stuff or woollen), and before going out or mixing with others, should change her outer garments and wash face, hands and arms in some disinfectant. All food, coals and other necessaries for the nurse or sick person should be taken to the outside of the infected chamber and left there, whence in a few moments the nurse can fetch them. Similar precautions need to be taken with crockery, knives, forks, spoons, etc., leaving the sick room; they should not leave the room without being first disinfected by washing, and then left outside by the nurse, to be at once removed by others. All attendants on the sick should be scrupulous in their cleanliness, taking care not to place their fingers in the mouth, nor touch articles of food until after careful washing. All excreta from the sick should be at once disinfected and removed; soiled linen and clothes must be at once taken away and soaked in a disinfecting fluid, then finally boiled and washed apart from all other clothing. Any discharge from the eyes, ears, nose, etc., should be wiped away with pieces of clean rag; these ought to be at once burned in the fire after use. If books are in use in the sick room, care should be taken that they are not those belonging to public libraries; in most cases it is advisable that books used under these circumstances should be burned. During convalescence from diseases such as small-pox and scarlet fever, in which infective matter is largely given off from the skin, it is desirable to moisten the surface of the body with some oily disinfectant, in order to prevent these dangerous particles passing into the air as dust.

At the conclusion of the infective illness great care must be taken to cleanse the body and hair by frequent baths; fresh clothes should be worn and, thus purified, the convalescent may be released: but even then, care should be taken to avoid too close contact with those susceptible to the disease.

Disinfection.—The next step is to render harmless the room which has been occupied, also the bed, bedding, clothes and furniture which have been used by the infected person; such things to include even the garments worn some days before the illness. In many towns, the sanitary authority will disinfect a room, house and clothing, etc., free of charge. Where such an arrangement cannot be made, the duty must be carried out by the householder.

Perhaps the most common method of disinfecting rooms, etc., is by fumigation with sulphur dioxide, prepared by burning sulphur in an open vessel, after having carefully closed all doors, windows, chimneys and other apertures. As usually performed, this fumigation is largely a waste of time and money. We are disposed to advocate as a preferable procedure the free perflation of air through the room, and the careful washing of all walls, ceilings, floors and woodwork with a solution of chloride of lime (½ lb. to 10 galls. of water). In many cases it will suffice to leave all the doors and windows open for three days and nights, scrub all furniture and woodwork with hot water and soap, re-paper the walls, and re-limewash.

Some difficulty occurs often in disinfecting pillows, mattresses and beds. If any suitable apparatus is available, such as a public disinfecting chamber, these articles should be taken there in a proper conveyance and subjected to steam under pressure (moist heat), which will thoroughly destroy all germs and their spores.

In circumstances where no means exist for disinfecting bulky articles of clothing and bedding by these methods, they should, if possible, be destroyed by burning; failing that they should be boiled, or at least be allowed to soak for twenty-four hours in some disinfecting liquid, such as either (*a*) chloride of lime, 2 ozs. to 1 gall. of water; (*b*) carbolic acid, 5 parts to 100 of water; or (*c*) bichloride of mercury, ½ oz.; hydrochloric acid, 1 oz.; aniline blue, 5 grs. to 3 galls. of water. Both these last two solutions are very poisonous, and, moreover, being powerful disinfectants, serve also excellently for adding to enteric or cholera discharges before passing them down closets or drains.

In the event of death from any infective disease, we must bear in mind that the dead body is equal to the living in its power of infecting those who may come in close contact with it; and, owing to this, we must exercise the same care in regard to it as to the other. It should be washed with fluid containing either bichloride of mercury or carbolic acid, quickly placed in its coffin, and removed to its last resting-place. Burial or cremation should never be delayed, and all unnecessary exposure avoided.

In conclusion, we must remember that if a person suffer from one of the infective diseases, his illness does not affect himself alone, but is a matter which concerns the community in which he lives. It is the duty of every person so suffering to submit to certain restrictions, which must be placed upon him on behalf of the safety of other people. Every person should assist, both in his own interests and that of those among whom he dwells, in having each case of infective disease properly investigated, both as to the cause of its origin and the manner of its communication. Only by such means can the prevention of other cases be seriously undertaken, and the prevalence of this class of disease among us be reduced.

SUMMARY.

The human body is occasionally attacked by animal and vegetable parasites. The chief animal parasites affecting man are various insects such as lice, fleas, bugs and the itch insect ; also various worms such as tape, round and bladder worms. The chief means by which they gain access to man's body, are dirty water, dirty food and general uncleanliness.

The various vegetable parasites affecting man embrace the different fungi associated with the various forms of ringworm, and the large group of organisms known as micrococci, bacilli and bacteria. These are all intimately concerned in the causation and propagation of the various infective diseases and fevers.

In its natural history, an infective disease closely resembles, both in its nature and course, a fermentation. Examples are familiar to us in the form of small-pox, scarlet fever, measles, mumps, whooping cough, enteric fever, etc.

For their control and prevention, all this class of diseases require that those afflicted should be efficiently isolated from those unaffected, and that all discharges from the sick, the clothing and rooms used by them and, too, also the persons of the sick should be suitably and efficiently disinfected.

PART III.

DOMESTIC ECONOMY.

CHAPTER XXIX.

ON THE CARE AND MANAGEMENT OF THE SICK.

The Sick-room.—The first matter to which those in attendance on the sick must direct their attention is the selection, preparation and cleaning of the sick person's room. For many reasons, particularly among the poor and in small houses, it is not always possible to obtain the most suitable room for the sick person to inhabit; but, should any choice be possible, the sick-room should be large, well ventilated and open to the light. A quiet room is essential, and one well away from streets, roads or workshops should be chosen. The first thing with regard to its preparation is to see that it is clean and dry. No curtains are advisable in a sick-room, except of the thinnest and lightest kind, and then only just enough for necessary purposes. Strips of carpet or matting can be laid down on either side of the bed; such are in every way much better than one large piece, as they can so much more readily be taken up, shaken and cleaned every day.

The bed should be in the centre of the room; never put it in a corner, nor in a draught or bright glare of light. The best kind of bedstead is that made of iron, of just sufficient width to allow one to reach across it easily, and high enough to save bending down and consequent back-aching. As to the bedding, if possible, have a horse-hair mattress. The bedding over the person should be light and warm; the use of quilted coverings is not suitable for the sick-room; such keep in the perspiration and are usually collectors of dirt. See that the sick have pillows, but not too many, and that the same are so placed as to support the shoulders, neck and head. Pillows should not throw the patient's head forward; they should be soft and free from lumps, and never covered over by the bottom sheet. All sheets on a sick-bed should be laid straight and tight; the lower one particularly should be tucked in tidily, and pinned with safety pins on each side and at the foot. The upper sheet needs only to be pinned at the bottom, so that the person's feet may not be uncovered and get uncomfortable; do not pin it at the sides.

Avoid any weight upon the chest of a sick person lying in bed, but see that his coverings are light and porous in material. In some cases, more particularly in long illnesses or accidents, an article called a "draw-sheet" is a necessity; it is usually either a piece of waterproof or else an ordinary sheet folded and placed under the person, so as to reach from the middle of the back to the knees; it is intended to catch any discharges that may arise, and thereby save the soiling of the under-sheet. It can be readily changed by either lifting the sick person and drawing it away, or by rolling it up and then pulling it out.

The furniture of a sick-room should be as simple as possible, and consist only of those articles which are absolutely required. If they can be provided, pictures and flowers may be placed in a sick-room; their presence, giving the room a cheerful air, has a most beneficial effect upon the patient; plants should be removed from sick-rooms during the night. No food or drink should be kept in a sick-room, neither should the presence of animals be ever tolerated there.

Every sick-room ought to have a fire-place with chimney to it, as well as one or more windows. All windows should be capable of being opened at the top. Ventilation should be equally maintained both during the day and night; similarly efforts should be made to keep an even temperature; nothing harms a sick person more than being exposed during one portion of the day to a warm and close atmosphere, and then at another time to be placed in a cold air. It is the duty of those attending on the sick to see to this point; a temperature of

60° Fahr. is, as a rule, the best for sick persons. So far as concerns ventilation and heating of the sick-room, three points should be kept in view, they are, (1) an outlet must be provided for the air fouled by the sick; (2) the outer air is both at night and day purer and sweeter than the air of the room; (3) the outer air must be allowed into the sick-room continuously and equally, not in sudden or occasional puffs and rushes.

The Nurse or Attendant.—Although the foregoing are among the necessary needs of the sick-room, yet it must be remembered that they are not everything, and that much depends upon the attendant himself or herself. Any one of us may be called upon, some time or other, to act in the capacity of nurse, the wife to a husband, the father or mother to a child, the son or daughter to a parent, the husband to a wife; but still we are not all equally qualified to satisfactorily perform the duties of attendant on the sick. The qualities of a good attendant for the sick are that such a person be clean, tidy and neat, both in appearance and work; firm, but not domineering; gentle and kind, yet withal punctual and attentive, not only to the sick person's wants, but to the doctor's instructions also.

Women usually possess these qualities more than men, and on this account are eminently suited for the difficult and responsible calling of a sick nurse. The dress for a nurse should be quiet and neat, and of such material as not only to admit of being easily washed, but also of such texture that no rustling noise is made on moving; it should be worn short, and, as a rule, made of print. The boots or shoes worn should be without heels, so as to allow of movement without noise. Nurses should be ever careful of their own cleanliness and health; they should eat regularly but liberally, likewise obtain their share of sleep and daily amount of fresh air or exercise. A nurse should not eat or take her meals in the sick-room, nor should she talk much in the presence of the sick person.

The Washing of the Sick.—Some people think that when persons are ill and in bed they do not need the same amount of washing as when in health. Now nothing could be more wrong than this idea, for, if anything, the sick need more personal cleanliness than the healthy. The face, neck, arms and armpits of a sick person should be washed daily with soap and warm water, and then carefully dried with a towel, while the whole body from head to foot should be washed in a similar way at least twice a week, or even daily if possible, unless ordered otherwise by the doctor. In washing a sick person, care must be taken not to expose more than one part of the body at a time, and to have clean and dry clothes handy for putting on when wanted. As each part is washed it should be quickly dried with a towel, and rubbed well. Nothing is so refreshing to a sick person as a thorough washing, for it usually results in a comfortable sleep following. In like manner the hair of all sick persons should be combed and brushed every morning, and also, if need be, washed; in performing this part of the toilet the greatest gentleness is required, particularly if the sick person is a woman, in order to avoid giving her pain by rough or careless handling of the hair. All sponges, brushes and towels used in cleaning the sick should be dried carefully each time after use, and left for a while, daily if possible, in the open air. Never keep slop-pails or dirty water about in a sick-room; such should be removed always at once when done with.

In close connection with washing the sick is the prevention and management of bed-sores. These are horrible sores, found generally on the back or over any prominent piece of bone exposed to pressure in persons who have been ill and lying in bed any great length of time. Rucks or wrinkles in the bed-sheet, and crumbs from food in the bed are the commonest causes of these troublesome sores. Apart from their being a fruitful cause of sores, but also on account of the discomfort they give to a sick person, crumbs should be always carefully removed from the bed by the nurse. To prevent bed-sores, keep out crumbs, avoid irregularities in the bed-sheets, and never let the draw or under sheet remain soiled for a minute; the hips and back of the sick person should be inspected carefully every day, so as to detect the earliest signs of redness or abrasion; if found, these must be sponged with spirit lotion or weak brandy and water, and dusted thickly over with starch or toilet powder, and shown at once to the doctor. Should by chance a bed-sore arise, it must be treated as the doctor directs. A bed-sore is a most serious thing, and in feeble persons or those suffering from a long illness, often results in the death of the patient.

How to change the Sheets and Clothing of the Sick.—Since both the bedding and the clothing of the sick are constantly getting soiled, it is very important to know how to change them readily without disturbing the person too much. Of course, the upper bedclothes are easily changed, but not so the under ones; and these are best removed in the following way: First, have the clean sheets ready before you begin; then roll up lengthways the soiled sheet along one side of the patient, and push it as far as possible under his side; now roll up the clean sheet and place its roll next to the other, and by gently turning the patient over both rolls, and then taking away the dirty article and unrolling the clean one, one has only to turn the patient back again to finish the whole business. With sick people who can sit up in bed, the sheets can be changed readily in a similar way, but by rolling them breadthwise instead of lengthways. Both methods should be learnt at the bedside, and, like many other things, require practice to do perfectly.

To change the clothing or shirts of a sick person also requires practice to do it quickly and skilfully. As a rule the garment should be well opened, if possible, both in front and back; it then can be slipped easily down over the hips of the patient, and a clean one passed over the head and shoulders after it. The great object in all these efforts to change bedding and clothes is to disturb and expose the sick person as little as possible.

On moving or lifting Helpless Patients.—If the sick person is small, or a child, this can usually be easily done; but if it is an adult who is at all helpless from accident or disease, considerable method and care need to be employed to do it properly. The easiest way to move a patient in bed is to roll him gently on one side with both his arms straight down; place one of your own arms under his shoulders, and the other under his thighs, and then draw the sick person steadily but firmly towards you. Never push a sick person in bed. If it is required to lift a patient out of a bed, or from one bed to another, two persons are at least needed, while, if a limb is injured, there ought to be a third to take charge of it during the lifting process. The best way to lift a person is to first place the head of the fresh bed, or whatever it is you are going to place him upon, quite close up to the foot of the bed on which he then is; next, let some one stand on each side of the bed about opposite the sick person's hips, and, stooping down, join their hands that are nearest the foot of the bed under the thighs of the patient, and their other hands under his back; then, by slowly rising, they lift the sick person, carry him to and slowly put him down, wherever they wish. If so able, the patient can help much by putting his arms round the necks of the two who are lifting him. When moving a sick person, always do it gently, quickly and without a lot of talking and fuss; a sick person dreads usually being moved, and requires to have every confidence in those to whom he trusts himself.

How to warm and feed the Sick.—In some illnesses the sick suffer much from cold. The mere heaping of clothes and blankets upon them is not right; these, though they do give warmth, often from weight cause more discomfort and harm than the evil they are intended to remedy. The best method of warming a patient is to place either bottles full of hot water or heated sand-bags, against the feet; few things are more soothing and beneficial than warmth applied to the feet when cold.

Of all the duties of those attending upon the sick, none are more important or more difficult than the giving of food. First, the food must never be kept or cooked in the sick-room; next, all the cups and basins required should be carefully cleaned each time after using. Food for the sick needs to be given frequently, but in small quantities; if solid, not more than once every three or four hours. But if the diet consist only of liquids, it must be given more frequently, even to as often as every hour, or less. Nourishment is needed as much during the night as through the day, though no sick person should be awakened out of a sound sleep to take nourishment, except in cases of great exhaustion, in which frequent feeding is the only hope of life. If the patient is unable to sit up to take food, the same must be given by means of a feeding-cup. In lifting a sick person to take liquid food, put the left arm firmly under the pillow, and then raise the head on it; do not put the hand under the patient's head, but let it rest on the pillow and the pillow on your hand or arm. It must be remembered, never ask a patient whether he fancies this or that; simply bring to the bedside what has been ordered by the doctor, and tell him firmly that it has been brought and must be taken. When, in many cases, it is impossible for the invalid to take even a moderate quantity of nourishment without vomiting, very small amounts given at frequent intervals can be often retained. Food should be given either quite hot or quite cold; tepid or half-warm food is horrible, and so is anything which is fatty or greasy. Occasionally some people are so ill that it is impossible to give them food by the mouth; in such cases the food or nourishment has to be injected, or thrown up into the bowel by means of a special syringe, under orders from the doctor. Food so given must be liquid and the quantity never more than four fluid ounces at one time; it, too, must be given cold.

With regard as to what food a sick person should get, much will depend upon the doctor's orders, and whether he is in a condition of fever, or of debility and weakness, or even of both. The fever patient is usually thirsty, consequently he needs drink and his food in a liquid form, if, indeed, any other food can be even taken. Milk is the great and first article of a sick person's diet. It may be given plain, or with some aerated water, such as soda or seltzer water, or with ice. Next come the meat broths, beef-tea and the many forms of meat essences now sold. These articles are not true foods, but only stimulants, and alone cannot support man, either in sickness or in health. Beef-tea may be given hot, cold or iced. It is readily made by cutting up a pound of lean beef into small pieces, the size of dice; place these into a covered jar with one pint of cold water and a pinch or two of salt, allow the jar and its contents to stand for half an hour, then place the jar in a saucepan of boiling water and keep the saucepan boiling for four hours. The result will be about a pint of good beef-tea. Too much should not be made at one time, nor is there any advantage in making it particularly strong. Combined with oatmeal (two table-spoonfuls), or cream (a tea-spoonful), beef-tea (a pint) can be made into the equivalent of a true food.

In feeding the sick always try and make a variety in the diet; do not weary them with the same things over and over again. Beef-tea can be alternated with mutton, veal or chicken broths; similarly, milk may be given as pure milk, or with lime or barley water, with soda or some other aerated water, or combined with eggs and brandy, as egg-flip, or as a custard pudding, and with sago, tapioca, rice, oatmeal or arrowroot.

As to stimulants and alcohol for the sick, never go by the wishes or desires of the patient much, but rather follow in this, as in all other matters, the directions of the doctor. Unless really required, alcohol, oftener than not, does more harm than good. Apart from milk and liquid foods, the fever-stricken often need drinks to allay their excessive thirst; this means usually a drink containing a small but distinct quantity of sugar, yet withal an acid or sharp taste to please the patient's palate. An infusion of tamarinds, or apple water, some lime-juice or lemonade, or the following, made by putting a couple of sliced lemons to a pint of water in which an ounce of sugar and the white of an egg have been added, will commonly meet their requirements.

There are times when the sick cannot digest food or retain milk either plain or diluted; it is then that the great value of artificially or partially digested milk and other foods become apparent. But much of this utility depends upon their being properly used and under direction. Malt extracts, peptonised and pancreatised preparations compose this group of foods for the sick. The malt extracts are employed to supplement the salivary digestion of starchy food-stuffs, and need to be added to farinaceous foods before they are taken into the mouth; but care needs to be taken that the same is not added while the food is too hot to be eaten; if this precaution is not observed, the digestive action of the malt extract will be destroyed or killed by the heat. Peptonised foods have generally had pepsin added to them, this digests the proteid elements and acts as an aid or substitute for the stomach juice. The pancreatic preparations contain usually the active ferment of the pancreas, and are of notable value when the digestion of fat is defective.

All these foods should be given to the sick only under medical supervision and guidance; but, as a ready method of artificially digesting milk for the use of those very ill, the following method may be noted. Dilute fresh milk in the proportion of three parts of milk to one of water. Heat a pint of this mixture to boiling point and pour into a covered jug. Allow this to cool down to about 140° Fahr., and then add two tea-spoonfuls of the "liquor pancreaticus" sold by chemists, together with a pinch of bicarbonate of soda, also to be obtained from chemists. Place the jug under a thick quilt or "cosy" in a warm place for an hour; after this boil it for two minutes, and then use just like ordinary milk. Care should be taken that this artificial digestion of the milk is not carried too far, otherwise it will taste bitter and be unpleasant. The above procedure, though perhaps not within the reach of all, is still worth knowing, and may at times be useful when least expected.

How to give Medicine.—So much then for the food of the sick. We have now to consider the giving and taking of medicine. To most persons this latter is a very disagreeable task, but if set about in a proper way is not so bad as it seems. Medicines are usually given in a liquid state, but sometimes as a tabloid, pill or in a powdered form. It is of the utmost importance in giving medicine that the exact quantity ordered should be given, no more or less. This is not possible unless a proper measure glass be used; but for the information of those to whom a measure glass is not available, it must be remembered that—sixty drops are equivalent to one tea-spoonful or a drachm; four tea-spoonfuls make one table-spoonful or half a fluid ounce; two table-spoonfuls make a fluid ounce; and twenty fluid ounces make a pint.

One or more tea-spoonfuls or table-spoonfuls, or half or one ounce, are the common doses ordered by doctors; but whether they be these quantities or merely so many drops, never forget to be accurate and carefully measure the medicine. Another point is to always shake up the medicine well before using; sometimes this is most important, owing to the fact that the chief ingredient often sinks to the bottom of the bottle; also remember to re-cork bottles directly the dose of medicine is poured out. If any difficulty arises in giving medicines owing to their nastiness, place them in a spoon and, passing this well back into the mouth, it will generally be found that the medicine will be readily swallowed. For removing the taste of disagreeable medicines from the mouth, nothing answers so well as chewing a piece of bread or biscuit and spitting it out; it is much more effectual than rinsing the mouth out with water.

Medicines ought to be given at the exact intervals ordered; but, except in special cases, the patient should not be awakened from sleep for the giving of physic any more than for food. In giving effervescing medicines, always use a large glass and pour the alkaline portion in first and add the acid afterwards; this makes the mixture better and also more agreeable. To give pills, which, though generally the easiest of medicines to take, are in some cases the most difficult, the best plan to adopt is to put just a little water in the mouth, then place the pill in, swallow the whole, and wash down with some more water. Powders are frequently ordered by doctors, but are not an agreeable form of medicine; they are best given in a little jam or floated upon water. In some cases they can be placed upon the tongue, and then washed down by a drink of milk or water. Quinine, if given as a powder, is best taken mixed with or floating upon milk, which has the effect of greatly masking the bitter taste.

The Observation of the Sick.—Those in attendance upon a sick person, or the nurse, can often help the doctor by careful and correct observations regarding the patient's condition during the intervals between his visits. All cannot do it equally well, for some people are much more suited for the duties of a sick nurse than others; however, it is within the power of all to try, and the first thing to be remembered in this matter is never to trust to the memory, but write down from time to time all observations made, and thereby be able to give the medical attendant a clear and reliable account of all that has taken place since his last visit. The chief points upon which useful observations can be made by the nurse or attendant are the following: (1) How much sleep the sick person has had, and whether the same has been profound and heavy, or merely a fitful dose. (2) With regard to pain, where it has been, how long it has lasted, and if severe, sharp, stabbing or dull, aching and throbbing; also whether any remedies applied have had the desired soothing effect. (3) Observations as to posture or position assumed by the sick are of great value; their recognition often offers information as to seats of pain and injury. (4) The condition of the skin needs constant watching, especially in fever cases. It should be noted whether it is moist, hot, cold, pale, red, or whether covered with any rash; if so, where. The existence or not of great perspiration affords often much information to a doctor as to the patient's condition and strength. (5) The appetite is another thing which the nurse ought to observe. The word of some patients cannot be relied upon, in some cases, as regards what and how much they eat and drink, and what they like and dislike; in such circumstances the nurse, if observant, can help the doctor in arriving at a right conclusion. (6) The state of the respiration, or breathing, is frequently of importance to note; particularly as to its frequency and characters. It is easily observed by counting the number of times the chest heaves or moves in a minute; but when doing this the sick person should never be allowed to know that his rate of breathing is being counted. (7) The pulse, too, can be counted by feeling it just below the wrist, half an inch from the outer side of the forearm. Little more than mere counting of the pulse can be done by the nurse; the condition and strength of the pulse is best left to the doctor, who learns by experience only how to form an opinion from it regarding the sick. (8) One of the most common duties of a nurse is to take the temperature of the sick; for this purpose an instrument called a thermometer is used. This is a glass tube, with a graduated scale marked on it, and having at one end a bulb in which is some mercury; it is the rise and fall of this mercury in the tube which indicates the amount of body-heat. To take a temperature, first see that the mercury is shaken down to 97° Fahr.; then place the bulb of the instrument in the mouth under the tongue, or in the armpit; if placed in the mouth, it should be kept there for three minutes; if in the axilla, for five minutes. In both cases no air should be allowed to reach the bulb. When the thermometer is taken out, the position of the mercury should be read off and noted down at once. The value of temperature taking, like all other observations, depends upon its accuracy and regularity. (9) With regard to coughing, the nurse should note whether it comes on only occasionally or if it is more or less incessant; whether it is dry and hard, or fairly loose, and accompanied with spitting; also whether it causes pain, or is worse at some special time. If there is much spitting, the nature of this must be noted, specially if mixed with blood; if so mixed, whether the blood is really coughed up, or vomited up, or whether it comes only from the back of the throat or mouth. (10) Several points need to be noticed with regard to the bowels, more particularly how often moved; if attended with pain, the colour and nature of the matter passed, and whether containing blood or worms. All nurses or attendants should remember to place on one side, for the doctor to see, anything which seems unnatural in the motions, and never to forget, in the case of enteric fever, dysentery, or cholera, to add some disinfectant at once to the bowel motion and get it removed away. (11) If the doctor wants the urine kept, he will say so; but in any case the quantity passed, and how often, in the twenty-four hours, should be observed, also its colour, and if accompanied or not with discomfort or pain. (12) The occurrence of shivering attacks, vomiting, and delirium are other points to be recorded by all nurses for the doctor's information. Their exact importance can only be appreciated by himself; but he will none the less always look to and depend upon the nurse for information, not only on these but other facts connected with the condition of the sick.

The Application of Local Remedies.—Much of the usefulness of a nurse depends upon her or his capabilities of applying local remedies and doing many other little things for the sick which the doctor orders. These include such matters as the making of poultices of all kinds, giving baths, applying blisters, leeches, and bandaging. First, as to poultices: they may be of either linseed, bread, charcoal, mustard, or bran; and in making them one must remember to have all things ready beforehand, for method and rapidity are particularly essential to the making of poultices.

Linseed poultices are best made by pouring boiling water into a hot basin, and then sprinkling quickly the meal into it, at the same time stirring the mixture constantly until a thin smooth paste is formed. Always make quickly, so as not to let it get cool, and always add the meal to the water, not the water to the meal. Next spread by means of a knife the linseed paste or dough quickly, over or on to a piece of previously arranged linen, leaving about an inch of free edge of linen all the way round; this free edge is to be turned over the meal, and the whole applied at once to the part with the linseed next to the skin. Before applying it, try the poultice on the back of your hand, so as to be sure of not applying it too hot. A linseed poultice, if properly made, ought to keep hot for an hour and a half. Before taking off one poultice, see that the new one to replace it is ready.

Bread poultices are made by placing slices of bread without crust into a basin and pouring boiling water over them; drain this off and add fresh boiling water, drain that off, beat the bread up with a fork and spread on linen as described for linseed. Properly made bread poultices will keep hot for about an hour, and are usually employed when only a small surface, such as a finger or eye, needs mild moist heat.

Charcoal poultices are used only for wounds or sores, to cleanse them and remove the smell. They are made by preparing a bread or linseed poultice, and then beating up half an ounce of powdered charcoal with each two ounces of the other;

the surface of the poultice should be always sprinkled with charcoal also before it is applied. Mustard, too, is often mixed with linseed if a stimulating effect is wanted, but the commonest method of using mustard is in the form of a **mustard plaster.** This is best prepared by mixing dry mustard with cold, not hot water, so as to form a thin paste; this is next spread on a piece of rag or paper and then applied with either a piece of thin muslin or tissue-paper between it and the skin. It may be left on for fifteen minutes, and when taken off the part should be dusted with flour or starch. In making a mustard plaster, care must be taken not to use either hot water or vinegar, as they destroy the active property of the mustard; the mustard itself should be fresh; if stale and old it will do no good. Other kinds of poultices, having much the same use and made in the same way as linseed poultices, can be prepared with either bran or sawdust. They have not any special virtues, but are occasionally useful.

Closely connected with poultices is the use of **fomentations.** These are applications of moist heat, and may be simple or medicated by the addition of some drug, such as laudanum, henbane, or turpentine. Fomentations are prepared by soaking a piece of flannel in boiling water in a basin; but as the flannel has to be wrung out—and it is very difficult to do this with the bare hands—it is best to place a towel in the basin first, with the ends hanging out, and on this towel put the flannel, and then pour boiling water over it so as to soak it thoroughly. The towel or wringer is rapidly twisted round and round till all the water is squeezed out, and then the dry but hot flannel quickly applied to the part requiring it. To keep the fomentation hot, it is advisable to cover it with some waterproof material, which checks evaporation. A fomentation, to do much good, needs to be changed every half-hour. Medicated fomentations are made in a similar way, with whatever drug is ordered sprinkled over the flannel after it is wrung out, and before it is applied to the body. The quantity of medicament added varies from a few drops upward, according to the size of the flannel and the amount of irritation required. Too much turpentine applied in this way will cause a blister.

Every person professing to attend on the sick should know the use of **baths**, when ordered, not so much for cleansing and washing as for medical purposes. Doctors frequently order baths—particularly cold baths—in order to lower the heat of the body in fever. The temperature of the water in a cold bath should be from 40° to 60° Fahr., but it is sometimes given as a graduated temperature, beginning at 90° and slowly cooled down to 50°, or so. The temperature of a hot bath varies from 98° to 103° Fahr. Whatever bath is given, always first test its temperature with a thermometer before allowing the sick person to get in, and see that the proper temperature is maintained during the time that the patient is in it. A sick person should not remain in a hot bath more than ten minutes, nor in a cold one longer than from three to five minutes. When they come out of baths, see that the sick are well rubbed and dried, and, too, observe whether the sick person feels either cold or chilly on coming out, for if so it shows that the bath is doing more harm than good.

Another kind of bath which doctors sometimes order is the vapour or steam bath, and when the sick person can sit up out of bed it may be given in the following way: Place a bucket full of boiling water under a cane-bottomed chair, then let the person sit on the chair, surrounded or covered by two thick blankets, which must reach to the ground. In a short time the skin will perspire freely; then rub the patient dry, and put back at once into bed between two fresh and dry blankets. When persons cannot get out of bed, a warm vapour bath can often be given by putting them between blankets and placing six or more bottles in the bed, each filled with boiling water. After perspiration has been well started, the patient should be rapidly rubbed and dried as in the former case.

Closely allied to the cold bath is the **wet-pack**, which is not infrequently ordered by doctors to lower the body heat. It is applied by first covering the bed or mattress with some waterproof material, and upon that spreading a large sheet which has been steeped in cold water and well wrung out. Upon this lay the patient, quite undressed, and roll the sheet round him closely, leaving only the head out; over this place blankets, and tuck these well in all round, so as to keep out the air This may be left on for half an hour, and after it the skin be sponged and dried. Occasionally the wet sheet alone is applied without the blankets; but this will always depend upon the doctor's directions.

Blisters are sometimes ordered, and may be applied either as a liquid to be painted over the part, or as a plaster already spread. In the former case, the blister will not usually rise up unless a linseed poultice is applied afterwards. In the latter, it is sufficient to leave the plaster on for twelve hours, or less. When the blister is sufficiently raised, snip it with a pair of clean scissors at its lowest point, so as to drain out the water or serum, then dress with vaseline or some simple ointment, as the doctor may wish.

Leeches are occasionally used to draw blood from a part, and to employ them needs usually some skill and patience. To make them bite, the skin must be first carefully washed clean with soap and water, and the soap washed off and the part dried. The leeches themselves usually need to be put in a small box, and this then turned over and retained on the spot until they bite. When the leeches have sucked enough and are full, they soon fall off. They should not be pulled off, as they may leave their teeth behind. If the part to which leeches have to be applied is very hot and inflamed, it is better to place them first into some tepid water. After leeches have fallen off, the part should be bathed with warm water and the bites covered with cotton-wool. If the bleeding is to be encouraged, put on a poultice; if otherwise, a tight pad pressure will usually stop it.

There remains one more point to consider; it relates to **bandages** and **bandaging.** It is almost impossible to describe properly how to put on a bandage; the art of bandaging can only be learnt by practice and by experience. Bandages are generally made of calico, flannel, or linen, and are used sometimes as supports to different parts of the body, or to apply pressure, or for fixing splints, dressings, etc. The chief kinds of bandages are two—the roller bandage and the triangular bandage. The roller bandage is a strip of linen or other stuff, usually three to six yards long, and from three-quarters to four inches wide, according to the part of the body on which it is to be used; as, for instance, the finger requires a much narrower bandage than the leg. What roller bandages are really like, and how to apply them, can only be learnt by a practical lesson; but so far as theoretical knowledge goes, it must be remembered that in putting on a roller bandage, three rules must be observed. They are: (1) bandage from within out; (2) commence always from below and work upwards; (3) apply the bandage evenly, but withal not too loosely.

The triangular bandage is of German origin, and is largely used in the army owing to the great number of ways in which it can be employed. It is made of calico, triangular in shape, measuring forty-eight inches along the lower border and thirty-four along either side. Its application can only be learnt by practical demonstration.

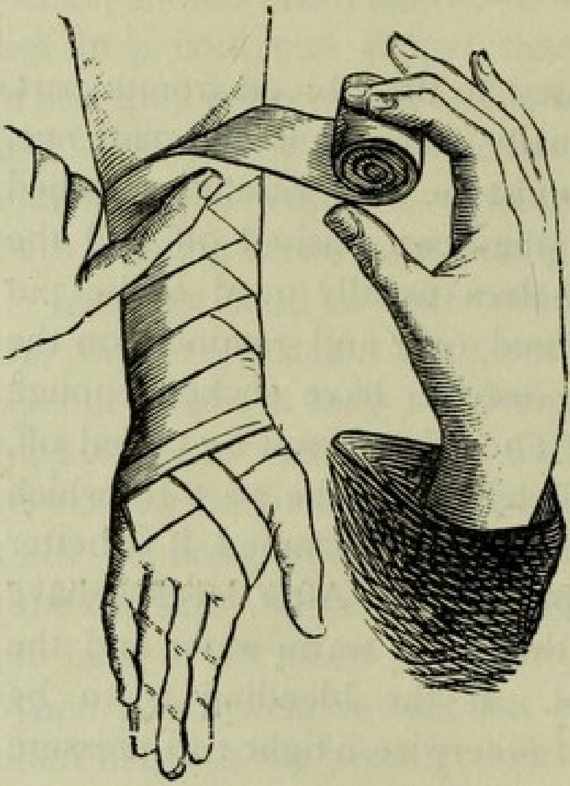

FIG. 70.—Application of Roller Bandage to Forearm.

FIG. 71.—Triangular Bandage applied to Hand.

Figures 70 and 71 illustrate the applications of the ordinary roller and the triangular bandage respectively to the forearm and hand. Their practical application cannot be efficiently learnt by means of a written description; but it is only to be understood and efficiently learnt by a practical course of illustration in "first aid."

CHAPTER XXX.

MANAGEMENT OF SLIGHT ACCIDENTS AND EMERGENCIES.

Most of us, at some time or other, have either suffered injuries or have seen others suffer, though probably but few of us at the time knew what was best to be done under the circumstances. In every home, the most simple things may give rise to accidents or emergencies endangering life or limb; the removal or minimizing of their possible results is a most important matter, and depends chiefly upon the quickness with which professional or technical help is given to the injured person. Only in exceptional cases, is the immediate attendance and advice of a doctor possible; hence, in the greater number of cases reliance must be placed upon, and measures for the relief of the sufferer taken by those about him. This relief can only be of value if the persons present to render first aid are acquainted with the measures necessary for the proper management of the emergency, and apply their knowledge with care. Therefore, to know what to do in order to stop the flow of blood when we cut ourselves, how to prevent a broken bone doing more damage than has already occurred, what to do when a person faints or becomes insensible from any cause, and also to know how to render such assistance in many other cases as will allay suffering, and more serious trouble, until the doctor arrives, is knowledge of the first importance and necessary in every household.

Flesh Wounds and Bleeding.—The importance of an ordinary wound of the skin or soft parts depends upon its depth, extent, locality and the rapidity with which it can be made to heal. The process of healing is naturally more slow in extensive wounds, where the loss of tissue has to be filled up by the growth of new material from the bottom, than in small or clean cut wounds where the edges of the injured part can be brought together. As a rule, wounds should never be handled by the fingers or washed with an ordinary sponge or household rags; these are rarely clean, and if recklessly applied to cuts and injuries may seriously pollute the wound. If a wound is soiled by sand or mud, it should be gently washed with clean water, using as clean linen or rags as it is possible to obtain; if available, the use of a syringe is preferable, taking care not to allow the stream of water to strike or impinge directly upon the open or raw surface of the wound. Clots of coagulated blood should not be removed from wounds.

The majority of small and superficial wounds heal quickly after having their edges carefully adjusted and the application of a covering of clean rag or a piece of ordinary sticking plaster. Larger and deep wounds do not heal so readily, owing often to bruising of the adjacent parts and actual loss of tissue; these should be first gently cleaned with water, bleeding stopped, and then protected against dirt by a clean cloth or bandage fastened lightly but firmly on the part until the arrival of the medical man. The chief and most urgent complication of all wounds, especially large ones, is bleeding.

Bleeding may be from either an artery, a vein, or from capillaries, and the character and danger of bleeding depends entirely upon the kind and number of the blood-vessels injured. **Capillary bleeding** is the commonest and simplest form of hæmorrhage, being usually caused by any scratch or graze; by it little blood is lost and what is lost is commonly in the form of an oozing of blood, readily stopped by bathing the part with cold water, or by tying a pad of linen soaked in cold water firmly on the spot. When a large **vein bleeds,** the circumstance is rather more serious; in such a case the blood is blueish in colour and wells up in a steady dark stream. To check this, a pad of linen or lint dipped in cold water should be applied at once to the wound and fastened on either with strings or a bandage; the part, too, should be elevated and not allowed to hang down. If this is not sufficient to stop the loss of blood, a handkerchief or bandage should be applied round the limb on the side of the wound farthest away from the heart.

When an **artery bleeds,** the loss of blood is often considerable, particularly if it be a large one. The blood always spouts out in a bright red forcible stream; sometimes, if it be a large artery, in jerks, being pumped out as it were by each beat of the heart. To stop this, pressure must be at once applied to the wound; and if the bleeding still continues, in spite of this pressure on the bleeding point or part, the main artery supplying blood to the region must be pressed upon. This pressure is best exercised on the vessel in some part of its course where it passes over a bone or other prominence, and usually as near the wound as possible. The pressure applied should not be so severe as to cause pain, but just sufficient to stop the stream of blood. Pressure upon a blood vessel may be applied either by the finger, or, in the case of the limbs, and when the pressure is required for a long time, by tying a knot in the middle of a handkerchief, placing this on the artery and then tying the ends

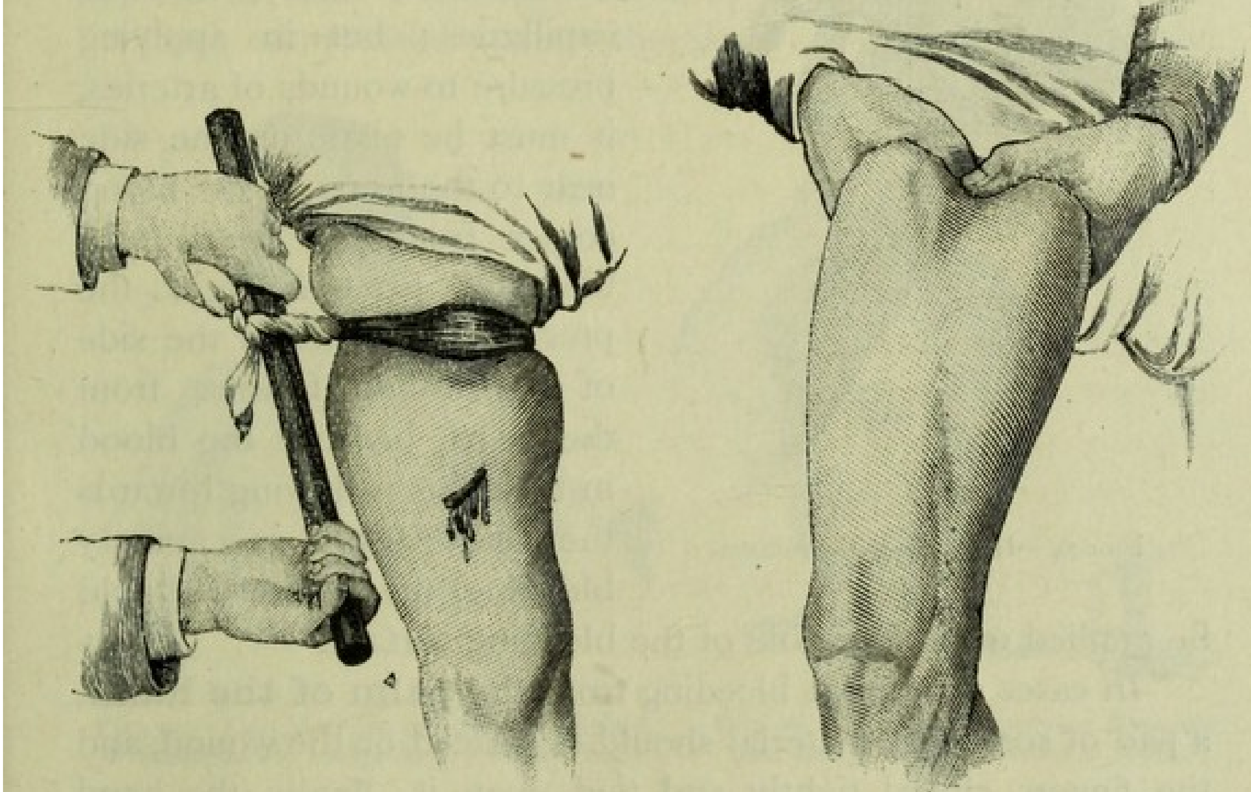

FIG. 72. FIG. 73.

Two Methods for stopping bleeding from the Lower Limb.

round the limb to keep it in place. For the knot, a flat stone, reel of cotton, or other hard substance may be substituted, the same being fastened over the artery and tied tightly on. If the pressure is not enough to check bleeding, pass a stick under the bandage and twist it round till the pressure is sufficient (Fig. 74). In trying to stop bleeding, remember that there is no bleeding from the outside of the body which cannot be temporarily checked by firm pressure, no matter whether it be from an artery, vein or capillaries; but in applying pressure to wounds of arteries, it must be made on the side near to the heart, as the blood comes from the heart. In bleeding from a vein the pressure must be on the side of the wound furthest from the heart, because the blood in the veins is flowing towards the heart; while in capillary bleeding, the pressure should be applied over the whole of the bleeding surface.

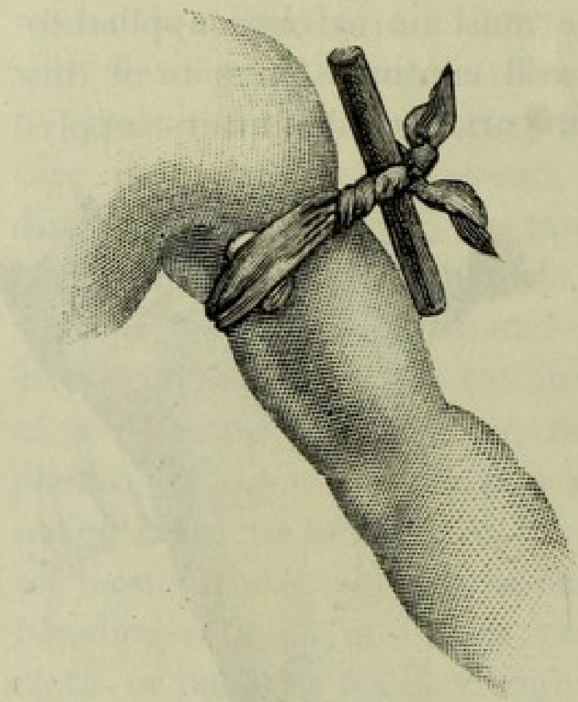

FIG. 74.—Improvised Tourniquet.

In cases of arterial bleeding from the **palm of the hand**, a pad of some firm material should be placed on the wound, and the fingers closed tightly and tied upon it; finally, the hand should be placed in a sling till the arrival of a doctor. If arterial bleeding occur from a wound **on the forearm**, a pad must be placed in the fold of the elbow, and the forearm bent up and tied firmly to the arm. In similar cases, the large artery in the arm may be compressed. This vessel runs along the inside of the arm, where the inner seam of the arm of a coat goes. It is best pressed by standing in front of the person and allowing his arm to rest in your palm, and then pressing the artery with the thumb; or it can be manipulated also as shown in Fig. 75. Pressure can also be applied by fastening a handkerchief tightly round the arm. In cases where arterial bleeding is taking place from a **wound in the armpit,** first press a large pad into the armpit and bind the arm down to the side; if this does not do, pressure must be made upon the large artery at the root of the neck, by placing the hand on the person's shoulder and pressing the thumb firmly down into the hollow behind the inner bend of the collar bone. The left hand is required for the right side of the person injured, and the right hand for his left (Fig. 76). Pressure in this spot is often required for deep bleeding from the neck.

In arterial bleeding **about the head**, pressure should be applied at once over the wound, as then the bleeding vessel becomes compressed against the skull. In bleeding from the forehead, the temporal artery should be pressed, if necessary, just in front of the ear. Wounds about the face often bleed profusely; this hæmorrhage can commonly be checked by pressure immediately over the part, supplemented by pinching the sides of the wound between the thumb and fingers.

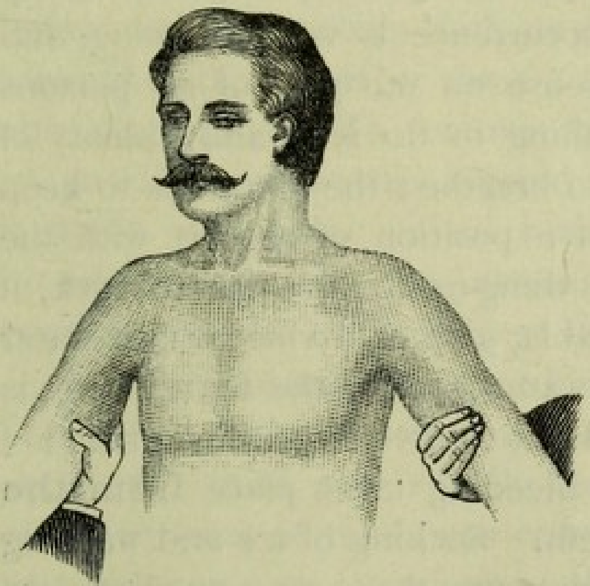

FIG. 75.—Two Methods of applying Digital Pressure to the Large Artery of the Arm.

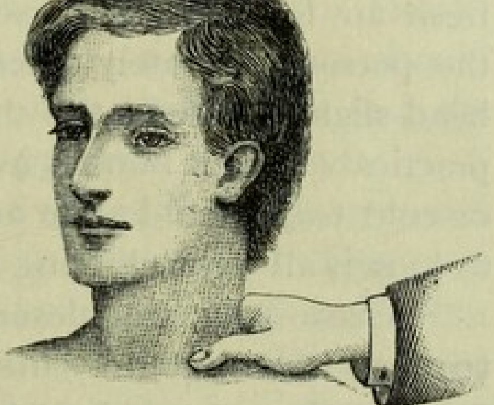

FIG. 76.—Method of applying Pressure over Large Artery at Root of Neck.

When wounds occur in the **lower limb,** and arteries bleed, they need treating in the same way as the upper. If it be the foot, apply pressure directly on the wound; if it still goes on, put a pad behind the knee and bend the leg back and tie to the thigh. Should the bleeding be from a wound above the knee, the large artery running down the thigh must be pressed upon; this commences at the middle of the fold of the groin, and runs towards the inner side of the thigh. Figs. 72 and 73 show how pressure may be applied either by means of the thumbs or by a knotted handkerchief or bandage in this situation. As soon as the bleeding has stopped, the wound, wherever it be, must be treated as an ordinary one, by washing the part carefully with cold water and then placing the edges of the wound as near together as possible, fixing them with plaster, and finally tying firmly on a pad of linen to heal it and keep it clean.

Sometimes, from broken ribs or other causes, severe bleeding takes place **from the lungs**; when so, the blood comes up in mouthfuls, is bright scarlet in colour, and, too, very frothy from mixture with air. Its occurrence is very alarming, and requires both calmness and sense on the part of all persons about the sufferer. The first thing to do is to allow plenty of fresh air for the sick person to breathe; the second is to keep the person absolutely quiet, in a position of repose, with the head slightly raised; the third thing is to give ice to suck, if practicable, or, if none is available, give cold vinegar and water or cold tea, or cold alum and water to sip; the fourth thing is to loosen all tight clothing and not to give any stimulants.

Occasionally, troublesome bleeding takes place **from the tongue** when bitten by the teeth. Sucking of ice and washing the mouth out with cold water are the best remedies. In profuse **bleeding from the nose**, remove all clothing from the neck, and douche the head and face freely with cold water. In all cases of bleeding, from whatever source, try and keep cool; do not become excited. First try the application of cold and direct pressure upon the bleeding part; if that fails, apply pressure on the side of the wound nearest to the heart and in a position over the course of the artery supplying the part. Next raise the limb and keep both it and the sufferer perfectly quiet, with plenty of fresh air, till the doctor comes. Do not give brandy or spirits; cold and fresh air are the best stimulants; give wine or spirits only when the medical man orders it.

The chief injuries which happen to joints are what are called sprains and dislocations, while to bones occur fractures or breaks.

A Sprain means a twist, strain or rick occurring at a joint. The most common sprains occur at the ankle, and, if neglected, often lead to most serious consequences. When a sprain occurs, the bones of a joint are suddenly separated, the ligaments or bands which hold them together being much stretched, torn and made to bleed, while the blood so poured out enters the joint itself and flows too all around it; the result is that the joint instantly swells. The pain in such accidents is usually severe, often much more so than if the bone had been actually broken. In attempting to treat a sprain, two things must be remembered; one is to apply pressure at once before swelling occurs with anything which is handy, such as a handkerchief, scarf or shawl; the other is to keep the joint absolutely quiet. To remove the pain and help the swelling to go down, place the injured part in hot water, or foment it freely with bran; in all such cases a medical man should be asked to examine the joint as soon as possible, for fear the accident may be worse than at first appeared.

Dislocations.—Another kind of accident which sometimes happens to bones is what is called a dislocation. This only occurs at a joint, and is really the slipping from off each other of the surfaces of the bones constituting a joint. Dislocations may be simple or compound; the former kind is when there is no skin wound, while in the latter kind there is a skin wound, by which often the ends of the bones may protrude. A dislocation may be known from a fracture or break of the bones by the fact that it always occurs at a joint; also that the limb is firmly fixed instead of being unnaturally movable, and that gentle pulling will not bring the limb into its natural position; neither is there any sensation of grating when the parts are handled. As dislocations are always serious accidents, no one except a doctor should attempt to replace dislocated bones, as the operation requires a special knowledge of the parts; but if no medical man is handy, the limb should be supported on pillows or by a sling, and placed in the most comfortable position possible until he can see it.

Fractures.—A bone may be broken either by direct violence, as when a blow falls directly on to the bone; or by indirect violence, when the bone is broken by being squeezed between two fixed points, as when the collar-bone is broken by falling on the shoulder. When a bone gets broken, no power on earth can make it join together again at once; that can only be secured after some weeks of care, under the experienced guidance of a doctor. But, on the other hand, by a want of knowledge of what to do on the part of friends or those near, when it first happens, a fracture or break in a bone, which at first is simple and uncomplicated, may become a much more serious thing.

Fractures are generally spoken of as being either simple or compound. A simple fracture is one in which the bone only is broken, while a compound fracture is one, in which, besides the bone being broken, there is a wound of the skin and soft parts leading down to and usually exposing the broken ends of the bone. A simple fracture may be so unskilfully handled that it becomes a complicated or compound one, necessitating weeks longer to cure or mend, not to mention the danger to limb and life which follow the tearing of the main artery and vein of a limb, or the pushing of the broken bone ends through the skin.

The **signs of fracture** by which one can tell when a bone is broken are: (1) there is a loss of power in the part or limb; (2) there are pain and swelling at the place of injury; (3) if a limb, and it be compared with the sound one, some distortion or deformity will be noticed, it being either longer or shorter, or lying in some unnatural position; (4) if the limb be gently pulled, it will regain its natural shape, but return to its deformed position so soon as traction ceases; (5) if the limb be gently moved, it will be found to move somewhere in the shaft of the bone, instead of at the joint only, at the same time a grating sensation will be felt as of two rough surfaces rubbing together; (6) if the bone be near the skin, some irregularity will be felt in passing the finger along or over it.

When a bone is suspected of being broken, it is absolutely necessary, in examining the part, to handle it most carefully and gently, and, above all, attend to the injured person on the spot where the accident has happened; do not move him about. The reason of this is, as explained above, that a simple fracture may be made into a complicated or compound one. The next thing to do is to send for a doctor. If a doctor cannot come at once or is not at hand, much can be done by those present to relieve the injured person and make him more or less comfortable until the arrival of the medical man, provided attention be given to the following explanations as to what is necessary in cases of certain special fractured parts.

In the case of a person who has **broken his skull**, the symptoms would be probably unconsciousness with a history of a fall or blow upon some part of the head; perhaps a skin wound, perhaps not; probably also the discharge or running of a sticky bloody fluid from either the nose or ears. Until the doctor arrives, nothing should be done beyond placing the person on his back upon a bed or couch, with the head raised and the maintenance of perfect quiet, coupled with the constant application of cloths soaked in cold water to the head.

If the **jaw be fractured**, the person will be unable to speak properly, while, if the finger be passed along the teeth or over the outside of the jaw, a depression will be felt or some rough edge of bone. The best thing to do in such a case would be to gently raise the jaw to its natural position, and tie a handkerchief round the jaw and over the head as shown in Fig. 77.

FIG. 77.—Application of Bandage for a Broken Jaw.

If it be the case of a **broken collar-bone**, the person will be found generally holding the elbow of the injured side with his sound hand. The sufferer will be unable to raise the arm above the shoulder, while the fingers, if passed along the collar-bone, will detect a sharp edge of bone or some irregularity. So far as treatment goes, first place a pad of some firm material, such as a handkerchief rolled up tightly into the armpit; then raise the arm gently and place it in a broad sling, finally tying the injured arm to the side by means of a broad bandage passed round the arm and chest outside the sling (Fig. 78).

When the **arm-bone gets broken** there will be pain, swelling, inability to move the arm, deformity or displacement and grating. The treatment will be to support the arm by what are called splints; these may be improvised from bits of wood or book-covers cut to the proper length and roughly padded.

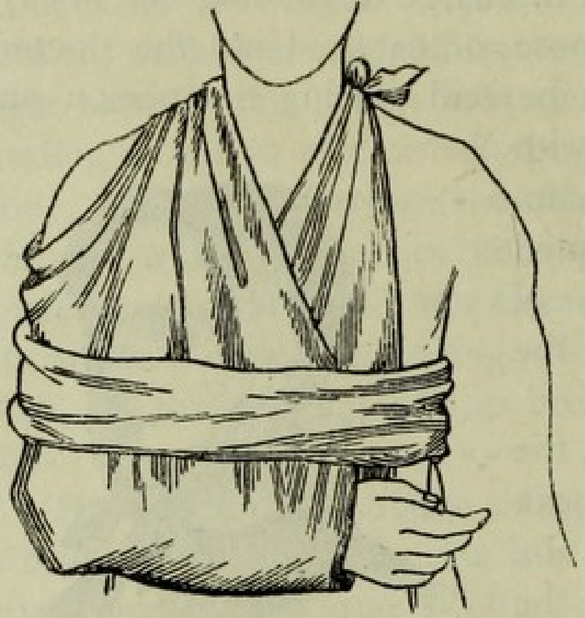

FIG. 78.—Application of Bandages for a Broken Collar-bone or Injury to Shoulder.

FIG. 79.—Application of Splints to Arm.

Place one such splint or support inside and the other outside the arm, and secure them in position by a handkerchief or bandage; keep the elbow bent at a right angle, and then sling the forearm as shown in Fig. 79.

In cases where the elbow-joint is injured, or one or both bones of the **forearm broken,** there will be the usual signs of fracture. The temporary treatment of either of these accidents, till a doctor comes, will be best carried out by making an angular splint by crossing and securing two pieces of wood at right angles and padding it well. Next place the whole arm on the splint with the thumb upwards, and, after tying securely and carefully with handkerchiefs, lay the whole limb in a broad sling. If the **fingers** are fractured there will be the usual signs; these accidents are best managed by placing the whole hand on a broad piece of wood or a book, tying up firmly and then resting the arm and hand in a large sling.

Broken ribs are of frequent occurrence; and owing to the possibility of the tender organs with which they are in contact being torn by the ends of the broken bones, this apparently trivial accident may have very serious consequences. A rib when broken, notwithstanding the fact that it has other ribs above and below it to keep it in its place, has still a drawback which no other bone has, and that is, it cannot be kept quite still, owing to the continuous movements of the act of breathing. The signs of a broken rib are a sharp cutting pain on taking a deep breath, while the person so injured will usually keep the hand firmly pressed on the injured part to prevent as much as possible the side moving; also, if the hand be placed over the seat of pain, a grating may be felt when the person breathes. There is not much that can be done in these cases, beyond applying the centre of a broad bandage over the painful spot and tying it firmly round the chest till the sufferer feels relief owing to the enforced lessening of the thoracic movements while breathing.

A broken thigh presents the usual signs of fracture; but owing to the large size of the bone itself, and the thickness of the muscles surrounding it, its treatment and relief are often matters of some difficulty. In cases where this accident has occurred, first grasp the foot firmly to prevent it moving about, and then pull gently, but steadily, on the foot until the limb is of the same length as the other, when hold the two feet firmly together. Secondly, while doing this with one hand, by means of a handkerchief in the other hand, tie the feet together. Having done this, one may let go of the injured leg and try to secure a splint or support of some sort; anything long, strong, and stiff enough, will do—for instance, a broom handle or umbrella. If these appliances cannot be readily obtained, tie the two legs firmly together and wait the arrival of a doctor.

The great thing to remember, in dealing with such a serious kind of fracture as that of the thigh bone, is to keep the limb as quiet as possible, and prevent it being moved or rolled about; while you are doing this send some one else, if possible, to find and bring a suitable splint or support. To fix a broom-handle, or any similar support, to a broken leg or thigh, first place it along the outside, from the armpit to the feet, then tie the feet together, including the splint, as shown in Fig. 80. Next pass a handkerchief or scarf behind the hollow of the knees, and tie the two limbs and the splint firmly together. In like manner, pass a bandage round the thigh and splint, just below the hips, and tie firmly; also round the body pass two bandages, one just above the hips, and the other round the chest, both including the broom or splint; then tie firmly. Finally tie the two legs together. The injured person is now rigid and stiff from the armpits to the heels, and as the bandages are tied over the ankles, knees and hips, there is no danger of movement. In this state he can be left till a stretcher or ambulance comes, on which he can be carried away to either his home or hospital.

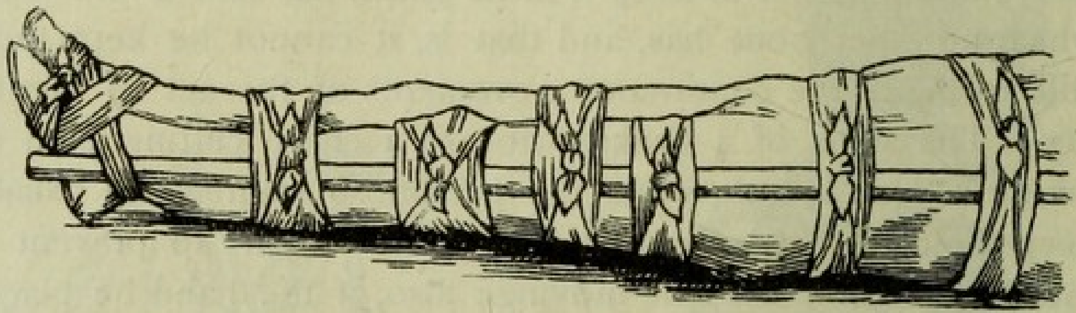

FIG. 80.—Improvised Application of Splint for a Broken Thigh.

When the **leg is broken**, that is, the portion between the knee and ankle, the usual signs of fracture will be present, more especially if both bones are broken; but if the shin bone only be hurt, the fracture will easily be detected by passing the hand gently down the leg, when the rough ends of the bone will be felt; but if only the smaller and outer bone of the leg is broken the signs of fracture may be less and more or less masked. In either case, the proper treatment will be to apply some sort of support or splint on both the outside and inside of the leg very firmly, and then to tie both the legs together as shown in Fig. 81. In cases of this kind, whatever splint is applied, it should be long enough to reach from above the knee to below the foot, the object being to keep both the knee and ankle joints from moving. In all instances of broken knee-caps and injuries to the legs, knee, or ankle, it is always a safe rule to tie the two limbs together until the doctor comes; this precaution guards against undue movement of the parts, which is the chief source of danger after a fracture of any kind or place. Should it be necessary to remove the clothes or boots, these should be carefully cut off or slit down the sides, and not recklessly pulled off in the usual manner.

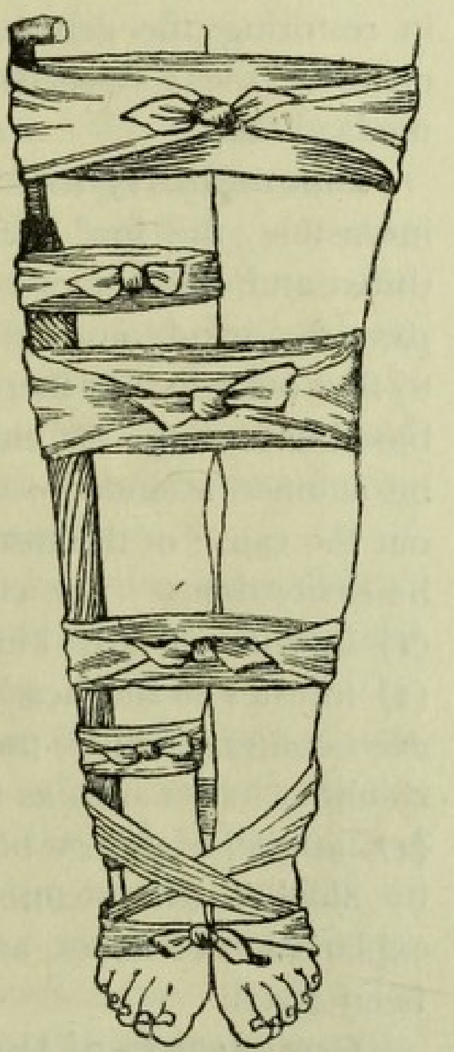
FIG. 81.—Improvised Splints applied to a Broken Leg.

Shock and Collapse.—Whenever a person meets with an accident, whether it be a simple cut or a severe blow or fracture, the system suffers from a certain amount of *shock* over and above the pain caused by the local injury. The injured person feels faint and sick, has a pale face, looks frightened, cold drops of perspiration stand on his forehead, the skin is cold and damp; this condition is the effect of shock or collapse, and may vary in different people from a mere temporary feeling of faintness only to downright insensibility. Trivial accidents and injuries in some people produce alarming symptoms, while in others severe accidents are often borne without any such effects. There is not much which can be done in these cases beyond placing the sufferer on his back, giving stimulants such as weak spirits and water, allowing plenty of fresh air, taking care to loosen the clothing, especially that round the neck and chest, applying smelling salts to the nostrils and bathing the face with cold water. In cases where the shock is very severe, the person may pass into a condition of collapse as indicated by much coldness, with a free perspiration; in these circumstances, in addition to general stimulation, a hot bottle or hot brick wrapped in flannel and applied to the feet, hands, and back is of the greatest value in restoring the general functions. The subsequent management of these cases should invariably be in the hands of a medical man.

Insensibility and Fits.—When a person is found to be insensible, the first duty is to loosen the clothes round the throat and chest, more particularly any belt or braces; then pass the hand quickly over the body, beginning at the head, to find out whether there be any wound or fracture from which blood is flowing. If either of these injuries be found, it should be at once attended to. The second duty is to try and find out the cause of the insensibility, though sometimes that cannot be easily done. The chief causes of sudden insensibility are: (1) injuries of any kind giving rise to shock or collapse; (2) injuries to the head leading to concussion or stunning or even compression of the brain; (3) diseases of the brain itself, resulting in fits such as those of apoplexy, epilepsy or hysteria; (4) fatigue, fright, or bleeding, causing fainting; (5) poisoning by alcohol (intoxication), or by drugs such as opium. An explanation of shock and its general management has already been given.

Concussion of the brain is the common result of blows on the head, and may be slight or severe, varying from momentary confusion to prolonged insensibility, according to whether the brain has received a lesser or greater shaking. When it is severe, the injured person lies motionless, sometimes vomits, the skin feeling cold and the pupils of the eyes contracted. Such a case needs to be treated by the lying down position, with the head slightly raised; also with the application of cold water to the head and warmth to the body and feet.

Compression of the brain occasionally happens from blows on the head driving in pieces of the bone or tearing a blood vessel across inside the skull, with the result that the brain is unduly pressed upon by the blood poured out and its function either disturbed or arrested. A wound of the head accompanied by insensibility, with one or both pupils of the eye dilated, is highly suggestive of danger from compression of the brain; it is at all times a serious condition, and needs the presence and advice of a doctor, though the other precautions given for concussion may in the mean time be adopted.

Apoplectic fits or **strokes** are common in elderly people and often associated with unconsciousness. When such occurs the insensibility is sudden, commonly coming on just after a heavy meal or some great excitement. The breathing is usually very laboured and noisy, while one or more limbs are frequently helpless or paralysed. The best thing to do for these cases is to lay the person on his back with the head slightly raised, loosen all clothing and apply warmth to the feet and cold to the head. Never attempt to give such a person any stimulants, emetics, or anything by the mouth.

Epilepsy is another common disease causing insensibility, in which the person is suddenly taken with a fit, usually screaming before falling down and becoming unconscious. The hands are clenched, the legs and arms violently jerked, the face becomes purple, froth and blood often come from the mouth, while the tongue is frequently pushed between and bitten by the teeth. Usually after a few minutes the convulsions cease, and the patient either gets up and walks away or drops off to sleep. In attempting to treat such a case, do not try and stop the fit, for that is impossible, but endeavour to save the tongue from being bitten by putting a cork, a small piece of wood, or a rolled-up handkerchief between the teeth. Unloose the coat or collar round the neck, place something soft under the head, and use just sufficient force to prevent the person injuring himself without trying to restrain the convulsive movements. When the attack is over, should the sufferer wish to go to sleep, do not prevent him.

Infantile convulsions are best managed by giving the child a warm bath without delay, pending the arrival of a medical man. As in the majority of these cases the convulsions or fits are caused by giving the child indigestible and improper food, the routine administration of a purgative is advisable, but the general treatment of these cases, especially the question of feeding, should be left in the hands of a doctor.

Hysteria is a peculiar disease chiefly attacking women, and not unfrequently associated with partial or complete loss of consciousness. In this affliction, the fits or attacks come on suddenly, and usually after some excitement; the person falls down, but rarely hurts herself; alternately cries or laughs, and grinds the teeth. The best treatment to adopt is to douche the head freely with cold water, and then place the patient in a quiet room for the encouragement of sleep.

Syncope, or the ordinary fainting fit, is due to failure of the heart's action, and an insufficient supply of blood to the brain; it is usually brought on by fright, hunger, heat, fatigue or prolonged and excessive bleeding. The person suddenly gets pale, feels giddy, falls down, has a cold and moist skin, and then loses consciousness. To manage such a case, keep the patient on his back, loosen the clothes, rub the chest and hands vigorously with cold water, apply smelling-salts to the nostrils and give stimulants, such as warm spirit and water, or tea and coffee.

Insensibility from alcohol is common, and often mistaken for apoplexy; it is always a dangerous condition. The face is commonly flushed, and the breath strongly tainted with the smell of liquor. If possible, give an emetic of salt and water, or a tablespoonful of mustard in half a pint of warm water; failing these, place the person on his back with the head slightly raised, and douche the head freely with cold water, covering the feet and lower part of body with warm clothing.

In **poisoning by opium** or laudanum, the person becomes drowsy and sleeps heavily, passing gradually into a state of insensibility. The pupils of the eyes are always contracted to a small point, while, too, the breathing is slow. When such a case occurs, or the insensibility is suspected to arise from this cause, do not delay about sending for medical advice; but, until the doctor comes, try your best to keep the individual awake by walking him up and down, dashing cold water over the face, making him drink strong coffee, and, if possible, make him vomit by administering a mustard emetic. Similar treatment must be followed in other forms of drug intoxication, but they will be more especially alluded to in the section dealing with poisoning.

Burns and Scalds.—Burns are caused by hot solid substances or by flames; scalds are caused by hot fluids; both may vary from a slight redness of the skin to complete charring and destruction of the flesh. The object of all treatment in these cases is to exclude the air as quickly as possible, but before that can be done it is necessary to remove the clothing. This always needs to be carried out with the greatest care and caution; it is generally useless and unwise to try and save any part of the clothing; this should be carefully cut through with a large pair of scissors in such a manner that it falls off of itself; nothing should be removed by pulling or tearing; if any of the clothing adheres to the skin, it should be left, only cutting round it with the scissors.

Should the part be blistered, these should not be broken, as by doing so the raw surface becomes exposed; but if the blisters are very large, they may be pricked with a clean needle, so as to let the fluid run out of them. If no doctor has arrived, and the burnt part is cleared of clothing, it should be protected from the air as soon as possible. There are several suitable means of doing this, but probably the best are either by dusting the parts thickly with flour or by covering them with rags soaked in oil. The oil must be either linseed, olive, or almond oil—never any mineral oil, such as paraffin or naphtha. If it can be obtained, an excellent application for burns and scalds is a mixture of equal parts of linseed oil and lime-water, sometimes called *carron oil.* So soon as the oiled linen has been applied to the burns, apply, if possible, over the whole a thick layer of cotton wool or flannel.

Persons who have been burnt or scalded suffer much from shock, and need relief from that as well as the burns; to guard against this, give warm stimulating drinks and apply warm coverings.

A frequent source of accident is the catching fire of a woman's dress. If the sufferer can only but retain her presence of mind, which is rarely the case, the best thing she can do is to throw herself on the ground or floor and roll over and over, and thus by pressure extinguish the flames. If any one else is present, he should at once seize a blanket, rug, sack, or carpet—even tear off one's own coat—instantly wrap it round the burning person; then, throwing her on the floor, roll her about rapidly till the flames are put out. In the case of burning spirits or petroleum, sand is the best extinguisher.

Of the nature of burns or scalds are the corrosions caused by quicklime, soap-lye, acids, alkalies, etc. The essence of all effective treatment in these cases is to remove the corrosive substance as soon as possible from the surface of the body, either by drying it off with cloths, or by throwing water plentifully over the person. To some extent, the caustic action of quicklime is increased by water; it is therefore better, if possible, in accidents of this kind, to apply vinegar and water; similarly, douching with alkaline water or chalk, ashes or lime-water is of advantage in cases where the corrosive agent has been one of the acids.

Sunstroke.—In hot weather and in hot countries a not uncommon accident or emergency is the occurrence of sunstroke or heat-stroke. The former comes on suddenly whilst exposed to the direct rays of the sun; but heat-strokes, which are rare in this country, may come on in the shade, or even at night, during very hot seasons. If due care is taken to have the head and back of the neck covered by a suitable hat, sunstroke will rarely occur, no matter how hot the sun's rays may be. Against heat-stroke the precautions are not so obvious; the chief safeguards, however, are never to go to sleep immediately after taking food, and never to sleep in a room which is overcrowded or its ventilation faulty. Should either sun or heat-stroke occur, at once strip off all the person's clothes, lay him down with his head and shoulders a little raised, and pour cold water over the head, chest and spine from a height of two or three feet, till he appears to revive or a doctor comes. Always carry a person so attacked into the shade or into a dark room, where it is cool; and after consciousness has returned, let him lie perfectly quiet and undisturbed.

Frost-bite is an emergency which occurs but rarely in this country; but still it may happen, and a knowledge of what to do under the circumstances may be useful. The parts commonly bitten or atacked by extreme cold are the tips of the fingers, toes and nose. When so affected, first rub the parts with snow or ice water. Do not carry the patient into any warm room, nor place him before a fire; if you do this, probably harm will follow. The parts, when first bitten, must not be warmed too rapidly, but require the circulation in them to be restored very gradually by means of gentle rubbing with cold wet cloths. As the circulation improves, and the limbs or parts become less stiff, the person should be carried into a moderately warm room, and covered lightly over with cold coverings and sheets. Only by degrees after this may he be rubbed with warm cloths, and the warmth of the room gradually increased. These stimulating efforts may be supplemented by drinks of cold coffee or soup, or cold weak brandy and water, and the employment of smelling-salts, ammonia, ether, etc.

Bites and Stings.—A frequent emergency arises from the bites of animals and snakes, and from the stings of the more venomous insects. The importance of these minor accidents depends upon whether the animal causing the injury is mad or not, and whether the snake is a poisonous one. In the greater number of cases the animals causing bites'or wounds with their teeth are not mad, and the snakes are not venomous in a fair proportion of snake bites. However, as it is not always easy to determine at once whether the animal or snake producing the injury is really either mad or venomous, it is always advisable, in accidents of this kind, to adopt immediately a means of treatment as though they were so. Such a precaution can do no harm, and may do good.

When a person is bitten by either an animal or snake, the wound should be at once sucked vigorously and the saliva spat out. If the part injured be on a limb, especially in the case of snake bites, the limb should be firmly and instantly tied above the wound on the side nearest the heart, with a view to the encouragement of bleeding, the checking of the venous circulation, and the arrest, if possible, of any absorption of poisonous matter from the wound. So soon as this has been done, the bitten part should be again vigorously sucked. This may be performed fearlessly, provided the person sucking have no wound on either lips or tongue. Next clean the wound, if possible, with hot water and Condy's fluid. If no doctor is at hand, the bitten place should be burnt freely with either some acid or a red-hot iron, or even ordinary caustic (nitrate of silver). If possible to obtain them, a few crystals of permanganate of potash may be vigorously rubbed into the wound. The idea of adopting these precautions is to destroy, if possible, the poison present in the wound before it can be absorbed into general circulation. The teeth of the animal or snake are not the poison—it is the fluid or saliva which is on their teeth, and which gets into the blood by the wounds made by the teeth. When the bite is into a part covered by clothing, the teeth or fangs get wiped as they pass through the clothing, and consequently enter the flesh more or less clean and freed from the poison. This explains why bites on the hands, face, and other exposed parts are so much more fatal than those in more or less protected regions of the body. The subsequent management of bites from animals or snakes should always be left to a medical man, especially when the injury is at all severe, and the nature of the assailant open to suspicion.

Not unfrequently the stings of some insects are productive of much pain and swelling; this is particularly the case with hornets, wasps, bees, etc. If numerous, in the case of children or those in feeble health, severe consequences have been known to follow these minor accidents. When a person has been stung by an insect, the sting should be looked for and if possible removed. The part should then be sucked vigorously, and ammonia or strong vinegar and water applied to the spot; if, as not infrequently happens, there be any shock, stimulants may be necessary.

Drowning and Suffocation.—There are few occasions on which intelligent and prompt action is sooner followed by satisfactory success than when we are called upon to help the apparently drowned or suffocated. If a person has been under water more than fifteen minutes, efforts to restore life are usually useless; but as in these cases no one knows exactly how long the unfortunate person has been in the water, it is the duty of every one to make some efforts to restore him to life again, no matter how dead he may seem to be. In cases of those drowned or apparently dead, medical assistance should be sent for without delay; but at the same time much can be done by those at hand, especially by loosening or removing all tight clothing from the neck and chest, and by making efforts to restore respiration, and, after breathing has returned, by promoting warmth and circulation.

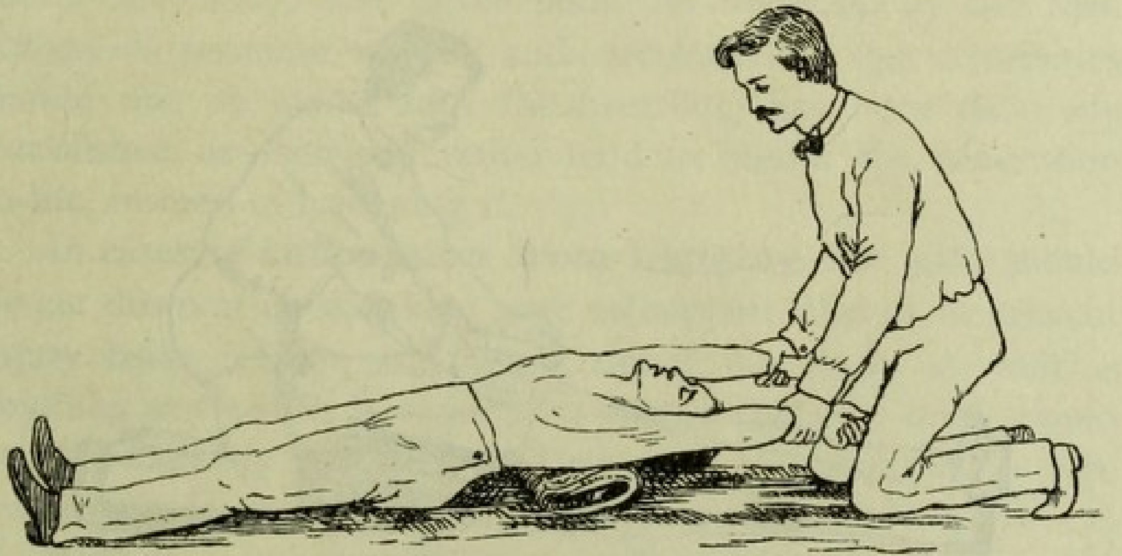

FIG. 82.—Inspiration in Artificial Respiration.

To restore the breathing, first rapidly clear the mouth and throat of froth or dirt; pull the tongue out, and then turn the person over on one side, resting the head on the forearm; next rub the chest vigorously, and excite the nostrils with snuff, a feather or with smelling-salts. If, following these stimulations, some attempt is not made almost at once by the person himself, not a moment should be lost, but artificial respiration started without delay.

Artificial respiration is best performed by first pulling the tongue well out of the mouth, then placing the person on his back, with the head and shoulders slightly supported by clothes or whatever is handy; next stand at the patient's head, grasp his arms just below the elbows, and draw them gently and steadily upwards above the head, and keep them thus stretched upwards for two seconds (Fig. 82); by this means air is drawn into the lungs. Then push down the patient's arms and press them gently but firmly for two seconds against the side of the chest (Fig. 83); by this means the air is pressed out of the lungs. These movements must be repeated deliberately and perseveringly, alternately raising and lowering the arms off and on to the chest at the rate of about fifteen times in a minute, until spontaneous efforts to breathe are perceived; so soon as spontaneous efforts to breathe are shown by the patient, the attempts to artificially promote respiration may be stopped, and efforts at once made to induce the circulation of the blood and warmth by rubbing the limbs upward towards the trunk with a firm grasping energy. While these efforts to restore the circulation and encourage warmth are being made, hot bottles and hot flannels should be prepared and applied over the pit of the stomach, to the thighs and to the feet; later on, as the return of life becomes more manifest, small but frequent drinks of hot water, coffee, tea, wine and broth should be given.

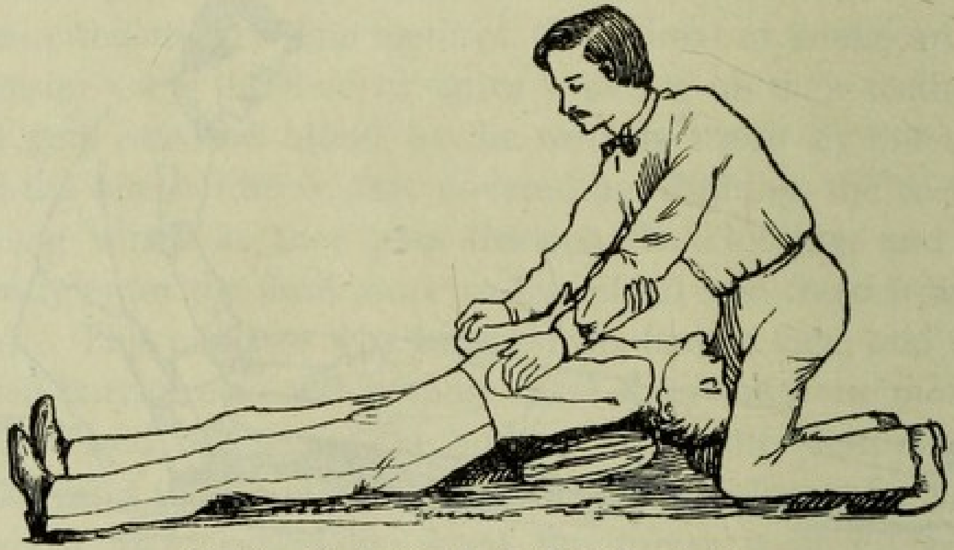

FIG. 83.—Expiration in Artificial Respiration.

In all efforts to carry out artificial respiration, it is an advantage if a second person can assist in the work; this he can best do by kneeling at the head of the patient and increasing the compression of the chest during expiration by pressing the person's arms closely against his sides, and the expansion of it during inspiration by raising his arms above the head. Should artificial respiration succeed, the patient should not be left alone and unwatched for some hours, as there is often danger from the breathing again failing; in such a contingency artificial respiration must be again tried.

The foregoing treatment needs to be persevered with for an hour or more, as often people come to life again under its effects when apparently no hope of life existed. Should death happen, the signs of its occurrence will be complete cessation of both breathing and the heart's action, the eyes will be half-closed, the pupils dilated, with marked pallor and coldness of the body surface. The great point in all these cases is to avoid all rough usage, prevent people crowding round the body, and never hold the body up by the feet. Efforts to promote warmth and circulation in the extremities should not be made until the breathing has been definitely established, as such will rather tend to hinder the restoration to life, instead of hastening it.

In cases of **suffocation from hanging**, the body should be cut down at once, taking care to support it so as to prevent injury from falling; the noose round the neck, as well as anything else which is tight, such as the collar or shirt, should be immediately released and the steps taken to restore respiration as recommended for those apparently drowned.

Persons sometimes become **suffocated by gas**, smoke, or noxious vapours from charcoal fires; if such happens, they should be rapidly removed into the fresh air, the clothing loosened, cold water thrown over the face and chest, and, if the breathing is laboured or stopped, artificial respiration at once commenced. In giving aid to persons in danger of suffocation by gas, smoke, etc., those engaged in the work of rescue should observe certain precautions for their own safety. Before entering rooms filled with noxious vapours, endeavour to establish ventilating currents by either breaking in the windows from outside or by opening the doors fully; the rescuer himself should envelope the mouth and nostrils with a cloth soaked in water or dilute vinegar, and, if possible, crawl along the floor, as often the lower strata of air are not so impure as the upper, but this will depend often upon the nature of the noxious gas and other circumstances affecting its density. Rooms suspected of containing ordinary coal-gas should never be entered with a light; in such cases at once have the main gas-cock closed belonging to the premises, and, having entered the chamber, make a dash for and open the window; the suffocated inmates should then be removed into fresh air as rapidly as possible, and restorative steps taken as for those drowned.

Among children, a fruitful source of choking or suffocation is caused by their swallowing food too quickly, or by drinking boiling or other irritating liquids. In the former case, the forefinger should be quickly passed into the mouth, behind the tongue, and attempts made to dislodge the food by promoting coughing or vomiting. For small children, the old way of thumping the back or quickly reversing them by holding them up by the heels is often successful; these procedures, however, need to be judiciously carried out. When children scald their mouths and throats by drinking out of teapots or other vessels containing very hot or boiling liquids, the parts swell quickly, and suffocation is generally both frequent and rapid. In circumstances such as these, a doctor should be sent for without delay, as operative procedures to give relief may be necessary; but whilst he is being fetched, some good may result by wrapping the child in a blanket, applying very hot flannels to the outside of the throat or neck, and by giving oil or barley water to drink.

Poisoning.—When a person takes poison, either accidentally or wilfully, it is very often difficult to know what poison has been given or taken, particularly as the unfortunate sufferer either cannot or will not, under the circumstances, give any information himself regarding the matter. The subject of poisons is much too large for precise details of all their symptoms to be given in this place; but so much information will be given concerning them and their action as will afford a simple, sufficient and safe guide to any one having to manage a case of poisoning on an emergency.

In all cases of suspected or alleged poisoning, it is necessary to first decide whether it is probable that any given case of illness has resulted from poison or not. To settle this question, the following circumstances must be considered: (1) In a case in which poison has really been taken or given, the symptoms appear more or less suddenly; now, such is very rarely the case in true disease, except it be sunstroke, cholera, or apoplexy and epilepsy. Hence there is every reason to believe that poisoning has occurred if a person, a short time previously in good health, is suddenly seized either with vomiting and purging, or with delirium or with insensibility. (2) The symptoms appear a short time after taking food or drink; this is very important, as it not only indicates that a poison has been given, but will often lead to a well-founded suspicion as to the person who has given it, or the means by which it was given. (3) If several people partake of the substance containing the poison, all suffer from the same symptoms. Cholera is about the only disease which is likely to affect at the same time several healthy persons shortly after a meal; hence this is a most important observation or indication when it occurs. In such a case it is always necessary to find out whether the sick person ate some of each of the dishes of which the others partook, or whether he had any substance specially for himself.

Having settled that a person has probably really been poisoned, the next thing is to determine, if possible, what sort of poison has been taken. Usually poisons are divided into two classes, namely, those which induce sleep, preceded in some cases by excitement and delirium; and those which destroy, mainly by their corrosive action, the tender lining of the mouth, throat, and stomach.

The first class of poisons, or those which induce sleep, are commonly called **narcotics**; examples of which we have in opium (laudanum), morphine, belladonna, hemlock, foxglove, tobacco, alcohol, prussic acid and strychnine. Poisoning by members of this group is characterised by loss of consciousness, by contraction of the pupils (opium, morphine), or dilatation of the pupils (belladonna, hemlock, foxglove, tobacco, alcohol), by convulsive contractions of the muscles (strychnine), and by stertorous breathing and a congested countenance. Vomiting rarely occurs without an emetic, except just before death.

The treatment for these cases is the early administration of an emetic, such as a tablespoonful of common salt in a tumbler of warm water, repeated every quarter of an hour till vomiting takes place; if available, sulphate of zinc in doses of 30 grains, or sulphate of copper in doses of 10 grains, may also be given to promote vomiting; the action of emetics may be greatly increased by irritating the throat with a feather, or by the finger. At the same time every effort should be made to rouse or wake the sufferer by talking and calling in his ear, walking him about, if feasible, dashing cold water over the face, and the giving of strong coffee, coupled with the application of mustard plasters on the stomach and calves of the legs. In extreme cases, when the stupor is very heavy, and the breathing laboured, artificial respiration may be needed and kept up for some hours, until the danger is past. Should the patient be kept alive for twenty-four hours or more, it is advisable to give a purgative.

Two poisons usually included in the narcotic group, namely, prussic acid and strychnine, demand special notice, as their action is so much more rapid than the others. In poisoning by prussic acid, emetics have not time to act; very little can be done beyond vigorous stimulation with cold water, smelling-salts, brandy and artificial respiration; in most cases death quickly ensues owing to sudden failure of the heart. Poisoning by strychnine is not uncommon, as this substance enters largely into the composition of some vermin killers. Its treatment is a case entirely for a medical man, but if the accident is discovered in time, an early and powerful emetic should be given, and may result in the rejection of some of the poison.

The second group of poisons includes those which produce irritation, coupled with more or less destruction of the lining of the mouth, throat, and stomach, and are distinguished from all other poisons by their causing pain and other indications of disturbance in the parts to which they are applied. These poisons are often called **irritants**, and include the strong acids and alkalies and some metals. The acids most commonly taken as poisons are oxalic acid, carbolic acid, sulphuric acid, nitric acid and hydrochloric acid. The alkalies most commonly taken as poisons are caustic soda and potash. The only metals in this group are arsenic, corrosive sublimate and antimony.

A person who has taken either acids or alkalies complains of burning pain in the throat and stomach, with a feeling of sickness, followed later on by vomiting and purging. The treatment in these cases is never to give an emetic, but at once administer bland and oily fluids, such as linseed or salad oil, white of egg, or even milk. If it is an acid which has been swallowed, give alkalies, such as magnesia or chalk. In poisoning by alkalies, give acids, such as strong vinegar and water, the acetic acid of which will counteract the alkalies; in all these cases, too, raw eggs and milk may be given.

When arsenic or corrosive sublimate has been taken, give an emetic at once, and then a mixture of equal parts of olive oil and lime-water frequently. As a constituent of tartar emetic, antimony is occasionally met with as a cause of poisoning; it is best combated by giving at once strong tea, and the whites of eggs beaten up with milk. For phosphorus poisoning, very little can be done beyond giving an emetic of sulphate of zinc, administering later on half a tea-spoonful of turpentine, and guarding against collapse by a free application of hot bottles and other stimulants to the body.

As the treatment of poisoning is really most important, it may not be inappropriate to briefly recapitulate the chief rules to be observed. First, always send for a doctor without delay. Second, try and find out what the poison is. If you do not know what kind of poison has been taken, get mustard, salt, eggs, flour, milk and tea. Then give an emetic of either salt and water or mustard and water. Next give the patient one or two raw eggs with some milk, or give a handful of ordinary flour beaten up with water. Vomiting will now probably come on; if it does not, give more mustard or salt emetic. When vomiting has ceased, give the patient a cupful of strong tea and put to bed.

If, though still not knowing what was the poison taken, you yet find stains and marks about the lips and mouth, do not give an emetic, but at once give some linseed or salad oil (not almond oil); also give milk with raw eggs, and apply hot cloths to the throat and place in bed.

Should you by chance really know what the poison was, do not waste time by trying to remember a special antidote to it, but send for a doctor at once, and you yourself act on the following principles: these are—when a person has swallowed a poison and threatens to go to sleep, keep him awake at all costs; if he seems likely to go off into a fit, throw cold water into his face; when there are no stains about the mouth, give an emetic, eggs, milk or oily fluids, and end up with strong tea; when there are stains about the mouth, give oil, but no emetic.

INDEX

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