A MANUAL OF HEALTH SCIENCE

WILSON.

HEALTH SCIENCE

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A MANUAL

OF

HEALTH SCIENCE

ADAPTED FOR USE IN SCHOOLS AND COLLEGES AND SUITED TO THE REQUIREMENTS OF STUDENTS PREPARING FOR THE EXAMINATIONS IN HYGIENE OF THE SCIENCE AND ART DEPARTMENT; ETC.

BY

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TO

ANDREW COATES

AND TO

JAMES COATS, Junior

THIS VOLUME IS DEDICATED

AS A SLIGHT MARK

OF

FRIENDSHIP AND ESTEEM

PREFACE.

THE modern revival, or rather development, of public interest in all matters relating to sanitary science, renders needless any apology for adding the present Manual of Health to the list of works dealing with hygiene in its various aspects. The object of this Manual is that of presenting to the student, and to the general reader as well, a popular and comprehensive account of the leading facts and features of sanitary laws. With this view, I have sought, as far as possible, to avoid undue technicality, and to lay stress on those phases of hygiene and its teachings which possess the most intimate bearings on public and personal health. I would fain hope that the Manual will possess some attraction for those who are desirous of acquiring information regarding the general scope of sanitary teaching, without reference to further utilisation of such knowledge than is comprised in the intelligent regulation of their health-details as individuals and as householders. For those who care or require to make the subject of hygiene a special study—as indicated, for example, in the Syllabus of that topic issued by the Science and Art Department—and for students in health-classes at large, this Manual may also be found useful. For the benefit of the latter class of readers, a series of questions, suitable for testing their progress in sanitary instruction, has been added as an Appendix to the work.

A. W.

EDINBURGH MEDICAL SCHOOL :
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MANUAL OF HEALTH.

CHAPTER I.

THE GENERAL CONDITIONS OF HEALTH.

HEALTH may naturally be defined as the pleasurable or painless discharge of all the functions through which our existence is maintained. The human body is a complex machine, the various organs of which are adapted each to perform a special duty, or 'function,' to use the physiological term. When each function is performed in a natural, unconstrained, and painless fashion, the sum total of this perfect discharge of bodily work is 'health.' Conversely, any disturbance of this condition of bodily equilibrium results in ill-health, or, to use the more familiar expression, 'disease.' From slight disturbances of health, in which the working of an organ has been interfered with to a slight extent only, onwards to grave interferences with the details of existence, there are many degrees, stages, and gradations; but all such interferences with the normal work of the body are to be classed under the designation of health-disturbance—seeing that even the slightest derangement of bodily functions may occasionally prove the precursor of serious maladies and affections. The aim and object of the science of Hygiene may be summed up in the statement that this branch of science takes cognisance of every cause and condition which contributes to the maintenance of health and the prevention of disease. Health-science coincides with that of medicine, in so far as both labour to prevent disease and prolong life. It is the aim of medicine to treat disease when the symptoms of disorder have actually appeared, and when health-disturbance has declared itself within the system. It is the province of hygiene to enable mankind so to place themselves in relation to their surroundings, and so to regulate their existence, that disease may be warded off, ailments rendered unlikely of occurrence, and length of days secured.

To this end, the science of health, as can readily be imagined, lays well-nigh every other branch of inquiry under contribution. It appeals to chemistry, for example, to afford information respecting the nature of air impurities, the composition of soils, the sources of water-contamination, and the composition of foods. It enlists natural philosophy in its service, when it seeks to know how sewer-gases gain access to our dwellings through faulty drainage, and how traps and other sanitary contrivances may be constructed so as to obviate these evils. It calls upon zoology and botany to explain the nature of the parasites, animal and plant, which infest our food and so render it liable to produce disease from acquiring the germs of these forms of life. It appeals to physiology, or the science of the functions of the body, to declare how, in the natural condition of things, the healthy frame performs its labours. It inquires of geology the nature and distribution of water supply; and it calls to its aid the technical skill of the house-builder, plumber, carpenter, and other artizans in the attempt to make 'the Englishman's castle,' in a sanitary sense, what it professes to be in a legal sense—a home and refuge from the ills and dangers of life.

The aims of hygiene are thus seen to be of a highly extensive kind and of somewhat complex order; in reality, however, they are of tolerably simple nature. The conditions necessary for the healthy existence of the human being are by no means either numerous or difficult of appreciation. Civilised existence is no doubt of itself a complex condition ; but the causes which produce disease, and the means at our hand for preventing disease, are, in either case, comparatively few. When humanity began to awaken to a knowledge of the fundamental fact underlying all health science, namely, that man is largely the minister and maker of his own fortunes or misfortunes in the way of health, the first step was taken towards a rational solution of the problems of sanitary science.

In early eras of thought, disease was assumed to be a mysterious principle invading the human domain ; and when bodily disorder, as often as not, was regarded as the gift of the gods, it was not wonderful that mankind should esteem the task of preventing disease a hopeless and unprofitable labour. The fever which walked abroad at noonday was regarded as beyond the power of human knowledge to explain. The epileptic fit was believed to be caused by demoniacal possession ; plagues were regarded as judgments ; and the entire course of human events tended, in early history, to place disease utterly beyond the province and scope of human knowledge. To-day, this state of matters has been completely changed. The fever can now be traced pretty accurately to its origin ; the plague is investigated, and its causes are tolerably well understood. The mysterious diseases of brain and mind have been, and are being, investigated ; and thus health-science progresses hand in hand with the art of healing, in placing disease and its phenomena within the sphere of accurate scientific investigation.

That man possesses the power of preventing many of the ailments which shorten his life and decimate the population of the globe, has been alluded to as a fundamental axiom of hygiene. If proof of this statement were wanting, we should find it in the story which science has to tell regarding the improvement of public health which has taken place even within the last two or three centuries. Dr. Guy, in his work on 'Public Health,' tells us that in the twelfth century as many as fifteen plagues, and many famines, devastated the civilised world. To this succeeded twenty epidemics and nineteen famines in the thirteenth century; whilst the fourteenth century saw, in its earlier part, eight epidemics and many famines. In 1348, the 'Black Death,' or Great Mortality, first appeared in this country. It came from the east, and, spreading westwards, attacked England with marked ferocity. Over one hundred thousand persons died of this malady in London alone. Throughout Europe twenty-five millions perished. To the 'Black Death' succeeded the 'Sweating Sickness' of 1485. This disease was no foreign invader, but appears to have been generated by the insanitary conditions of the life of the period. It attacked for the most part middle-aged men, and killed off an immense proportion of the adult population. The last visit of the 'Sweating Sickness' occurred in 1551. Succeeding this disorder came the Plague, which the Great Fire of 1666 terminated.

Meanwhile, the slowly growing but sure lessons which bitter experience was teaching the people, together with the rise of our modern civilisation, were beginning to exercise a distinct effect on the public health; and the idea of self-help in sanitary science was commencing to make its mark amongst thinking minds. Such men as John Howard, Jenner, and Capt. Cook appear before us as sanitary reformers, who in their day and generation accomplished much good work in the discovery of means of preventing some of the most serious diseases which have afflicted our race. In the eighteenth century the Black Death, Sweating Sickness, and the Plague had disappeared, never apparently to return; while Howard, in his reformation of the gaols and the consequent abolition of gaol-fever, proved himself a distinct pioneer in the history of hygiene. Capt. Cook and Jenner, by their respective work in the prevention of scurvy, and in the establishment of vaccination, similarly aided the science of healthy life.

The idea thus promulgated of the power of man to limit the scourges which decimate his kind, has further developed, and has been amazingly perfected. During the last half century, we have come to see that by strict attention to the drainage of our houses and by preventing accumulations of filth and decomposing sewage matter, we may practically command the inroads, and largely prevent the appearance, of the typhoid fever which breeds amid such surroundings. We know that by securing perfect ventilation of our houses, and by limiting overcrowding, we may prevent the appearance of typhus fever, which, in its turn, seems to breed amongst the foul, unchanged atmosphere found in the dwellings of the poor. We have been taught that by draining land and by abolishing damp, and by constructing our houses on dry soils, we may practically stamp out ague, a disease formerly common in this country but now seldom seen save in marshy and malarious districts. By supplying the crews of our ships with proper food we similarly, according to the lines of Capt. Cook's discoveries, abolish scurvy amongst our sailors ; and, through the protective influence of vaccination, we have learned to guard against those epidemics of small-pox which in former years literally ravaged the land.

Extending the lines of inquiry and research which have led to the improvement of public health in such a marked degree, we also become aware that personal or individual health, in the second place, is no less susceptible of being improved and established. Personal hygiene concerns itself with the regulation of individual life, as public hygiene devotes itself to investigating the laws which regulate the health of masses of individuals living gregariously in towns and cities. The lessons taught by health-science to the individual are founded on the same basis as those which hygiene inculcates on the mass. Thus the individual must firstly possess an intelligent conception of the normal and natural process or functions through which his life is maintained. This constitutes the study of physiology. He must become acquainted with the study of foods ; the quantities of food necessary for the human body under varying circumstances of life ; the scientific and economic preparation of foods, and the conditions necessary to be observed by way of ensuring their healthy digestion. He must know the composition of the beverages he imbibes, and their effects on the frame. He must be acquainted with the composition and properties of air, and of the means most suitable for the renewal of fresh air, and for the expulsion of effete air from his vicinity. Health-science, as further applied to the individual, will teach him the principles on which clothing may be properly constructed and adapted for the varying ages and conditions of life. He will be taught, similarly, the share played by rest, sleep, and cleanliness in maintaining health ; and, by way of further education in health-knowledge, he will naturally seek to know the elementary principles of medical and surgical science, and will acquire the knowledge which will fit him to render assistance to those who are in distress or danger, and who may demand his help in the absence of the physician or surgeon.

Divided thus into its two great aspects of *public health* and *personal health*, the science of hygiene is found to include every detail which can be shown to contribute towards the prevention of disease and the prolongation of life. The conditions for healthy living may be summed up in the statement that man requires pure food, pure air, a pure and sufficient water supply, a healthy home, well-ordered clothing, the exercise of cleanliness, and the power to aid himself and his fellows when in danger of disease or death. To this end, every civilised nation assists itself by legislation, and by the enactment of laws which deal with the questions of health and with the prevention of disease. Doubtless these laws are absolute necessities of our time. All progress requires a guiding hand; and the concentrated wisdom of health-reformers, formulated in the health laws of governments, aids in protecting the weak and in strengthening the hands of those who desire to reform abuses and to secure healthy lives and sanitary dwellings for the people. But beyond and above all class and national legislation, and far exceeding in power the compulsory enactments of Governments and States, lies the intelligent culture of health-science by the individual. The progress of health is, after all, an individual rather than a national question. The safety of the nation consists in the exercise, by individual effort, of health-laws and statutes. The unit who observes faithfully every detail of hygiene in his own person and home, is liable at any moment to suffer from the ignorance of his fellows who may neglect the precautions he himself is so anxious and careful to observe. The dairyman who ignorantly washes his utensils with water drawn from a polluted stream may spread abroad typhoid fever among ignorant and cultured alike. The parent who, through ignorance of health, lets loose his child to mix with its fellows before it has completely recovered from an infectious disease, overrides, through his ignorance, all the precautions which others may take by way of guarding their offspring against infection.

It is in health-science, as in other departments of human inquiry and advance—it is to the individual culture of health-knowledge, and to the observance, by the units, of the laws of hygiene, that we can alone expect that general advance in the art of prolonging life which the present age is so earnestly striving to attain.

CHAPTER II.

THE GENERAL FUNCTIONS OF THE BODY.

In order that we may clearly appreciate the true bearings of the laws of health in their relation to the preservation of the individual existence, a knowledge of the general physiology of the body is necessary. *Physiology* is the 'Science of Functions.' In this light, the science explains to us the manner in which the various actions of the bodily organs are performed. Life, as we have seen, may be regarded, in one sense, as the sum total of all the actions whereby an animal or plant maintains its normal and healthy existence. Hence, of old, 'Physiology' was not inaptly designated the 'Science of Life.' To-day, and in modern scientific estimation, it is that branch of science which deals with the *functions* or *duties* performed by the various organs and systems of the body. But physiology itself is based on the science of *Anatomy*. In other words, we must first know the *structure* and *build* of an organ before we can intelligently understand its duties—we must know what an organ *is*, before we can understand what the organ *does*. Thus anatomy is the 'science of structure,' as physiology is the 'science of function'; and preparation in the former science is needful for the appreciation of the teachings of the latter branch of inquiry.

The human body in its general structure exhibits a type precisely similar to that on which the bodies of all other *Vertebrated* or 'backboned' animals are constructed. It consists in reality of a double tube (fig. 1), the limbs being appendages of the main axis or *trunk*. Thus we see in the familiar section of the sheep or ox, which the butcher makes lengthwise through the animal's body so as to divide it in two, the double-tube arrangement which is characteristic of man and of all other Vertebrata. The first tube is formed by the *skull* and *spine.* It is a bony canal, within which are lodged the great *nerve-centres*, consisting of the *brain and spinal cord.* Hence this first tube was to be called the *neural* or *nervous tube* (see fig. 1), or, from the fact that it occupies the back region, we may name it the *dorsal tube.* The second tube is formed by the walls of the body, in front of

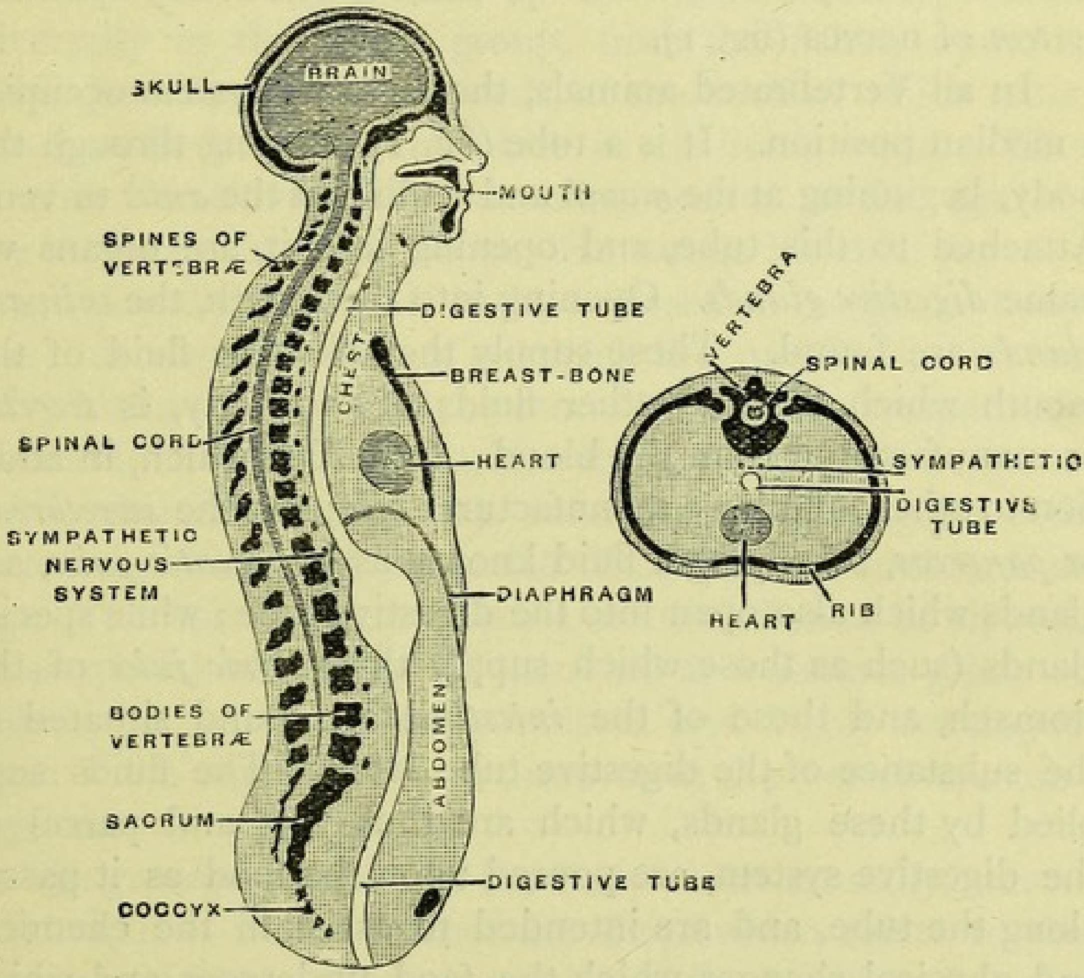

FIG. 1.—Diagrammatic section of body, longitudinal and transverse.

the spine. The ribs, with the breast-bone in front, bound this second tube in the *chest-region* ; while below, the walls of the *abdomen*, or lower cavity of the body, constitute its boundaries. The positions of the systems or organs of which the Vertebrate body is built up are highly characteristic, and are seen in no other type of animal life. The chief nervous centres, consisting of brain and spinal cord (fig. 1), are contained, as we have seen, in their own special tube, They lie dorsally, or along the back. Within the second tube we find enclosed the other systems of organs, viz., the digestive organs ; the heart or centre of the blood system ; the excretory organs (lungs and kidneys, &c.), or those devoted to the separation and conveyance of waste from the body ; the reproductive organs ; and lastly, a second nervous system, devoted chiefly to governing parts which are involuntary in their action, and named the *sympathetic system* of nerves (fig. 1).

In all Vertebrated animals, the digestive system occupies a median position. It is a tube (fig. 1), running through the body, beginning at the *mouth* and ending at the *anus* or vent. Attached to this tube, and opening into it, are organs we name *digestive glands.* Opening into the mouth, the *salivary glands* are found. These supply the *saliva* or fluid of the mouth which, like the other fluids of the body, is *secreted* or manufactured from the blood. The *liver* which, in addition to other functions, manufactures *bile* ; and the *sweetbread* or *pancreas*, supplying a fluid known as *pancreatic juice*, are glands which also open into the digestive tube ; while special glands (such as those which supply the *gastric juice* of the stomach, and those of the *intestine*) are found situated in the substance of the digestive tube itself. The fluids supplied by these glands, which are thus part and parcel of the digestive system, are poured upon the food as it passes along the tube, and are intended to assist in the chemical and physical changes which the food undergoes and which we term collectively *digestion.*

The *heart*, as the centre of the blood system, occupies in Vertebrate animals a *ventral* position (fig. 1); that is, it lies below the digestive tube, on the floor of the body, if we think of the body as existing in lower animals ; or we may speak of the heart as lying in front of the digestive tube, if we take the erect posture of man into consideration. As a fish swims, as a crocodile, dog, or horse walks, the heart is nearest the ground, and it occupies a precisely similar position in man, being simply brought to the 'front' of the human body by man's special mode of progression. Lastly, the *sympathetic nervous system* occupies in vertebrate animals a position in front of the spine (fig. 1) and behind the digestive system. It appears essentially as a double chain of nervous masses (or *ganglia*), connected by nervous cords.

Man thus shares the general characters of all Vertebrated animals. His body is built up on the common type seen universally in that great group, from the fishes, upwards to the quadrupeds or Mammals, at the head of which latter class man finds his natural place in the living world. Like all other Vertebrates, his characters consist in the double-tube arrangement of his body. He carries his chief nervous system dorsally, or in his back, enclosed in its special bony tube; his digestive system occupies the middle line of the body; his heart lies lowest, or ventrally; and his sympathetic system of nerves, in its turn, lies above the digestive system. In his other characters as an animal form, man agrees with the features which the naturalist discovers in Vertebrates at large. The human characteristics are therefore to be viewed, not as special belongings of mankind as a distinct group of animals, but as the most specialised and highly developed stages of the organisation we discover in the Vertebrate sub-kingdom.

The *general functions* of the body which naturally interest the student of health-science are those which relate to the digestion of food, to the circulation of the blood, and to the work of excretion, or that of getting rid of the waste materials, the production of which is inseparable from the ordinary work of living and being. The subject of foods and their uses will be hereafter considered. We may in the present instance, therefore, seek to form a broad view of living functions such as will fit us for the understanding of the numerous points which the investigation of the conditions of health necessarily involves. It is impossible to appreciate, with intelligence, the necessity for fresh air as an absolutely essential condition of health, without a knowledge of the details of the breathing or respiratory function and its nature. Similarly, the study of foods is largely assisted by a knowledge of the digestive processes; and the story of the heart, and its work in circulating blood, likewise forms an essential part of preliminary health-studies. The necessity of attending to the functions of the skin as a health-measure can only be understood when we know what the skin is and what the skin does; and the general details of the body's structure and functions are essential parts of that scheme, whereby we are enabled to assist those who are in danger of death from accidental injury. Knowledge of general physiology, with its implied anatomical details, lies at the root of health-science at large. In this light, therefore, we may enter upon a brief account of the general functions of the body and their bearing on the maintenance of normal life.

The function of *digestion* may be defined as that whereby the food is converted into a fluid (*chyle*) adapted to replenish and renew the blood. The organs concerned in digestion are the *digestive tube* already noted and the *glands* connected therewith—liver, pancreas, &c. The terms *alimentary canal* or *alimentary tract* are frequently applied to this system. The work of digestion may be divided into three stages:—1, digestion in the *mouth*; 2, digestion in the *stomach*; and 3, digestion in the *intestine.* Each stage passes naturally into the next; but each, nevertheless, presents certain characteristics of its own.

In the *mouth*, the food is subjected to three processes. It is firstly divided by the *teeth*, this act constituting the work of *mastication*; it is secondly mixed with the *saliva*, or fluid of the mouth, this act being known as *insalivation*; while it is thirdly swallowed, the latter process being named *deglutition.*

The *Teeth* number twenty in the first set, and thirty-two in the second, or permanent, set (fig. 2). There exist in each of the jaws of the adult four incisors, or front teeth, two canines, or eye-teeth, four premolars, or bicuspids, and six molars, or grinders—sixteen in all. As the molars are wanting in the first set, there exist only ten teeth in each jaw of the young child, giving a total of twenty. The last molar is popularly known as the 'wisdom tooth.' There seems to be a tendency on the part of these teeth to become rudimentary in civilised races. By the teeth the food is divided, and thus adapted for being easily acted upon by the gastric juice of the stomach. The practice

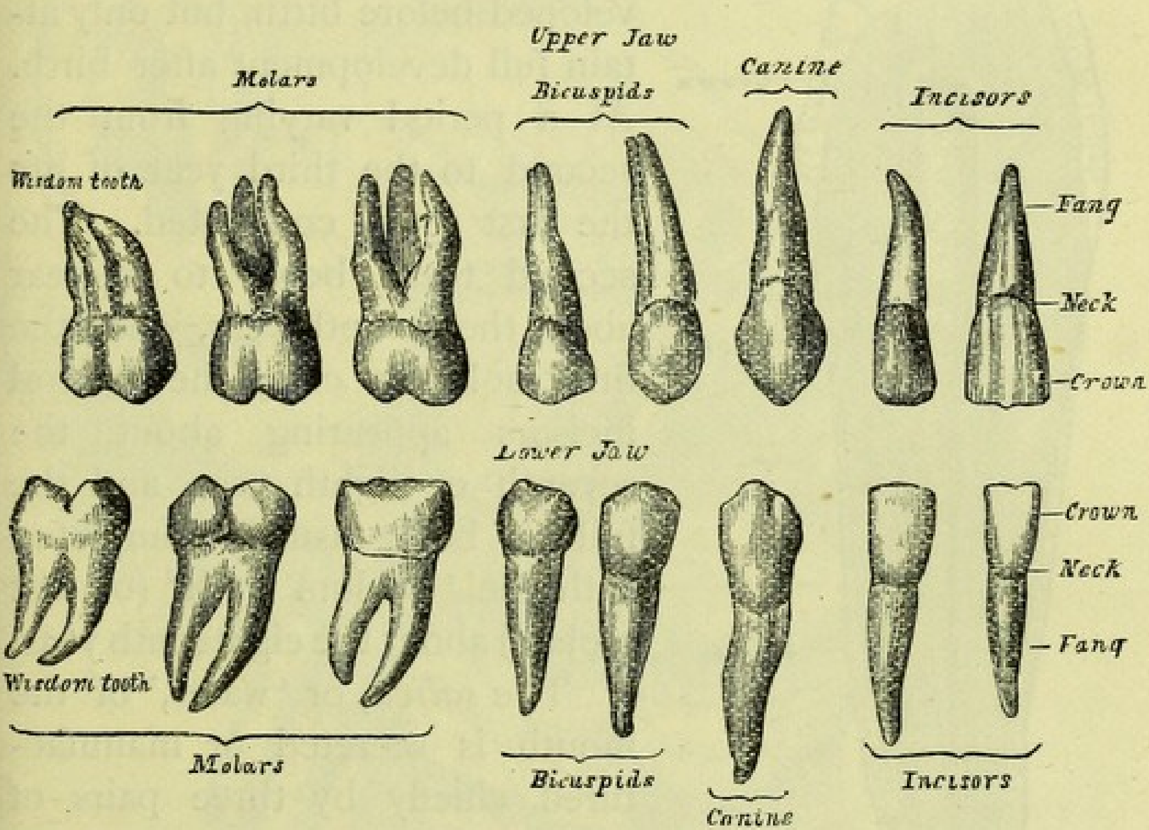

FIG. 2.—The permanent teeth removed from the jaws.

of 'bolting' the food is often the beginning and cause of serious digestive ailment. Hence attention to the health of the teeth, and to keeping them clean and in good order, is a measure which unquestionably tends towards the prevention of disease. Teeth, it may be noted, are developed from the mucous membrane of the mouth, or 'gum' as it is familiarly termed. They are organs which therefore belong to the skin structures, and, as such, are related in their essential nature to nails and hairs. Each tooth (fig. 3) consists of *dentine*, or *ivory*, the top of the tooth being coated with *enamel*, and the roots, or 'fangs,' with a substance named *cement*. The interior of the tooth, as shown in the figure, is hollow, and contains the *pulp*, which, being richly supplied with nerves and blood-vessels, serves to nourish the tooth-substance. The first teeth appear about the seventh month after birth, when the central incisors of the lower jaw are cut. All the teeth, it may be noted, begin to be developed before birth, but only attain full development after birth. At a period varying from the second to the third year of life the first set is completed. The second teeth begin to appear about the seventh year, when the first molar is cut; the central incisors appearing about the seventh or eighth year, and the full set being usually completed with the 'wisdom teeth' (or last molars) about the eighteenth year.

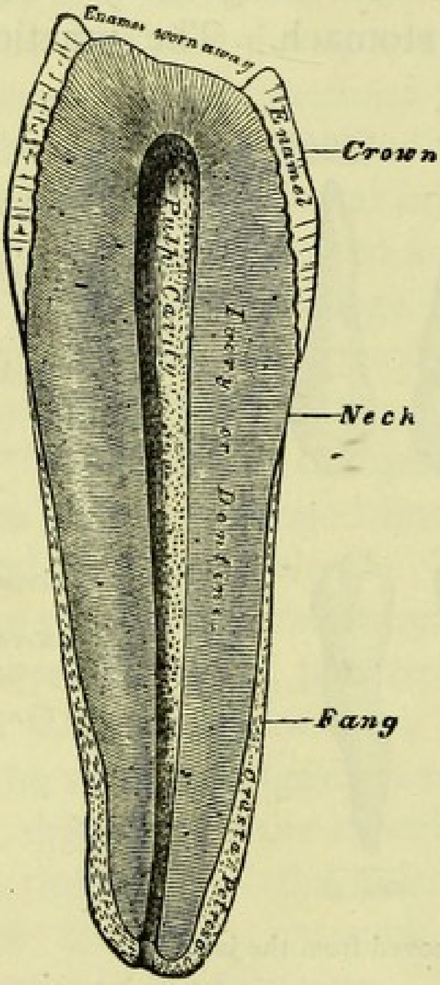

FIG. 3.—Vertical section of a bicuspid tooth.

The *saliva*, or 'water,' of the mouth is secreted or manufactured chiefly by three pairs of *salivary glands* (fig. 4). Of these, the first and largest pair is situated below and in front of the ears; these are the *parotid glands*, (fig. 4), which are liable to become inflamed in the disease known as 'mumps.' The other two pairs (*submaxillary* and *sublingual glands*) (fig. 4) lie within the mouth-cavity, each salivary gland opening into the mouth by a tube (*salivary duct*) of its own. Other and minor glands are found in the walls of the mouth. These glands secrete saliva from the blood with which they are supplied. The active agents in this and allied works of *secretion* are the *cells* (fig. 5) found in the glands. These cells are microscopic particles of living matter (or *protoplasm*), and it is only by referring the work of secretion to their properties and powers, that we can account for the differences between

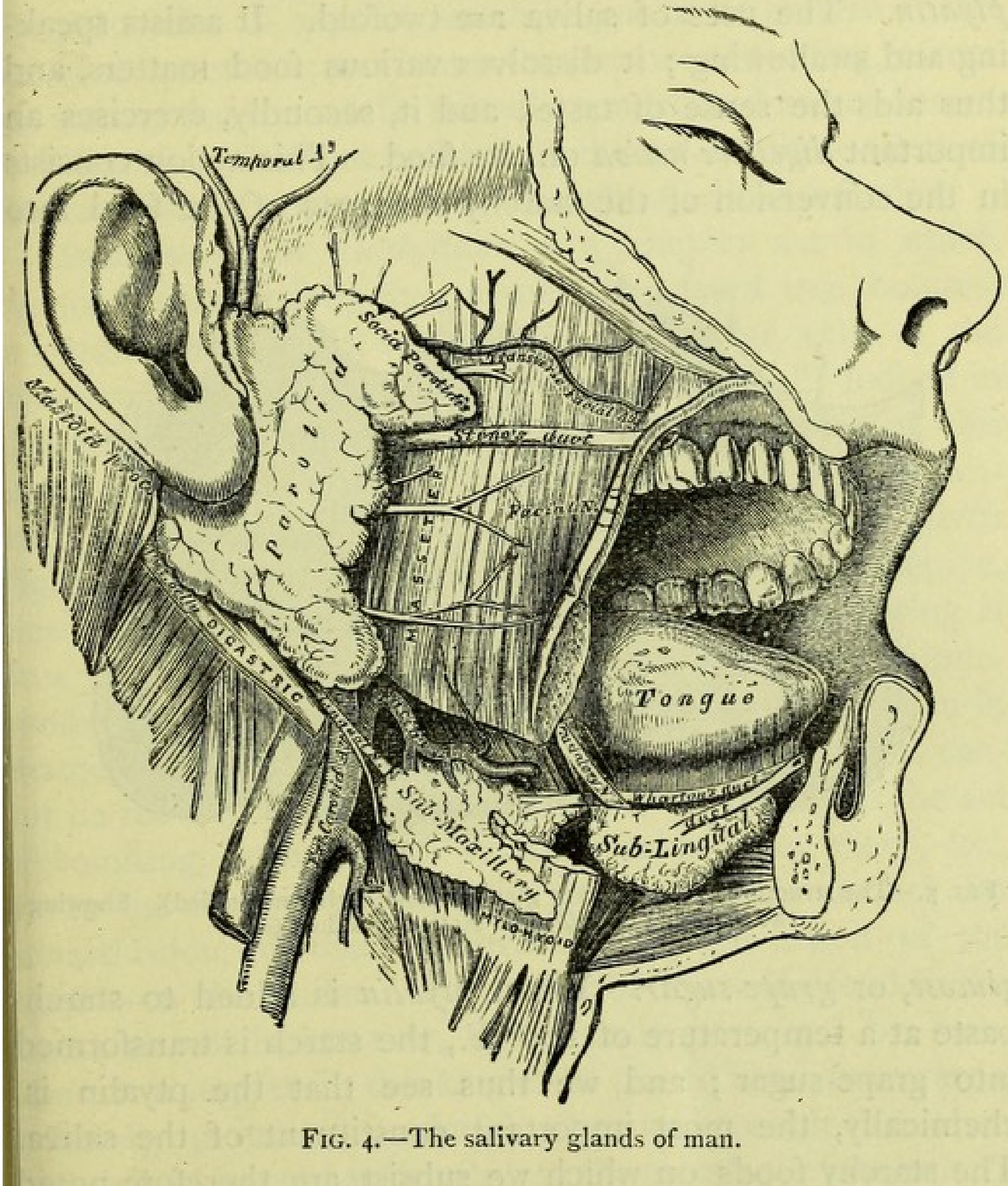

FIG. 4.—The salivary glands of man.

the secretions of various glands—that we can understand how, from one and the same material, namely, the blood, one gland, the liver, manufactures bile; another, the pancreas, sweetbread-juice; another set, the eye-glands, tears; and a fourth set, the stomach glands, gastric juice.

Saliva is a fluid, alkaline in its nature, with a specific gravity varying from 1·005 to 1·009. It is composed of water, minerals, fat, various matters derived from the lining membrane of the mouth, and of a special substance or 'ferment,' found in no other fluid of the body, and named *ptyalin.* The uses of saliva are twofold. It assists speaking and swallowing; it dissolves various food matters, and thus aids the sense of taste; and it, secondly, exercises an important *digestive action* on the food. This action consists in the conversion of the starchy elements of the food into

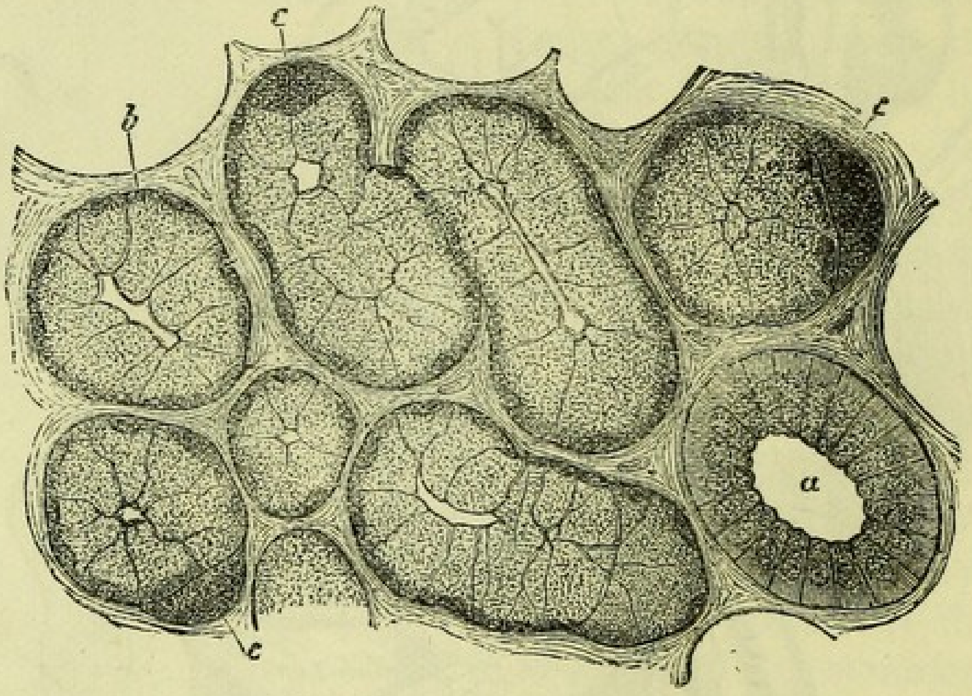

FIG. 5.—The structure of the salivary gland of dog (highly magnified). Showing the secreting cells (*b*) and section of a duct (*a*).

glucose, or *grape-sugar.* When *ptyalin* is added to starch-paste at a temperature of 100° F., the starch is transformed into grape-sugar; and we thus see that the ptyalin is chemically, the most important constituent of the saliva. The starchy foods on which we subsist are therefore noted to undergo a preliminary digestive process in the mouth; and the importance of allowing the food full time for mastication as a health-measure is augmented, when we reflect upon the importance, in its digestive action, of the salivary secretion. The saliva is also held to be useful in preventing decay of the teeth, and in assisting the sense of hearing by keeping the 'Eustachian tube' of the ear (which opens into the mouth) more or less continually open through the acts of swallowing which the constant secretion of saliva necessitates. The saliva of young infants does not contain the proportion of ptyalin, which begins to be present at the age of six months or so; hence the practice of feeding infants on starchy foods is to be soundly condemned as conducive to ill-health. Eminent authorities, indeed, attribute much of the mortality of young infants to such injudicious feeding.

Swallowing, or *Deglutition*, is a complex act in which the food, collected by the tongue and massed into boluses, is pressed backwards, seized by the muscular walls of the *pharynx*, or hinder part of the mouth, and finally lodged in the gullet (or *œsophagus*) (fig. 6). The muscles of this latter tube, in their turn, propel the masses of food downward to the stomach. Choking is prevented by the *epiglottis* (fig. 6), or little lid protecting the opening of the windpipe, closing over the entrance to the latter tube. Swallowing is thus largely an *involuntary* act; that is, is performed independently of the will. Once the morsel has been taken in charge by the muscular arrangements of the throat, it cannot be recalled by any exercise of the will. Only in the act of vomiting, or in that of 'rumination,' in cows, sheep, &c., where the food is periodically returned to the mouth for remastication, is there a reversion of the action of the muscles of the gullet. The power of returning food to the mouth at will is, however, occasionally possessed by man. The act of jugglers in drinking while placed head downwards, is thus by no means wonderful, when we consider that when food or fluid is sent backwards into the mouth, the involuntary mechanism of swallowing intervenes to complete the act.

The food now passes into the *stomach* (figs. 7 and 8), entering the organ from the gullet by the *cardiac* aperture (fig. 7, c) of the organ. The stomach is merely a dilatation or expansion of the digestive tube which is seen so typically in the gullet and in the intestine, or bowel (fig. 7), which succeeds the stomach itself. The stomach is a pear-shaped

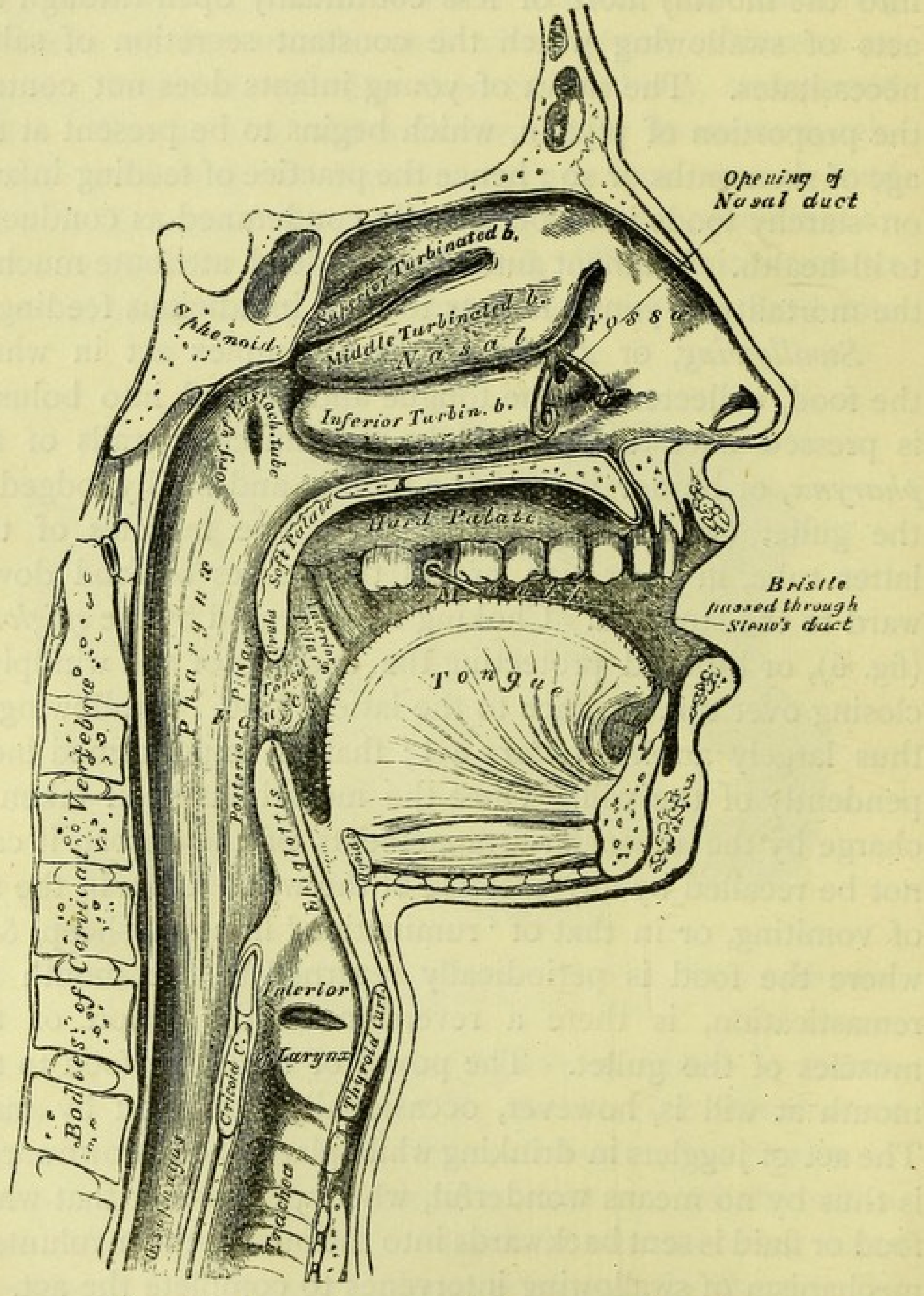

FIG. 6.—The mouth, nose, and pharynx, seen in section.

bag, lying somewhat obliquely in the abdomen, and having the liver (fig. 8, *l*) on its right (viewing the body from the front), the spleen (*m*) to the left, and the pancreas (*b*) somewhat behind and below. In structure, the stomach, like the rest of the digestive tube, is composed of several 'coats' or layers, the inner coat being that with which the food comes into contact, and being named the *mucous* or *glandular coat.* The *muscular coat* of the stomach consists of involuntary fibres, and provides for the movements of the organ which mix the food thoroughly with the gastric juice. The cubic capacity of the adult human stomach is about five pints. The organ is continued by its hinder extremity into the *small intestine* (or bowel) (fig. 7, D) ; the name *pyloric aperture* (P) being given to that by which the food leaves the stomach. This opening is guarded by a muscular valve, which prevents the food leaving the stomach until digestion therein has been completed.

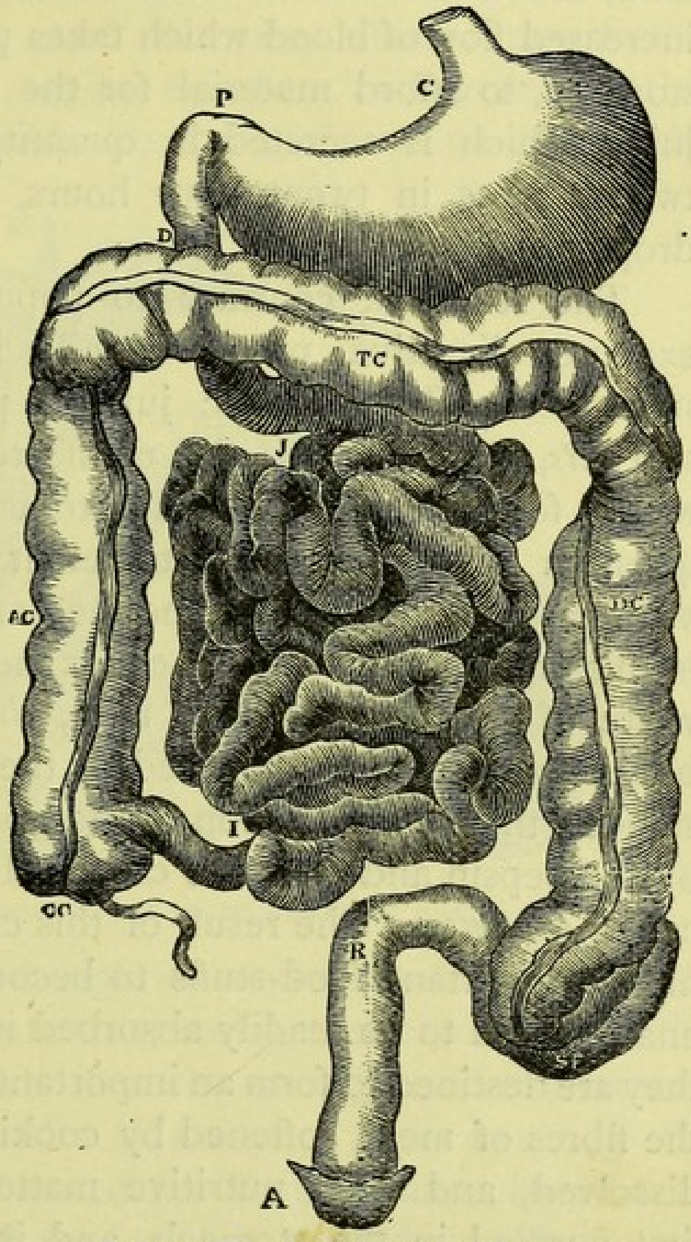

FIG. 7.—The digestive tube of man.

The *gastric glands* which secrete the *gastric juice* are minute pocket-like depressions, situated in the substance of the walls of the stomach. These glands are lined by *cells*, which are the active agents in the manufacture of the gastric juice. This latter fluid is acid in its nature, contains water, minerals, free hydrochloric acid, and *pepsin.* Its specific gravity is about 1002·5. The solids amount to over 990 parts per 1000, the remainder being water. The *pepsin* is seen to be the special constituent of this fluid, as was ptyalin of saliva. Before food enters the stomach, the lining or mucous membrane of the organ is pale-coloured. After the entrance of food, the mucous membrane becomes reddened, from the increased flow of blood which takes place to the walls of the stomach, to afford material for the secretion of the gastric juice, which is secreted in quantity varying from ten to twenty pints in twenty-four hours, and is poured out in drops on the food.

The stomach, contrary to popular opinion, does not exercise digestive power equally in all kinds of food-substances. Thus gastric juice is powerless to digest *oils* and *fats*, while *starch* is also unaffected in the stomach. On which foods, then, does the stomach specially act? is a question answered by the statement that the *albuminous* or *nitrogenous* compounds of the food are affected and digested in this organ. Such substances as the *albumen* of meat juice, white of egg, &c., *casein* of milk, *gluten* of flour, *gelatin* of bones and horns, are digested by the stomach. These substances, through the action of the gastric juice, and specially by the pepsin and acid, are chemically changed into matters called *peptones.* The result of this change is to cause these highly important food-stuffs to become soluble, and thus to enable them to be readily absorbed into the blood, of which they are destined to form an important part. In the stomach, the fibres of meat, softened by cooking, are broken up and dissolved, and their nutritive matters extracted. Milk is first curdled in the stomach, and is then dissolved. The *nitrogenous* food-elements thus seized upon and modified by the stomach, pass through its walls, are probably conveyed to the liver, therein modified, and thence sent onward with the blood-circulation, to assist in the renewal and repair of the tissues at an early period of digestion.

At the close of digestion in the stomach, the food is converted into a pulpy mass called *chyme*, which consists of the comparatively unchanged fats, starches, and sugars, together with indigestible matters. By the contraction of the stomach, the chyme is forced onward into the first part of the long tube already noted, and named the intestine or bowel (fig. 7). In man the intestine measures about twenty-six feet in length, the *small intestine*, which immediately succeeds the stomach, making up about twenty feet of this measurement. The *duodenum* (fig. 8, *d*), or first part of the

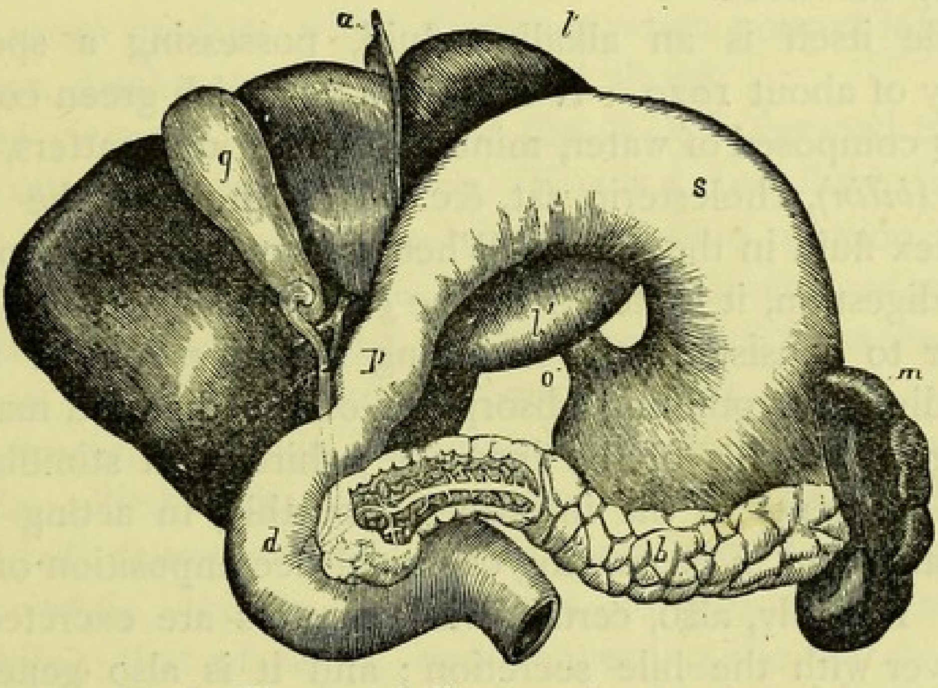

FIG. 8.—The stomach, liver, sweetbread, and spleen.

small intestine, is about eight or ten inches long, and is an important part of the intestine, seeing that the *bile* from the iver, and *pancreatic juice* from the sweetbread, or pancreas, are poured upon the food at this stage. In its structure, the intestine resembles the stomach. It has a muscular coat, by the contraction of which the food is propelled along its length, and imbedded in the lining membrane of the canal are various *intestinal glands* which pour their secretions on the food.

Of the digestive glands which materially affect the food (or *chyme*, as it may now be termed), the liver and pancreas are the most important. The *liver* (fig. 8, *l*) is the largest gland in the body. It is comprised of *lobules* or small rounded portions measuring $\frac{1}{20}$th of an inch in diameter, each of which in turn receives branches of blood-vessels and consists of the characteristic *cells* (*hepatic cells*) of the organ. These liver-cells vary from the $\frac{1}{800}$th to the $\frac{1}{1000}$th of an inch in diameter. They are the bile-makers. They elaborate the bile from the blood supply with which they are provided, and which is supplied to the liver by the *portal vein.* The bile passes out of the liver by a special tube or *duct*, which enters the *duodenum*, or first part of the small intestine already described.

Bile itself is an alkaline fluid, possessing a specific gravity of about 1020. It exhibits a yellowish-green colour, and is composed of water, minerals, colouring matters, bile acids (*bilin*), cholesterin, fat, &c. It is probably the most complex fluid in the body. When not required for immediate digestion, it is stored in the *gall-bladder* (*g*). Its uses appear to consist, firstly, in aiding the digestion of fats; secondly, in promoting absorption of the digested matters through the walls of the intestine; thirdly, in stimulating the movements of the intestines; fourthly, in acting antiseptically, and in preventing chemical decomposition of the food. Possibly, also, certain waste matters are excreted by the liver with the bile secretion; and it is also generally held that this organ assists in the elaboration of the blood. Lastly, the liver discharges what has been named a *glycogenic function.* The liver, in health, forms a substance resembling sugar, and named *glycogen*, and temporarily stores this substance, which is also allied in composition to starch. Formerly, Bernard thought that this substance, derived from the food, was converted by the liver into sugar, which in turn, he believed, was sent into the circulation and was used in the production of heat. Dr. Pavy, however, showed that, in health, no sugar could be detected in the vessels returning blood from the liver to the heart, and maintained that the conversion of glycogen into sugar only took place as an after-death change. Hence, Dr. Pavy believed that this glycogenic function of the liver represents a work ultimately destined to form fat from materials (starches and sugars) absorbed into the liver from the digestive system. In this latter view, the liver is regarded as a fat former; and the fat so formed, is considered to be used, in part at least, in the manufacture of bile. On a diet in which starches and sugars form prominent elements, the liver of the dog secretes glycogen in large quantity; while on nitrogenous foods alone, a moderate formation of this substance takes place. The bile in these later views of liver-function is regarded as representing a waste product, which, however, when poured into the intestine, discharges the duties noted above.

The *pancreas*, or *sweetbread* (fig. 8 *b*), is devoted to the manufacture of *pancreatic juice.* This is a clear fluid, added to the food along with the bile, of alkaline reaction, and composed of water, minerals, and several ferments, of which *pancreatin* is probably the chief. The effect of pancreatic juice on the food appears to consist, firstly, in its power over nitrogenous foods in converting them into peptones—an action allied to that of the stomach. Then also, it exerts a decided action on fats, emulsifying and decomposing them; while, thirdly, it possesses an action on starch, resembling that of saliva, and converting the starch into dextrin and grape sugar.

Mixed thus with the *bile* and *pancreatic juice*, and with the intestinal secretions, the food (or chyme) is converted in the course of its passage through the small intestine into a milk-like fluid named *chyle.* This latter fluid contains the food-elements modified and altered so as closely to resemble blood in their relations. It is alkaline in nature, and possesses a specific gravity ranging from 1012 to 1022. We have now to see how this chyle, containing all the elements necessary to replenish the blood, is conveyed to the current of the blood-circulation, which it is destined to repair. Already, in the chyle, we may find corpuscles or globules which resemble the white corpuscles of the blood ; and indeed chyle may be said to differ from blood chiefly in its want of coloured elements, and in its high proportion of fat.

The function by means of which chyle is removed from the digestive tube and conveyed to the blood system, is that known as *absorption.* This function is performed by means of vessels named *absorbents* or *lymphatics.* As the chyle passes along the intestine, it strains through the intestinal wall and chiefly through certain minute processes termed *villi* (fig. 9), of which immense numbers exist in the mucous membrane of the small intestine. Within each *villus* is the commencement of a fine vessel, named a *lacteal* or *absorbent* (fig. 9, 1). By these vessels, the chyle is carried onwards from the intestine to a tube lying along the left side of the spine, and named the *thoracic duct* (fig. 10, *a*). This duct, in its turn, ends in a large vein at the root of the neck on the left side (*c*), and it is, therefore, in this situation that the junction between the chyle and the blood, or between the food and the circulation, takes place. It seems probable that the absorbents, which begin in the villi of the intestine are mostly concerned in the absorption of *fats* ; whereas, other elements of the food appear to be absorbed directly into the blood-current by the fine blood-vessels of the digestive canal, and are conveyed to the liver, which exerts important changes in their constitution. It appears also probable that the chyle enters the blood-circulation at intervals. A large quantity enters the circulation about two hours after digestion has commenced.

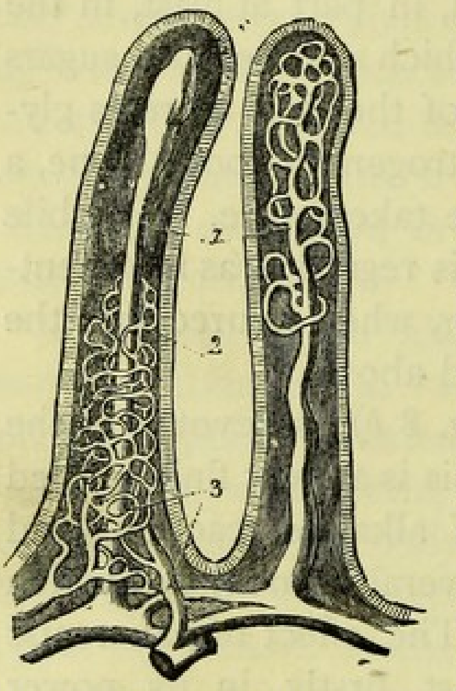

Fig. 9.—The villi of the intestine (highly magnified), showing absorbent vessels.

The function of 'absorption,' however, is not confined to the carriage of chyle from the digestive tract to the blood. Everywhere throughout the tissues of the body (fig. 10)

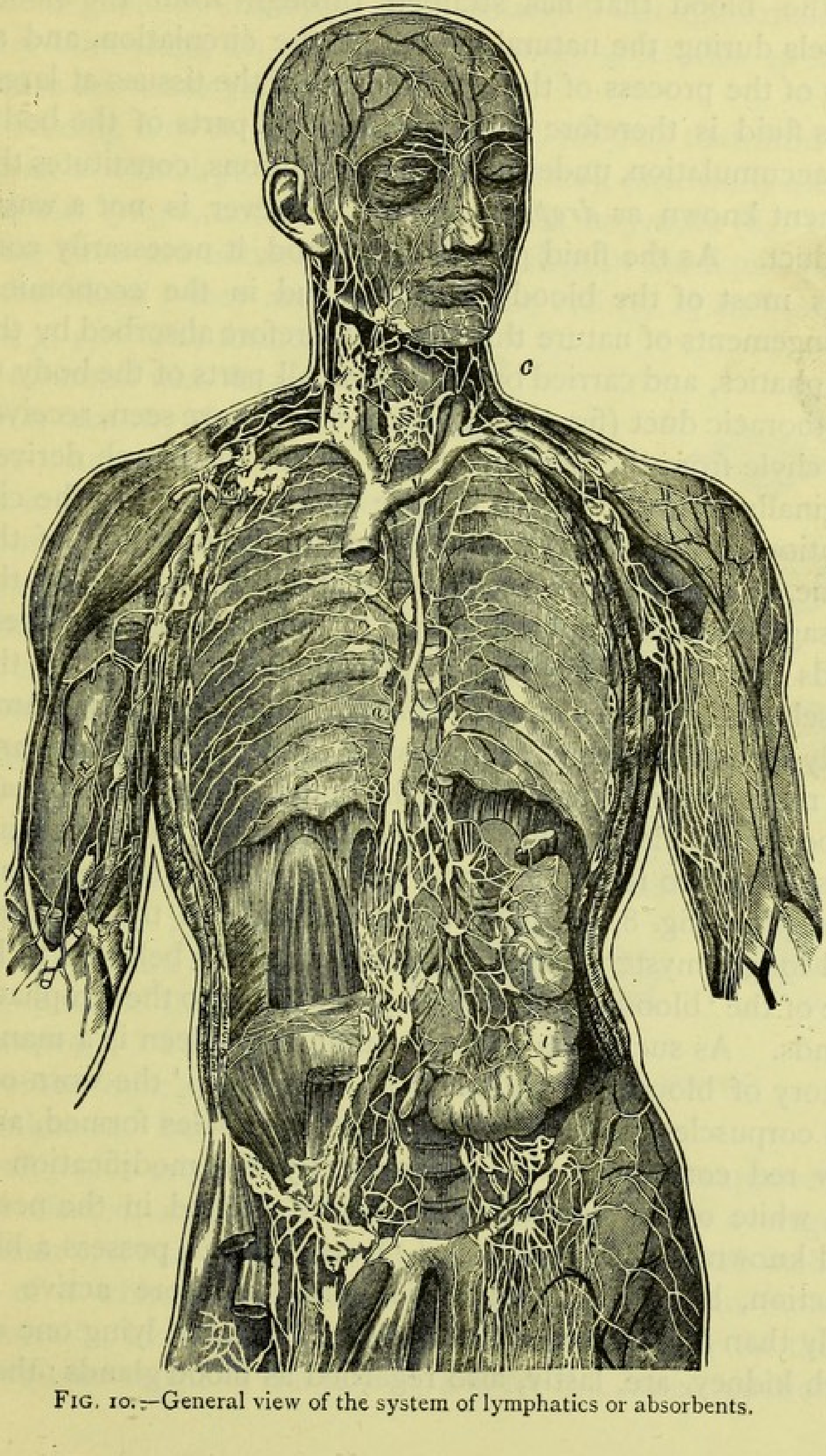

FIG. 10.—General view of the system of lymphatics or absorbents.

delicate *lymphatic vessels*, or *absorbents*, are found. These contain a fluid called *lymph*, which is merely the liquid part of the blood that has strained through from the blood-vessels during the natural course of the circulation, and as part of the process of the nourishment of the tissues at large. This fluid is therefore gathered from all parts of the body. Its accumulation, under abnormal conditions, constitutes the ailment known as *dropsy*. Lymph, however, is not a waste product. As the fluid part of the blood, it necessarily contains most of the blood-elements ; and in the economical arrangements of nature this fluid is therefore absorbed by the lymphatics, and carried by them from all parts of the body to the thoracic duct (fig. 10, *a*), which, as we have seen, receives the chyle from the digestive tract. Thus the lymph derived originally from the blood, is once again returned to the circulation, and made to do duty anew in the nutrition of the frame. It may lastly be noted, that in the course of the passage both of lymph and chyle to the thoracic duct, these fluids traverse certain organs placed in the course of the vessels, and named *lymphatic glands*. These glands are familiarly seen in the groin, armpit, sides of the neck (fig. 10), and are numerous in other parts of the body. Their duty appears to be that of elaborating the chyle and lymph, and of causing these fluids to resemble blood more closely in composition. The *spleen* (fig. 8, *m*), lying to the left side of the stomach, and long a mystery as to its functions, is now believed to be one of the 'blood glands' allied in its nature to the lymphatic glands. As such, it is probable that the spleen is a manufactory of blood corpuscles. Within its 'pulp' the worn-out red corpuscles are broken up, white corpuscles formed, and new red corpuscles also produced by the modification of the white ones. Probably the glands situated in the neck, and known as the *thyroid* and *thymus glands*, possess a like function, but these glands are doubtless more active in early than in later life. The *suprarenal bodies*, lying one on each kidney, are, lastly, also regarded as blood glands ; their special mission being probably connected with the development of the colouring elements of blood and body. The thyroid gland of the neck, when enlarged through drinking water containing an excess of minerals, gives rise to the disease known as *goître.*

Passing now to consider the *blood*, we find that fluid to consist of a fluid part (the *serum* or *plasma*), practically identical with *lymph*, and of solid parts—the *corpuscles* (fig. 11). These latter are minute bodies which float in the liquid part of the blood; they are of two kinds, *red* (*r*, *r*) and *white* (*c*, *c*, *p*, *g*). The former are coloured with *hæmoglobin*, are by far the more numerous, and give to the blood its red colour. They carry the gases of the blood, the *hæmoglobin* being the special element concerned in this action. Oxygen gives a light red tint, and carbonic acid gas a dark purple tint to the corpuscles; thus producing the light and dark (or arterial and venous) tints of the blood respectively. The function of the white globules is unknown, but they probably give origin to the red globules, an action supposed to be effected, as already noted, in the spleen. The average diameter of a red corpuscle of man is the $\frac{1}{3000}$th of an inch, that of a white corpuscle being the $\frac{1}{2500}$th of an inch. Chemically, blood contains the elements necessary for the renewal and repair of the tissues, and for this latter function

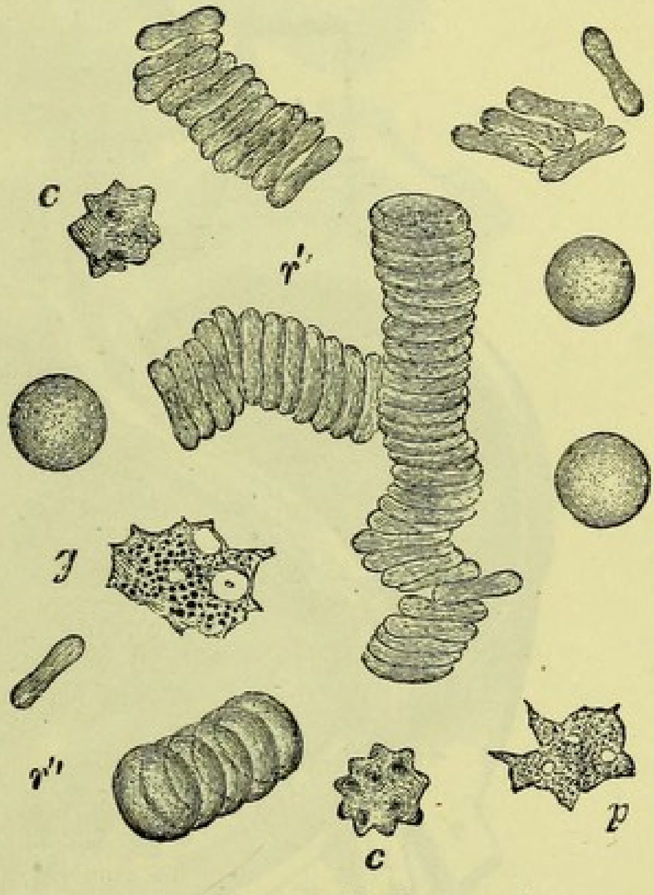

FIG. 11.—Human blood corpuscles (highly magnified).

it requires to be *circulated*, or to perform an incessant round of duties.

The *circulation of the blood*, in addition to its work of *nourishment*, discharges certain other important functions.

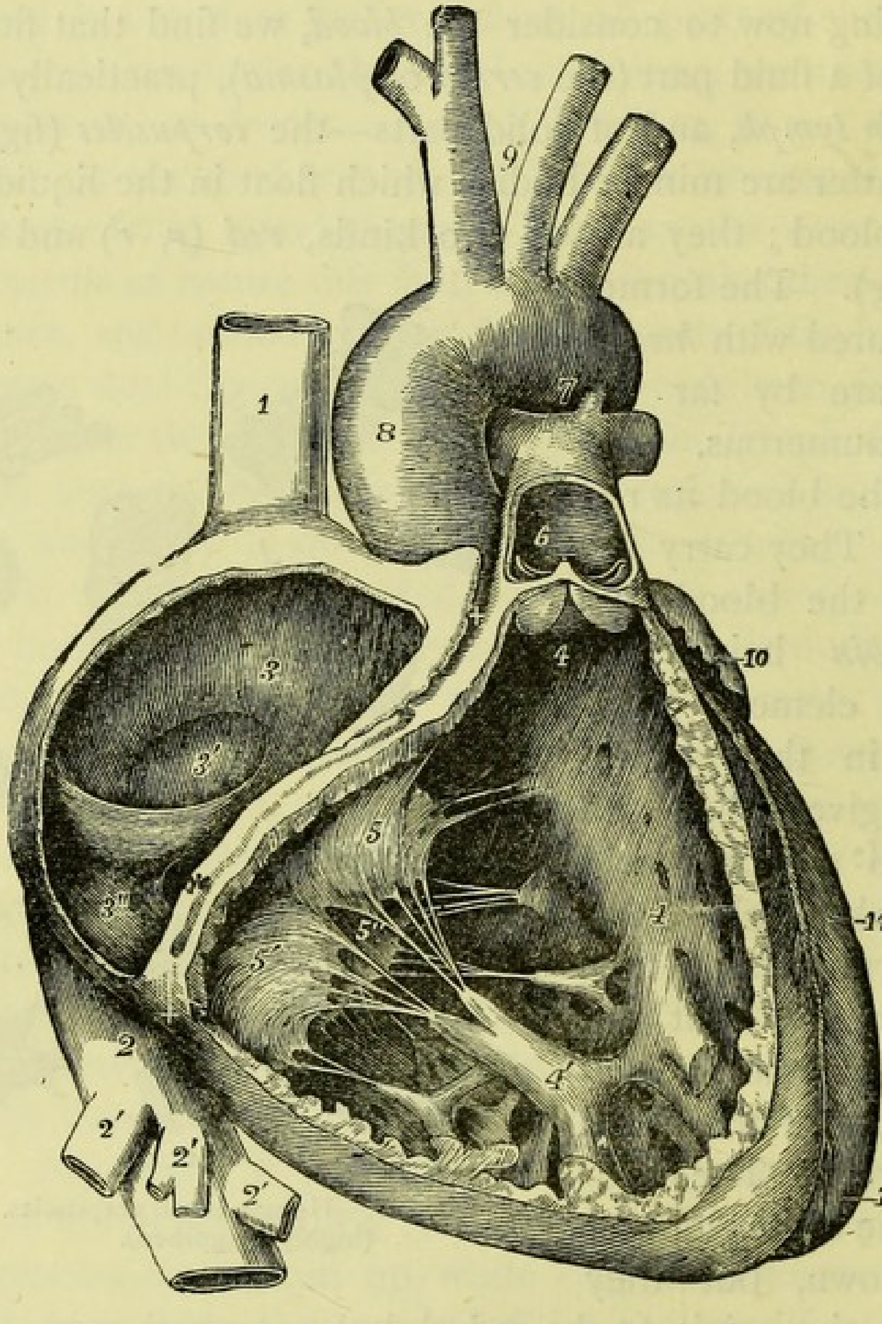

FIG. 12.—Right side of heart dissected, showing its valves.

Thus it distributes heat, conveys the oxygen breathed in from the atmosphere to the tissues, supplies raw material for the elaboration of the secretions (bile, saliva, tears, &c.), and, lastly, acts as a carrier of waste products to the organs (lungs, skin, and kidneys) specially intended to remove these products from the economy.

The circulation is carried out by means of the *heart* and

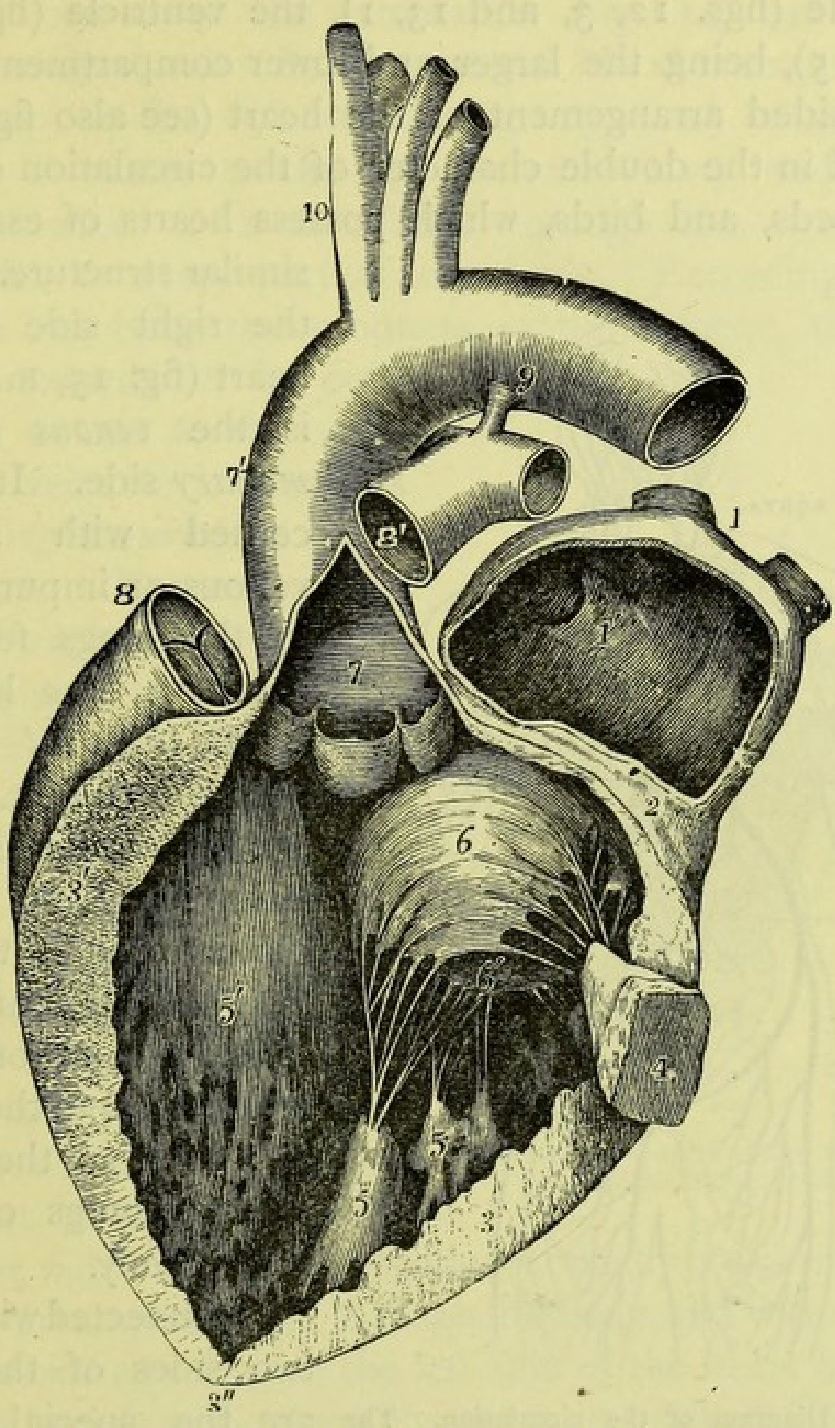

FIG. 13.—Left side of heart dissected, showing its valves.

blood-vessels. The heart itself is merely a hollow muscle, and the force which it exerts in driving blood through the system is therefore essentially that represented in the work of the ordinary muscles of the frame. The human heart is a two-sided or double organ. Each *side* (*right* and *left*) is divided into two chambers, named respectively *auricle* and *ventricle.* The auricle is the smaller and upper chamber of each side (figs. 12, 3, and 13, 1), the ventricle (fig. 12, 4, and 13, 5), being the larger and lower compartment. The double-sided arrangement of the heart (see also fig. 15) is reflected in the double character of the circulation of man, quadrupeds, and birds, which possess hearts of essentially similar structure. Thus the right side of the heart (fig. 15, R.A., R.V.) is the *venous* or *pulmonary* side. It is concerned with sending venous or impure blood to the lungs for purification. The left side is the *arterial* or *systemic* side (L.A., L.V.), and is concerned with circulating pure or arterial blood through the system. Blood cannot pass directly from one side of the heart to the other, but must go the round of the lungs or body respectively.

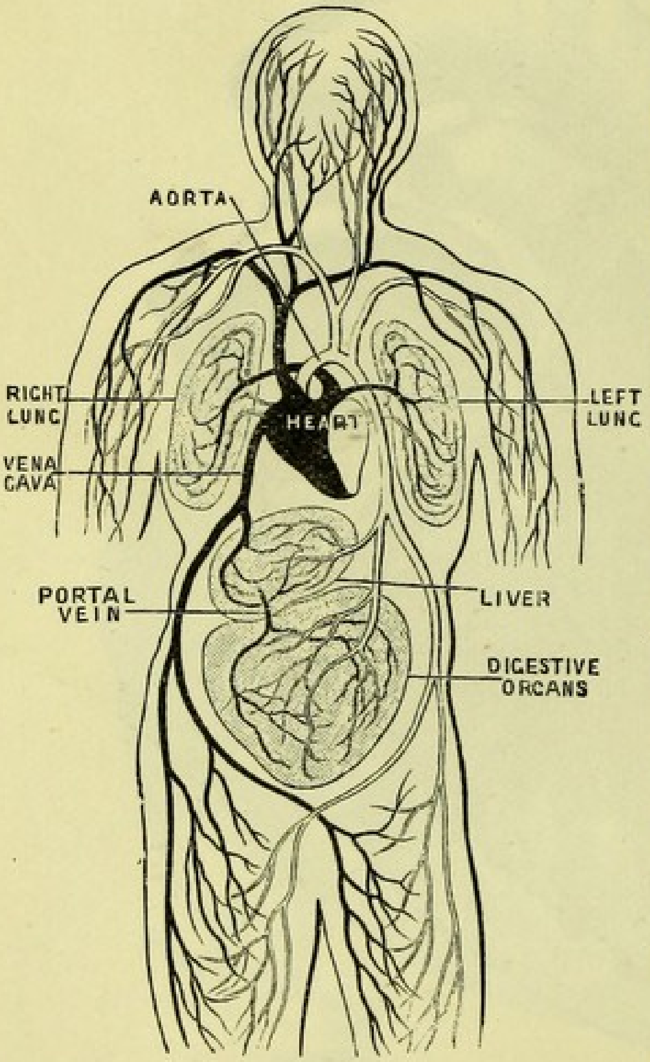

FIG. 14.—Diagram of the circulation. The arteries are shown white, and the veins black.

Connected with these two sides of the heart are the special blood-vessels of the body. The *arteries* are thus the vessels which carry pure blood from heart to body. The *veins*, conversely, return impure blood from the body to heart and lungs. Connecting the outgoing arteries with the incoming or returning veins, are the *capillaries*, or minute blood-vessels, which, forming meshworks of delicately fine nature, supply the minutest parts and tissues with the nutrient fluid.

The course of the circulation (fig. 14) can now be readily understood. Pure or arterial blood is returned from the lungs to the *left auricle* (fig. 15, L.A.) of the heart. Thence it passes to the *left ventricle* (L.V.), and by this latter chamber it is circulated through the arteries and capillaries to every part of the body. Becoming impure through receiving the products of tissue-waste, the blood passes onwards in its continuous course to the *veins*. By the veins it is returned to the *right auricle* (R.A.) of the heart. Thence passing into the *right ventricle* (R.V.), it is driven by this latter chamber to the lungs. After purification in the lungs, the blood returns to the left auricle, whence, as we have seen, it is again sent on its incessant round. Thus there is one circulation through the lungs (named the *pulmonary circulation*), and with this part of the circulatory work the right side of the heart is practically concerned. The second circulation is that through the body, and with this latter (the *systemic* circulation) the left side of the heart has to do.

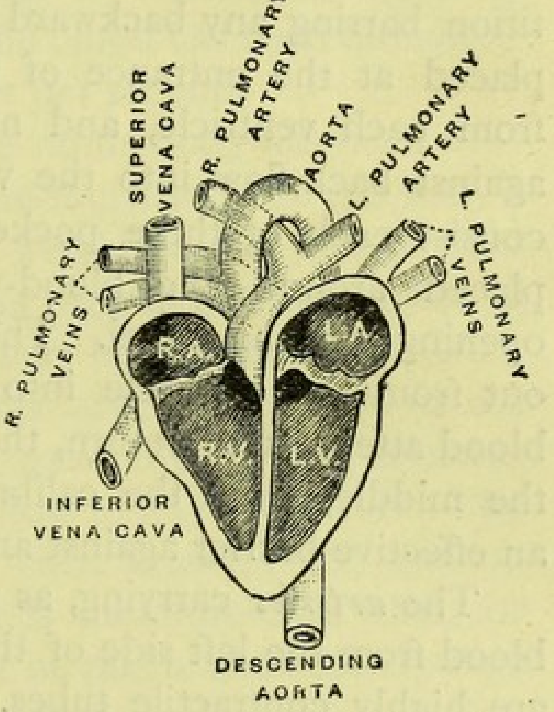

FIG. 15.—Theoretical (vertical) section of the human heart.

The heart's work alone shows us, in marked fashion, the literally enormous extent of the bodily labour. It is calculated that in twenty-four hours an adult's heart performs an amount of work which, if exerted in one huge lift, would be equal to raising 120 tons one foot high. The heart beats in the adult from seventy to seventy-five times per minute, and its auricles contract simultaneously, as also do the ventricles. Valves regulate the flow of blood through the chambers of each side, and prevent regurgitation, or back-flow of blood. Thus the *mitral* (or *bicuspid*) *valve* (fig. 13, 6), between the left auricle and ventricle, prevents the blood which has passed from the auricle to the ventricle from flowing back into the auricle when the ventricle contracts. A similar valve (the *tricuspid*) (fig. 12, 5, 5′), placed between the right auricle and right ventricle, discharges a like duty on the right side. These valves consist of flaps which float up on the blood as it fills the ventricle, and present a partition barring any backward flow. Other two valves—one placed at the entrance of the great blood-vessel leading from each ventricle, and named *semilunar valves*—guard against back-flow into the ventricles. These latter valves consist each of three pockets (fig. 12, 6, and fig. 13, 7) placed around the blood-vessel's entrance, the pockets opening into the vessel. These pockets allow blood to pass out from the ventricle into the blood-vessel; but as the blood attempts to return, the pockets fill, and, meeting in the middle, close the calibre of the vessel, and form thus an effective barrier against any regurgitation.

The *arteries* carrying, as we have seen, pure oxygenated blood from the left side of the heart and lungs to the body, are highly contractile tubes. By their elasticity they convert the otherwise intermittent blood-flow into a continuous stream. When an artery is wounded the blood leaps from the wound in jets, or jerks, corresponding to the impulses of the left ventricle. The blood-vessels are under the control of the nervous system, as is familiarly witnessed in blushing; and the quantity of blood to each tissue is thus determined by nervous action. In the *capillaries*, the blood-flow is uniform, the average rate of flow in these smallest vessels varying from $\frac{1}{100}$th to $\frac{1}{50}$th of an inch per second. In the *veins*, the blood-flow is also uniform, and is free from the pulse, or 'jerking,' movement of the arteries. The return of the blood in the veins to the heart (often against gravity, as in the case of the lower limbs) is regulated by a variety of causes. Thus the heart's force exerted in driving blood outwards through the arteries also aids the return of the blood in the veins. Then, also, the veins are provided with pocket-like valves, which open towards the heart; and as the veins are compressed in the ordinary muscular movements of the body—a fact well seen in the back of the hand when the fingers are moved—it follows that such muscular pressure will act by forcing the blood upwards to the heart. A suction-power is, no doubt, also exerted on the veins by the heart during the heart's expanding or dilating movements. In the jugular vein of the horse, the blood has been estimated to move at the rate of four inches per second.

The *quantity* of blood in the adult body has been esti mated at from one-twelfth to one-fourteenth of the body's weight. A man of twelve stone weight would thus possess about fifteen pounds of blood. As regards the distribution of the blood in the frame, one part may be regarded as existing in the liver, one in the heart and large vessels, one in the muscles, and one in the organs generally. Exercise naturally determines a greater blood-flow to any given part. The brain thus receives less blood when muscles act, and so also do the digestive organs. It is therefore clear that, for health's sake, exercise should not be taken immediately after a meal, and mental work should also then be avoided. The truth of the old proverb, 'after dinner sit awhile,' is thus demonstrated anew by these physiological considerations.

The blood, in the return part of its course, has been noted to become impure and to assume its *venous* characters, or those it possesses when seen in the *veins*. This remark leads us naturally to consider the question of the nature of the impurities with which the blood becomes loaded in part of its round; and also that of the source, origin, and mode of disposal of these waste matters.

The function of *excretion* is that devoted to the work of getting rid of such waste materials. It is discharged in chief by three organs, *lungs*, *skin*, and the *kidneys*; which, in reality, perform essentially similar functions, and differ from each other principally in their manner of working and in the proportions of waste materials they excrete. The lungs and skin, it is true, in addition to excreting waste materials, may also be regarded as subserving a nutritive function, since by these organs oxygen gas is absorbed. This gas is an essential feature, not only in the production of heat, but likewise in most of the tissue changes through which the frame maintains its place as an organic whole.

The waste materials, or *excretions*, into which the human body is perpetually being broken down as the result of its work, consist of *water*, *carbonic acid gas*, *urea*, *ammonia*, *minerals*, and *organic matter*; while to these items may be added so much *heat*, which is perpetually being given off from the bodily surfaces and from the tissues at large. Lungs, skin, and kidneys thus get rid of the same substances, but in different proportions. For example, while the lungs give off most carbonic acid gas, the kidneys excrete most urea, and the skin, in its turn, separates from the blood a large amount of water. These three organs of excretion may thus be regarded as forming a kind of physiological trio. Performing the same work they are mutually helpful, and, in case of disease, each can assume a share of the work of the injured organ. Thus, the skin and kidneys aid the lungs, when the latter are in any way affected; while lungs and skin in turn can, to a certain extent, aid the kidneys when these organs are disabled.

The waste materials, of which we have spoken, are the natural results of the 'wear and tear' of the body—meaning by this term the results of the physical and chemical processes through which life is maintained. For example, the substance known as *urea*, given off chiefly by the kidneys, is to be regarded as the result of the chemical changes which the nitrogenous matters of the body undergo in their passage through the body's tissues ; while the presence of the water and carbonic acid gas, excreted from the body, can similarly be explained on the principles which govern the chemical relations of living actions. Thus, in the production of heat, oxygen added in the blood to various food-stuffs enters into combination with them, oxidises them, and thus produces water, carbonic acid, urea, and other waste matters. The blood-current, in this view, is not only the source of supply of the chemical conditions necessary for the production of heat, for nutrition, and for all other bodily processes, but likewise is the means whereby the waste materials resulting from chemical action are collected and carried to the organs specially adapted for their elimination from the frame.

The *Lungs* (fig. 16), contained within the *thorax*, or chest cavity, are two in number, and essentially consist, each, of a bag of small compartments called *air-cells.* The *trachea*, or *wind-pipe*, low in the neck, divides into two main branches, or *bronchi* (2), one supplying each lung with air. Within the lung, each bronchus divides and subdivides into a meshwork of fine tubes, which ultimately end in the 'air-cells' of the lungs. These cells, which are grouped together to form the 'lobules' of the lungs (fig. 17), vary in diameter, from the $\frac{1}{40}$th to the $\frac{1}{70}$th of an inch. They are thin-walled cells, on the walls of which branches out the exceedingly fine meshwork of *capillary blood-vessels.* Into this meshwork, as we have seen, the right side of the heart is perpetually driving venous, or impure, blood, laden with waste materials ; while, after circulating through the lung-capillaries, and undergoing purification, the blood is returned to the left side of the heart in a pure state, adapted, as we have noted, for re-circulation through the frame. The lung is therefore a kind of market-place, or exchange, into which blood containing impurities is perpetually passing ; these impurities being given up to

D 2

the lung to be breathed out of the body, and air being inhaled for the sake of its oxygen, which is, in its turn, received by the blood.

The acts of breathing include *inspiration* and *expiration.* The former is carried out chiefly by means of the *midriff*, or *diaphragm*, the great muscle which forms the floor of the chest-cavity, aided by the little muscles (*intercostals*), which are situated between the ribs. In inspiration, therefore, the chest-cavity is enlarged, the ribs are separated somewhat,

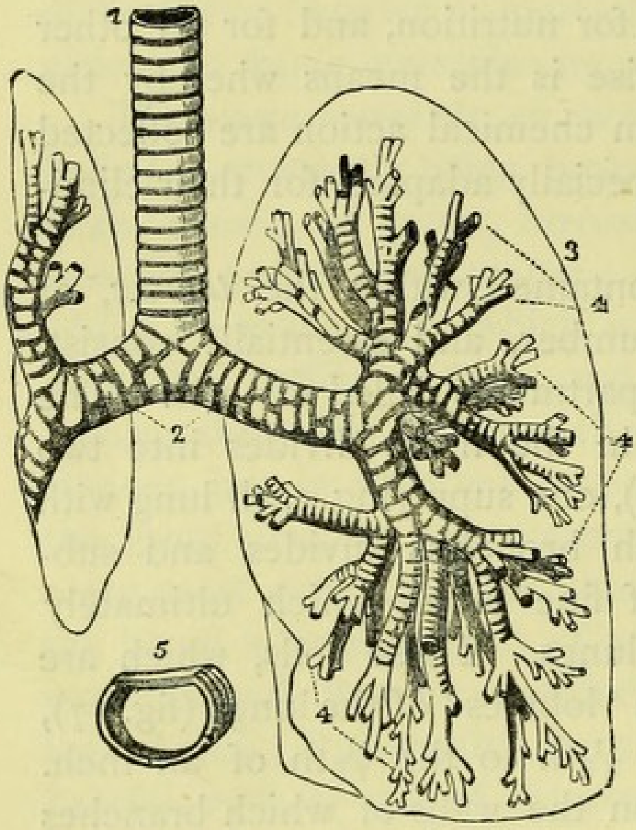

FIG. 16.—The air-tubes of the lungs.

FIG. 17.—Air-cells of the lungs.

and as the pressure of the air within the lungs becomes less than that outside of the body, the difference causes an inflow into the lungs until the pressure inside and that outside become equalised. 'Expiration,' or breathing out, is largely a matter of return of the chest-walls to a position of rest in virtue of their elasticity, when the muscles of inspiration become relaxed.

Fresh air thus passes into the air-cells of the lungs, and this air, laden with its natural oxygen, diffuses amongst, gives up its oxygen to, and receives carbonic acid and other waste products from, the air already contained within the lungs. The air which thus passes in and out of the lungs in ordinary breathing is called *tidal air*; that to which it gives up its oxygen, and from which it receives carbonic acid, being named *stationary air*. The ebb and flow of the former in breathing, and the diffusion or exchange of gases between it and the stationary air, constitute ordinary respiration. By a 'deep breath,' or *inspiration*, we may inhale an additional quantity of air (called *complemental air*), while the deep expiration corresponding to this act will necessarily get rid of so much additional air, called *supplemental air*. Lastly, by the fullest attempt at exhausting the chest, the lungs can never be emptied of air. Were it otherwise, the outside air pressure would crush in the chest walls, and the air which remains in the lungs after the deepest expiration is therefore named *residual air*. In ordinary breathing, about 32 cubic inches of air are inhaled into an adult's lungs at each breath, the residual air having been calculated to amount usually to 75 or 100 cubic inches.

The changes which the blood undergoes after passing through the lungs are very characteristic. Thus while it is dark purple (or venous) on entering the lungs, it is light red, or arterial, on leaving these organs; a change due to the fact that the red corpuscles have received oxygen and given up their carbonic acid gas. Then, also, the blood has become slightly cooler; it contains less carbonic acid and more oxygen than before, and it has a tendency to coagulate (or to clot) more readily. As regards the changes which accrue to the air after being respired, it may be said that the air, after passing through the lungs, has an increased temperature (nearly that of the blood), loses oxygen, gains carbonic acid, gains watery vapour, and has added to it a quantity of organic matter and ammonia—these last, together with the water and carbonic acid gas, being waste materials.

Such being the work of the lungs, we may now pass to consider that of the *skin* and *kidneys.* The skin discharges the duties of a body-covering, of a sensory apparatus (that of touch), of a regulator of bodily heat, and of an excretory apparatus. It is the last-named of these functions which

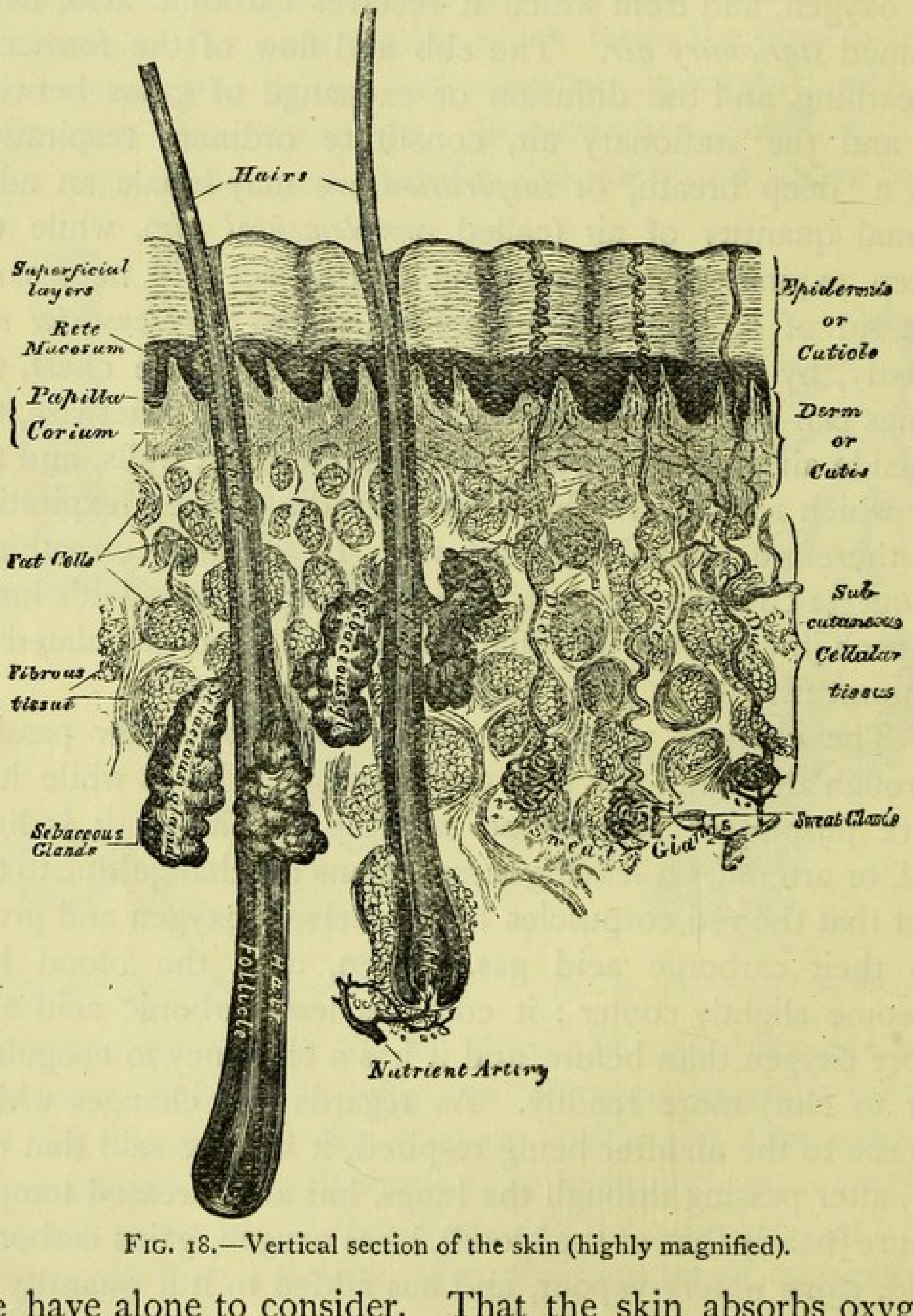

FIG. 18.—Vertical section of the skin (highly magnified).

we have alone to consider. That the skin absorbs oxygen seems to be proved, the quantity of this gas received by the skin as compared with that absorbed by the lungs, being given as 1 to 127. From the skin, water, minerals (amongst which common salt ranks high), carbonic acid, and traces of urea and ammonia, together with heat, are given off as we have already noted. These matters constitute the *sweat*, or perspiration, which, under ordinary circumstances, amounts to about two pounds per day.

The skin (fig. 18) consists of two chief layers, the *epidermis*, or scarf skin, or outer skin, which contains neither nerves nor blood-vessels, and the *dermis*, or true skin, which is provided with both of these structures. The *sweat glands* (or *sudoriparous glands*) are most numerous in the palms and soles, where they number between 3,000 and 4,000 per square inch. The sweat glands (fig. 18) are essentially coiled tubes, opening on the skin surface in *pores*. Each gland is surrounded by a meshwork of capillary blood-vessels, and from the blood which is continually circulating through these capillaries, the glands separate out the waste products already mentioned. As a proof of the high importance of the skin's work in the process of excretion, may be mentioned the fact that when a child's body was covered with gold leaf, by way of representing a character in a Papal procession at Rome, the child died in a few hours from the resulting interference with the functions of the body's surface.

The *kidneys* are situated in the lumbar region, or that of the loins. Each opens into the urinary bladder by means of a duct or tube—the *ureter* (fig. 19 *u*). The *urine* or kidney-secretion, amounts in a healthy man to about $2\frac{1}{2}$ pints per day ; this amount being liable, however, to considerable variations induced by food, exercise, and allied conditions. Urine consists of water, urea, uric acid, and other acids, minerals, organic matters, &c. In structure, the kidney is found to consist of a multitude of fine tubes or *tubules* (diameter $\frac{1}{600}$th inch), which originate in the outer part of the organ in certain little sacs containing loops of blood-vessels, and called *Malpighian bodies* (diameter, $\frac{1}{120}$th of an inch), and which end in the *pelvis* (*p*) or hollow of the organ. A large artery (*renal artery*) enters the kidney, branches out within its substance, and finally forms the loops of blood-vessels found within the 'Malpighian bodies.' These fine loops are continued to form the beginnings of the *renal vein*, which carries blood away from the kidney. Thus a constant stream of blood passes into the kidney by the artery, and a continuous stream passes out to the renal vein to join the general venous circulation. In its passage through the kidney, therefore, we find that the blood is subjected to the process of excretion. The kidney is, in fact, a tubular filter, devoted to the separation of waste products from the blood; while in all probability the gland also acts as something more in its elaboration or secretion from the blood of matters which appear in the urine.

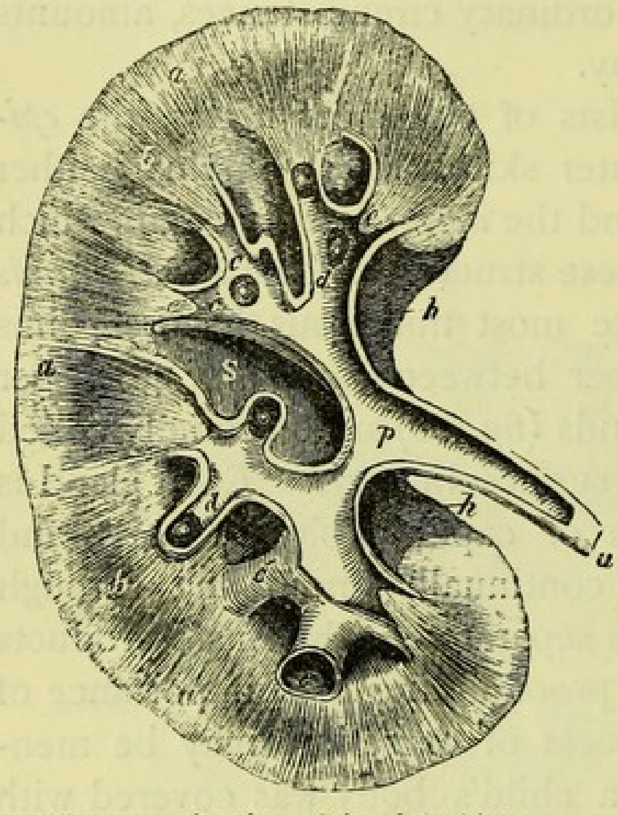

FIG. 19.—Section of the right kidney.

Summing up our considerations regarding the general history of the bodily processes, we see again, and perchance more clearly, that a living body is in reality a complex machine, which performs an amount of work, proportionate to the food or fuel with which it is supplied, and which, in the course of its work, is itself subject to wear and tear; while it likewise gives off waste materials as the result of its work.

An interesting calculation has been made respecting the general income and expenditure of the adult human body, the details of which may appropriately be repeated here. The sources of daily *income* are respectively set down as arising from solid food (chemically dry) 8,000 grains, water from 35,000 to 40,000 grains, and oxygen (inhaled by the lungs) 13,000 grains. The sources of *expenditure* may conversely be given as consisting, firstly, of excretions from the lungs 20,000 grains, from kidneys 24,100 grains, skin 11,750 grains, and digestive system 2,800 grains. Assuming the water (on the side of income) to be set down at 37,650 grains, we might contrive to strike a daily balance between income and expenditure of 58,650 grains on each side. This would give us about $8\frac{1}{3}$ lbs. as the daily incomings and outgoings of an adult man.

Life's actions, it is true, cannot be mathematically calculated or determined with arithmetical exactness; but the above figures are a near approach to the quantities of matter received and expended in the maintenance of an adult existence. The amount of energy (or power of doing work) which the adult body expends in twenty-four hours, in maintaining heat, and in the performance of its varied actions, external and internal, has been calculated at 3,400 foot tons. Gathered up into one huge lift, this amount of energy, popularly expressed, would raise 3,400 tons weight one foot high; and this 'power of doing work,' it should be added, represents the body's profit, gained from the food with which it is supplied.

CHAPTER III.

FOOD, DIET, AND COOKING.

'FOOD,' of whatever variety or composition, may be defined as matter by which the waste of the body may be repaired and the bodily substance duly renewed. In this light, 'food' is simply matter derived from the outer world, and which, by the processes of digestion and absorption, is converted into a fluid—the blood—adapted to serve as a common storehouse or medium, from which each tissue of the body may, in turn, draw its supply of nutriment. It, therefore, follows that in the food we should find the elements or materials of which the body is composed, and this expectation is realised when the chemistry of food-stuffs is known. In addition to its primary use in renewing the tissues and substance of the body, the food also acts the part of fuel in supplying material which, when duly burnt (or oxidised) in the body, maintains the bodily heat, and supplies us with 'energy,' or the power of doing work. But these latter functions of food are really included in the general statement that food is matter, through the absorption of which the body repairs its losses, renews its substance, and maintains its place in the living series. Now, the *classification of foods*, which may be appealed to by way of introducing us to the scientific consideration of the whole subject of nutrition, reflects in an apt fashion the chemical composition of the body. The food-stuffs on which man and his neighbour-animals subsist, may be divided, as follows, into two well-marked groups :—

I. NITROGENOUS FOODS, composed of *carbon*, *hydrogen*, *oxygen*, and *nitrogen* (with traces of *sulphur* and *phosphorus*). Represented by such substances as *albumen* (the type of the group) seen in white of egg, juice of meat, &c. ; *casein*, found in milk ; *gelatin*, seen in bones, hoofs, and horns ; *fibrin*, obtained from blood ; *gluten*, found in flour ; *legumin*, from vegetables of the pea and bean tribe ; *syntonin*, from muscle, &c.

II. NON-NITROGENOUS FOODS :—

(*a*) WATER (H_2O) composed of hydrogen and oxygen. (*b*) MINERALS, e.g. lime potash, soda, &c.	Inorganic, or non-living materials.
(*c*) OILS and FATS obtained from animals and plants, and consisting of carbon (C), hydrogen (H), and oxygen (O). (*d*) STARCHES and SUGARS (CARBOHYDRATES or AMYLOIDS), starch, sugar, gum, &c., formed by plants (or animals), also consisting of C, H, and O, but having a larger proportion of O than the fats and oils.	Organic materials.

When the dietaries of different individuals or of different races are examined, they are found to present a wonderful agreement in chemical composition. Whatever the substances used for food, they must contain, firstly, the matters necessary for the support of the body, and, secondly, must exhibit these matters in the proportions of nitrogenous and non-nitrogenous substances requisite to maintain the body as a whole. It is one of the primary rules for food-taking, *that the human body demands a due mixture of nitrogenous and non-nitrogenous foods.* Starvation and death result if an attempt is made to subsist on either class of foods alone ; and serious health derangement occurs when the requisite proportions of these two classes of foods are not represented in any dietary. Animals fed on nitrogenous food alone, die starved ; and the same result is seen when only a non-nitrogenous diet is offered them for their support. The reason for this absolute dependence upon a mixture of nitrogenous and non-nitrogenous foods becomes clear when we reflect that both classes of substances occur in the tissues, and that both are needed for the due discharge of the chemical functions which the acts of living and being entail. If any additional proof were needed of the necessity for such a combination of foods, we should find such verification in the composition of nature's own food, *milk*, and in that of the egg also—this latter structure presenting us with the substances from which an animal body is completely built up.

The chemical composition of milk (in 1,000 parts) may be given as follows :—

			Human	Cows
WATER			890	858
SOLIDS			110	142
			1,000	1,000
SOLIDS CONSIST OF	Nitrogenous matters (casein, &c.)		35	68
	Fats (butter, &c.)	(Non-nitrogenous substances)	25	38
	Sugar of milk, &c.		48	30
	Minerals		2	
			110	142

The egg we similarly find to consist of *nitrogenous matter*, *water*, *fats*, and *minerals*; and both milk and egg are therefore seen to present us with a combination of nitrogenous and non-nitrogenous materials.

A classification of foods, formerly much in vogue, divided food materials into 'flesh-formers' and 'heat-producers.' The nitrogenous foods were included under the first head; while the starches, sugars, and fats among the non-nitrogenous foods were regarded as heat-producers, or as 'respiratory foods.' This view of food materials has, however, been very generally discredited by later research. It may be stated as a general fact that both classes of foods contribute to the support of the tissues, the production of heat, and the development of bodily force or *energy*. It seems true, to quote the words of Dr. Pavy, that 'wherever living changes are carried on, nitrogenised matter is present;' and again, 'wherever vital operations are going on, there nitrogenous matter is present, forming, so to speak, the spring of vital action;' while this eminent authority is no less clear when he maintains that 'the primary object of nitrogenous alimentary matter may thereupon be said to be the development and renovation of the living tissues.' Thus the term 'flesh-formers' might be held still to possess an application to the uses of this first class of foods, in that these foods specially add to and renew the most vital parts of the frame. But that this is not their only function is equally clear; and it is also proved that the non-nitrogenous foods are something more than mere 'heat-producers.' While nitrogenous matter constitutes, so to speak, the basis of the body, and while it is an absolute necessity for the healthy existence of the body, the non-nitrogenous foods seem to be equally necessary for the production of the muscular force or energy which we exert. A muscle, for example, contains matter which is non-nitrogenous in character; and it would seem, therefore, that materials of this latter kind are necessary for its sustenance and for the production of its force. But the muscle, in turn, is also supplied with nitrogenous matter; and hence both classes of foods appear necessary for nutrition—the nitrogenous to form the basis of its substance, and the non-nitrogenous to develop force and to produce heat. The two classes of foods, in fact, as far as is known, possess in many respects interchangeable and common actions while preserving the broad distinctions we have above drawn between them.[1]

A highly instructive series of experiments concerning the nutritive values of these two groups of foods was performed by Drs. Fick and Wislicenus of Zurich. These observers performed an amount of work, the ascent of a mountain, capable of exact measurement. Their contention was, that if the work performed by their bodies was due to the destruction of their muscular substance, as contended by Liebig of old, they should find evidence in their excretions, and particularly in the amount of urea (as representing nitrogenous waste), of this assertion. The food they consumed was wholly non-nitrogenous in character. The result was that the amount of oxidation, or chemical breakdown, of the muscles, was found to be sufficient only for the production of a fraction of the force expended in the performance of the calculated work. Hence arose the conclusion that muscular power was imparted by, or derived from, the oxidation of the non-nitrogenous food they had consumed; and this view of the power of such food to produce muscular force, is that now generally accepted by physiologists. Voit, experimenting on the dog, showed also that non-nitro-

[1] Regarding the place and power of gelatin among the nitrogenous foods, it should be remarked that this substance will not supply the place of the other nitrogenous food-stuffs in a dietary. Experiment has shown that animals fed on gelatin (as representing the *nitrogenous* part of the dietary) and on non-nitrogenous food, die as if they had been fed on the latter food alone. Thus, while most of the nitrogenous foods can replace one another in a dietary, it is clear that gelatin stands on a different basis. It cannot replace, or act as a substitute for, albumen, for example; the reasons for this want of power being believed to consist in the rapid oxidation or destruction of gelatin in the blood. The function or use of gelatin as a food would appear to consist rather in its preventing tissue-waste, than in its actually contributing to the support of the tissues themselves.

genous food—probably fat—afforded, by its oxidation, the means for producing muscular force.

The place and power of the fats, and oils, and sugars, and starches of the food may therefore be regarded as that of supplying to the bodily machine, the necessary fuel from which it can generate force or energy. The fats and oils are specially heat-producers, their power in this respect being two and a-half times as great as those of starch and sugar; while they also assist the manufacture of other foods into tissue-substance, and aid in the work of excretion. The association of fats and starches and sugars appears to represent a necessary condition for health. Absence of fats, or the influence of any cause which prevents fat-assimilation, appears to be specially conducive of ill-health; a fact well illustrated in cases of tubercular disease, of which *phthisis*, or consumption itself, stands as a too familiar example. The starches and sugars, on the other hand, also aid in heat-production, and contribute, as we have seen, to the production of force. They may be converted into fat in the body, and may thus become heat-producers; while they also play a part in the digestion of nitrogenous food-stuffs. These last, as has been noted, seem to unite in their action the functions of other foods, and, in addition, to possess as their principal function the repair of the tissues themselves. As Dr. M. Foster points out in his 'Physiology,' with a fixed quantity of fatty or starch and sugar food an increase of the accompanying nitrogenous food leads, not to a storage of the surplus carbon contained in the extra quantity of the latter, but to an increase in the consumption of carbon. Nitrogenous food increases, not only nitrogenous change, but non-nitrogenous tissue-change as well; hence an excess of nitrogenous food may, through this latter action, reduce fatness.[1] The exact differences, also, between starches and

[1] Lawes and Gilbert fed a pig on 100 parts of fat along with other food. The animal produced 472 parts of fat, or nearly five times as much fat as was given in the food. Here the fat was probably produced from starches and sugars, and possibly from nitrogenous foods as well.

sugars as foods, have yet to be fully determined. In their chemical combustion, fats require more oxygen than starches and sugars, and the starches and sugars are, on the whole, more digestible than the fats : the latter, however, containing more potential energy, weight for weight, than the starches and sugars.

The uses of the remaining foods on the list—*water* and *minerals*—deserve special notice in their turn. Of all foods, perhaps, *water* (H_2O) is in one way the most necessary, seeing that, firstly, it enters into the composition of every tissue and fluid of the body ; that, secondly, it is essential for the solution and digestion of other foods ; and that, thirdly, it is required for the work of tissue-change, and of excretion itself. About five pints of water are given off from lungs, skin, kidneys, and digestive tract in twenty-four hours; this loss being made good by the water we receive in chemical combination with the solid food, as well as by that actually drank as water and contained in various beverages. Of the weight of the body, water forms nearly 60 per cent. It forms 30 per cent. of fat ; makes up of the liver-weight 69 per cent. ; of that of the blood 83 per cent. ; of the skin 72 per cent. ; of the brain 75 per cent. ; and of the muscles 75·7 per cent. A fluid so universally distributed throughout the body, must needs constitute a highly important article of food ; and this fact is perhaps most strikingly illustrated when we discover that life may be prolonged for many days (from thirty to forty, or even fifty-five days) on water alone, and in the absence of all other foods.

The *mineral constituents* of the food consist of various compounds of lime, soda, potash, iron, magnesia, chlorine, phosphoric acid, sulphuric acid, carbonic acid, &c. Phosphate of lime exists in the bones, and in most other tissues of the body ; iron is found in the blood, as also are potash salts. The exact uses of these mineral matters is still undetermined. They may be present in very small quantities in many cases, but their importance appears to bear no relation to their amount. For, that they are of extreme importance cannot be doubted. They are believed to assist tissue-change, and to thus play a part in the process of excretion. As has been remarked, phosphorus seems to be as essential for human growth as for that of the fungus; while sulphur is found entering into the composition of all nitrogenous substances, and even of that typical nitrogenous compound, *protoplasm*—the 'matter of life' itself. Certain forms of disease are, lastly, liable to appear when the requisite minerals are not added to the tissues. 'Scurvy' itself, is a disease apparently associated with a deficiency of potash salts in the blood, and is cured when fresh meats or vegetables, containing mineral matters, are made to form a part of the dietary.

Having seen that a combination of nitrogenous and non-nitrogenous matters is necessary for the maintenance of the body in a state of health, our next duty is that of ascertaining the relative values of various articles of diet or of various combinations of food. It should be clearly borne in mind, that we may obtain the necessary combination of nitrogenous and non-nitrogenous matter, either from animals alone, from vegetables alone, or from animals and plants combined—the water as an essential constituent of the food being allowed for as a separate item. The source of the food is immaterial, so long as the necessary proportions and constituents are obtained. As a matter of fact, the history of the world's dietaries shows that all three modes of obtaining food exist. There are purely animal feeders—such as the Eskimo and Pampas Indians, or Guachos—as there are purely vegetable eaters—witness the Hindu or Arab—and examples of mixed animal and vegetable feeders are, of course, abundantly represented at our own doors. The difference between one dietary and another exists, not so much in the essential principles received in the food—for these latter have been settled by nature—but in the special forms and combinations which the food-principles assume. Man, in truth, possesses the power of accommodating himself very completely to his surroundings. In the North he is perforce an animal feeder, as in the South he becomes naturally a vegetarian. He takes for food that which comes easiest to his hand ; and therefore climate and situation on the earth's surface may be said to determine the food of a *race.* Those conditions which determine the food of the *individual* may be varied enough; age, sex, habit, constitution or temperament, health, occupation, and other conditions materially affect the nature of the food. To lay down any hard and fast rule in the matter of food-taking, is therefore both unscientific and absurd. The arguments which would counsel universal vegetarianism are as irrational as those which would insist on an animal dietary as the exclusive food of mankind. That which is above all mere 'isms' in this matter of foods, as well as in most other concerns of life, is the intelligent educated knowledge of scientific principles, and the regulation of life conformably to the teachings of these safe guides. In this light, vegetarianism may be found to suit certain individuals, just as a mixed diet may be found to be that best adapted to others. The choice of diet is a matter for individual selection, guided by the knowledge which science supplies, and by the general principles which the scientific investigation of foods, in their relation to bodily wants, has formulated.[1]

The *relative values* of different kinds of foods may be gathered from the following table :—

[1] 'Not only,' says Dr. Pavy, 'is there thus a correspondence between the amount of food required and the inclination for taking it, but, probably arising from the teachings of experience, we find the nature of the food selected in different countries to vary, and to constitute that which is most in conformity with what is needed. For example, the dwellers in the Arctic regions, besides consuming an enormous—even prodigious—quantity of food, partake of that kind which abounds in the most efficient form of heat-generating material, viz. oleaginous matter. It is from the bodies of seals and whales, and such-like sources, that the food of the extreme Northerner is obtained. It is true the coldness of the climate will not permit the production and supply of the carbo-hydrates by vegetable growth, as occurs in low latitudes ; but, if it did, they could hardly be consumed in sufficient quantity to yield the requisite amount of heat.'

Percentage Composition of Various Articles of Food (Letheby).

	Water	Albumen or Nitrogenous matter	Starch, &c.	Sugar	Fat	Minerals
Bread . .	37·0	8·1	47·4	3·6	1·6	2·3
Oatmeal .	15·0	12·6	58·4	5·4	5·6	3·0
Rice . .	13·0	6·3	79·1	0·4	0·7	0·5
Peas . .	15·0	23·0	55·4	2·0	2·1	2·5
Potatoes .	75·0	2·1	18·8	3·2	0·2	0·7
New Milk .	86·0	4·1	—	5·2	3·9	0·8
Cream . .	66·0	2·7	—	2·8	26·7	1·8
Skim Milk .	88·0	4·0	—	5·4	1·8	0·8
Cheese . .	36·8	33·5	—	—	24·3	5·4
Lean Beef .	72·0	19·3	—	—	3·6	5·1
Lean Mutton .	72·0	18·3	—	—	4·9	4·8
Poultry . .	74·0	21·0	—	—	3·8	1·2
White Fish .	78·0	18·1	—	—	2·9	1·0
Eels . .	75·0	9·9	—	—	13·8	1·3
Salmon . .	77·0	16·1	—	—	5·5	1·4
Egg . .	74·0	14·0	—	—	10·5	1·5
Butter and Fats	15·0	—	—	—	83·0	2·0
Beer and Porter	91·0	0·1	—	8·7	—	0·2

These figures give as near an approximation as is possible to the composition of the articles of food described. The substances analysed vary much in their composition, and hence no hard and fast results are attainable; but as far as the nutritive values of the foods analysed are concerned, the amounts just given may be accepted as substantially correct. The analyses thus detailed, will be found instructive enough in their general details. We are taught that while oatmeal is in itself a nutritious food, containing the various principles fairly represented throughout, potatoes, on the other hand, by comparison, are seen to constitute a poor and innutritious food, and to consist practically of a mass of water in combination with starch, the proportions of nitrogenous matter being far below those found in oatmeal. In further proof of such differences in the nutritious character of these foods, it has been calculated that a man dependent on potatoes as his staple article of diet, would require to eat from ten to eleven pounds daily to afford him the requisite amount of nourishment, even when these vegetables are supplemented by milk and fats, whereas the man who lives on oatmeal and milk would be well nourished by a very much smaller quantity of these latter foods. So, also, about two and three-quarter pounds weight of butchers' meat and bread would be equivalent, in nutritive value—that is, about three-quarters of a pound of meat and two pounds of bread—to the whole potato dietary above noted, and would serve to nourish and sustain an adult man, doing a moderate amount of work, for twenty-four hours.

The amount of food required for the support of the human body varies according to the circumstances and conditions of life. Thus age, sex, health, occupation, and many other conditions assist in determining the kinds and amounts of food required for the support of the body.

As regards *age*, we know, for example, that the growing body consumes a larger amount of food, proportionately to its weight, than does the adult frame ; the reason for this increase being plain, when we consider that provision has to be made for the growth of tissues and organs. Again, as has already been noted, the infant under the age of six months or so cannot digest starchy foods, and the carbohydrates must therefore be altogether omitted from the diet of very young children. In old age, on the other hand, the food requires to be presented in an easily assimilable form. Less food is required when the bodily powers fail, but the diet should be light and nutritious ; milk, eggs, soups, &c., are indicated, and the use of alcohol, in the form of wine, is universally admitted by competent authorities to exert a favourable influence in its stimulating effects on the nutrition of the aged subject.

The influence of *sex* is also marked on diet. The diet of women, working as indoor operatives, is about one-tenth less than that of men. The question of *health* in relation to foods is often of extreme importance. The whole question of *dietetics* lies within the province of physiological medicine; and wise selection of food is found to be, not only an adjunct to the treatment of disease, but in itself to constitute a frequent cure of ailments. Scurvy, a disease induced by improper feeding, is cured by a return to normal food. Again, if a dietary contains an excess of nitrogenous foods, and no additional exercise be taken or work performed, various diseases, such as gout and other inflammatory troubles, are thereby apt to be induced. In the opposite direction, a diet poor in nitrogenous matter tends to make its effects felt in a want of vigour, in indisposition to work, and in inability to endure long and continuous exertion. 'As the instrument of living action,' says Dr. Pavy, 'power will be proportionate, other circumstances being equal, to the amount of nitrogenous matter existing in operation.'

The question of *occupation* or *work* in relation to food naturally becomes one of high practical interest. A fair estimate of the amounts of foods (in a *dry* state) required for the support of an adult man, at ordinary labour, per day, has been given as follows by Moleschott :—

Dry Food	In ozs. avoir.	In grains	In grammes
Nitrogenous matter . .	4·587	2006	130
Fatty matter . . .	2·964	1296	84
Starches and sugars .	14·250	6234	404
Minerals	1·058	462	30
Totals . .	22·859	9998	648

To the above amount of dry food, amounting thus to about 23 ozs. per day, from 50 to 80 ozs. of water naturally require to be added. This amount of food represents a force-value of 3,960 foot tons.

Dr. Letheby's calculations are as follows :—

Daily diet for	Nitrogenous matter	Carbonaceous matter	Carbon	Nitrogen
	ozs.	ozs.	grains	grains
Idleness . .	2·67	19·61	3816	180
Ordinary labour	4·56	29·24	5688	307
Hard labour .	5·81	34·97	6823	391

In such a table we see how the nitrogenous foods are increased proportionately to the work, and also how a marked difference is made in the non-nitrogenous or carbonaceous articles of diet, in conformity with the greater demand which exists for force-producing nutriment.

The following items may be held to represent the food sufficient for an adult performing ordinary work (power) :—

Breakfast: Milk, ¾ pint; water, ¼ pint (with coffee or tea); bread, 4 to 6 ozs.; butter, ¾ oz.; sugar, ¾ oz.; bacon, 3 ozs.; or eggs, 4 ozs.; or cooked meat, 3 ozs.

Dinner: Cooked meat, 4 to 6 ozs.; potatoes, 8 ozs.; bread, 3 to 4 ozs.; pudding, 8 ozs.; cheese, ½ oz.; soup, 6 ozs.; water (or beer), ½ pint.

Tea: Water (with tea), ¾ pint; sugar, ¾ oz.; milk or cream, 2 ozs.; bread, 3 ozs.; butter, ½ to ¾ oz.

Supper: Milk, ¾ pint; oatmeal, 1 oz.; bread, 3 to 4 ozs.; or eggs, 4 ozs.; or cooked meat, 3 ozs.; and bread, 3 ozs.; butter or cheese, ½ oz.; water or beer, ½ pint.

A highly interesting table has been constructed by Dr. Frankland, showing the amounts and cost of various foods, capable each of producing energy powerful enough to raise a man's weight (140 lbs.) 10,000 feet high, this being the amount of work performed by Fick and Wislicenus in their experiment alluded to (see p. 45) :—

	Lbs.	Price per lb.	Cost
		s. d.	*s. d.*
Bread . . .	2·345	0 1½	0 3½
Oatmeal . . .	1·281	0 2¼	0 3½
Potatoes . . .	5·068	0 1	0 5¼
Beef fat . . .	0·555	0 10	0 5¼
Cheese . . .	1·156	0 10	0 11½
Butter . . .	0·693	1 6	1 0½
Lean Beef . .	3·532	1 0	3 6½
Pale Ale . . .	9 bottles	0 6	4 6

In the *selection* of his foods, man is led by instinct to combine those which together afford a perfect dietary or a near approach thereto. Certain foods are found in practice to be united to others which supply deficiencies observable on chemical analysis in the former. Thus butter is eaten with bread which is deficient in fats, and milk or cheese is similarly combined with bread. Butter sauce, as a form of fat, and oil, is respectively combined with fresh fish and salad. Bacon is served with veal, and with fowl and liver, to supply mineral constituents in which these foods are deficient, while milk is also taken with farinaceous foods, such as rice, sago, tapioca, and the like.

Excess of food, besides tending to produce various diseases, before mentioned, also serves to induce abnormal increase of the body or 'corpulence.' Doubtless the tendency to *obesity*, or fatness, is often hereditary; but that it is fostered by over-eating, idleness, and want of exercise, and may be prevented by a properly adjusted mode of living, is equally true. It would appear that fat can be generated either from excess of fatty foods, of starches and sugars, or of nitrogenous matter (see p. 46). Superfluous fat, not oxidised or used in the production of heat or force, remains to be stored in the tissues; and that sugar is a fattening food is proved by the fact, among others, that negroes grow fat during the sugar harvest (March, April, and May), when much saccharine material is eaten. It is curious likewise to note that the grubs or larvæ of flies, fed on blood, in which only a minute amount of fat is contained, develop fat rapidly, thus proving that nitrogenous diet may give rise to fatty increase; and, as has been shown, the fat of Roquefort cheese is formed from the 'casein' the cheese contains.

Thus, to produce stoutness, fat meats, butter, cream, milk, cocoa, bread, potatoes, farinaceous puddings, oatmeal, sugar, sweets, sweet wines, porter, ales, &c., should be taken. For the reduction of corpulence, on the other hand, the foregoing articles are to be avoided, and lean meat, poultry, game, eggs, green vegetables, a moderate allowance of milk, ripe fruits, claret, hock, &c., dry sherry, bitter ale, and spirits, substituted. As a substitute for bread, the gluten biscuits used in the treatment of diabetes have been also recommended for the corpulent. Mr. Banting's treatment of himself in the reduction of obesity, consisted less in adopting any new or physiological dietary, than in substituting a healthy for an erroneous mode of living. With increase of flesh meat, Mr. Banting found that the tendency to fat formation was diminished, especially when exercise was taken freely. This, as has been already noted, is in accordance with scientific expectation ; while, starchy matters being largely diminished in his foods, the usage or oxidation of fat in the body was allowed to proceed without interference.[1]

In *starvation*, death ensues when the body loses two-fifths, or 40 per cent., of its original weight. The fat loses 93 per cent. of its original weight in starvation ; blood, 75 per cent. ; the muscles 42 per cent. ; bones, 16 per cent. ; and the nervous system nearly 2 per cent. Death in starvation really results from *loss of heat* ; the fatal issue being readily foretold, inasmuch as the subject dies when the loss of temperature falls to about 30° F. Life may be preserved in the absence of sufficient food by supplying external heat. A wise wife and mother made the scanty supply of food go far in the Lancashire cotton famine, by keeping her men-folk in bed and wrapping them up in warm blankets ; and on the same principle, the application of heat is the first course to be pursued in the rescue of the starving man. The influence of *water* in prolonging life has already been alluded to. In the absence of solid food and water, death results in man in from six to eight or ten days.

Respecting the sources of food materials, we have seen (p. 42) that while the nitrogenous foods are derived solely from animals and plants, the starches, and sugars, and

[1] A book to be consulted on corpulency is that of Dr. Ebstein, translated by Professor A. H. Keane, and published by H. Grevel, London, 1884.

oils, and fats are also obtained from the worlds of living beings. In contradistinction to the minerals and water, which are obtained from the *inorganic* world, the former foods have been named *organic* (*i.e.* of living origin) nutriments. The composition of the chief articles of food having been already detailed, it remains to notice the nature of the principal substances in daily use.

Of *animal foods*, the chief are derived from the flesh and bones of various creatures. These foods include meat, poultry and game, fish and shellfish, or 'molluscs.' Under the designation 'meat,' are included the flesh of the ox, sheep, calf, lamb, pig, and deer, whilst rabbits and hares may also be included in the list. The reptile class also contributes the turtle, which is used in making the well-known soup. Eggs may, perhaps, also be properly included under the designation of 'meat.'

As regards *Beef*, this consists, as already shown, of water (about 72 per cent.) and the remainder solids; the latter being made up of nitrogenous matters, fat, and minerals, of which latter, potassium makes up the greater bulk. The quantity of fat is very variable, and depends on the feeding of the animal. In its characters good meat should present a marbled appearance, and in colour should neither be too pale nor too dark, whilst it should be firm to the touch, and be free from specks or points of blood. The juice should give an acid reaction to test-paper, while the odour of fresh meat is pleasant.

The chief *parasites* liable to affect meat are—(1) the *Cysticerci*, or young form of tapeworm (fig. 20), (more common in pork), which appear as minute bags or vessels (fig. 21), with the head and hooklets of the future tapeworm. The presence of these parasites constitutes 'measly' beef or pork. (2) *Trichinæ* (fig. 22), which are small worms coiled up each in a capsule, and distinctly visible when examined by a low power of the microscope. These are found mostly in the midriff, jaw muscles, and rib muscles, They cause, when eaten, a usually fatal disease known as *Trichinosis.* Such diseases as pleuro-pneumonia, rinderpest, anthrax, or splenic fever, braxy (in sheep), foot-and-mouth disease of advanced type, and fevers generally, unfit the animals suffering therefrom for the butcher's shop.

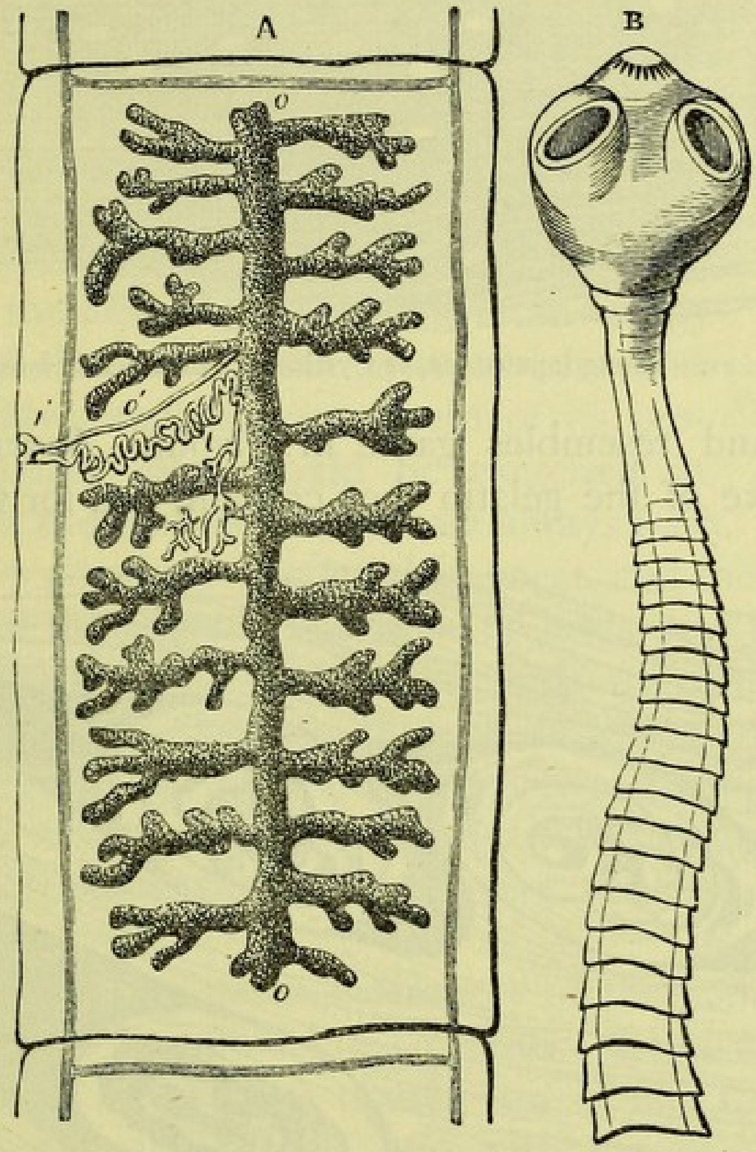

FIG. 20.—Pork tapeworm (*Tænia solium*). A, a joint magnified; B, head, suckers, and neck (enlarged).

Mutton is regarded as easier of digestion than beef, and is better adapted for invalids and dyspeptics. *Veal* and *lamb* resemble beef in digestive properties, and veal itself may occasionally be found to be highly difficult of easy assimilation. *Pork* resembles veal in a digestive sense, while *cured meats* are, as a rule, less digestible than the same meats in a fresh state. *Venison*, on the contrary, is regarded as easy of digestion. In colour it is dark, is of lean con-

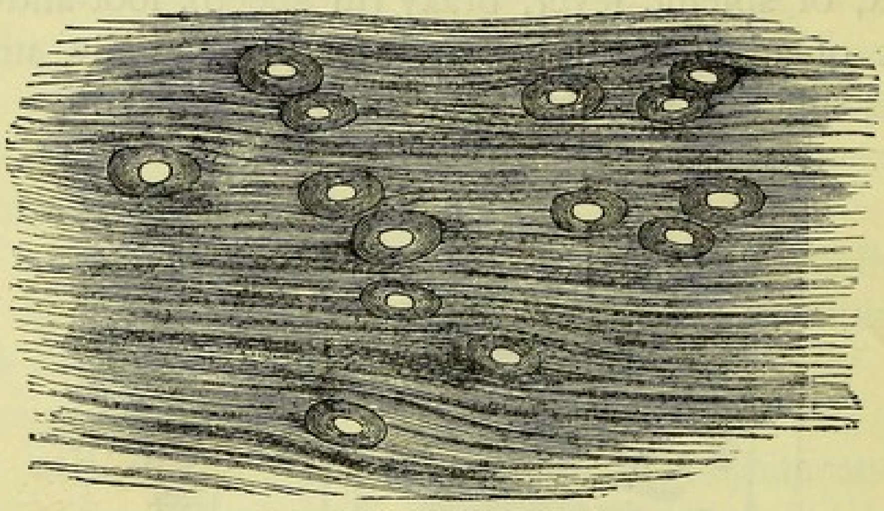

FIG. 21.—Young tapeworms, or Cysticerci, imbedded in muscle.

sistence, and resembles game in flavour. *Bones* are used for the sake of the gelatin they contain, and for their mar-

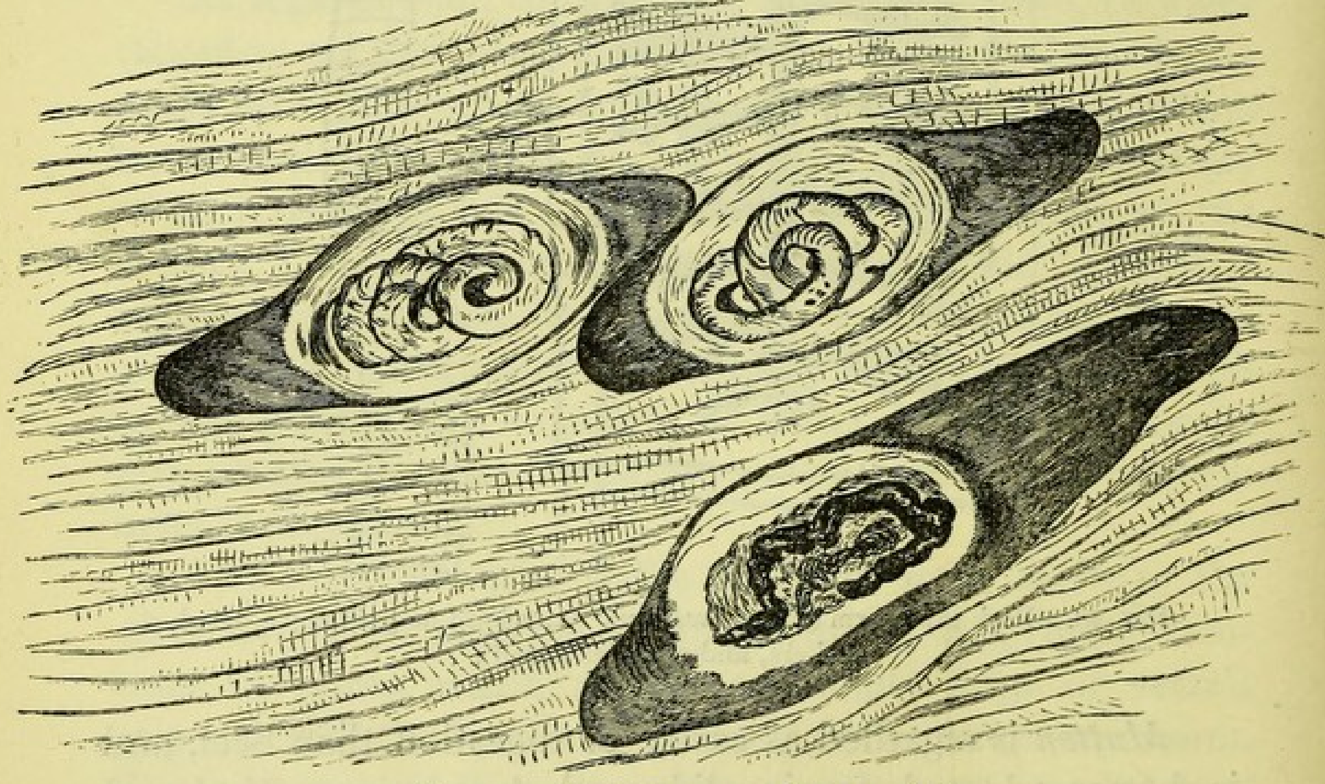

FIG. 22.—Trichinæ encysted in muscle.

row. The *blood* of animals is alone used in the case of the pig, and is employed in the manufacture of 'black puddings.' The *liver* of the pig, lamb, and calf is often used.

It should be carefully scrutinised for parasites, and specially for the *flukes* (fig. 23) which it may contain. The flukes cause the 'rot' of sheep. *Kidneys* are difficult of digestion, and cannot be regarded as of nutritious character. The *heart*, even properly cooked, is somewhat tough in fibre. *Tripe* is, however, readily digestible. The *sweetbreads* of animals include not merely the pancreas proper, but also the thymus gland of the throat. They are nutritious when properly cooked and not over-richly dressed. As regards the *rabbit* and *hare*, the flesh of the former is more readily assimilated than that of the latter, which seems to be highly stimulating in certain of its properties. Great care should be exercised in seeing that those latter 'meats' are always fresh.

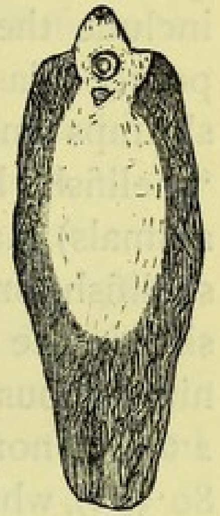

FIG. 23.—Liver fluke (*Fasciola hepatica*).

Poultry possesses less fat than meat, and the fat is not mixed with the fibres. The flesh of birds may be white or dark-coloured. The white-fleshed birds are certainly better adapted for easy digestion than those with dark muscles; *duck* and *goose*, for this reason, are less easily digested than fowls. *Partridge* and *quail* are delicate in character as food-birds, while snipe and woodcock are richer in respect of their flesh.

Fishes vary very much in respect of the composition of their flesh and digestibility. Thus *white fish* gives us in 100 parts 18·1 of nitrogenous matter, 2·9 of fat, 1·0 minerals, and 78·0 of water; while *eels*, with 9·9 of nitrogenous matter, contain 13·8 of fats, 1·3 of minerals, and 75 of water; *salmon* having 16·1, 5·5, 1·4, and 77·0 of these substances respectively. The *whiting* is, perhaps, of all white fishes, most to be commended for weak digestions, the haddock, sole, and flounder ranking next in order. The *cod* is somewhat tough, while *turbot* resembles the sole and flounder. It is notable that the special flavour of fishes depends greatly on the nature of their food. The flesh of the *sturgeon* is tough, and resembles veal in its nature.

The *shellfish* which are most frequently used for food include the oyster and mussel, the whelk is eaten by the poorer classes only, while crayfish, crabs, and lobsters, shrimps and prawns (which, although classed popularly as 'shellfish,' belong in reality to an entirely different group of animals) may also be ranked with these animals. As regards shellfish, one important point connected with their use consists in the caution to see they are fresh. Oysters (analysis: nitrogenous matter, 14·010 per cent.; fats, 1·515; minerals, 2·695; non-nitrogenous matter and loss, 1·395; water, 80·385), which are regarded as being in season only in those months whose names contain the letter 'r,' are usually considered nutritious, but are in many cases digested with difficulty. Their restorative qualities have certainly been largely exaggerated; probably as soup, their effects are most beneficial. *Mussels* should be eaten with care; they are singularly liable to develop poisonous properties when their feeding has been of uncleanly character. On one occasion, at Leith, in 1827, 30 persons were seriously affected by eating mussels, and two persons died. The mussels in this case were believed to have acquired poisonous properties in the docks. *Lobsters* and *crabs* are not digestible foods, though their richness in certain minerals has credited them with being specially adapted as brain-food and as nervous nutriment. Cases of 'nettle-rash' are not infrequently seen in many persons, as the result of eating even sound shellfish.

The composition of *eggs* and *milk* has already been given (p. 50). Both may be regarded as presenting us with typical foods. When fresh, eggs are translucent; by keeping they assume a cloudy appearance when held up to the light. In an average egg of two ounces weight, reckoned as a dry mass, the shell, according to Dr. Pavy, makes up $\frac{1}{10}$th of the weight, and the remainder consists of nitrogenous matter, 110 grains; fats, 82 grains; and minerals, 11 grains, giving the total *solids* as 203 grains. As food, and as a basis for other foods, the value of eggs is too well known to need comment here. In the treatment of many wasting diseases, in insanity, &c., eggs and milk form the sheet-anchors of nutrition.

Milk varies greatly in character and density, but pure cow's milk should present an opaque appearance, a full white colour, and should yield 6 to 12 per cent. of cream by volume (G. Wilson). If boiled it should not alter in appearance, and should leave no deposit. Its specific gravity varies from 1026 to 1035 ; if below 1026 adulteration with water, or a very inferior quality of milk, may be suspected. Under the microscope, milk is seen to contain round oil globules, and a few cells derived from the milk glands. The milk of diseased animals should on no account be used for food. The milk of cows suffering from 'foot-and-mouth' disease has been proved to be capable of producing sore throat and other ailments in man. Again, milk is exceedingly liable to absorb deleterious gases, and to become contaminated from contact with lead or zinc. It should therefore never be stored near drains or sinks, and should not be kept in metallic vessels. *Cheese* is a variable product, owing to difference in its mode of manufacture, and in respect of its digestibility likewise varies greatly. The poorer kinds, though rich in casein, are less digestible than the richer varieties.

The following is a comparative analysis of the milk of various animals (Payen) :—

	Woman	Cow	Goat	Sheep	Ass	Mare
Nitrogenous matter and insoluble salts	3·35	4·55	4·50	8·00	1·70	1·62
Butter . .	3·34	3·70	4·10	6·50	1·40	0·20
Sugar of milk, &c.	3·77	5·35	5·80	4·50	6·40	8·75
Water . .	89·54	86·40	85·60	82·00	90·50	89·33

In the case of the sheep and mare the percentage total does not exactly correspond with the figures as above given, but the results may be taken as sufficiently correct for all ordinary purposes.

Preserved foods now form an important series of nutritive articles. Many kinds of meat, shellfish, fruits, &c., are imported in tins, and milk in its 'condensed' form (consisting of pure milk with added sugar) is also sold in this latter form. There appears to be little danger involved in the use of tinned meats, always provided they are used soon after the tin is opened and not allowed (save, perhaps, in the case of preserved milk) to stand for some days in this condition, in which case injurious effects are liable to accrue from the action of the preserved substances on the metal of the case. Various kind of 'meat-essences' are also preserved in a handy form. Brand's 'Beef Essence,' Mason's 'Beef Extracts,' Carnrick's 'Beef Peptonoids,' and 'Kreochyle,' are amongst the best-known products of this class.

The *vegetable foods* consist chiefly of cereals; leguminous plants (peas, beans, lentils, &c.) which are rich in nitrogenous matters and starch; the potato rich in starch; and other plants resembling the potato in their characters. Of the *cereals*, wheat, corn, barley, rye, Indian corn, rice, and millet are the best known. Wheat in the form of bread, and corn in that of oatmeal, form staple articles of diet. The analysis of the more important of these articles has already been given (p. 50). If *wheat flour* (dry) be estimated to contain 16·5 per cent. of nitrogenous matter or proteids, and 56·25 of starch, *barley* is found to contain more proteids and less starch, while *rye* stands opposed to barley in its fewer proteids and greater amount of starch. *Rice* has little nitrogenous matter (7 or 8 per cent.), and 78 parts or so of starch.

Bread is made by mixing flour, water, yeast, and salt at a warm temperature. The nitrogenous matters undergo fermentation, and cause the starch to become decomposed into dextrin and sugar; the latter in turn being split up into alcohol and carbonic acid gas. This gas gives to bread its light and aerated texture, the alcohol escaping in the process of manufacture. In making unfermented, or, as it is often named, 'aerated bread,' the dough is baked with water containing carbonic acid gas; and by another well-known process the same result is attained by mixing carbonate of soda with the dough and adding hydrochloric acid. The acid combining with the sodic carbonate gives rise to carbonic acid gas, which 'aerates' the bread, while chloride of sodium (common salt) is left behind.

The leguminous seeds, or 'pulses,' as they are also named, including peas, beans, and lentils, are notable for their containing *legumin*, a nitrogenous food allied to *casein* in its nature. These seeds are the sheet-anchor of the vegetarian, and they are no doubt highly nutritious; but as a counterbalancing quality, they are difficult of digestion, and cannot be well used by most persons, unless when skilfully combined with other foods. *Potatoes* form a very poor food by themselves (see p. 50), but are handy and valuable adjuncts to foods rich in nitrogenous matter. *Carrots* consist of proteids or nitrogenous matters, 1·3; starch, 8·4; sugar, 6·1; fat, 0·2; minerals, 1·0; and water, 83·0 (Letheby). They are indigestible, unless young and perfectly cooked. *Parsnips* resemble carrots closely in composition. The *turnip* is by no means nutritious, containing, as it does, about 90 per cent. of water and only 1·2 of proteids, and 5·7 of starch. The *cabbage tribe* includes plants which are valuable as anti-scorbutics or scurvy-preventives, containing, as they do, a large percentage of minerals, amongst which potash ranks high.

Several members of the *fungus tribe* are eaten, the mushrooms, morels, and truffles being the most familiar. Payen gives the amounts of proteids in dried mushrooms at 52 per cent. *Fruits* consist of so much sugar, *pectin*—a gelatin-like compound—minerals, and various organic acids.

The amount of water in fruits is high, and the proteids exist in too small proportions to be of service for foods; but most fruits have valuable anti-scorbutic properties, and their employment is often of service where the movements of the digestive tract require stimulation. *Sugar* itself has already been prominently mentioned as a member of the *carbohydrate* group of food-stuffs. It aids in force-production and also in the formation of fat. *Cane sugar* and *glucose* (or *grape sugar*) are familiar examples of this class of foods; the latter being found in grapes and other fruits.

Condiments consist of substances used to season or to flavour foods. They are in general use amongst most nations, and thus appear to be employed by natural instinct by way of adding to the zest and relish of digestion. *Salt* itself is the chief condiment, and is of high value as assisting the digestion of food in the stomach. *Pepper*, *vinegar*, *mustard* and *lime juice* may also be ranked under the present heading. *Vinegar* is itself of hygienic value, and was highly esteemed by the Romans. *Lime juice* has a special action as a preventive of scurvy, and in this light is used on board ships and in other places. *Sauces* and *pickles*, and all other condiments, simply act in promoting digestion by causing a free flow of the saliva and other digestive secretions, and also by stimulating the movements of the digestive canal.

The *preparation of food by cooking*, has for its object not only the rendering of the nutriment pleasing to the taste, but also that of assisting its digestion by the conversion, into an easily assimilated form, of matters which would otherwise be indigestible. The texture of meat, for example, is rendered less hard by cooking, and its juices are combined more readily with its fibres through the culinary processes to which it is subjected. The aim of all cooking is thus to aid the digestion of food; the 'culinary art' being specially brought into play to render the nutriment agreeable to taste and flavour. Meat well cooked has its fibrin solidified and its tendinous parts gelatinised. The texture of the meat is loosened, in addition, and the rule that the digestibility of meat stands in direct relation to the looseness of its fibres, is thus explained on this theory of the cooking process and its effects. Of vegetables, the same remarks hold good. The tissues of the plant are loosened, separated, and softened, and are thus rendered readily amenable to the action of the digestive juices. Starchy matters are also acted upon; the granules are made to swell up and their contents liberated, so as to be readily acted upon by the digestive secretions. When we reflect that in the stomach meat and vegetables are really taken to pieces by the actions occurring during the process of digestion, we can realise the immense aid to easy assimilation of the food which proper cooking affords. Lastly, the mere warmth which this process supplies is an important factor in the digestive process.

The process of *boiling* food has frequently for its object the extraction from the food of its nutritive principles. In this case, where these principles are destined to pass into the fluid from the meat, as in the case of soup and broth, the meat must be finely divided and placed in cold water. After some time, heat is applied and is gradually raised, so that, for soups, the boiling point is kept up for the extraction of the gelatin. In the case of broth, on the other hand, where the albumen of the meat is desired, the boiling process is avoided; the meat in either case being deprived of its most nutrient parts. When the meat itself is intended for boiling it is not divided, but plunged into water which is kept at the boiling point for a few minutes. By this process, the meat has its albumen coagulated on the surface, and the juices are thus prevented from escaping. Thereafter, the meat is to be kept at a temperature of between 160° and 170° F., so that its central portions may remain juicy and preserve their tenderness. The essence of skilful boiling consists in the meat being kept at the above temperature after the first and short period of boiling is over. In boiling *fish*, it should be borne in mind that the firmness of the flesh will be proportionate to the hardness of the water. On this account, salt should be added to the water in which fish is to be cooked. Probably boiling is a process which prepares food suitably for easy digestion, if, also, it is credited with presenting us with less attractive viands than those prepared by roasting. Meat ordinarily loses about one-fourth of its weight in cooking ; roasting being most destructive in this sense.

In *roasting* food, the same principle to be observed in boiling applies. The first heat is to be high, so as to coagulate the outer layer of albumen and to preserve the internal juices. Thereafter, the heat should be gradually and long applied at a lower temperature, so as thoroughly to cook the internal mass. *Broiling* consists in exposing a larger surface of the meat to a sharp heat. In *baking*, the meat is allowed to become more thoroughly infiltrated with products of its own chemical alteration : the fatty acids given off in boiling and roasting being confined, and being made to pass into the substance of the meat. *Frying* is a process in which the heat reaches the food through the medium of boiling oil, with which it becomes more or less completely impregnated. Of all modes of cooking, it may be said that frying is that least adapted to prepare food for easy assimilation. The fatty products thus thrown into the food, tend to render it in many cases extremely indigestible. *Stewing* consists in allowing the food to simmer at a low heat, boiling being strictly guarded against. If the vessel in which the meat is contained, be covered and placed within another amidst water, and so allowed to simmer at a gentle heat, the meat may be cooked in its own vapour. This principle is acted upon in the construction of many 'cooking pots,' where, by a kind of 'water-bath' action, the meat is gently and effectually prepared.

Another interesting form of cooking apparatus is that called the 'self-acting.' A box, constructed to retain heat, receives a vessel in which the meat is contained, amidst water which has previously been brought to the boiling point. Enclosed in the box, the vessel and its contained meat and water are maintained at a proper temperature in any situation and in the absence of further heat.

CHAPTER IV.

WATER AND BEVERAGES.

THE importance of water as a necessary condition for the existence of both animals and plants cannot be exaggerated. Water may be described as absolutely necessary for the continuance of life, and for the discharge of all the vital functions. Its importance may be demonstrated when the fact is borne in mind that water itself enters into the primary composition of *protoplasm*. This latter substance—one of the nitrogenous or proteid class—is the 'physical basis of life.' It constitutes the one substance which can be named 'vital' or 'life-forming,' and as such, forms the living tissues of all organic beings, from monad to man. The lowest animals and plants exist, each as a mere speck of protoplasm; so that a microscopic fragment of this substance is capable of discharging all the functions of life in its lowest manifestations and in the absence of all structures or organised parts. The highest animals and plants arise, each, as a speck of this wondrous material; this speck constituting the *ovum*, or *egg*, of the animal, and *germ*, or living principle of the seed, respectively. The ovum of the human subject is such a speck, measuring in diameter the $\frac{1}{120}$th of an inch. When the animal or plant grows to maturity, it does so through the increase and multiplication of the protoplasm of its cells; and when it has attained its full growth, it is through the living protoplasm of these cells (forming its tissues) that all the ways and works of life are carried on. Thus protoplasm is the primary material of nature, through which alone life is manifested to us. It therefore becomes interesting to note that *water* enters into the composition of this substance, as one of its component compounds. Protoplasm consists of the elements carbon, hydrogen, oxygen, and nitrogen, with traces of sulphur and phosphorus, and in respect of this constitution falls into the nitrogenous class of substances, as already remarked. But these elements (C, H, O and N) unite to form carbonic acid (CO_2), water (H_2O), and ammonia (NH_3), and it is from these latter compounds that protoplasm is elaborated. The green plant, for example, feeding on these matters, elaborates living protoplasm therefrom. Hence, as a protoplasm-manufacturer, the plant may be taken as the type of such organisms ; and water is therefore seen to be an essential condition for life, seeing that it enters into the intrinsic composition of life's substance and material.

In another and equally important sense, water has been shown to be a necessity of life. It has already been described as entering into the composition of each organ and tissue of animal and plant forms. Both animals and plants can exist, only when their tissues and fluids receive a continuous supply of water, and this material besides represents, as we have seen, part of the waste-products of the economy. The high importance of water as a condition of healthy existence may be appreciated on grounds of scientific nature, and the necessity for a pure and plentiful supply of the fluid becomes justified as a necessity for the normal continuance of all living beings.

The *chemistry* of water is of simple character. It consists of two elements, hydrogen (H) and oxygen (O), combined so that in each volume of water we find twice as much of the former as of the latter. On this account the chemical formula for water is written H_2O ; chemical nomenclature thus expressing the composition of the substances it describes. Two parts by weight of hydrogen (which stands as 1 in the combining proportions of the elements) unite with 16 parts of oxygen (this gas standing as 16) to form 18 parts of water; or, if by measure of volume, 2 volumes of hydrogen unite with 1 volume of oxygen to form 2 volumes of steam. Water has everywhere the same chemical composition. Its differences are never due to alteration in its chemical nature, but to the substances which become *mechanically* suspended or dissolved in the fluid. An experiment which demonstrates the composition of water in an effective manner is that of decomposing or splitting it up into its two gases by electrical action. By means of the electrical current, the water is split up into the gases of which it is composed; and when the tubes into which the gases are received are noted, it is seen that the tube connected with the zinc end or pole of the battery contains twice the volume of gas observed in the other. The former is the hydrogen gas and the latter the oxygen; this experiment showing by analysis the elements of which water is built up.

The *source* of the fresh water used by mankind is, of course, the atmosphere, in which are contained the clouds which have been formed by evaporation from the earth. As these clouds return the water to the earth in the form of rain (or snow), they may be regarded simply as 'bankers' of water. So that a continual circulation of water is taking place between earth and air; the sun's heat evaporating water to form clouds, and the clouds returning the water to the earth as rain. The rainfall is disposed of in various directions. So much goes to form rivers and lakes, so much falls directly into the sea, and so much disappears into the soil. In the latter case, the earth again appears as a storehouse of water; seeing that sooner or later, the water received by the soil will make its appearance on the surface in the form of springs, or may constitute wells. In the course of its progress through the earth and amongst the strata, water is liable to absorb certain materials from the rocks. It may thus take up lime, soda, and other minerals in its course, or it may become heated through contact with volcanic conditions. In the latter instances, and when impregnated with certain substances—iron, magnesia, potash, &c.—or when its temperature becomes raised, the water appears on the surface as a *mineral water* or as a *hot spring*. It is needless to add that in such cases, springs become useful for the cure of disease, and by their presence contribute to the celebrity of many towns and cities.

In considering water from a health aspect, its sources may therefore be regarded under the heading of (1), rain-water; (2), water from springs and wells; and (3), water from rivers, lakes, and the sea.

Rain water, of itself, is a pure water. In its passage through the air it becomes aërated, and, did it remain pure, would be a safe water for drinking purposes. But in its aërial descent, rain is liable to contamination from the substances which the atmosphere holds suspended; this action being specially observable in the neighbourhood of towns and of manufactories. Chemical impurities of various kinds, particles of soot, &c., are thus liable to render rain water impure, while more serious contamination may result from the presence in the air of effete animal and vegetable products. Hence rain water is rarely stored or used except for washing purposes, although in certain places it may be utilised for drinking. In Venice and in the West Indies, this is the case. The uncertainty of the supply in the case of rain water, is another reason why little dependence is placed upon it. The water derived from the melting of *ice* and *snow* may be placed in the same category as rain water. When water freezes it assumes a greater purity than before, through the disappearance of many of its mineral constituents, while its contained air is also largely expelled. But ice and snow are liable to contamination, as is rain water, and diseases of serious type—typhoid fever, cholera, &c.—have been known to be propagated by the use of ice and snow which had absorbed impurities from the soil or air.

Spring and well waters are largely used for drinking purposes, and derive their special characters from the geological strata through which they have passed. The amount of rain water which passes into the soil varies greatly with the nature, porosity, &c., of the strata. As the water passes underground, the carbonic acid gas it has received in its passage through the air is largely increased. It is to the chemical action of this gas that the various substances which spring and well waters contain are absorbed. Thus carbonate of lime (or chalk) is dissolved by the action of carbonic acid, while lime itself, silicate of soda, and other salts are also decomposed. Spring water is thus seen to be singularly liable to variation in composition, and to exhibit corresponding differences as regards its desirability for human use when regarded from a health point of view. In the case of *wells* the same opinion holds good. The variation in depth of wells has much to do with the nature of their contained water. Thus the water of shallow wells (50 feet deep or so) is exceedingly liable to contract impurities through the surface-drainage passing into the fluid. Matters derived from soils—vegetable and animal products—often contaminate such waters, and when such wells are situated near human habitations, there is more than ordinary risk of serious pollution from sewage matters taking place.

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 rocks of volcanic nature (e.g. granite) is usually of pure character. Chalk waters are also pure, but are very 'hard,' from the large amount of carbonate of lime they hold in solution. In other cases the presence of compounds of magnesia—as in waters from magnesian limestone—may impart purgative properties. Sandstone waters are also of pure nature, whereas that derived from clays and gravels tends to become impure from the ease with which surface matters may percolate through the soil and subsoil.

The water of *rivers and lakes* is, as a rule, 'soft' in its character; that is, it contains only a limited or average quantity of the minerals (chiefly lime and its salts) to which the 'hardness' of water is due. Lake water may be charged with vegetable and peaty matters, but river water, from its constant movement, acquires a certain degree of purity through the free oxygenation to which it is thus subjected. Naturally, where a river is converted into a sewer, and is made to receive the sewage of a city or town, or where manufactories are allowed to discharge their waste products into its current, the water becomes unfit for drinking purposes. Much illness and frequent outbreaks of epidemic diseases have been traced to this perversion of river supply. The *sea* is occasionally made to supply drinking water through the process of *distillation* carried out on board ship. The taste of distilled water is insipid, owing to its want of aëration, but this defect is obviated by aërating it by allowing it to fall from a height from one vessel (a barrel, the bottom of which is perforated with holes) into another. In distilling water at sea, the use of lead pipes should always be avoided. Block tin is the most suitable material for use in distilling apparatus.

'Hard' and 'soft' waters have already been mentioned. In an ascending scale from 'hard' to 'soft' waters we find the following to be the order:—(1) Shallow well water; (2) deep well water; (3) spring water; (4) river waters; (5) surface water from cultivated land; (6) upland surface water; (7) rain water. Water which contains from 8 to 10 grains of mineral matter per gallon is an average water in respect of hardness. On the side of softness, a water with 3 or 4 grains only, per gallon, would be considered typically so, while 20 or more grains per gallon would contribute extreme hardness. We familiarly experience the nature of hard water from the difficulty with which soap forms a lather when used with it; and this test is scientifically used by chemists in the examination of water. Soap itself is composed of fatty acids, combined with soda or potash. In using soap with hard water no lather is formed until the materials of the water form compounds with the fatty acids in question; therefore with a high percentage of minerals a large amount of soap is wasted in neutralising the mineral constituents.

A highly useful classification of waters, in respect of their utility for drinking, &c., has been given by the Rivers Pollution Commissioners, in their Sixth Report, as follows :—

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

The *characters of a pure water* are largely negative. It should have no colour, no odour, no taste, no deposit, and it should be aërated and not hard. It should be borne in mind, however, that a clear, sparkling water may be a highly impure and dangerous water. Clearness is therefore no test, taken by itself, of the potability of water. The characters of any water must be judged as a whole chemically, microscopically, and physically, before any accurate or trustworthy opinion of its character can be formed.

Water may be rendered *impure* and unfit or dangerous for human use—(1) by *mineral impurities*; (2) by the presence of *organic impurities*—i.e. animal or plant matter in a state of decay. In considering this all-important topic we may, firstly, regard the *impurities themselves*, and secondly note the *effects* such impurities are liable to produce on the human race.

That the *mineral impurities* of water are capable of inducing disease has been established by many undoubted facts. We have seen that from 8 to 10 grains of minerals per gallon is a fair average of such constituents in a potable water. Thus excess of sulphates of lime and magnesia (7 to 10 grains per gallon) may constitute a source of mineral impurity. The chlorides of lime and magnesia, as well as the nitrate of lime, are also to be regarded with suspicion when they exist in any quantity in water. The presence of carbonate of lime, on the other hand, is not necessarily injurious where the salt is present in moderate quantity, but chloride of sodium (or common salt), when found in waters removed from the sea or from salt-bearing rocks, is regarded as an unfavourable indication. In addition to these natural impurities we require to take into account also the occasional presence in water of accidental or extrinsic matters, such as iron, zinc, lead, and even arsenic and copper. These impurities are derived from the pipes or cisterns in which water is conveyed or stored. Lead is, perhaps, the most common source of contamination. This latter impurity arises from the chemical action exerted in leaden pipes by certain waters, even very pure waters exhibiting this action. The quantity of lead which may act injuriously appears to be very minute. Parkes considers that 'any quantity over $\frac{1}{20}$th of a grain per gallon should be considered dangerous, and that some persons may even be affected by less quantities.' Cases of severe lead-poisoning have been caused by $\frac{7}{10}$ths of a grain of this material per gallon. Arsenic and copper are likely to be found in water, only in situations in which chemical industries form the sources of contamination.

Animal and vegetable matters form frequent sources of serious impurity in water. A large number of diseases are due to such contamination, which chiefly arises from sewage matters being allowed to escape into a water-supply. Vegetable matter itself, such as peat, &c., may not constitute a source of danger, and may be capable of removal by filtration. But in some cases, such materials have given rise to disease; and when it is remembered that ague and allied disorders arise from malarious or marshy exhalations, it may be seen how vegetable contamination acts as a source of illness. *Animal matter*, on the other hand, must be regarded as invariably injurious. Thus matter derived from the bowels of cholera and typhoid fever patients, conveyed into water, is a common and fruitful source of distribution of these diseases. The 'germs' of disease are not destroyed, but, on the contrary (as asserted to be the case with the cholera germ), acquire a high vitality and reproductive power in water. Hence all sewage contamination is to be regarded as a highly dangerous impurity of water, and it should be remembered that, according to received opinion, even a mere trace of infected matter may in time render a water supply unwholesome.

In addition to these matters, consisting of animal and vegetable products in a state of decay, there may exist in water living animals and plants of lowly grade, or of minute size, capable of producing disease. Thus the eggs and embryo of tapeworms, flukes, and other parasites may exist in and be conveyed by water. The lowest plants—fungi, bacteria, and other germs—are common in stagnant waters especially, while the water-fleas (*Cyclops*, *Cypris*, *Daphnia*, &c.) are also found in many clear supplies, in addition to many animalcular forms. Such organisms as the water-fleas do not certainly indicate that any water-impurity exists; but, *cæteris paribus*, water containing an abundance of life must be regarded as inferior, and less desirable, than that which is clear or comparatively lifeless.

The *diseases* produced by impurities in water are very numerous. Leaving out of count parasitic diseases produced by actually drinking the eggs or embryos of tapeworms and other forms, and dismissing cases of lead-poisoning, &c., there remains a long list of serious maladies which owe their continuance and propagation to infected water.

Primarily, mineral impurities are found capable of producing disease. Diarrhœa and other digestive disorders have been known to follow the drinking of water containing excess of sulphates of lime and magnesia ; dysentery has also followed the drinking of contaminated water ; but the chief ailment associated with hardness of water, and especially with salts of magnesia, is *goître.* This is an affection of the *thyroid gland* of the neck. The gland enlarges under the influence of abnormal stimulation, and often produces a hideous deformity. In England goître is often called 'Derbyshire neck.' This ailment occurs in Derbyshire, Yorkshire, Hampshire, Sussex, and elsewhere, and it is notable that in these districts Magnesian Limestone abounds. Of old, Aristotle and Hippocrates attributed goître to the use of impure water. French authorities have seen this disease appear in a gaol in ten days through the use of over-hard water, while conversely it has been seen to disappear under the influence of pure water. Recent investigations in Oude, show that in districts in which limestones abounded 33 per cent. of the inhabitants were affected with goître, whereas in districts in which clay slate was found as a water-bearing formation, the proportion of goître cases was only 0·54 per cent., and where the water was derived from granite and gneiss only 0·2 per cent. It seems probable, however, that magnesia salts are not the sole cause of goître. In Rheims and in Auvergne, in France, no such salts exist in the water, and yet goître is developed, while Dr. J. B. Wilson, investigating goître in India, found only three of the water samples of the district in question to contain lime, while none gave evidence of magnesia or iron. The presence of sulphide of iron in water has been suggested by M. Saint-Leger as a cause of goître, but it does not appear that any reliable evidence has been adduced in support of this belief. Another fact which seems to complicate the question of goître and its origin is that derived from the consideration of the immunity from this disease which is enjoyed by districts in Scotland, Ireland, and other countries, notwithstanding the presence of limestones as water-bearing formations.

Of vastly greater importance, however, are the diseases which are spread abroad by water contamination from *animal matter*. There is no question that such diseases as cholera, typhoid fever (also named enteric fever and gastric fever), and diphtheria, together with diarrhœa and dysentery, already mentioned, are chiefly spread through the medium of water. The discharges from the bowels of infected patients, allowed to escape into wells and other sources of water supply, form a powerful means of contagion. Polluted water, in other words, is at the root of the propagation of many of the epidemics which decimate our race. The whole history of preventive medicine teaches this great truth with singular force, and the records of sanitary science are full to overflowing of examples of such contagion.

One notable example of the check which disease receives when a water supply is properly regulated is found in the well-known case of Glasgow. When that city was supplied with Clyde water—a polluted source of supply—it passed through two cholera periods. In the first of these (1832) the deaths numbered 2,800 from this disease, in the second (1854) the mortality from cholera was 3,900. Thereafter the pure water of Loch Katrine was introduced into the city, and when the next cholera invasion took place, in 1866, the mortality was only 68. Facts like these speak for themselves. So also, in London, the history of the water supply tells the same tale. In the cholera epidemic of 1848–49, the disease raged most fiercely when the water supply was proved to be of impure character. When Thames water was taken from Hungerford Bridge the death-rate stood at 12·5 per 1,000; but when this source was exchanged for that at Thames Ditton, the mortality fell to 3·7 per 1,000. A notable fact was also seen in the same districts in which the latter rate of mortality was found. The death-rate in these districts, amongst families supplied with water from the Thames at Battersea, was 13 per 1,000.

Hundreds of examples might be cited by way of showing how the spread of cholera through an infected water supply is a matter of certainty. Scottish experience of cholera outbreaks has invariably shown that the fierceness of the epidemic stood in direct ratio to the impurity of the water, and that the introduction of a pure supply checked the disease. In 1854, a cholera outbreak in the parish of St. James's, Westminster, was traced to the water of Broad Street pump, reputed, by the way, for its sweet and fresh character. Analysis showèd that this water was impregnated with organic matter; further examination demonstrated that the cholera cases occurred only amongst those who drank this water, 486 fatal cases having occurred within a circular area whose radius scarcely exceeded 200 yards; while accurate investigation ultimately disclosed the fact that into the well of the pump, the sewage of a neighbouring house freely leaked, and that, moreover, the discharges of a patient who had suffered from a form of cholera must have mingled with the sewage. In this way, a single case of illness spread disease and death broadcast through infecting the water supply; yet the handle of Broad Street pump had to be removed before the people could be made to relinquish the use of the pleasant but deadly water.

As regards *typhoid fever*, the evidence regarding the part played by water in its spread runs parallel to that brought forward in the case of cholera. Even the washing of dairy utensils with polluted water, or the mixing of such water with a milk supply, has spread the disease to all the customers of the dairy; the fever being, in these cases, often confined, with singular exactitude, to the consumers of the infected milk. The original source of contamination is, of course, the introduction, into a water supply, of matter from the bowels of a typhoid fever patient, and this knowledge should impress most strongly upon the public the absolute necessity which exists for the careful supervision of such patients, and for the effective sanitary disposal and disinfection of all excreta. It is remarkable to find in many cases of typhoid epidemics, how strikingly proved the disease may be, in its origination from the evacuations of a single patient which have been allowed to escape into a water supply. *Diphtheria* is a disease which, amongst other modes of infection, may be conveyed by water, while *dysentery* and *diarrhœa* are admittedly caused most frequently by an infected supply.

The purity of a water supply being the first consideration, the *quantity* of the supply may next be considered. Dr. Parkes's estimate of the quantity of water required per head per day was about 12 gallons, distributed as follows: cooking, ·75 gallon; drink, ·33; personal use, including bath, 5·0; utensil and house washing, share of, 3·0; clothes washing, share of, 3·0. The quantity, according to other authorities, should be 30 gallons per head per day, 10 gallons being used for domestic purposes, 10 for municipal uses, and 10 for trade. The supply given per head in various towns differs greatly. Thus Glasgow receives 50 gallons per head per day; Edinburgh, 35; Liverpool, 30 (reduced by waste-preventers); Paris, 31; Sheffield, 20; London (average), 32; Norwich, 12; Derby, 14. Twelve gallons may be regarded as a minimum supply, and from 16 to 20 a fair and health-producing average, while 35 gallons may be considered by no means excessive, where trade, municipal, and closet supplies require to be included. One important means of water saving is found in the use of 'waste-preventers,' which are special appliances designed to prevent waste of water, in closets especially.

The water supply of a town may either be *constant* or *intermittent*. In the latter case, especially, storage for water in the shape of cisterns, &c., becomes imperative. A fixed law in sanitary science is that which advocates strongly the adoption, wherever practicable, of a *constant* water supply. The disadvantages of the intermittent supply are obvious. Dangers to health are apt to arise where the supply of water becomes exhausted, and where no provision for emergencies is possible; while special dangers from the sucking of sewer gases into the empty pipes, form not the least powerful objections to this form of water distribution.

The *cistern*, however, becomes a necessary article of furniture in our houses on any system—we had almost added 'a necessary evil.' For, as a rule, the attention of the householder to the cistern of his house is *nil*, and the cistern itself, becomes a source of serious annoyance and of disease, when, as is usually the case, it is neglected. Many householders do not even know where the cistern of the house is placed; it is rarely, if ever, cleaned; and year by year there accumulates in this tank, a sediment which, if not actually the cause of disease, certainly fosters and predisposes thereto. It is clear, therefore, that a necessary household rule, as far as health is concerned, should be laid down regarding the periodical cleaning of the cistern. If the cleansing and sweeping of our rooms is a necessity of healthy life, no less imperative is the thorough cleanliness and purity of the source of our water supply. The cistern should, further, be carefully covered in, so as to exclude dust particles and other extraneous matters, and the cistern itself should be placed in a situation to which easy access is to be had. Too frequently this latter rule is neglected, and the proper care of the tank becomes an impossibility, from the difficulties which supervene in the way of its being readily cleansed.

The cistern may also become a source of great danger to health from defective plumbing arrangements, whereby its overflow pipe is led directly into a drain or sewer (see fig. 37), so that the sewer gases are liable to pass upwards and to impregnate the water supply. Serious disease has in this way been introduced into households, and that such causes of illness are readily avoided becomes evident, when we reflect that the overflow pipes of cisterns can in all cases be carried outside, so as to discharge in the open air, or in specially protected positions, familiar to all plumbers who know their business after the true fashion.

As regards the material for cisterns, probably galvanised iron is that to which least objection can be taken. Glazed stoneware cisterns are also now in common use. Lead cisterns are dangerous, however, only when there is risk of chemical action taking place between the water and the lead. Soft waters especially are liable to attack lead ; but in most cases the lead becomes coated with salts which, being insoluble, protect the cistern from further action. In cleaning a leaden cistern, however, it is well to bear in mind that no hard brush, or other implement calculated to scratch the metal—and thus expose a fresh surface to the action of the water—should be used. A soft cloth should be used, and the cistern itself well flushed out with water. Slate cisterns are usually objected to on account of their liability to breakage.

When a water supply from any cause is regarded as in any way unsafe or disadvantageous to use, means are adopted by sanitarians for its *purification*—that is, where no better supply can be procured. Water may be *purified*, firstly, for the removal of matters which are apt to prove directly injurious to health. River water, which is apt to contain vegetable matters, or even unfortunately to be tainted with sewage, should in all cases be filtered before use. On a large scale, water is filtered by being passed through *filtering-beds* composed of gravel and sand. For domestic use, several excellent filters exist. Any filter, it should be clearly borne in mind, is merely a kind of 'dust bin,' which receives and retains the foreign matters it has separated from the water ; and every filter, therefore, requires to be thoroughly cleaned at stated periods. Neglect of this precaution is the source of much disappointment in connection with filters at large. That a dirty filter is much worse than none, should be a maxim constantly borne in mind. Filters may be made of various materials, more or less effective in their action on the matters suspended in water. Thus, the 'Spongy Iron Filters' are to be highly recommended, their action being both mechanical and chemical in nature; while, according to Parkes, spongy iron retains its filtering properties for a great length of time. Charcoal filters form, also, excellent means of purifying water. The 'Filtre Rapide' of Maignen, in which the water is strained through both coarse and fine media of this nature, is an excellent example of such appliances, and possesses the advantage of being easily cleaned and renewed in its filtering parts. Other forms of filters adapted for household use are the 'Manganous Carbon Filter,' that of the 'Silicated Carbon Co.' of London, and Doulton's 'Improved Granular Charcoal Filter.' 'Carferal'—a mixture of iron, clay, and charcoal—has also been used as a filtering medium. With care in the use and cleansing of these filters, they will be found to act admirably in purifying water for domestic use. Filters of special make are often fitted to cisterns, so as to deliver the water ready purified in the house pipes.

Other processes of water-purification are devoted to altering the chemical properties of water. Thus, *boiling* water is a good plan where impurities are suspected; many, although not all, disease germs being thus destroyed. *Alum* has been long used in the east to purify water. 'Clark's Process' consists in adding lime-water to a hard water. This lime, uniting with the carbonic acid, forms chalk (carbonate of lime), which falls to the bottom of the vessel or tank. 'Condy's Fluid,' which is a solution of *permanganate of potash*, is also used to purify water; and is in itself a test for the presence of organic matters in water. Added to a pure water, a little 'Condy's Fluid' simply forms a beautiful purple solution, its colour being unaltered. But if organic matter be present in the water the purple tint is lost, and the 'Condy' will not again show its purple hue, on addition to the water, until the organic matter has been thoroughly oxidised. In the cleansing of filters, cisterns &c., 'Condy's Fluid' is of great service.

With regard to *well-waters*, the general rule should be borne in mind, that wells are very liable to pollution from the drainage into them of the surrounding soil. Wells in towns and villages often form sources of disease from this cause. No well-water should be employed without a chemical analysis of the fluid having first been made; and it is advisable that, from time to time, such analysis should be repeated to ensure the continued purity of the water.

The subject of the *Beverages* in common use, in addition to water itself, becomes of importance from a social, as well as a sanitary point of view. These beverages include *tea*, *coffee*, *cocoa*, and the various *fermented liquors* used in one form or another by well-nigh every nation. Very wide differences, it need hardly be said, exist in the nature and effects of these beverages; and it remains for us to point out the chief characteristics of their action, and their more prominent uses to mankind at large.

Tea, as the chief beverage, may be first considered. It contains but little albumen, and consists chiefly of *theine* (its active principle), a *volatile oil* giving the 'aroma' of the tea, and a bitter astringent substance allied to tannic acid in its nature. In the form of a beverage made by infusing the leaves in boiling water (the water should be boiling, and should have just 'come to the boil'), tea is used as an agreeable drink to assuage thirst, and for its stimulating effect on the nervous system. That the good effects of tea may be experienced, the infusion should not be allowed to stand too long; five or six minutes is sufficient, if the tea is of good quality. 'The eternal teapot simmering on the hob,' is at once a dietetic enormity and a physiological mistake. The tea should be of pure character, and, as an infusion, it should not be made over-strong. Tea is much subject to adulteration. Strong black tea, with an 'inky' taste, probably contains iron, which may be separated by the use of a magnet; while green tea contains more of the essential oil than black tea, but is apt to engender digestive troubles more readily through frequent use.

Coffee resembles tea in being composed of an essential oil, of astringent matter—present in less quantity, however, than in tea—and of the active principle named *caffein.* Soft water, it should be remembered, extracts, both from coffee and from tea, more of the constituents than hard water. Letheby maintains that a five-ounce cup should contain 66 grains extract of coffee; such a quantity being obtained when two ounces of freshly roasted coffee are added to or infused in one pint of boiling water.

As regards the physiological action and effects of tea and coffee, it should be remembered that neither can lay claim to being a 'food,' using this word physiologically. These beverages are rather adjuncts to food than foods proper. They contain too minute quantities of nutritive materials to be regarded as 'foods' in the true sense of the term; and their use is limited to the production of effects on the body which, under ordinary circumstances, are productive of benefit in relation to the utility and assimilation of true foods. It would thus appear that both tea and coffee aid the body, in conserving its powers in the absence of sufficient nourishment—an effect probably due to their action on the nervous system. By some authorities, these beverages are regarded as possessing the power of diminishing the waste processes (or *excretions*) of the body; but this view is denied by other physiologists. As nervous stimulants, and in all probability as serving to make ordinary nutriment go farther in the support of the body, tea and coffee are extremely useful adjuncts to nutrition. But this view of their use entirely excludes the common notions which profess to find, in tea especially, a form of nourishment. The common practice, amongst the poorer classes especially, of continuous tea-drinking is both physiologically pernicious and economically wasteful. The habitual use of tea, under such circumstances, induces dyspepsia and other ailments; while the money spent on tea, often of inferior quality, might be legitimately used to purchase articles of food of truly nutrient kind.

With *cocoa* the case is widely different. Cocoa is a true food, and, taken with milk and bread, constitutes a wholesome meal on which work can be performed. Cocoa, besides, contains an active principle, *theobromine*, which gives to this beverage the stimulant properties of tea and coffee. Analysis of good cocoa shows that it contains from 20 to 21 per cent. of nitrogenous matter, from 10 to 11 per cent. of starch, with traces of sugar, and from 48 to 50 per cent. of cacao butter. 'Looked at dietetically,' says Dr. Pavy, 'cocoa possesses, though in a milder degree, the properties of tea and coffee, but it stands apart from these articles in the high nutritive power which its composition gives it. Containing, as pure cocoa does, twice as much nitrogenous matter and twenty-five times as much fatty matter as wheaten flour, with a notable quantity of starch, and an agreeable aroma to tempt the palate, it cannot be otherwise than a valuable alimentary material. It has been compared in this respect to milk. It conveniently furnishes a large amount of agreeable nourishment in a small bulk, and in South America cocoa and maize cakes are used by travellers, and form a food, several days' supply of which is easily carried.' If the poorer classes of this country substituted cocoa for tea and coffee they would suffer less from digestive ailments, and would obtain a form of nourishment vastly superior to that of which they commonly partake.

The remaining beverages may be included under the name of *fermented drinks.* Of these, beer, wines, and spirits form the chief forms. Beer consists of an infusion of malt fermented and flavoured with hops. In malting, the starch of the grain is converted into sugar and dextrine. The alcohol contained in beer varies from 1 or 2 per cent. to 9 or 10 per cent. in volume. According to Parkes, a pint (twenty ounces) of beer will contain about one ounce of alcohol. In the case of *wines*, from 6 to 26 per cent. of alcohol (by volume) may be present ; port and sherry usually give from 16 to 25 per cent., champagne from 6 to 13 per cent., and lighter wines about 10 per cent. Many wines are, of course, fortified by the addition of alcohol. *Spirits* may contain, when undiluted, from 50 to 60 per cent. of alcohol.

A marked change in opinion has been formed respecting the use of alcoholic beverages in ordinary life. So far from now being regarded as necessary adjuncts to healthy existence, all physiologists are agreed that no such need for alcoholic beverages really exists. The whole question of the utility of these fluids may, in the present state of our knowledge regarding their action, be summarised in the statement that alcohol is not a necessity for the healthy adult body, and that it is absolutely injurious to the young and growing body. An addendum must likewise be made to these statements, to the effect that the utility of alcoholic beverages is limited to dietetic purposes. There are cases in which the addition of alcohol to the dietary may be followed by advantageous results. But while such a practice should only be followed under the guidance of matured individual experience, or under medical advice, it is perfectly clear that the scientific knowledge we do possess of the action and uses of alcohol effectually disposes of the too common drinking habits of this and other countries, in which such beverages are consumed to the material injury of even the moderate drinker.

CHAPTER V.

THE AIR WE BREATHE.

THE planet we inhabit is surrounded by a shell, or envelope of air, familiarly named the *atmosphere.* Regarding the thickness of this air-covering, opinions vary greatly, but the chemical composition of the atmosphere remains practically invariable under all variations of pressure and density. Of the necessity of pure air as a condition for healthy existence little need be said. As has well been remarked, without food life may yet be prolonged for days, but deprivation of air means well-nigh instant death. The effects of impure air, furthermore, are traceable on the whole frame, and many ailments are due either to the impurity of air as a whole, or to the seeds or germs of disease which impure air is known to carry and contain. If pure food and pure water are necessities of healthy life, pure air is a condition which, with even more inexorable sway, rules the health-destinies of animal life.

Pure air consists of a mixture—not a chemical combination—of two gases, *oxygen* and *nitrogen*, with varying proportions of *carbonic acid*, *watery vapour*, and *other matters.* The oxygen and nitrogen may be regarded as the essential constituents of the atmosphere ; the other matters, although rarely, if ever, absent from air, even in a pure state, being regarded as accidental components, liable to be increased under unfavourable circumstances to an extent which acts injuriously on animal life. Roughly speaking, 100 parts of air are composed of 21 volumes oxygen to 79 volumes nitrogen gas ; in 100 grains of air, estimating the quantities by weight, 23 grains of oxygen and 77 grains of nitrogen are contained. A table of air composition might be compiled as follows :—

In 100 parts of pure air there exist—

Oxygen	20·99 parts
Nitrogen	78·97 "
Carbonic acid	·04 "
Watery vapour, Ozone, Ammonia	traces

Of the substances above spoken of as foreign to the air or of extraneous character, the chief is carbonic acid gas, or *carbonic dioxide* (CO_2), as it is chemically termed. As shown in the above table, the quantity of this gas which exists in air that may be regarded as essentially pure is four parts in 10,000 volumes of air. If, however, this apparently trifling quantity should be but slightly increased—say to three volumes in excess of that mentioned as normal—serious impurity of the atmosphere results. It is this gas which is given off from the lungs and excretory organs of animals as a waste product; and it is the presence of this gas which forms one of the chief sources, if not the principal cause, of the necessity which arises for that process of the renewal of the air in our apartments which, however practised, receives the common name of *ventilation.* It may therefore be readily seen that wherever human beings are crowded together an excess of carbonic acid in the air is generated, and the need for efficient ventilation for expelling the tainted atmosphere, and for renewing it by supplies of pure air, becomes plainly apparent when this elementary lesson of physiology has been grasped.

The other 'accidental' components of the atmosphere include *water*, *ozone*, *ammonia*, &c. The quantity of *watery vapour* which the atmosphere may carry varies greatly. The higher the temperature of the air the more water it can retain, and *vice versâ.* Hence the temperature of the atmosphere is probably the determining cause of the amount of watery vapour it holds at any given time. The average amount of water has been estimated to consist of about 1·46 in 100 parts of air. It is only very rarely that the air is saturated with watery vapour; from 50 to 75 per cent. of the amount required for complete saturation being usually present. The *ozone* of the air is an altered and condensed, or, as chemists term it, an 'allotropic' form of oxygen. This gas has a peculiar odour, and possesses a remarkable power of speedily oxidising and destroying organic matters it may meet. More powerful in its action than oxygen, ozone is thus a powerful deodoriser and disinfectant. It occurs in sea and mountain air, and is present during thunderstorms, and its presence may be regarded as a test of the purity of the atmosphere. 'Take, for example,' says Dr. Fox, 'a little blood, and keep it in a warm place for months, until it putrefies. When the odour is something horrible, sufficient, indeed, to create nausea or sickness, send a stream of ozone over it, and its freshness, purity, and sweetness will be restored.' The quantity of ozone in the air is measured by exposing test papers dipped in iodide of potassium. The ozone decomposes this compound, and sets free the iodine, thereby tinting the paper a reddish-brown colour. *Ammonia*, a product of the decomposition of animal matters, is present in traces only in pure air; while such substances as *organic matters*—consisting of the effete or worn-out particles of animal and plant bodies—*nitrous* and *nitric acids*, may also be regarded as being represented in ordinary air by mere traces.

The *effects produced upon the atmosphere by its being passed through the lungs and blood*, are extremely constant and characteristic. In the first place, the oxygen is diminished; secondly, the carbonic acid and water are increased; thirdly, its temperature is increased; and fourthly, ammonia and organic matters are added to the air. The nitrogen of the atmosphere, it should be added, remains practically constant. This gas is inert, so far as animal life is concerned. It seems to act as a diluent of the oxygen, being mingled with the latter gas in proportions which constitute a respirable mixture. Nitrogen appears to pass in and out of the breathing organs unchanged ; little, if any, of this gas being absorbed into the blood.

The diminution of the oxygen in the air, after being breathed, is accounted for by the demand which exists for that gas on the part of the living tissues. The proportion of oxygen is thus diminished about 4·8 per cent. on an average. If ordinary air contains 21 per cent. of this gas, after expiration it will contain only 16·2 per cent. The carbonic acid of expired air is conversely increased to about 4·3 per cent. on an average. Before being breathed, ordinary pure air contains, as we have seen, 4 parts of carbonic acid in 10,000, while after expiration, this amount is increased to 430 parts in 10,000 volumes. The watery vapour of the expired air represents so much waste material. The air is saturated with water after expiration. It has been calculated that from 9 to 10 ounces of water are exhaled from the lungs of an adult man in 24 hours. The temperature of expired air is nearly that of the blood ; varying from 97 to 99·5 F. As regards the ammonia and organic matters, while the traces of the former substance are minute in quantity, it has been estimated that about 3 grains of organic matters are exhaled from the lungs in 24 hours.

It may be interesting to note, in connection with the expiration of animals, that green plants, in the presence of light, absorb carbonic acid (CO_2), decompose this gas into its component oxygen and carbon, retain the carbon for food, and return the oxygen to the atmosphere. In the absence of light, this action ceases, the plant then merely absorbing oxygen, and giving off carbonic acid like the animal. Green plants, however, even in the light, absorb small quantities of oxygen and eliminate a slight amount of carbonic acid gas, this latter act constituting *respiration*, whether occurring in animals or plants. The action of absorbing carbonic acid and of exhaling oxygen is an act of nourishment on the part of the plant ; seeing that the carbon in the latter case is retained for food. Plants which, like the fungi, are not green, habitually, by day and by night, absorb O and eliminate CO_2.

Before proceeding to treat of ventilation and its accompanying details it is necessary to consider the amounts of air which may be required for healthy existence, and under varying circumstances of life. Supposing a man breathes about eighteen times per minute, and gives off about 30 cubic inches of air per expiration, he will emit at each breath 1·29 cubic inch of carbonic acid gas, this being equal to 16·1 cubic feet of this gas in twenty-four hours. In this latter amount of carbonic acid, there exist about $7\frac{1}{2}$ ounces of pure carbon or charcoal. Such an estimate, popularly formed, shows how great is the amount of air-impurity which a single individual can produce. No less startling is the estimate that an audience of 2,000 persons, while seated in a public hall for two hours, will give off from lungs and skin in that period about seventeen gallons of water, and as much carbon (contained in the carbonic acid gas exhaled) as is contained in a hundredweight of coals. That respiration then, natural though the process may be, is fraught with serious dangers to health cannot be denied. Each human being is, in this light, a source of danger to himself, and 'the breath rebreathed' is one of the most fertile causes of lung-disease known to modern science.

Exact calculation has shown that whenever the amount of carbonic acid in our rooms exceeds that contained in the outside air by two parts in the 10,000, the air of our rooms becomes close and unfitted for breathing. This amount of air-impurity beyond which we must not pass is, of course, equivalent to ·2 part per 1,000 of air. Reducing the calculation to these convenient terms, we see that as each individual exhales about ·6 of a cubic foot of carbonic acid per twenty-four hours, he must breathe air mixed, or diluted, with 3,000 cubic feet of pure air, if the carbonic acid is to be reduced to the safe proportions above indicated.

Presuming, then, that each person is to be provided with 1,000 cubic feet of space, he will require the air to be renewed thrice per hour ; if changed four times per hour he may be content with 750 cubic feet of space, and so on. About 3,000 cubic feet of air per head per hour is a fair estimate of the amount of air required to maintain a healthy atmosphere.

As Captain Galton remarks : 'According to theoretical calculations it would appear, that with an initial air-space of 1,000 cubic feet, occupied by one individual, it would be necessary to supply 3,000 cubic feet per hour to maintain the room in a proper condition of humidity. As regards other impurities, if 0·2 per 1,000 of CO_2 are accepted as the limit of respiratory impurity in a well-ventilated air-space, in addition to the 0·4 per 1,000 in normal air, we can calculate out the amount of air necessary to maintain this proportion constantly ; and from this calculation it appears that it requires 3,000 cubic feet per hour to preserve the air-space in the required state of freshness.'

Another interesting point connected with the question of air-impurity is that of the time required to convert air to the impure point (= 0·2 per 1,000 of carbonic acid), the calculations here given being made in rooms of different sizes, and all change of air being prevented. Thus one man in 10,000 cubic feet of air will render his atmosphere impure in three hours and twenty minutes. In 5,000 cubic feet of air a man will reach the impure standard in one hour forty minutes; in 1,000 cubic feet, in twenty minutes; in 600 cubic feet, in twelve minutes; in 200 cubic feet, in four minutes; in 50 cubic feet, in one minute ; and in 30 cubic feet in thirty-six seconds. The rapidity with which the air may be contaminated is thus seen to be very great.

In these calculations the presence of lights is not taken into account ; and this latter consideration is a highly important one in face of the requirements of ventilation. It is estimated that the combustion of one cubic foot of coal gas, destroys the oxygen of eight cubic feet of air, and gives off to the atmosphere two cubic feet of carbonic acid gas and other impurities. As an ordinary gas-burner may be calculated to consume three cubic feet of gas per hour, it is clearly seen that in making provision for ventilating our dwellings on account of the impurities exhaled from our lungs, we must not neglect to think of those which are given off by our lights. The dawn of the electric light, as a means of domestic illumination, would thus certainly remove one of the most powerful causes of air-impurity at present in operation.

The *movements of the air*, which require to be taken into consideration in discussing the methods which may be adapted for air renewal in our homes, are of various kinds. The property of gases known as *diffusion*, whereby each gas distributes itself equally throughout the space in which it is contained, gives to the atmosphere a uniform constitution, but does not alter the chemical or mechanical nature of the air. Thus even the vitiated products of breathing will in time tend to diffuse themselves through the atmosphere of the room ; but other means are evidently required for the due removal of these deleterious products, and for the replacement of the air which has been rendered unfit for breathing. A point of importance in connection with the diffusion of gases in the air is found in the fact that while the carbonic acid gas itself will diffuse very rapidly throughout a room, the *organic matters*, consisting, as has already been shown, of the worn-out particles of the living body, do not so tend to become separated. These matters are given to settle down in corners and near the ceiling, and hence the necessity for ventilation being thorough and complete is well seen, when we regard the removal of these organic particles as eminently desirable in the interests of health.

Chief among the agents which produce movements in air, and which naturally become utilised as means of ventilation, is the *wind*. The passage of air driven by the wind between the windows on opposite sides of a room, exemplifies 'perflation,' or 'cross-ventilation,' as it is also called. Even a slow light wind—travelling at the rate of a mile or so per hour—will act as an efficient ventilating medium. But as we cannot depend on the regularity of the action of the wind, it is clear other means of securing the fresh inflow of pure air and the outflow of vitiated air have to be employed. Again, 'perflation' is liable to be carried out, as everyone knows, in a fashion which renders it unbearable for any length of time. The currents of cold air may be of such force as to prove dangerous to health; and thus, while 'cross-ventilation' is a highly effective means of securing fresh air, it is often to be avoided from considerations connected with personal comfort.

The air, however, undergoes other movements of high importance in ventilation. According to the laws which regulate the *expansion of gases*, air expands when heated and contracts on cooling. Warm air, being lighter than cold air, ascends. As it passes upwards, it becomes cooled through contact with the walls, glass, &c., of the room, and in consequence descends. Thus the colder air in a room will tend to force upwards the warm air, which is lighter, and the rapidity with which this interchange may take place will depend on the size, and other conditions connected with the openings through which the air has to pass. It becomes clear, therefore, that wherever there exist openings through which the warm air in a room may be placed in communication with the colder air outside, an interchange must take place. The warm and lighter air inside passes out, and the colder and heavier atmosphere outside rushes forcibly inwards. Thus a system of natural movements of the air appears to exist, and in the institution of ordinary, non-mechanical means of ventilation these movements are not only utilised, but require, as a matter of fact, to be always taken into consideration. We shall be able to observe later on how the principles just mentioned become included in the list of ventilating agents. It should be borne in mind, however, that on this system of air-dilatation, or expansion, under heat, and contraction under the influence of cold, the movements of the winds themselves depend. Mankind, in employing mechanical means for the production of air-currents in ventilation, is, after all, only imitating a principle of natural ventilation in which the winds and air-currents, produced by the law of expansion of gases, play the chief part. In chimneys and other shafts, the action of the wind exercises an *aspirating*, or 'sucking-out,' action. A temporary vacuum is produced in the chimney, the air below rushing upwards to fill the vacant space. The pressure of air in the shaft is also diminished by the wind, and the up-draught is therefore favoured. Where only feeble air-currents exist, as in the case of a shaft or chimney protected by the gable of some adjacent house, a smoky room is the practical result. There is no tendency to up-draught in such cases; and the remedy of a revolving cowl, which produces a movement of air, is, in such cases, found to cure the annoyance.

The question of *air impurities* is a highly important one in view of arriving at a clear conception of the importance of, and need for, ventilation. We have already noted how the presence of animal life tends to render air impure. Exhaustion of the oxygen of the atmosphere soon takes place in crowded rooms, while the noxious carbonic acid replaces the former gas. From lungs and skin besides, heat, watery vapour, ammonia, and organic matters are given off, and these products are known to be highly prejudicial in many ways to health. The impurities of air may therefore be held to consist of gases which are very noxious to health, and of suspended matters which do not chemically combine with the air, but which are borne mechanically by the atmosphere.

According to Tyndall, the air is 'a stirabout' of *minute particles* which the electric beam plainly reveals, and which are readily enough seen in the shape of the well-known 'motes' that dance in the track of the sunbeams. These solid particles, suspended in the air, consist very largely of mineral matters derived chiefly from the soil. Included among these particles, we also find shreds of clothing, fibres of cotton and wool, hairs and like objects, together with starch grains and vegetable dusts of various kinds. The air also carries many lower forms of life, amongst which stand prominently out in importance the 'germs' of various diseases. These latter consist of low organisms, presumably

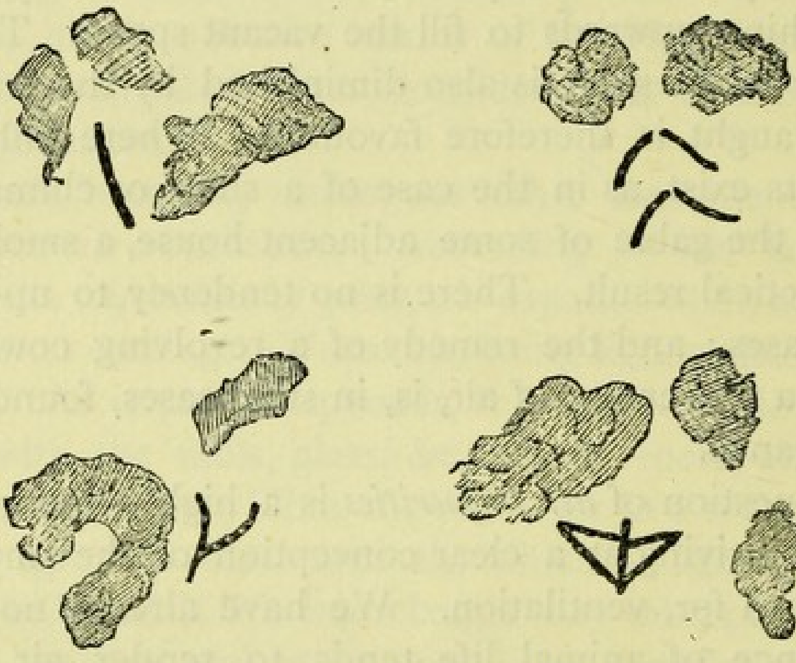

FIG. 24.—Bacilli from consumptive lung. (The bacilli are the minute rod-like bodies.)

vegetable in their nature. When breathed or otherwise received into the human body, these particles are capable of producing, under certain conditions, the specific diseases from which they were derived. As an illustration of this latter fact, we may cite the case of the atmosphere in the neighbourhood of cases of consumption. It has been proved that this disease is associated with the development, in the lung-tissues, of a special 'germ' or *bacillus*. These bacilli (fig. 24), which are microscopic in size, have been proved to be exhaled from the lungs of consumptive patients in breathing. Their presence has been experimentally demonstrated in the air of the wards in hospitals for consumption. Hence it is certain that such an atmosphere must contain such germs in high proportion. The presence of actual disease particles in the air is thus no longer a matter of speculation, but one of absolute certainty and proof. In this light, 'disinfection' of the air, or that process whereby volatile fluids are dispersed so as to thoroughly imbue the atmosphere with their principles, is merely a work of destroying the lower forms of life which the air is known to contain. There is little doubt that epidemic diseases are also carried by the air through the diffusion of their 'germs;' and the spread of plagues, under circumstances apart from diffusion by human means, may most rationally be accounted for on this latter hypothesis.

In addition to these *organic* or *living* matters suspended in air, the presence of various *dusts*, arising from the practice of trades and manufactures, must also be considered. In many cases the unhealthy character of trades arises from the impurities of the atmosphere which the workers are compelled to inhale. Hence, from an economic and sanitary point of view, this part of the subject becomes one of intense interest to both workers and sanitarians.

Amongst the *dusts* which operate with fatal effect on the workers in various trades *coal dust* stands out in high prominence. The continued inhalation by miners of coal dust is productive of a special disease—'coal miner's lung.' The same effects are seen in coalheavers and in the men who pack coal in the holds of ships, into which the waggon-loads of coal are shot, producing an atmosphere thickly laden with carbonaceous particles. The continued breathing of coal dust results in the production of lungs which are literally laden with the black deposit; the patient succumbing to the effects of the irritation which is thus induced. Allied to 'coal dust' in its effects, but probably more fatal in the rapidity of its action, is the *steel dust*, from the inhalation of which the grinders of Sheffield suffer. Here, the fine steel particles arising from the grinding of needles, forks, knives, saws, and other articles, constitute the source or irritation. In dry grinding, in which the articles (files, needles, &c.) are ground on the dry stone, the dust proves most dangerous ; whereas the mortality is not so great in cases in which 'wet grinding' is practised. Statistics collected from a reliable source, show the average duration of life in the various trades to be as follows :—

Dry grinders of	forks	29 years
"	razors	31 "
"	scissors	32 "
"	edge-tool and wool shears .	32 "
"	spring knives . . .	35 "
"	files	35 "
"	saws	38 "
"	sickles	38 "

Among masons, lung disease, arising from the inhalation of stone dust, is also common—'mason's lung' being a well-known complaint ; and of workers among the dusts arising from glass and sand the same remarks hold good. In sand-paper making, for example, the inhalation of the fine sand particles employed in the process is productive of serious lung disease, while the dust given off in the manufacture of earthenware may produce like results. 'Pearl-dust' proves to be injurious to workers in pearl ; and it is a remarkable fact that a curious disease, resembling an inflammation of the bones, is known to affect mother-of-pearl turners. This disease appears to attack those only whose skeletons, as in the case of youths, are under process of development. It is believed by Gussenbauer, who has made the affection the subject of special study, that the dust, entering the lungs, is absorbed therefrom, passes into the blood, is decomposed by the carbonic acid of the blood, and leaves a curious organic matter called *conchyoline* derived from the mother-of-pearl. This material is believed to be carried by the circulation to the growing points of the bones, and there to produce the inflammatory changes already noted. Wood and ivory turners are also liable to suffer from the inhalation of the dusts produced in the course of their avocations. 'Hair dust' is equally powerful in producing disease among hairdressers and wig-makers, and the dust of cotton, hemp, and flax is also known to produce serious results. The mortality among the Belfast flax-dressers, according to Dr. Purdon, is very high. A girl under eighteen years of age, rarely lives beyond thirty-seven, if she pursues her occupation of flax-dresser. The cause of death in such cases is stated to be consumption.

In addition to this list of diseases caused by the inhalation of the solid impurities of the air, we may mention the lung-irritation which is produced in the workers among cloths and other fabrics. The peculiar odour often experienced in a draper's shop is largely due to the charging of the air with the dust arising from the fabrics around. 'Flour dust' seems to be equally irritating in many cases. The well-known and highly fatal 'wool sorter's disease,' which appears to be a form of *anthrax* or *splenic fever*, may be lastly mentioned, as arising in workers among wool, &c. This disease, known to be caused by a minute living particle (*Bacillus anthracis*, fig. 25), is obtained through infection from the wool dust, or through handling the hides of diseased animals.

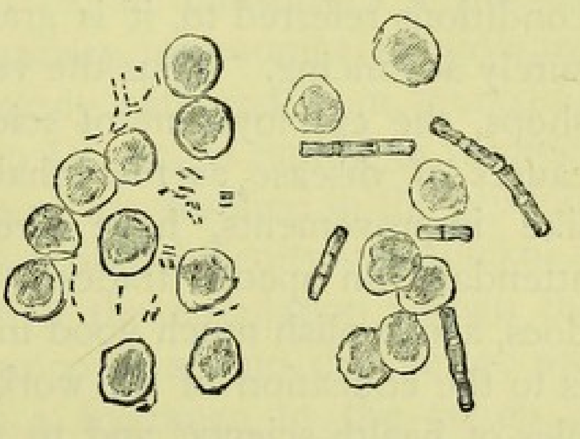

FIG. 25.—Bacilli from the blood in splenic fever, and from blood-poisoning of mice. (The round bodies are blood-corpuscles.)

Allied in their nature to the foregoing causes of disease are the various substances, vapours, &c., which pass into the air in connection with chemical manufactures of various kinds. Thus, carbonic oxide gas is often a source of illness amongst men employed in trades in which burning coke is used. Chloride of lime workers are similarly subject to the ill-effects of breathing the chlorine gas used in the manufacture of the former substance. Copper smoke produces a kind of asthma; while the curious phosphorus disease seen in match-makers is a disease (*necrosis*) of the lower jawbone, produced by inhaling the fumes of this substance.

Such being the effects of exposure to air-impurities of different kinds, the question of the removal of these causes of disease is seen to be one of national importance. Doubtless a certain proportion of fatal cases in the foregoing trades may be traced to the general unsanitary conditions under which the avocations are pursued. Imperfect ventilation, cold, over-heated rooms, uncleanliness, a stooping posture, errors in food, originally debilitated constitutions, and allied conditions, no doubt assist in the production of the fatal effects. But that the effects are also largely due to the special dangers which air-impurities cause and represent, is also a self-evident fact. The improvement of the conditions referred to, it is gratifying to note, is slowly but surely advancing. Thus the ventilation of mines and workshops, the employment of scientific means to arrest such causes of disease as the inhalation of steel particles, and like improvements, have already reduced the mortality attendant on special trades. Special legislation may, and does, accomplish much good in this latter direction. But it is to the education of the workers themselves in the principles of health-science, and to the instruction which teaches how much may be done by simple means to obviate disease, that we must chiefly look for amelioration. As an instance of the great good which is accomplished by attention to simple and ordinary details of personal health, may be mentioned the fact that, when the workers in white-lead factories are provided with, and encouraged to utilise, the means for ensuring ordinary cleanliness of their persons, the ailments from which these operatives suffer are reduced to a minimum. The medical officer of the Privy Council remarks that 'One must remember that in most cases either the artisan's ill-ventilated work-place is also his ill-ventilated dwelling-place, or else the dwelling-place to which he goes for his rest is as ill-ventilated as the work-place he leaves; that, during a great part of the year, the work-place has artificial light in it—in many cases gaslight—for some hours of the day, and in some cases has its atmosphere vitiated by other products of combustion; that in factories, during winter, the commonly adopted method of warming is one which in itself makes the air unpleasant, if not hurtful, for breathing; and that in many branches of industry good ventilation is essential as a safeguard against evils which are special to the employment; essential for the removal of injurious dust, or for the abatement of an oppressive temperature.'

The *deleterious gases* which the air is liable to contain, include the carbonic acid gas already noted as a result of animal respiration, and other gases arising from decomposing animal matter or from manufacturing processes. That the carbonic acid gas of air constitutes a gaseous atmospheric inferiority of primary importance in inducing ill health, will have been already gathered from preceding considerations. According to Dr. Angus Smith, 30 volumes of this gas per 1,000 volumes of air, resulted in the production of slowness of the heart's action, difficulty and quickness of breathing, and feebleness of the circulation; when the amount was 2 volumes per 1,000 of air, no discomfort was perceptible. In some cases a tolerance to the action of carbonic acid gas is exhibited. Pettenkofer found, for example, that air containing 10 volumes of carbonic acid to the 1,000 volumes might be breathed with apparent impunity for a lengthened period. Despite exceptions in the direction of tolerance to the action of this gas, it should never be forgotten that its effects are prejudicial, whether these be slowly exhibited or, on the other hand, quickly observable. Individual constitution, and, above all, habitual residence in an impure atmosphere, tend to induce an apparent toleration to the action of this gas. But the evil effects of breathing an impure atmosphere are cumulative in their action, and tend, sooner or later, either to induce disease of pronounced character or to render the subject less able to resist the attack of ordinary illness. In illustration of the tolerance which may be exhibited by the animal body to an impure atmosphere, may be mentioned an experiment of Claude Bernard. A sparrow was placed under a bell-glass calculated to contain a supply of air sufficient to sustain the bird for three hours. At the end of the second hour, when it had another hour to live, a fresh sparrow was introduced, with the result that the latter was instantly suffocated by the atmosphere in which its companion was undisturbed. A bird which will live one hour in a pint of air, lives three hours in two pints. It has also been shown that if two birds, of the same age and size, are placed in a quantity of air sufficient to sustain one of them for three hours, they will live only an hour and a quarter instead of an hour and a half. Such experiments prove that while the toleration to impure air is a fact, its injurious qualities to the normal and healthy organism is a no less stable deduction.

The case of the Black Hole of Calcutta, in which 146 men, women, and children were imprisoned—the apartment being about eighteen feet square—with the result that 123 died in one night, shows the dangerous nature of the breath re-breathed. The steamer 'Londonderry,' crossing from Ireland to Glasgow in 1848, encountered a gale; and, the hatches being battened down on 150 passengers, 70 perished during the night. Putrid fever carried off several of the 23 survivors from the Black Hole of Calcutta, thus proving the power of impure air to produce disease; while 'Jail Fever,' and its analogue, typhus fever, are known to be the direct products of overcrowding. In the case of the

Leopoldstadt Prison, in Vienna—a badly ventilated place of confinement—the proportion of deaths from 1834–47 was 86 per 1,000; and out of this number 51·4 were due to consumption. In the House of Correction of Vienna, a well-ventilated prison, the deaths during the same period were 14 per 1,000, and the mortality from consumption was only 7·9; leaving a balance of 43·5 per 1,000 deaths, as between the prisons, to be attributed to impure air. The well-known report of the Army Sanitary Commission, issued in 1858, proves the same great truth. The excessive mortality from consumption among the soldiers of particular regiments, was clearly traced to the deficient ventilation of their barracks. The Foot Guards were found to have been allowed only 331 cubic feet of space per man, the deaths from consumption amounting to 13·8 per 1,000; the Horse Guards, with a cubic space per man of 572 feet, showed a mortality from this disease of only 7·3 per 1,000. As a consequence of the investigations into the causes of the high mortality, the cubic space per man was increased, the result being a marked diminution of the mortality from all causes.

The lessons thus taught us by the bitter experiences of disease and death should prove more than sufficient for the inculcation of the truth that fresh air, like pure water, is a necessary condition for health. In addition to the carbonic acid gas, which is responsible for a large amount of disease and discomfort amongst civilised peoples, we may lastly notice other examples of deleterious gases liable to be found in air. Amongst these gases, the effluvia arising from drains and cesspools must be mentioned. There seems no doubt that sewage gases possess the power, under certain circumstances, of causing disease. Carbonic acid, sulphuretted hydrogen, ammonium sulphide, &c., are found in sewer gas; but it is highly probable that where such emanations produce disease, they do so through their conveying the low forms of animal life connected with such ailments. Typhoid fever is by no means uncommon among men who work in sewers;

and nausea, vomiting, headache, and other symptoms, are known to follow exposure to sewer gases. Again, the air-impurities which arise from cemeteries and churchyards, and from bone-burning and manure manufactories, are also credited with being injurious to health. The odours from brick-fields, alkali works, and like manufactories, may prove injurious. Although there is considerable divergence of opinion on this matter, it would seem to be a fair contention that no manufacturer is justified in polluting the atmosphere so as even to render it disagreeable or obnoxious to residents in the neighbourhood. The legal 'nuisance' is, as often as not, a health-danger, when all is said and done.

CHAPTER VI.

VENTILATION.

THE object of ventilation is a two-fold one. In ventilating a room we desire to provide for the removal of the foul or vitiated air, and to secure a supply of pure air. If we add to these aims, the further object of endeavouring to provide fresh air in such a manner that there shall be no draughts or exposure of the occupants of the room to undue temperature, we shall have summed up the chief points which the process of ventilation may be said to include. The topic of ventilation may, on all grounds, be said to constitute a sanitary difficulty of no mean order. It involves, when scientifically carried out, calculations connected with the amounts of air needed to ensure the purity of the atmosphere requiring renewal; considerations involving the best means of securing the entrance and exit of air; and, lastly, conclusions respecting the methods which are to be employed in carrying out the particular scheme selected for this latter purpose. It is probably due to the complex nature of the topic that ventilation as an ordinary condition of daily health has been so much neglected. The necessity for fresh air being recognised, then succeeds the difficulty of adapting effective methods to the existing architecture of our homes. As our houses are ordinarily built, the question of ventilation is practically ignored by architects. For light, for water-supply, and for warming, provision is made, but to the renewal of air no consideration is given. Each room is practically an air-tight box, depending for ventilation, when the windows are closed, on mere chance—on the fireplace and chimney, on the crevices of the doors and windows, and on the space which may exist between the door and the flooring. In the higher era of sanitation to which we are advancing, the ventilation of a house will form as important a consideration in the minds and practice of architects as the size of rooms and the cost of materials. In ancient times, ventilation formed a topic which received considerable attention. The Chinese have long made the subject a study ; and in classic times, the Greeks and Romans used fans and fires as means of ventilating their domiciles. Even in the bee-hive, ventilation is practically carried out by the flapping of the insects' wings ; and the modification of nature's ways and means to the wants of animal life is thus illustrated in a thoroughly practical fashion.

The principles which guide the sanitarian in his work of ventilating rooms and apartments are comparatively simple. He may utilise the currents of the atmosphere for this purpose ; he may employ fires so as to increase the strength of air-currents ; or he may adopt mechanical means, such as fans, pumps, propellers, &c., by way of setting air-currents in motion at will. In the present instance it is unnecessary to particularise the more technical forms of ventilating apparatus, and our attention may therefore be confined to those means which may conveniently be employed in ordinary houses, and under the ordinary conditions of every-day life. The mechanical means of air-extraction by fans and like apparatus become highly useful in the case of workshops, manufactories, and other large buildings in which it is necessary to provide for the rapid removal of dusts and other air impurities.

In providing for the renewal of air the chief points to be attended to, include, firstly, the positions of the air-inlets and outlets. Fresh air should thus never be admitted near the floor-level, since in such a case draughts would be caused, chills induced, and dust and foreign matter liable to be carried from the soil and floor into the room. Secondly, the orifices of air-entrance should be above the level of the heads of the occupants of the room, and an equally important point is that which insists that the incoming currents of air should be deflected upwards to the ceiling and descend gradually to mingle with the atmosphere of the apartment. This gradual mingling of the fresh air with the room-atmosphere may be secured by various methods, such as the existence of numerous small apertures which serve to subdivide the currents, or by conical openings (the large end of the opening being next the room), so as to disperse the entering air as freely as possible. Ellison's 'conical bricks' are constructed on this principle.

It is found, as a matter of experiment, that fresh air which has been admitted to a room near the ceiling, does not serve the purpose for which it is intended. In such a case, the incoming air readily diffuses itself among the existing atmosphere of the room, becomes speedily of the same temperature as that atmosphere, and thus ceases to disperse itself downwards as is desirable. The application of the principle of *natural ventilation* already alluded to in referring to the operation of changes of temperature on air (see page 94) is well illustrated in the handy system suggested by Dr. Hinckes Bird. Here, by a simple adjustment of the air-orifices—that of the pure air being situated below the aperture of exit for the foul air—a cheap and effective means of ventilation can be secured in the dwellings of rich and poor alike. Raising the bottom sash of the window, a block of wood (A, fig. 26) is inserted below this sash from one side to the other. The lower and inside sash of the window thus rests upon the block, and its top is thereby raised above the bottom of the upper sash to an extent corresponding with the depth of the block of wood. Air enters between the sashes, and should any draught be experienced, a strip of glass fitted on the top of the bottom sash, and inclining inwards, will serve to deflect the entering currents in an upward direction. This simple expedient will be found of the utmost value in ventilating rooms to which other methods are inapplicable. For bedrooms it is invaluable, and for the homes of the working-classes it is also well adapted.

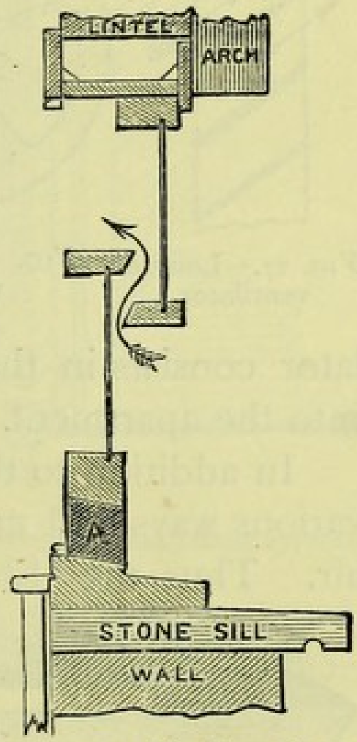

FIG. 26.—Hinckes Bird's plan of window ventilation.

An allied method to that of Hinckes Bird, consists in perforating the wood of the frame where the two sashes meet, with a number of perpendicular holes ; and Mr. Tobin's plan of cutting away the wood on each side of the sash-fastener should also be included in the list of expedients for domestic legislation. Where the air-supply is too great, or where draughts are experienced in this latter method, a flap of zinc hinged on the opening can be used to close the aperture ; while by placing cotton wool in the aperture, the air can be filtered, and freedom from soot and dust secured.

In many halls and other buildings, the upper part—and, if possible, a separate section—of the window may be made to open so as to slope inwards, and thus at once to admit air to deflect the currents towards the ceiling. Double panes of glass—open below outside and open above inside —are also used in many cases ; while what are called

'Louvre' ventilators (fig. 27), resembling venetian blinds in form, and consisting of strips of glass, fixed or movable (as in Moore's ventilator), in one or more of the window-panes, may also be used. 'Cooper's ventilators' (fig. 28) consist of a circular piece of glass perforated by five oval openings, and covering part of a window-pane, in which corresponding apertures exist. As the glass revolves on a central pivot the holes in the window-pane can be opened or closed at will. The defect of this ventilator consists in the fact that the air is apt to blow down into the apartment.

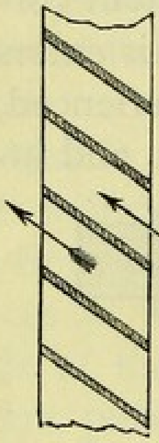

FIG. 27.—Louvre ventilator.

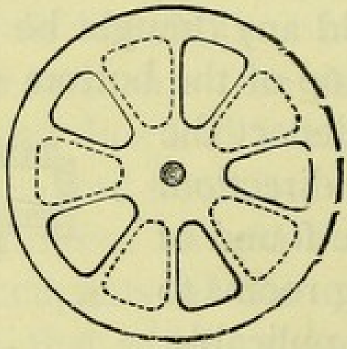

FIG. 28.—Cooper's ventilator.

In addition to these simple plans of ventilation there are various ways and means of providing inlets and outlets for air. Thus the 'Sherringham valve' (fig. 29) consists of an apparatus which can be closed at will by means of a weight, and which slopes inwards and upwards when the valve is opened. The current of air may be made to enter through a perforated brick or grating. Where more than one Sherringham valve is used in a room, the valves should not be placed opposite one another, inasmuch as the air entering by one valve is apt to pass out by the other. The system of ventilators known as 'Currall's,' made by Messrs. Jinks and Son, of Birmingham, possesses an inlet which can be applied to a door, wall, or window, while outlets are also provided for.

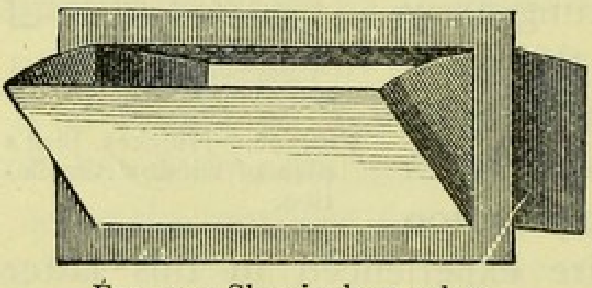

FIG. 29.—Sherringham valve.

A more systematic method of ventilation is found in

'Tobin's tubes' (fig. 30), which consist of tubes four or five feet in height, opening by their upper ends into the room, and communicating below, by means of horizontal tubes passing through the wall or floor, with the outer air. Air entering by these tubes passes upwards without draught, and, mixing with the air of the apartment, descends like spray from a fountain into the room. Contrivances for preventing the entrance of soot are also appended to 'Tobin's tubes.'

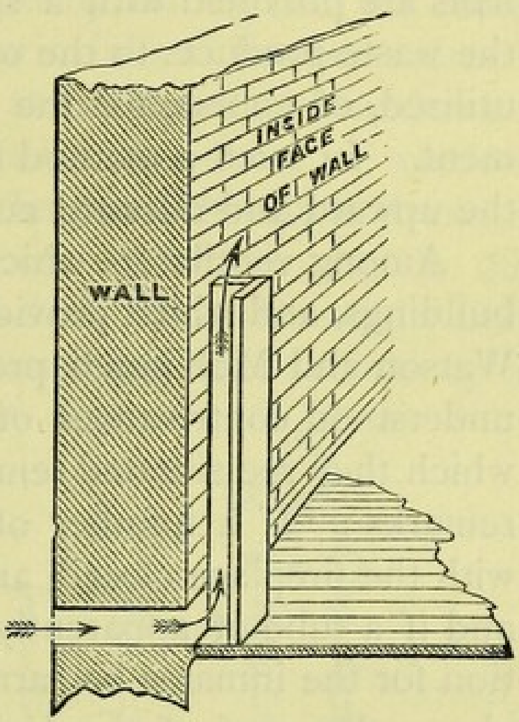

FIG. 30.—Tobin's ventilating system.

The question of air-outlets in connection with these and other methods of ventilation, is a difficult one. In the majority of cases the chimney is regarded as the most convenient exit-aperture for air. Hence it is well to bear in mind that the chimney aperture should be always open, and never closed, as is too often the case, by dampers or by boards. Dr. Neil Arnott's valve (fig. 31) was designed to serve as an exit-aperture, and is placed in the wall near the ceiling, so as to open into the chimney. The metal valve is so adapted that it swings towards the chimney when the air-pressure from room to chimney is sufficient. When the pressure from chimney to room is the more powerful, the valve closes, and thus prevents the escape of smoke or air into the room. 'Boyle's valve' is somewhat similar, and consists of flaps or valves of talc opening into the chimney, but closing as regards the room. Where the exigencies of

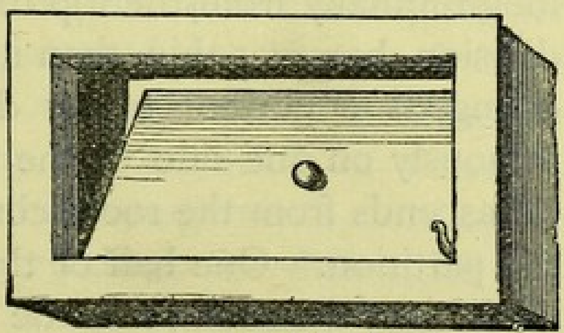
FIG. 31.—Dr. Arnott's valve.

gas-lighting have to be taken into account, numerous expedients have been contrived with the view of carrying off the effete gas products, and of providing, at the same time, for ventilation. Thus many gaslights in large rooms and halls are provided with a special flue or shaft which carries the waste products to the outer air ; and this shaft may be utilised, of course, for the general ventilation of the apartment. In such a method the gaslights aid in strengthening the upward and outward currents of air.

Among ventilators which are specially adapted for large buildings, and which provide both outlet and inlet, those of Watson and McKinnell present us with simple and readily understood contrivances of service so long as the room in which they are situated remains closed. As Captain Galton remarks : 'If a number of people be crowded into a room with the fireplace closed, and the doors and windows shut, and if a tube of apparently sufficient area to afford ventilation for the inmates be carried from the ceiling of the room above the roof of the building, there will be an irregular effort at effecting an interchange between the air of the room and the outside air. The outer air will descend, and the inner air will ascend, in fitful, variable, irregular currents, and the room will be badly ventilated—if ventilated at all.

'But, singularly enough, no sooner is the tube divided longitudinally from the top to the bottom by means of any division, however thin, than its action becomes immediately changed—a current of air descends into the room continuously on one side of the partition, and a current of foul air ascends from the room continuously on the other side of the partition. One half of the tube supplies fresh air to the inmates of the room, and the other half removes foul air, so that, if the size be properly adjusted, the air in the room is kept sweet.'

McKinnell's ventilator (fig. 32), acting on this principle, consists of two tubes, one enclosed within the other ; the inner and longer tube projecting below the ceiling of the room, and being provided with a flange. The inner, and longer tube, becoming the exit-tube for foul air, acts in this fashion, and the fresh air, descending through the outer tube, is thrown along the ceiling line by striking against the flange, and is thus diffused gradually throughout the room. Ventilators constructed on this principle, as has been already remarked, act perfectly so long as the doors and windows of a room are kept closed. Whenever the doors or windows are opened, the tubes act as outlets, and the air is drawn in from any other sources that exist. There is also the disadvantage of the fire tending to draw in its air supply from the ventilators, and of thus destroying their efficiency as outlets and inlets. In private houses, ventilators of this type cannot be applied, except in cases of detached rooms where the ceilings can be readily pierced. For chambers and halls they are, on the other hand, well adapted. Davies' system of ventilation is allied to that of McKinnell, and consists in placing tubes of unequal lengths in different parts of a room, instead of placing one tube inside the other. The systems of ventilation patented by Messrs. Banner, Boyle, Buchan, Stephens, the Æolus Waterspray Company, and other makers, are worthy the attention of those interested in this topic, and exhibit arrangements more or less ingenious and effective in overcoming the difficulties incidental to the ventilation of rooms, halls, &c. The 'cowl' system, represented in several of these inventions, was long ago utilised by Sylvester, who placed a cowl on the air-entrance shaft, and caused this cowl always to face the wind through the action of a vane. The air thus drawn or blown into the cowl, was carried into a chamber placed in the base-

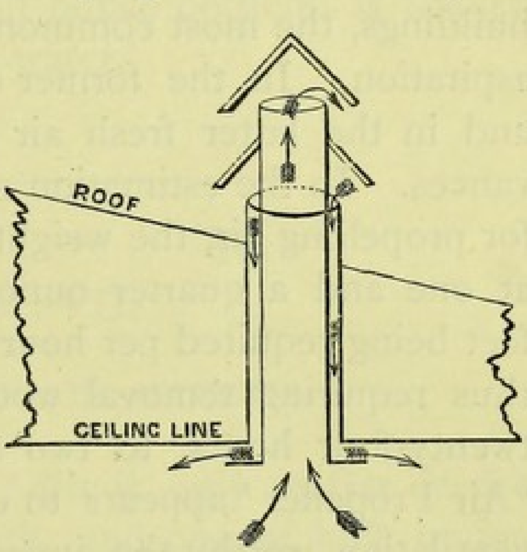

FIG. 32.—McKinnell ventilator.

ment of the house, whence it passed to the various rooms by tubes, and escaped by shafts which were fitted with cowls opening away from the wind, and therefore serving as means of extracting the air. It may be useful to note that the size of the openings through which air is admitted to an apartment, should, as a rule, correspond with those by which it is allowed to escape. A fair average idea of such openings may be formed on the basis of allowing about twenty-four square inches of air for each person tenanting the room, and, to avoid draughts, no single opening should exceed a square foot in dimensions.

Of the methods employed in the artificial ventilation of buildings, the most common are those by propulsion and by aspiration. In the former case, the foul air is drawn out, and in the latter fresh air driven in by mechanical contrivances. In the estimation of the amount and force required for propelling air, the weight of a cubic foot of air is taken at one and a quarter ounces. In the case of 3,000 cubic feet being required per hour for one person's supply, the air thus requiring removal would amount to two cwts., or, in twenty-four hours, to two and a half tons. Blackman's 'Air Propeller' appears to exemplify a form of mechanical ventilation worthy the investigation of those who are interested in this subject.

A simple test for the purity of air in rooms may be conducted as follows: Obtain a wide-mouthed stoppered bottle, capable of holding ten and a half ounces by measure of water. The bottle is to be thoroughly cleaned and dried. A dry linen cloth is stuffed into the bottle on entering the room, the air of which is to be tested. This cloth is now to be rapidly whisked out of the bottle—the door of the room having been previously shut. In this way the air previously in the bottle is withdrawn, and the air of the room allowed to enter the bottle. A bottle of clear lime-water is provided, and, into an ounce measure-glass, half an ounce of the lime-water is carefully poured, so that the solution trickles down the sides into the measure-glass, and is prevented from mixing with the air of the room. The half ounce of lime-water is now to be poured into the stoppered bottle, the stopper firmly replaced, and the bottle well shaken for a few minutes. If the air of the room be pure, the lime-water after being shaken will remain clear. If, however, the air is impure or vitiated, the lime-water will show a turbid, or even milky, appearance—due to the fact that the carbonic acid of the foul air has united with the lime, to form carbonate of lime, or chalk. The late Dr. Angus Smith's words in reference to this test are well worth bearing in mind : 'Let us keep our rooms so that the air gives no precipitate when a ten and a half ounce bottleful is shaken with half an ounce of clear lime-water.'

CHAPTER VII.

THE REMOVAL OF WASTE MATTERS.

THE well-known maxim that 'dirt is only matter in the wrong place,' states a grave truth, and one of high importance in practical sanitation. The removal of this wrongly placed matter is a direct necessity of healthy life. Hence, from the question of air-impurities and the means of avoiding them, we pass by a natural transition to the consideration of the removal of those other kinds of waste incidental to the ordinary requirements of civilised life.

Towards the removal of impurities, expedients of various kinds are directed. Personal hygiene—to be hereafter treated of—includes, for example, the care of the skin, the removal of the excretions from its surface, and the general care of the body in respect of cleanliness at large. Household hygiene, on the other hand, devotes itself to the care of the dwelling, to the removal of all waste matters resulting from the preparation of food, from the ordinary wear and tear of the house, and from the family, viewed as a collection of living units. Personal hygiene thus becomes linked to that of the domicile. The cleanly household is a necessity for health and cleanliness of body, just as attention to personal health reacts upon the care we are bound to exercise over the details of our home. Again, the conditions under which civilisation operates induce a necessity for additional care in the treatment of the dwelling-place, in respect of the removal of all waste and deleterious matters in the vicinity. When men, in virtue of their gregarious instinct, crowd together in the great centres of population, the conditions of 'society' are thereby instituted. But with the formation of societies and cities, health-dangers likewise begin. It would seem as if the increasing intelligence of the race which thus constitutes itself a civilised nation, were laid under a tax and obligation in the conservation of its health interests. The conditions which cause human social advance are exactly those which bring diseases in their train. Men massed together in cities encounter health-dangers unknown to their less civilised companions. The dangers of overcrowding are alone significant enough, to say nothing of the increased struggle for food and sustenance which is inevitably present in towns. The question under consideration, that of the removal of waste matters, owes all its importance to the fact, that, with the massing together of thousands of individuals, the exigencies of sewage-disposal and allied arrangements become increased proportionately with the increase of population. There is, therefore, no branch of sanitary science which merits the close attention of the sanitarian more deservedly than that at present before us. Waste matters—household and personal—allowed to accumulate near human dwellings, form a most potent source of disease. Their removal and effective disposal become topics which concern the sanitarian as nearly as does the question of water supply or of ventilation. Waste matters, improperly treated, are, in fact, common sources of air-impurity and of water contamination; and to improper methods and carelessness in the discharge of the duty of waste removal a large proportion of epidemic and other diseases is undoubtedly due.

Primarily, the ordinary duty of household 'cleanliness' may be said to consist in the free use of soap and water. This latter statement sums up three-fourths of the ordinary cares of the household, and of that part of it which is more immediately concerned with the removal of ordinary waste. A few words on *soap and washing* may, therefore, appropriately enough introduce the more technical details of sewage disposal and of the removal of allied forms of refuse material.

Ordinary hard soap is made by boiling together fats or oils and caustic soda. The latter compound is, in its turn, made by boiling the crude carbonate of soda with slaked lime and water. Carbonate of lime is in this way formed, the crude soda remaining in the liquid, and forming the 'lye,' or 'ley,' of the soap-boiler. The water used in preparing the 'lye' must be of pure character, otherwise the soap is liable to be decomposed by the lime and other minerals which 'impure' or unsuitable waters contain. The 'lye,' at first weak, has fat or oil added to it; the strength of the 'lye' being increased, while salt and water are also added. The soap particles, free from fat, in time rise to the surface of the liquid. These particles are then boiled in strong 'lye,' and the soap finally becomes separated in a mass, which is placed in moulds, dried, cut, and thus prepared for the market. The fat employed in the manufacture of soap is that of the ox and sheep, made into 'tallow.'

Variations in the make of soaps are, of course, common enough. 'Soft soaps' are made by substituting caustic potash for the soda; these soaps being, however, unsuited for ordinary use through the caustic nature of their action on the skin. Again, in the manufacture of soap intended for use in salt water, cocoa-nut oil is used; this substance being unaffected by the salt, and producing a lather when used in the sea water. Castor oil and soda are used in the preparation of the soap of that name, while lard and soda may also be employed.

In the manufacture of many toilet soaps palm oil is used, from its agreeable emollient qualities. Other soaps (e.g. Marseilles soap) contain olive oil; spermaceti is, however, rarely used, on account of its high price; while 'curd soap' contains tallow and soda alone. The finer varieties of soaps, or 'toilet soaps,' are prepared from those already mentioned; the soaps being melted, scented, and having colouring matter added. The transparent soaps may be made by dissolving dry tallow soap in spirits of wine, and by running the resulting fluid into moulds; while another process is that of boiling together various ingredients, such as cocoa-nut and castor oils, tallow, &c., and soda 'lye.' The advantage of transparent soaps is the absence of colour, and their consequent freedom from much deleterious matter. Messrs. Pears' Transparent Soap has attained its wide celebrity on account of the absolute purity it exhibits, and in respect of its freedom from colouring matter. The vermilion and chrome-red used to colour soaps, are preparations of mercury and lead respectively. That the action of such minerals on the skin must be highly injurious is an evident fact; and the cheaper kinds of coloured soaps should therefore invariably be eschewed. Medicated soaps are made by having added to them, in the course of manufacture, the various ingredients — carbolic acid, thymol, iodoform, &c.—indicated by their names.

While soda and oil separately possess no cleansing or detergent properties, the compound—'soap'—formed by their union possesses these qualities in a marked degree. The skin excretions themselves largely consist of oily (or sebaceous) matters. Hence, on the addition of water, soap parts with so much of its soda, which, uniting with the fatty matters of the skin surface, dissolves and removes them.

Soaps which are pure, and which do not contain excess of soda, should accomplish their purpose easily, and without producing skin irritation.

The strict exercise of cleanliness is, in itself, one of the most powerful means of preventing disease. The care of the skin, and the subject of baths, will be referred to later on under the head of 'Personal Hygiene;' but of the value of the careful removal of refuse from the household, the same experience in disease prevention is found to attend the thorough removal of impurities from the neighbourhood of our dwelling-places. That the healthy home must, of necessity, be a clean home, goes without saying. Impurities of all kinds—from the matters which collect on the skin to the dust on our rooms, and the sewage matter which requires to be effectually carried forth from the neighbourhood of our homes—are dread enemies of health. Hence the removal of waste matters, we repeat, becomes, like the question of ventilation, an all-important topic for the consideration of the sanitarian. Neglect of ordinary precautions in the matter of sewage removal, for example, may be followed by serious consequences to the health of a household or community; and, more especially in the case of disease visitation, is the removal and disinfection of the excreted matters an absolute necessity for the prevention of the spread of the ailment. In cases in which improved methods of sewage removal have been instituted, a marked improvement in the public health has invariably followed Diseases which—like typhoid fever, cholera, diphtheria, and the like—are fostered and propagated through the careless treatment of sewage, are found to disappear when the waste matters of a community or district are carefully treated and speedily removed from the neighbourhood of human dwellings.

Two chief plans have long been in operation for the disposal of the sewage and waste matters of houses; and any system at present in vogue is really a modification of one or other of these methods. The first of these methods is that whereby the solid refuse of houses, along with part or all of the liquid waste, are received in and stored either in receptacles or pits to which the name of 'cesspools' is given, or in heaps forming the 'ash-pits,' or 'midden-heaps,' of familiar language. This plan of collecting waste forms what is known as the *Conservancy method.* It is thus distinguished from the *Water-carriage system*, in which the solid waste matters are carried off, through sewers or pipes, along with the water waste of houses, and are thus transported to rivers or to the sea. Practically, however, both systems are ordinarily in operation ; since we usually adopt a sewage, or water-carriage, system in the drainage of towns, while a certain part of the solid waste of our homes—ashes, kitchen-refuse, &c.—is removed in a dry state, and by hand labour.

The system of waste removal in which *cesspools* form a prominent feature has always been open to the grave objection that contamination of the water-supply by such accumulation is a frequent occurrence. Not merely is any such collection of refuse a danger in itself when, as is often the case, it is situated in the vicinity of a house, but the contents of the cesspool are singularly liable to strain through the soil, and thus pollute wells. Numerous cases have been reported in which serious epidemics have been traced to the filtering through, into a water supply, of the contents of cesspools. Where such receptacles form the only convenient plan of disposing of refuse matters, their construction should be carefully superintended. The cesspool, in such a case, should be situated as far off as practicable from the house ; it should be removed entirely from the vicinity of wells. As regards its construction, the cesspool should be thoroughly tight, and made of brickwork fixed in cement ; it should be puddled with clay outside, and cemented inside. The roof and bottom may be arched, and the bottom should have a distinct fall to one side or end, so that the contents may, when necessary, be capable of being thoroughly removed by pump or syphon. As regards depth, about six feet may be regarded as a fair estimate ; beyond this depth the construction of the chamber will require special care on account of the increased pressure which is certain to be exerted. In most cases, a wire grating is so placed as to separate the solid from the liquid excreta. There should be a ventilator to the cesspool, and the soil-pipe should be carefully ventilated, and, of course, disconnected from the house drains. Where there is an overflow from the cesspool, the course of this latter channel must be carefully supervised, so as to avoid any possibility of water contamination ; and definite arrangements for the periodical clearing and cleansing of the receptacle should be included among the statutory rules of the household. It need scarcely be added, that under no circumstances whatever can the presence of a cesspool near, or under, a house, be regarded as permissible by sanitary laws and considerations. The very fact of many of these cesspools being concealed from view, leads to their being overlooked altogether, and to the consequent complete neglect of their existence.

Related to the cesspool system, are the methods in which, by means of separate and smaller receptacles, the waste matters of houses could be collected and removed with ease. Thus, the *dry-closet* and *pail-system* of removing excreta came into vogue. The ashes of the household and other waste matters were added to the excreta, and the collected matters removed at short intervals. In this 'privy,' or 'midden system,' the essentials for success in its practice consist in the frequent removal of the excreta, and in their being kept in a dry state. The further elaboration of this latter principle led to the establishment of the 'dry,' or 'earth-closets.' In many towns (e.g. Hull and Glasgow) the 'midden-system' prevails, and is found fairly to serve the purpose for which it is intended. The 'pail-system' is also modelled on the dry method of refuse removal. Either the simple dry pail or similar receptacle is used for the removal of ashes and excreta, or the pails may be supplied with disinfecting materials. In the 'Goux-system,' in operation at Halifax, the pails are lined with an absorbent layer consisting of hay, shoddy, or other matters, mixed with sulphate of iron or of lime, so that the wet excreta are absorbed thereby while the solid excreta are contained in a comparatively dry state within the pail proper. The 'Goux-system' appears to serve its purpose extremely well, and is decidedly preferable to the midden-system, if for no other feature than for the ease and frequency with which the removal of waste matters is carried out. Where this system is in operation, the house refuse—ashes, &c.—are, of course, stored in a special dust-bin.

In the 'dry-earth' system, of which 'Moule's Earth Closet' is the best-known example, advantage is taken of the deodorant and disinfectant powers possessed by well dried earth. About 1½ pounds of dry earth are found to be required for the effective disposal in this way of excreta each time the closet is used, the excreta being received into the dry earth and afterwards covered with this material. Slops, &c., of course, cannot be removed by Moule's system. The difficulty of procuring dry earth is an objection which has been made much of by critics of the 'Moule Closet.' It would appear that the excreta are so thoroughly disposed of by the proper use of the 'earth closet' that after an interval no such matters can be found in the earth which has been employed, and in the case of suitable earth, that which has been used may therefore be dried and re-employed several times in succession. Rich garden mould is placed first in order of merit as adapted for use in Moule's system, while sand stands last in order of suitability. In the 'Moser Dry Closet,' dry earth, road-dust, sawdust, or charcoal may be used, while this closet is also simple and automatic in its action.

Probably the necessity for providing means of disposal of the liquid excreta, slops, and other waste of households where the dry-pail system of dealing with solid refuse existed, early induced a preference for the 'water carriage' of refuse, whereby both solids and liquids could be readily removed. The system of drains and sewers now extant, was probably called into being by some such consideration as that just detailed. From the open drain of the village to the sewers of the town there is every gradation to be traced in the development of the 'water-carriage method.' But this system, while convenient, possesses its own special dangers, and demands more care and attention to its structural details than does the more ancient system by means of conserving the excreta in a dry state. The sewers of a town consist usually of stone-ware pipes, with built sewers for the larger channels, leading the sewage usually by gravitation to the point of discharge in a river, in the sea, or in tanks. In the latter case, various methods of utilising the sewage for manuring purposes have been devised, while occasionally land is irrigated with sewage, and thus made to yield large crops of various kinds.

In most cases, and certainly in all cases in which sanitary considerations have weighed in the construction of sewerage arrangements, the rain-water is carried off by special channels separate from the sewers. Proper ventilation of sewers becomes an absolute necessity in view of the offensive nature of their contents, while means for effectively and periodically flushing the sewers should also be provided. The proper ventilation of sewers tends to lessen one of the chief dangers of our houses, that of the backward escape of sewer gas into them. The usual method of sewer ventilation is that by means of street-gratings. The advantage of utilising stoneware as the material for sewers becomes apparent when we reflect that rats are less likely to disturb the pipes, while the pipes themselves are more easily laid and less likely to allow the matters they carry to soak into the soil.

Regarding the purification of sewage, various plans have been from time to time promulgated. Thus *precipitation* by lime has been carried out, the sewage being mixed with lime and utilised for manure or for making bricks. As, however, the fluid flows away in a highly concentrated state, this process has been roundly condemned as ineffective. In General Scott's process, lime and clay are placed in the sewer itself, and are thus thoroughly mixed with the sewage in its passage. It is then received into tanks in a deodorised state ; the matters deposited being burnt and converted into a cement.

Where land is *irrigated* by sewage as a means of disposing of the matters, a handy system of utilising refuse would seem to be placed within the reach of sanitarians. In the opinion of eminent authorities the disposal of sewage by irrigation is the only effectual method—if we except its complete disposal in the sea—of ridding ourselves of waste. The 'sewage-farm,' however, must be carefully attended to. The sewage requires to be systematically delivered and filtered, the land drained, the soil suitable, and a special rotation of crops observed. The rotation of Italian rye-grass, which grows well on sewage-fed land, with peas, maize, roots, &c., has been found to answer well. The question of the health of those resident near sewage-farms, and of the animals fed or reared on their products, may be disposed of by saying that, as far as is known, no injury results from such association or feeding. There remain, in many cases, of course, obstacles to this method of utilising and disposing of sewage. In many instances, the construction of huge works for the conveyance of sewage directly to the sea would seem to be a necessity of the near future. The case for the efficient disposal of sewage has been so well summed up in the resolutions of a conference on sewage held in 1876 by the Society of Arts, that two of these conclusions may be quoted here :—

'It was conclusively shown that no one system for disposing of sewage could be adopted for universal use, that different localities require different methods to suit their special peculiarities, and also that, as a rule, no profit can be derived at present from sewage utilisation.

'For health's sake, without consideration of commercial profit, sewage and excreta must be got rid of at any cost.'

Bound up in the most intimate manner with the topic of sewage and its disposal, is the subject of the management of drains and allied appliances which exist within our houses. Unless means are taken to insure the freedom of our domiciles from the risks of contamination by means of sewer gas, and through the ineffectual operation of drains and closets as parts of the water-carriage system of refuse-disposal, it is evident the conditions of health will become liable to disturbance of very serious kind.

In connection with the arrangements of house drains, two chief objects, as summarised by Captain Galton, require to be borne in mind. These are, first, the immediate and complete removal from the house of all foul and effete matter directly it is produced ; and, secondly, the prevention of any back current of foul air into the house through the pipes or drains which are used for removing the foul matter. The first of these requirements may be regarded as being served by the water-carriage system, when that method of refuse removal is represented in perfection. The second requirement is carried into effect by the various expedients in the way of arrangements of pipes and construction of 'traps' which have been devised of late years.

One of the chief rules to be observed in the construction of house drains is that which insists on the condition that, unless unavoidable, no drain should be constructed under the basement of a house. Whenever such a method of drain-construction becomes a necessary item of the arrangements, great care should be exercised in seeing that the drains are absolutely water-tight and air-tight as well. Leakage from a basement drain, in time impregnates the soil, and thus renders a house a hot-bed of disease.

The various kinds of 'traps' used in drain-construction are designed to prevent the back-flow of sewer gas into houses, and to ensure protection against a fertile source of nuisance and illness. The old 'dipstone' trap (fig. 33), which should always be discarded as inefficient, consists of a chamber receiving and giving into an inlet and outlet pipe respectively. A slab divides the chamber into two compartments, so that direct communication between the

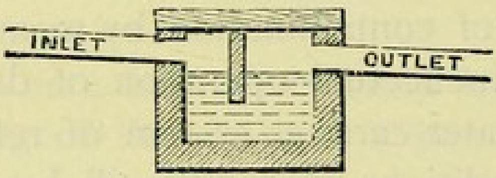

FIG. 33.—Dipstone trap.

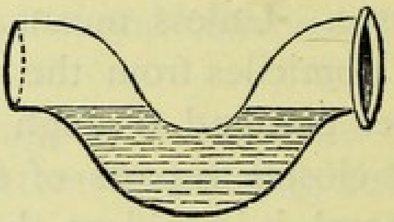

FIG. 34.—Stoneware syphon trap.

air on the side next the inlet and that on the outlet side is supposed to be prevented. 'Syphon traps' (fig. 34) of one kind or another have now superseded the 'dipstone.' This syphon trap is simply a bend in the pipe (fig. 35 A) containing water, which is maintained at a certain level (*w*), and which is intended to prevent any back-flow of sewer gas into the house. If the pressure of air in the drain is not greater than that which would support a column of water equal in height to the space between the lines *w* and B in the annexed diagram, the air of the drain will remain stable, so to speak. When this equilibrium is disturbed, however, and the pressure becomes increased, the air of the drain is liable to be forced through the water, and thus to escape into the house. Again, a second danger

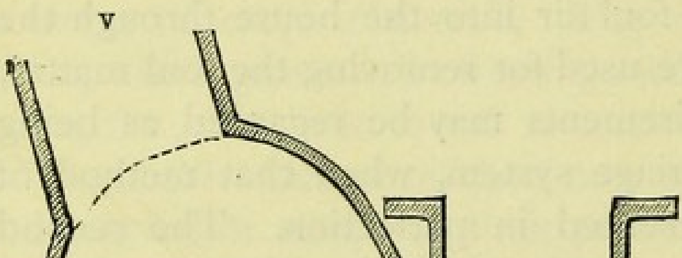

FIG. 35.—Syphon trap.

may await such a trap. A great rush or volume of water passing into such a trap may empty it of its safety-water by what is known as 'syphon-action.' The trap may thus be emptied of its water, and sewer gas may consequently pass freely into the house. This accident, however, is averted in all well-constructed traps, by the simple expedient of inserting a ventilating pipe (V), which, so long as its size or calibre is that of the drain, prevents the syphoning-out of the safety-water.

Efficient ventilation of house-drains forms the great source of protection, along with well-constructed traps, from sewer gas. Thus, as shown in the illustration (fig. 36), such ventilation is secured by means of a ventilation-opening (B 6) near the trap, and placed between the house and the trap; while a second opening is provided at the opposite extremity of the drain. This extremity is to be usually found placed at the top of a ventilating shaft (4, 5), (which should not be less than four inches in diameter) which arises from the drain, and is carried upwards outside the house to a height of at least ten feet—or, better still, to the roof—so as to avoid any possibility of the sewer gases entering rooms, where it is provided with a cowl. By an arrangement in which these essential points are duly found represented fresh air is thus made to traverse the drains throughout their entire length. In fig. 36 A, the absence of any opening for ventilation between the house and the syphon trap (6) simply vitiates the whole system of drainage, and renders it dangerous to health.

Various excellent traps and systems of drain-ventilation have been devised. Among these may be specially mentioned the 'Edinburgh Air-Chambered Sewer Trap,' manufactured by Messrs. Potts & Co., of Birmingham; Banner's patent trap, and the systems of Buchan, Sharp and Bostel. In all these appliances disconnection of the house from the sewer, and efficient drain ventilation, are duly provided for. Gregen's Patent Air Inlet, made by Messrs. Doulton & Co., should also be mentioned as an efficient preventive of contamination through sewer gas.

A highly important point, connected with house and drain construction, from a sanitary point of view, is that which

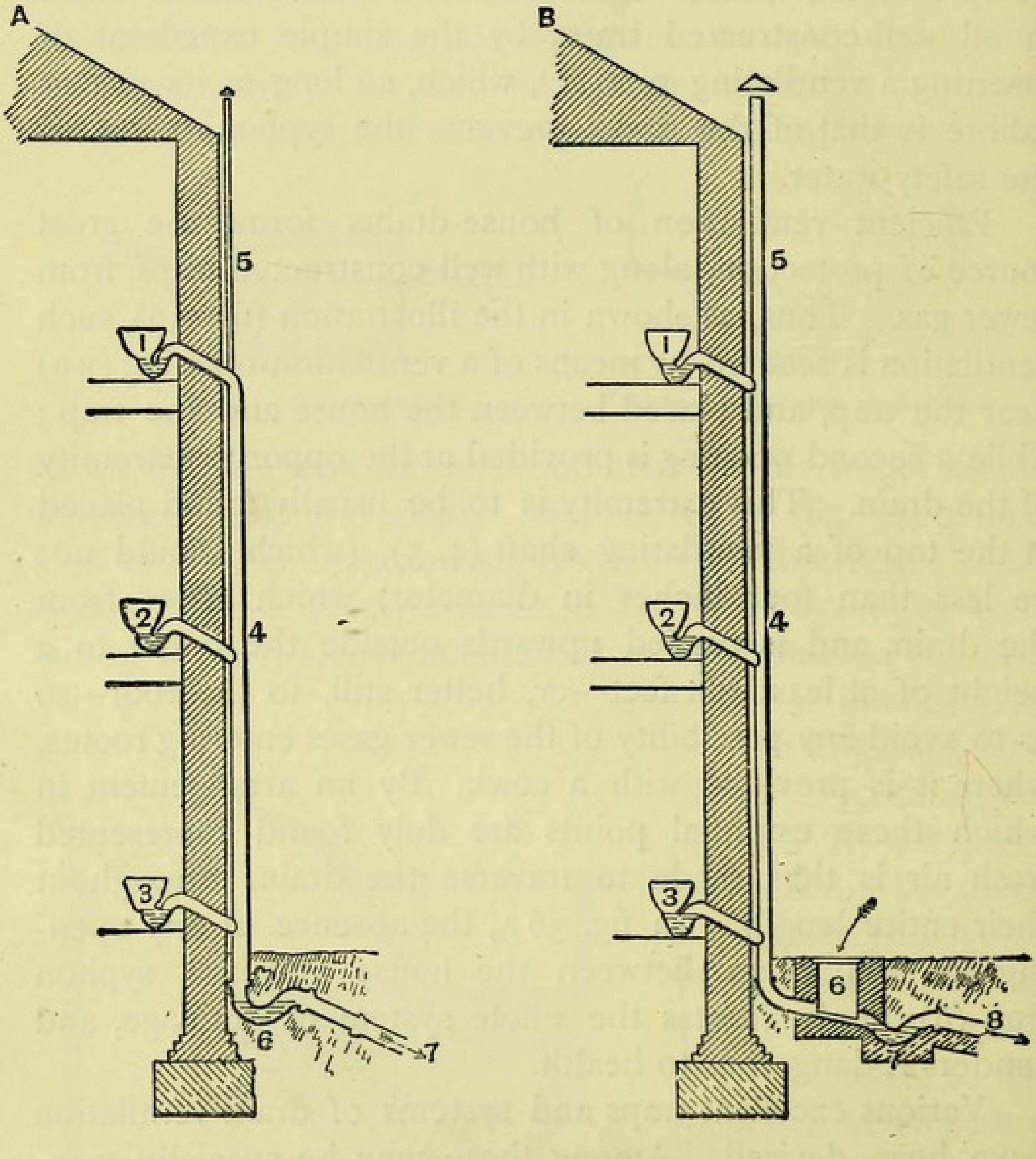

FIG. 36.—Sanitary (B) and insanitary (A) systems of house drainage.

deals with the construction of the waste pipes from cisterns, baths, closets, and sinks. It has already been shown that a fertile source of disease consists in the contamination of a water supply through the overflow pipe of a cistern being led directly into a drain (fig. 37, A 2). All such pipes should be led directly into the open air (fig. 37, B 2), and should be made to discharge over into a trapped gully (fig. 38). Of the waste pipes from baths and sinks the same rule holds good. They should have a syphon trap below the sink, and then be led through the wall to discharge

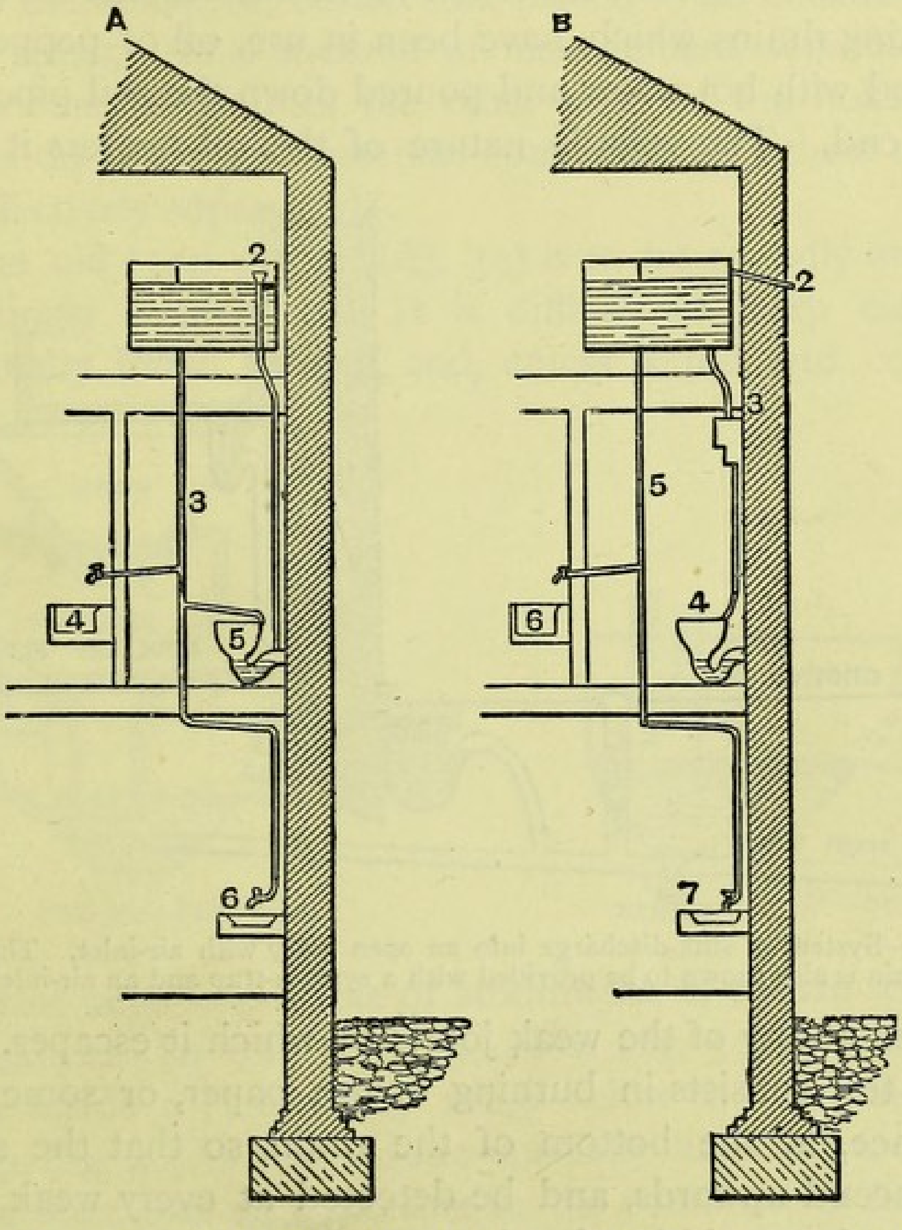

FIG. 37.—Sanitary (B) and insanitary (A) systems of cistern accommodation.

into the 'gully' as described (fig. 38). The waste pipes from bath safes and w.c. safes should, in the same way, be entirely disconnected from drains. It is advisable, with the view of preventing any accumulation of matters in sink-pipes, to interpose a 'grease-trap' therein. That of Doulton has the additional advantage of acting as a flush tank. House drains should be periodically and thoroughly flushed, by way of preventing accumulations of matter within the pipes.

The drains of a new house should be tested for the soundness of their joints, this being usually done by means of water, after the cement of the joints has become hardened. In testing drains which have been in use, oil of peppermint is mixed with hot water and poured down the soil pipe at its upper end. The volatile nature of this oil renders it easily

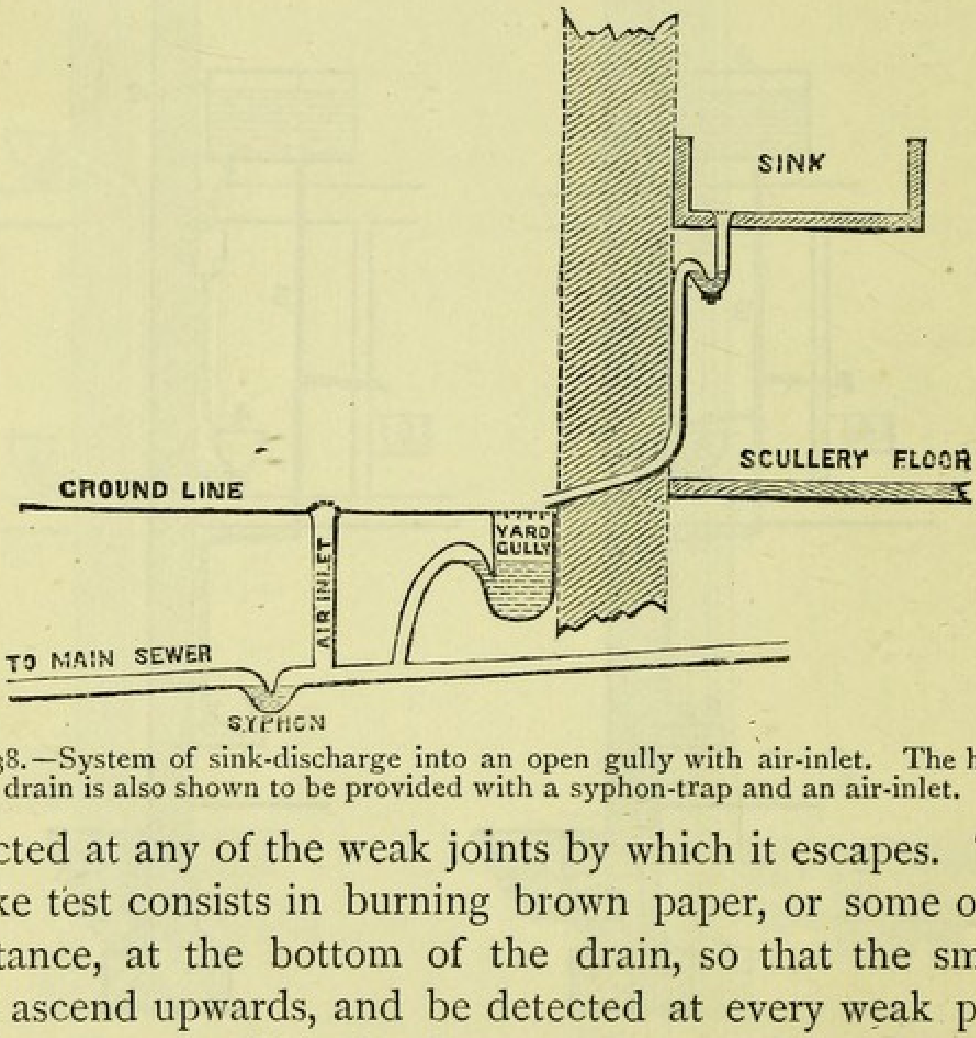

FIG. 38.—System of sink-discharge into an open gully with air-inlet. The house-drain is also shown to be provided with a syphon-trap and an air-inlet.

detected at any of the weak joints by which it escapes. The smoke test consists in burning brown paper, or some other substance, at the bottom of the drain, so that the smoke shall ascend upwards, and be detected at every weak point of the pipes within the house. A special machine, or 'Asphyxiator,' is constructed for the efficient application of the smoke test.

The *closets* of a house form a highly important feature of its sanitation. Not only do closets of imperfect construction and deficient arrangement tend to create a nuisance, but the dangers from sewer gas become intensified through such defects. The situation of closets in a house, judging by sanitary results, is frequently the last item which receives the architect's attention, and, as a consequence, the lighting and ventilating arrangements of these apartments are thoroughly inefficient. They should be built against the outer wall of the house, or, better still, placed in an outside shaft, so to speak. This method of management separates the closets completely from the other parts of the house, and renders the drain arrangements connected with them readily and effectively supervised.

The old 'pan closet' (fig. 39) is to be roundly and unhesitatingly condemned. It is difficult to keep clean, is continually liable to foul, and, unless a full and constant

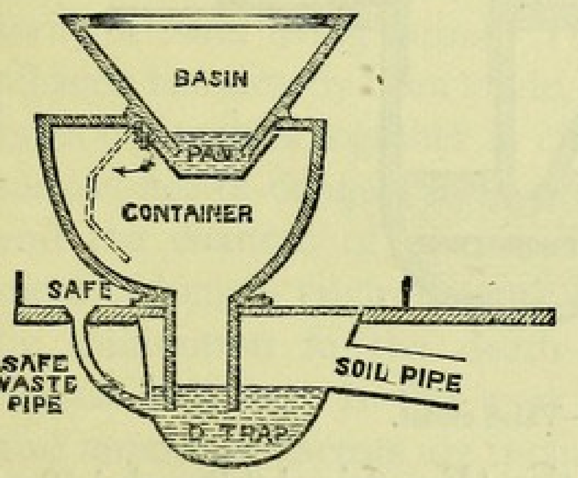

FIG. 39.—Pan closet.

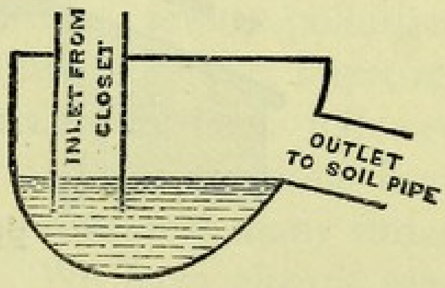

FIG. 40.—'D' trap.

supply of water is possible of attainment, is certain to create a nuisance. In this form of closet (fig. 39) a metal pan works inside a 'container,' while below the container is a D trap (fig. 40), which is one specially liable to foul. As will be seen, foul air collecting in the container is liable to escape into the closet whenever the handle releasing the pan is used. The points demanded in, and illustrated by all good forms of closet are—easy flushing, quick and effective removal of excreta, easy trapping, non-liability to the admission of sewage gas, and of convenient construction, so that all its parts can be readily inspected in case of accident. These conditions are found exemplified by many of the

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newer patterns of closets. The 'wash out' (fig. 42) patterns are effective appliances; and such makes as Bostel's, Jen-

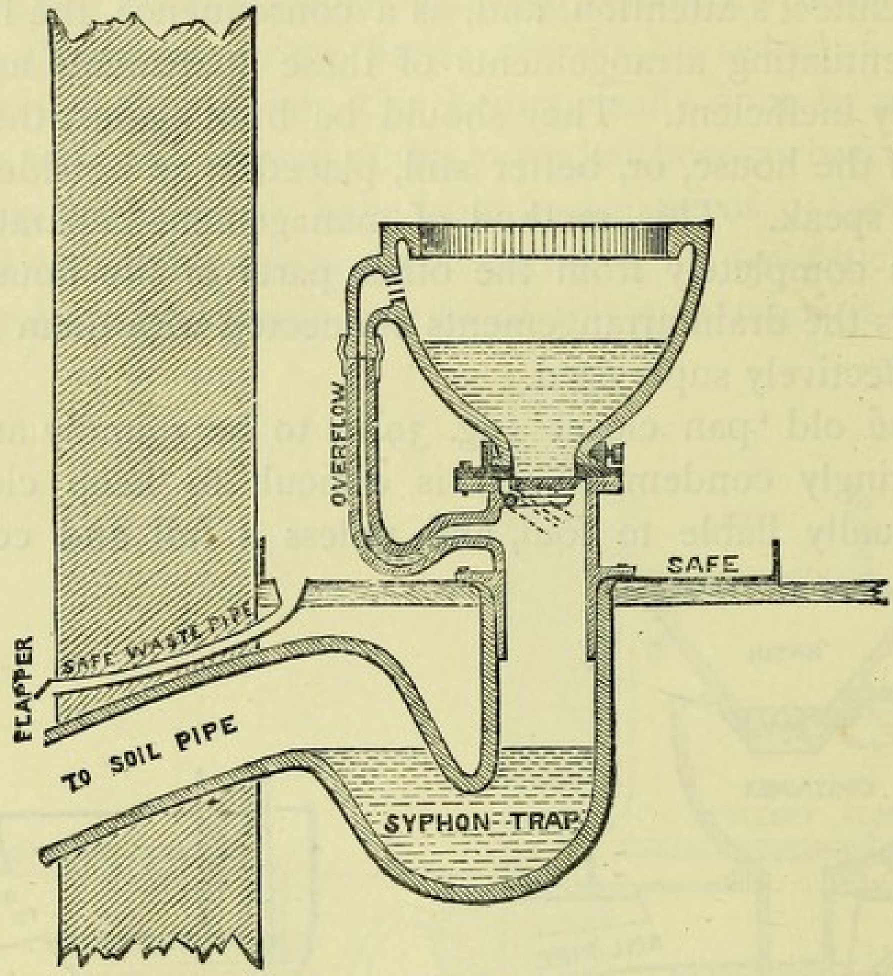


FIG. 41.—Valve closet.

ning's, Doulton's, Banner's, the 'Excelsior,' 'Bean's,' Twyford's 'National,' &c., will be found satisfactory in their working. The valve closet (fig. 41) has no 'container,' and is closed by a watertight valve. An overflow pipe exists for the escape of water which may overfill the basin. So long as the syphon trap is closed, this closet acts well. The soil pipes connected with closets should be specially ventilated by being carried upwards to the roof. The *safes* placed below closets to catch any water-overflow should, as already remarked, have their pipes carried out directly into the air (*see* fig. 41).

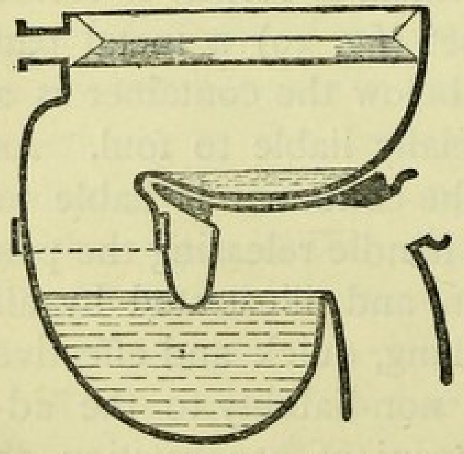


FIG. 42.—'Wash out' closet.

CHAPTER VIII.

LOCAL CONDITIONS OF HEALTH.

THAT the surroundings or environments of animals and plants possess an appreciable influence on the development of these forms of life, is a well-known axiom of biological science. The maxim holds equally true when applied to the environments of human life in a civilised state. The surroundings of man's existence are such that he is probably more dependent upon them for comfort and health than the majority of other living forms. The gregarious instinct to which allusion has already been made, and which impels mankind to mass themselves together in cities and towns, of itself entails serious health-dangers from overcrowding, sewage-pollution, and the chances of disease-dissemination. The improvement of human environments has invariably been followed by diminution in the death-rate, and by freedom from disease at large. In this work of improvement many varied and important factors are included. We have already seen that attention to the sanitary appliances of our houses is a necessity for healthy life; that purity of air and of water are likewise conditions on which sanitary excellence largely depends. Extending our view a little further from the house itself, it can readily be shown that the conditions of soil, foundation, aspect, elevation, and other circumstances, materially affect the health of the inhabitants of a given district. Even the fact of certain prevailing winds may render a district healthy or the reverse, and the near neighbourhood of marshes is an illustration of a condition, which, alone, tends to make a locality thoroughly insanitary from the prevalence of ague and allied disorders. So, also, the differences between town and country life, between inland and seaside districts, and between residence in northern and southern climates, represent in their own fashion the influence of surroundings on human existence.

The question of a suitable *soil* in relation to the house is one which appears of paramount importance in the eyes of sanitarians, while that of the *aspect* of the house is hardly less important on health-grounds. Several important researches regarding the influence of soils on health have been made by Dr. Buchanan and others. The results of these investigations reveal, in an interesting fashion, the dependence of health on this primary condition of life and living. Dr. Buchanan's report on the distribution of consumption as affected by dampness of soil, presents us with many extremely valuable facts in connection with this topic. He showed that through the improvement of drainage, and the abolition of dampness in certain towns, the death from consumption had decreased in a very decided fashion, while the decrease in question bore a marked relationship to the drying of subsoils. Regarding the latter point, it was found that such drying had caused the death-rate from consumption to fall from 50 per cent. downwards. Thus in Salisbury the mortality fell 49 per cent.; in Ely, 47; Rugby, 43; Banbury, 14; while a reduction was also noted in the case of thirteen other towns. Contrariwise, in Alnwick, Morpeth, Stafford, and Ashley, in which the subsoil had not been improved by drainage, the death-rate from consumption remained as before; and this, although the sanitary conditions and works had been well and thoroughly attended to in the towns in question. Here the ordinary rainfall or 'storm water' was carried off by special arrangements, and the dampness was therefore a stable condition of these localities. On the side of natural dryness, Penzance was selected, with a dry subsoil, and there the rate of consumptive mortality remained stable. Elsewhere, as at Carlisle, subsoil drainage produced no effect on the death-rate from phthisis, because the low-lying condition of the district resulted in a perennial dampness or 'waterlogging' which resisted attempts at improvement.

Dr. Bowditch, of Boston (U.S.), making inquiries into the influence of soils on health, arrived, independently of Dr. Buchanan, at similar conclusions. In 1862 Dr. Bowditch embodied his conclusions in the following words :—'First: A residence in or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and probably in other portions of the globe. Second: Consumption can be checked in its career, and possibly, nay, probably, prevented, in some instances, by attention to this law.'

The conditions which tend towards either dampness or dryness of soil, are found to consist in the pervious nature of the soil, or its reverse, and in its water-retaining powers. In this relation, geological circumstances have to be taken into account; a formation which in one case allows of ready natural drainage, in another position favours the accumulation and retention of moisture. The conclusions of Dr. Buchanan with regard to the influence of soils, taking into consideration the concomitant circumstances naturally attending such an inquiry, show that as regards Surrey, Kent, and Sussex, there is less consumption, speaking broadly, among populations living on pervious soils than among those on impervious soils. Within the same counties, also, there is less consumption among populations dwelling on high-lying pervious soils than among those living on low-lying soils of this nature. The populations in those counties living on sloping impervious soils show fewer cases of consumption than do those living on flat impervious soils. The relation between consumption and soil has been established by (1) the existence of general agreement between localities having the same geological and topographical features of a nature affecting the water-holding qualities of the soil; (2) the existence of general disagreement between districts possessing different features of the kind above named;

(3) by noting the common occurrence of regularity in the fluctuation of the two conditions, from prevalent consumption in much wetness of soil, to little consumption in slight wetness of soil. Dr. Buchanan's final conclusion, supported by the facts just stated, was that 'the whole of the foregoing conclusions combine into one, which may now be affirmed generally, and not only of particular districts, namely, that wetness of soil is a cause of consumption to the population living upon it.'

Consumption is not the only disease which is affected by special conditions of soil. It is a matter of fact that prevalence of ague is associated with districts in which malarious or marshy exhalations are liable to occur. Rheumatism and its concomitant, heart disease, are also characteristic of damp soils, and are decreased by attention being paid to the lessening or abolition of the excess of moisture. Again, as has been specially pointed out by Pettenkofer, dampness of soil is a condition which favours the prevalence of typhoid fever, cholera, and other diseases. The special matters which give rise to such diseases, run a greater risk of being conveyed to wells in wet districts than in dry soils. Good drainage is, therefore, a condition of health thoroughly within the command of man. Wisely using this condition, he is able to abolish from his midst many diseases of great fatality and to which his race has continually fallen victims.

According to Mr. Eassie, the earliest civilised inhabitants of Britain set their dwelling-places on the outcrops or edges of certain rocks, while they repudiated and avoided others. He mentions that in the eastern part of Northumberland, according to Topley, ancient villages were built only upon isolated areas of a particular sandstone. Out of a total of twenty-three villages, thirteen were built upon rock, six on sand, and one upon clay. No fewer than thirteen of the largest English towns, from Exeter to Carlisle, are named as being 'situated along the line of one geological formation, the new red sandstone.'

Other things being equal, the dry soil (fig. 43) is that to be preferred where we can make choice of the site of a dwelling-place. The study of the geology of a district, revealing as it does the special characters of the rock-strata, becomes, therefore, a necessity in so far as the special character of the site for a house is concerned. Dry gravel soils are naturally regarded as healthy sites for houses, but a gravel resting on hard and non-absorbent rocks might constitute an unsuitable formation from the retention of the water by the earth. A clay soil is, for the most part, to be eschewed as a site; but, properly built on concrete founda-

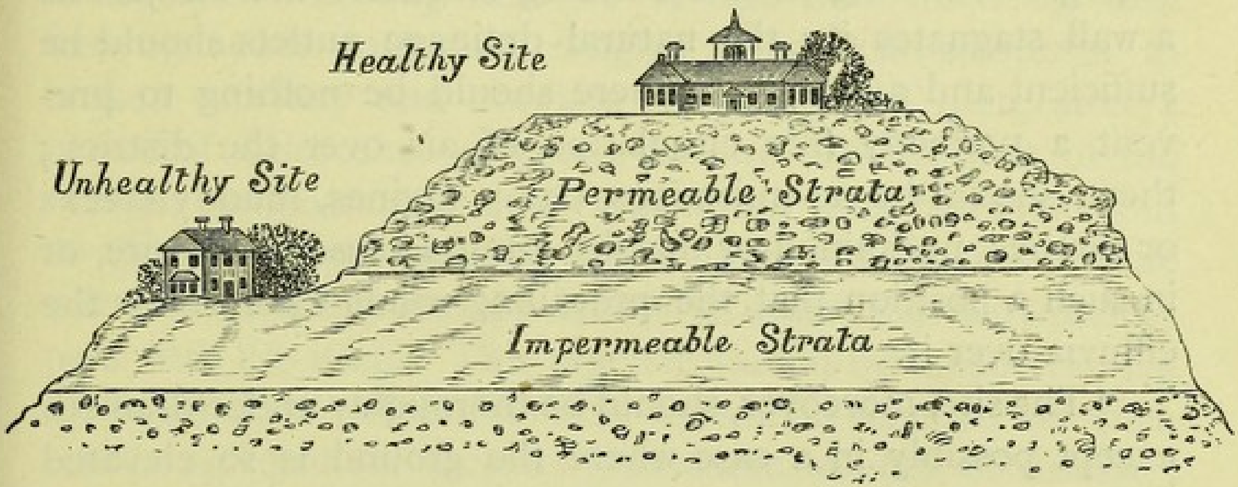


FIG. 43.—Healthy and unhealthy sites for a house.

tions, a house might be safely erected on the clay. According to Dr. Letheby, clay soils present a remarkable freedom from cholera. Dr. Parkes tells us that cholera is scarcely met with in localities in which granite, metamorphic, and trap rocks occur; but this conclusion is not supported by the experience of cholera epidemics, which really depend for severity on overcrowding and filth, irrespective of soil. The conclusion to which we are driven, in face of the fact that commonly we are not able to select particular sites for our houses, is, that even a soil which may be geographically unsuitable is capable of being rendered healthy by wise drainage arrangements, just as, conversely, the best soil may be converted into a hot-bed of disease by faulty and inefficient drainage.

Captain Galton admirably sums up the conditions for a healthy site as follows: 'The local climate should be healthy; the soil should be dry and pervious; it should be protected from the north and east by shelter at a sufficient distance to prevent stagnation of air or damp, otherwise the shelter from cold and unhealthy winds, which is an evil recurring only at intervals, will be purchased by loss of healthiness at other times. The ground should fall in all directions to facilitate drainage; it should not be on a steep slope, for high ground rising near a building stagnates the air just as a wall stagnates it; the natural drainage outlets should be sufficient and available. There should be nothing to prevent a perfectly free circulation of air over the district; there should be no nuisances, damp ravines, muddy creeks or ditches, undrained or marshy ground close to the site, or in such a position that the prevailing winds would blow the effluvia over it.

'The site, moreover, should be thoroughly under-drained, except possibly in a case where the ground is so elevated and pervious as to ensure that water remains in it; and if there is higher ground adjacent, the water from the higher ground should be carefully cut off by underground catch-water drains, and led carefully away from the vicinity of the site.

'The object to be attained in laying out the ground is the rapid and effectual removal of all water from the buildings themselves, and from the ground in their vicinity, so that there shall be no stagnation in or near the site.

'It is no doubt impossible always to procure a perfect site for building; but it will be necessary in the construction of buildings upon a given site to discount any departure from these qualifications by additional sanitary precautions in the building, *i.e.* by increased expenditure.'

A too common practice, and one to be as roundly condemned as one can find words for expression of opinion, is that of building houses on ground which has been 'made up' by pouring rubbish of all kinds into a pit or excavation, as a means of filling up open ground. This rubbish-bin, or 'free toom,' as it is termed in the north, is a disgrace to modern civilisation. The speculative builder selects a site utterly unsuitable for house construction, save at the cost of being made sanitarily perfect by a large outlay which, it need not be added, he does not for a moment contemplate ; advertises the said site—usually a deep hole—as a convenient receptacle for rubbish of all kinds ; contrives that the excavation in this way shall be in due time filled up with heterogeneous materials, ranging from road-scrapings to broken crockery and obsolete tin-pans ; and then, after a period of quiescence necessary for the solidification of the rubbish, commences the erection of the jerry-tenements out of which he hopes to make profit, as the inhabitants in time will run conversely into the debt of ill-health that is frequently paid with life itself. This practice should be made criminal by legislation. The new-built tenements erected on such 'made-up' ground, become permanent abodes of disease ; and if, as is usually the case, the houses thus erected are by no means of sterling quality, they present themselves as an insanitary colony, from which disease is never absent, and at whose gates the doctor is constantly in attendance. No words can, therefore, be too strong for condemnation of the practice so frequently seen in large towns and their suburbs, of thus erecting houses on literal foundations of filth.

The *aspect* of a house has much to do with its health and cheerfulness. Most persons choose the E. or S.E. as the aspect for the front of the house, owing to their obtaining the morning sun in their front rooms, while the afternoon sun warms the back rooms. The dining-room which faces the north or north-east will probably be found most suitable ; while bedrooms placed in this aspect possess the advantage of morning warmth and of night coolness. The drawing-room may face the south-east, and the nursery may advantageously be placed here also. The south-west aspect is the least suitable for any purpose, on account of its extreme heat in summer, and because it directly faces winter winds and autumn rains.

Concerning the relation of sites for houses in relation to the sea, much will depend, of course, on the aspect of the site, and on the direction of prevailing winds, on sand blown by the winds, and on similar conditions. As a rule, the temperature by the seaside is more equable than that of inland districts ; but, other things being equal, the considerations that weigh in the choice of an inland site are those which should guide a selection by the sea. The sea air and salubrious atmosphere are really secondary conditions when compared with purity of soil, and with effective drainage.

The influence of trees and vegetation may be summarised in the statement that trees growing in too close proximity to dwellings tend to engender damp, and the same remark holds true of ivy permitted to grow on house walls. Decaying vegetation and collections of plant matter should on no account be allowed to accumulate near houses. Ebermayer found that the ground covered by a forest showed an annual temperature lower by several degrees than that of the surrounding soil. This difference of temperature extended 4 feet deep, and was greatest in summer and least in winter. The growth of trees, besides, leads to an increased rainfall.

Attention has already been directed to the high importance of securing dryness of soil. Should, by any chance, old drains or waterways appear in the site, these should be carefully excavated out and attention paid to freeing the ground from any former contamination to which such drainage may have given rise.

Overcrowding of buildings is another evil which threatens the healthiness of any site. This overcrowding is invariably associated with increase in the death-rate. Thus, it has been shown that a population of 12,092,982, living on 3,183,965 acres in the chief towns of England, gave an average death rate for 10 years of 24·4 per 1,000. In a population of 9,819,284, living on 34,135,256 acres in districts represented by small towns and country parishes, the death-rate for a like period was only 19·4 per 1,000. In over-crowded towns, with little free space between the houses, the risks of air-pollution are very great; and attendant disease is, of course, certain to appear under such circumstances.

Dampness in houses, as a source of disease, also demands attention when the matter of site is discussed. House walls built so that they impinge on earth, are almost certain to show dampness sooner or later. It is, of course, the architect's business to ensure that precautions are taken against this preventible accident. In making the foundations of the house, what is known as a *damp course* is usually introduced into the walls where they rise above the level of the ground. This course consists of asphalte, or slate, laid in cement; while stoneware may also be employed. Such a layer prevents damp from gaining access to the bricks or stones which lie above it. The need for exercising similar precautions in dealing with area and underground rooms can be readily estimated.

The materials used for the walls of houses vary with the district and country; durability and strength, combined with dryness and an absence of injurious porosity, are the characters required in a good building material. It has been estimated that with a temperature of 72° F. inside and 40° F. outside, there passed through a wall built of sandstone 4·7 cubic feet of air per hour; in the same time 6·5 cubic feet passed through magnesian limestone, 7·9 cubic feet through brick, 10·1 through limestone, and 14·4 through mud. The porosity of different materials is thus seen to vary immensely, and similar differences are noted to exist in materials denominated by one and the same name.

Thus, the variations in the qualities of bricks are numerous, and in using these materials for building, care must be taken that the best qualities are employed. Some bricks are so soft and porous that it has been estimated that each brick will absorb about a pound of water. A notable example of the misuse of material in building is afforded by the stone used in the erection of the Houses of Parliament. Here a magnesian limestone was employed, this stone, under the influence of London air, being gradually eaten away. The sulphurous compounds of the London air attack the limestone and its component magnesia, and convert the stone into the soluble sulphate of magnesia.

There is a growing opinion in favour of *hollow walls*, bound at intervals by cross-bricks, as favouring heat in winter and coolness in summer; while their porosity tends to prevent the accumulation of the moisture commonly seen in impervious walls, which, while they keep outside damp from penetrating, yet constitute, from their texture, a source of internal dampness. *Roofs* should be made of materials which are thoroughly waterproof, and which are not liable to retain damp or to catch fire; effective arrangements for draining the roof of rain-water are also necessary. Well-seasoned wood should be used for the *floors*, and the introduction of air-bricks, so as to allow a free current of air to pass between the lowest floors and the damp course, is a necessity for the prevention of rot and smells from dampness of the wood.

The *arrangement of the house rooms* is a matter dependent for settlement upon the size of the house and the available accommodation. In the case of flats it is important that the water-closets, for example, should be built in an abutment of the main building, so as to avoid a nuisance and to render their sanitary arrangements capable of being easily supervised. The common stair, or passage, should be well lighted by a top light, which should possess abundant means of ventilation. The central part, or stair, in a flat tenement, acts, in such a case, as a ventilating shaft ; and it is important that the houses in the flat should not be ventilated from this stair but from the outside air. In too many instances, the closet windows and ventilation outlets open into the stair ; this should be avoided in all well-planned flats. The position of the *kitchen* is a matter demanding attention from the fact that the odours of cooking are apt, in badly placed kitchens, to become diffused through the house. As a rule, kitchens are imperfectly ventilated ; and the want of this essential condition tells injuriously on the health of servants, in addition to rendering the kitchen a domestic nuisance from its odours passing through the house. Where, as in many cases, the kitchen forms the living-room of servants, the necessity for attending strictly to its ventilation can be readily justified. The application of one or other of the methods of ventilation already described (see Chapter VI.) will tend to obviate the faulty conditions to which reference has just been made. Double doors between the kitchen and the lobby, or staircase, with which it communicates, may also be found useful. The various kitchen-offices—pantries, larders, &c.—should also be well ventilated. The storage of food in close and ill-ventilated cupboards is a frequent cause of health-disturbance and of unnecessary waste of materials. No pantry or larder should be placed near a closet, for very obvious reasons, and what has already been said regarding the storage of milk (page 61) may be here recalled to mind. Milk, of all fluids, is most apt to absorb deleterious gases, and thus to become a source of danger to health.

The *sitting-rooms* of the house are, as a rule, wisely placed on the ground floor, while the *bedrooms* are situated above—an arrangement perfectly in accordance with health laws. The ventilation of rooms having been already treated, no further mention of this topic is necessary. As regards the arrangement of floor coverings, the modern innovation in favour of carpets which occupy the middle of the room only, and which thus leaves a broad margin at the side of the room to be covered with wax-cloth, or with layers of oak or other woods readily kept clean and polished, is altogether a decided improvement on the former state of matters, in which the carpets covered the entire floor space. The ease with which apartments can be cleaned under the latter fashion is a distinct gain in domestic economy; and what has been said of the wisdom of the fashion of carpeting the middle of rooms alone, applies with increased force to the case of bedrooms. The saving of trouble in cleaning, added to the absence of dust-accumulation, are two points of extreme importance. No carpets should extend below beds. The sleeping accommodation of servants is not always what it should be, even in large mansions; and improvement in respect of the cubic space allowed in the apartments of domestics is earnestly called for by every sanitary consideration.

Wall coverings form an item of household economy which is not without its due effect on the health both of body and mind. The question of a wall covering is, ot course, a matter chiefly of expense—taste and suitability here, as elsewhere, being ruled by considerations of cost. The ceilings should be whitewashed regularly, where this method of treatment is in use; a varnished paper ceiling is often found preferable on the score of cleanliness, but demands renewal at intervals.

In connection with the subject of *wall papers*, the ruling consideration to be borne in mind is the necessity for purity of material. Papers which are non-arsenical are now manufactured by every firm of paper-stainers of any repute; most, if not all, firms of note manufacture non-arsenical papers, and no others.[1] But the cheaper classes of paper-hangings undoubtedly contain arsenic, and this often to an injurious extent. A common error is that of believing

[1] Messrs. Woollams & Co., of London, were the pioneers in this excellent movement.

that green papers alone are liable to contain arsenic. As a matter of fact, papers of all shades of colour have been proved to be arsenical, some 'French greys' rivalling the greens in the amount of arsenic they contain. Dr. Fox tells us that not less than 700 tons of arsenical compounds are annually consumed in this country in the manufacture of feathers, wall papers, artificial flowers, &c. He adds, that 'many wall papers that are not green are loaded with arsenic, especially pale or white drawing-room papers with an enamelled or opal-white ground, which have yielded fifteen to twenty-five grains of arsenic per square foot. Mr. Wigner, on recently examining samples of all the papers in a ten-roomed house—none of which were green—discovered that five of them contained arsenic in such quantity as to be injurious to health. The symptoms of arsenical poisoning, such as are likely to occur from the continued inhalation of the arsenical dust of wall papers—consist in stomach derangements, diarrhœa, nausea, vomiting, and thirst. The eyes are often inflamed, the nervous system is disturbed, there is restlessness combined with inability to sleep, and the throat is dry, sore, or may even be ulcerated. Many illustrative cases are given in which mysterious cases of illness have been traced to arsenical poisoning through wall papers.

Dr. Hodges, of Belfast, relates the following case, which is particularly instructive. The account is quoted from Mr. Carr's 'Domestic Poisons':—

'I beg to give you the following particulars in reference to the effects produced by the green wall papers which you so kindly analysed for me a few months ago. I bought them last November to paper the walls of the children's day and night nurseries, from a shop in Belfast. I got a paperhanger to put them up, and he got sick before he had half finished the job, and left his son to finish it out. He has since told me that some green papers always affect him in this way. The paper had not been on ten days before two of the children (there were three in all) began to lose their vigour and animation. They had all been particularly healthy before. One little boy of three and a half years old was the first to show it. His throat became much ulcerated, and he got languid and weak. He was put to sleep in another room for about a fortnight, and his strength and vigour came back again; whereas our eldest little girl, who was still in the nursery, remained as she had been. We had no suspicion at the time that the paper had anything to do with it. On the little boy returning to sleep in the room with the green paper, he again fell back into the state he had been in before, and grew gradually worse and worse every week. We called in the local doctor, but he was quite at a loss to understand the apparent epidemic. The children had by this time become all more or less affected in the same way, also the nurse and Mrs. —— ; whereas all others in the house, who were not in the habit of being in the nurseries, were quite free. From fine healthy children they became weak and fretful; their necks became swelled and knotted, and their throats very much ulcerated. Ultimately it was suggested that the paper was the cause, and on getting your report we at once had it taken off. In a very short time all became well, with the exception of the little boy and eldest girl. The health of the former was so completely undermined, that at one time it appeared as if he would not recover.'

Mr. Carr quotes similar instances in his handy and interesting book. Thus :—

'Dr. Hinds, of Birmingham, papered his own study with green paper. Suffered from severe depression, nausea, pains in the abdomen, faintness, &c. Same occurred every evening when door closed and gas lighted: tested the paper, found it arsenical; paper removed; no return of the symptoms.

'Another case in Birmingham: two rooms papered with arsenical paper. Gentleman and his wife, who were in perfect health, in less than a week suffered from weakness, headache, fever, thirst, loss of appetite, inflammation of the surface of the eyes, heat and dryness of the throat. The gentleman went to Ramsgate, and recovered in a week; the lady remained at home and got no better. In two days after his return the gentleman was again ill. The paper was removed, and both recovered in a week.'

The reality of the danger to health thus represented, is proved in a very complete manner, and it remains to show how the presence of arsenic may be tested for in a simple and efficient manner. Mr. Carr, who has devoted much time and trouble to the elucidation of this important matter, gives the following instructions:—

'The advantages of Reinsch's test are, that it can be undertaken by any professed chemist at a fee within the means of every one, no small consideration when a large number of papers have to be examined. Indeed, with the apparatus provided at the suggestion of the society by Messrs. Townsend and Mercer, 85 Bishopsgate Street Within, London, manufacturers, tradesmen, and intelligent householders might use it for themselves.

'They thus hope that the end they have in view, the discouragement of the employment of arsenical colours, would be more speedily attained by the education of the public generally than by a few isolated cases of prosecution.

'*Testing by Reinsch's Process.*—The following is the mode in which this test should be used:—Sixteen square inches of the paper, either in one piece or several, so as to include all parts of the pattern, to be cut up and put in a test-tube or flask, with two ounces of dilute hydrochloric acid (4 distilled water to 1 of acid), and brought to the boiling point, a vertical condenser being used, if convenient; it is, however, not essential. A piece of copper foil, 1 inch by $\frac{1}{2}$ inch, clean and bright, is now placed in the flask (fig. 44), suspended by a thin platinum wire, by means of which it can be withdrawn, from time to time, for examination. After boiling gently for half an hour, the copper must be rinsed repeatedly in water, and finally held under a tap, in a pair of forceps, to remove all traces of acid, &c. On no account is the copper to be touched with the fingers, as, even when wet, the grease of the finger interferes with the subsequent

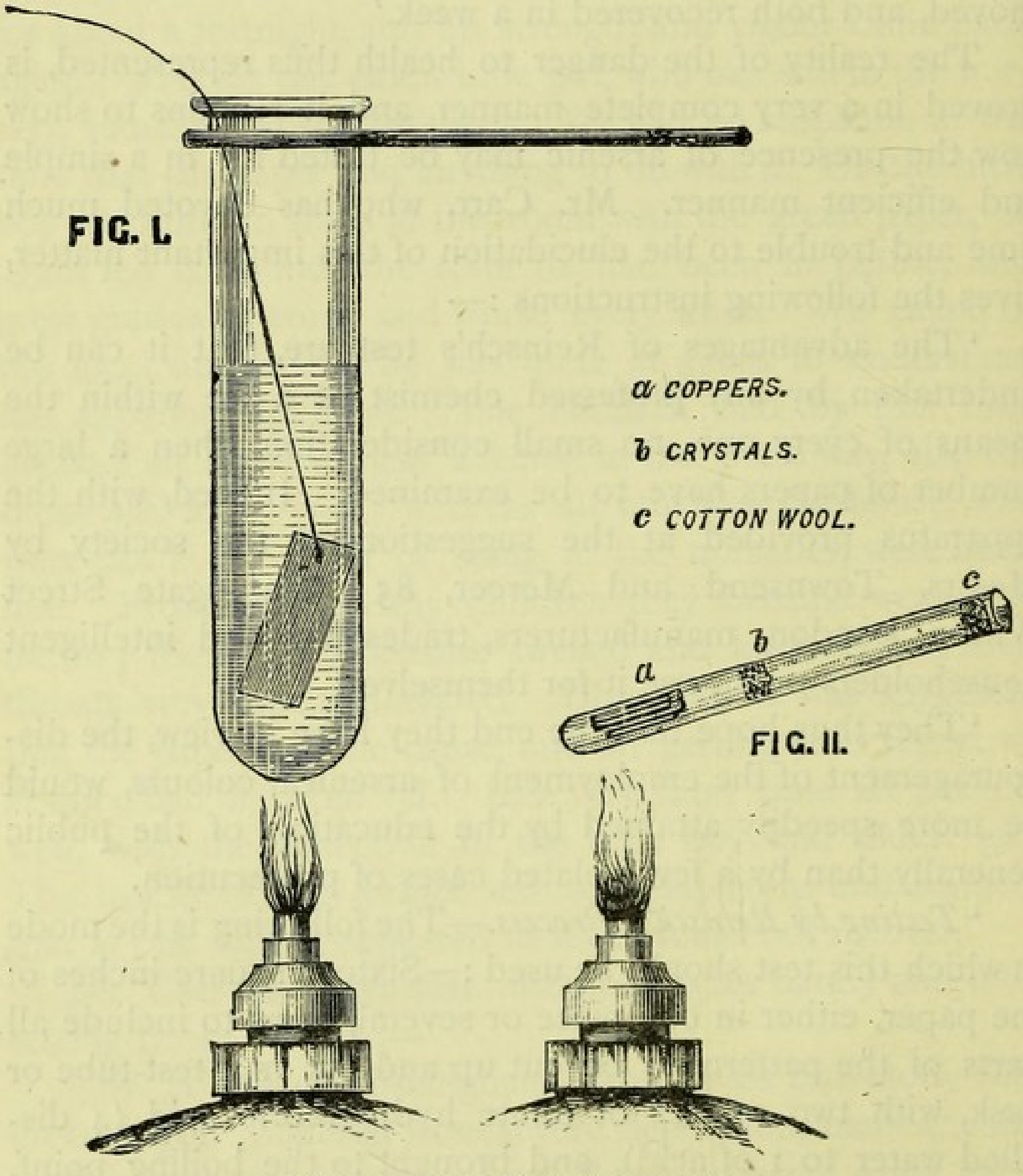


FIG. 44.—Reinsch's test for arsenic.

operations. No great stress can be laid on the amount of discoloration, as it varies very much, even with the same amount of arsenic, in the presence of other substances, such as sulphur, mercury, &c. If there be much arsenic present the copper will be coated almost immediately of a *black* or *dark steel* colour; if less arsenic be present a longer time will be required, varying from half a minute to half an hour, half an hour being the limit of time for boiling; if in that time the copper be not coated all over of a lamp black or dark steel colour, the paper may be accepted, the cases being very rare in which this process does not detect the arsenic. If the copper be coated all over, the paper is in all probability arsenical.

'The copper must then be treated as follows:—Dry it between two pieces of clean blotting-paper, and, holding it in the forceps, warm it very gently over a spirit-lamp; then, still holding it in the forceps, cut it into strips. Take a thin glass tube, $\frac{1}{4}$ inch internal diameter, and $1\frac{3}{8}$ inch long, sealed at one end, and lipped like a test-tube at the other. Suspend this by dropping it through a hole cut in a piece of stout sheet-brass or copper not less than 4 by 1 inches, so that the lip just supports the tube, and place the brass or copper plate on the ring of a retort-stand. Heat the tube nearly to redness, to expel the last trace of moisture; and, when cold, put the copper strips within, and place over it, resting on the mouth of the tube, a microscopic slide, warmed in a spirit-lamp till all the moisture at first deposited has disappeared. Now heat the tube with the spirit-lamp, letting the flame play on the under side of the brass plate. In a few seconds a sublimate will appear on the slide. Watch this until it begins to shrink from the edges and form a patch just the size of the bore of the tube. Remove the lamp, allow the slide to cool, and examine the sublimate with the magnifying power of 220 diameters. If the sublimate consist of octahedral crystals (fig. 45), the discoloration of the copper is due to arsenic.

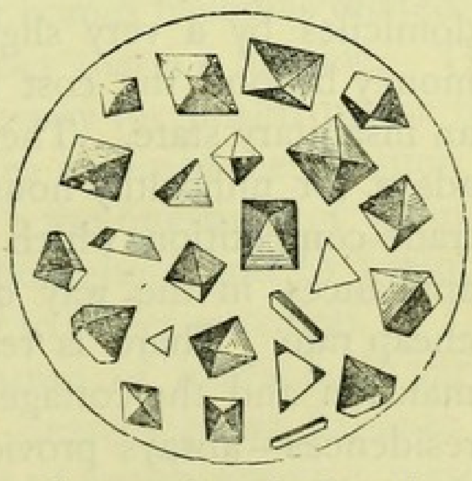


FIG. 45.—Crystals of arsenic.

Or the crystals may be obtained by using a tube about 3 inches in length, as shown in the foregoing figure (44).'

Mr. Carr adds that 'when sending a wall paper to be tested for arsenic, the sample must be large enough to include all colours, as some may be arsenical, others not so. In the case of small-pattern papers, a piece the size of a sheet of note-paper will be sufficient to allow of part being tested, and the result being written on the back of the remainder. Writing on the back is most important, in order to secure the identification of the report with the sample tested.'

The many questions connected with the topic of the house in its relation to health are thus seen to demand the close attention, not only of the architect and tradesmen employed in its construction, but of the occupier as well. The architect, in the first instance, is chargeable with the arrangement of the house, with the disposition of its details, and with the general characters of the building; while the artisans who carry his ideas into practical effect are responsible, in their turn, for good workmanship, and for the faithful discharge of the duties incumbent upon them. This much is certain, that where a landlord is anxious to possess valuable, because sanitary property, in the shape of healthy houses, he may, as things are, acquire such value in his domiciles by a very slight, if indeed any, expenditure of money beyond the cost required to leave the dwellings in an insanitary state. There is really little excuse left, nowadays, for unhealthy house construction, in the face of the trade-competition which has provided so many effective appliances in the way of drains, traps, closets, &c., at a cheap rate. There is really no adequate reason why the mansion and the cottage should not alike be made healthy residences—always provided builder and occupier unite in the work of constructing, and of attending to the wants of, a sanitary dwelling respectively.

No one should enter upon the tenancy of a house, and far less purchase one, without first ascertaining, through the skilled inspection of the premises, the exact state of the drains and other items. Such skilled inspection can now be had everywhere for a very moderate fee, and even were the cost of such inspection much greater than it is, the money would be well expended in the prevention of possible diseases, and in the saving of probably a large sum in the shape of doctor's fees. In the higher era of sanitation, a certificate of the sanitary excellence of every house will be demanded by law, as a just protection against preventible disease ; and there are already signs on the near horizon of public opinion, that such a system of house-registration is not only contemplated as perfectly possible, but as eminently desirable in the interests of national health.

CHAPTER IX.

SHELTER AND WARMING.

THE topic of 'warmth' possesses various aspects which relate themselves in a more or less intimate fashion to certain of the subjects already noticed in these pages. Thus the question of the warmth of our homes becomes related to the topic of ventilation, as also does that of lighting. The preservation of the warmth necessary for health under the varying circumstances of life, opens up again the question of dress and its sanitary aspects. To the questions of warmth, therefore, as thus related to the household and to personal health, it now becomes necessary to direct attention.

The average internal temperature of man's body varies from 98·5° F. to 99·5° F.—these degrees being liable to be materially influenced by age, state of health, exercise, season, climate, food and drink, disease, and other conditions. This heat is produced partly by chemical and partly by mechanical processes. Thus the oxidation of certain foods (*e.g.* fats) produces heat, as we have already noted, while the mechanical action of friction, such as that seen in the passage of blood in the vessels, in the workings of the tendons of muscles in their sheaths, and so forth, must also be taken into account in estimating the sources of heat of the body.

In making allowance for the variations of climate and temperature experienced by mankind, it has been found necessary to supplement internal sources of heat-production by external methods, and thus the question of artificial warming comes into play as a condition necessary for the maintenance of human health. The methods at command for warming our houses resolve themselves into open grates, stoves, warmed air distributed by pipes or flues, and steam pipes. In the case of an ordinary open grate, the heat is conveyed to the walls of the room by radiation from the glow of the fire, while we also obtain a proportion of the heat from the reflection of the grate itself. This property of radiation of heat is one cause of the sensation of cold many persons experience in a cold room. On sitting near a cold surface, such as a wall, radiation takes place from the body towards the wall, and a consequent coolness or chill is the result. Coolness of the air in a room, along with sufficient warmth in the wall and contents of the room itself, are the conditions which probably represent the perfection of artificial warming. The merit of the open, bright fire consists in its acting (even if imperfectly) in this fashion ; whereas, in the case of stoves and other forms of heating, the air is apt to become warm to an unpleasant degree.

In the open fireplace, a constant current of heated air escapes up the chimney. The fire, in such a case, sucks in cold air by all the chinks or openings which may exist in doors or windows. Thus the air-supply enters chiefly beneath the door when the windows are shut, passes along the floor to the fire, and is warmed in its passage thereto. The air, thus warmed, escapes in part up the chimney ; while part naturally ascends into the room, and, as a rule, passes to the opposite end of the apartment, where, after cooling, it descends to mingle again with the incoming current along the floor towards the fire. This circulation of air, it is evident, does not subserve the requisite conditions for maintaining warmth and ventilation ; since the end of the room most distant from the fire is kept cooled, while the cold air of the floor is likewise chilling in its effects. As a heat-producer, there can be no doubt the open fire is by no means an economical or satisfactory means of producing warmth. Captain Galton calculates that one pound of coal is more than sufficient to raise the temperature of a room 20 feet square and 12 feet high to 10° above the temperature of the outer air, provided, of course, the products of combustion are fully utilised. If, further, the air of the room did not escape by the chimney, and if the walls were non-conductors of heat, the amount of fuel required to raise the temperature to the above-named extent would be much less than has been noted. In an ordinary open fireplace, on the other hand, 8 lbs. of coal per hour are required to heat a room of the dimensions given above. This amount of coal requires for its combustion 1,280 cubic feet of air—as a matter of fact, much more than this amount is consumed—and at least from 14,000 to 20,000 cubic feet of air per hour must pass up the chimney, while from 25,000 to 30,000 cubic feet per hour is by no means an exaggerated estimate. In a room 20 feet square and 12 feet high, and therefore containing 4,800 cubic feet of space, the air is removed by a blazing fire six or eight times in an hour. It has been calculated that less than 15 per cent. of the heat ordinarily generated in an open fireplace is available for heating purposes, the remaining 85 per cent. being wasted or lost to the room. Still, with these faults in the way of heat-loss, the open grate has its own advantages in the way of ventilation. Where the fire is placed against an outside wall, there is great loss of heat and difficulty of ventilation, whereas in the centre of the house the fireplaces act better, and create less draught. In practice, it has been found that if fresh air be delivered above the chimney-piece into a room with an open fireplace,

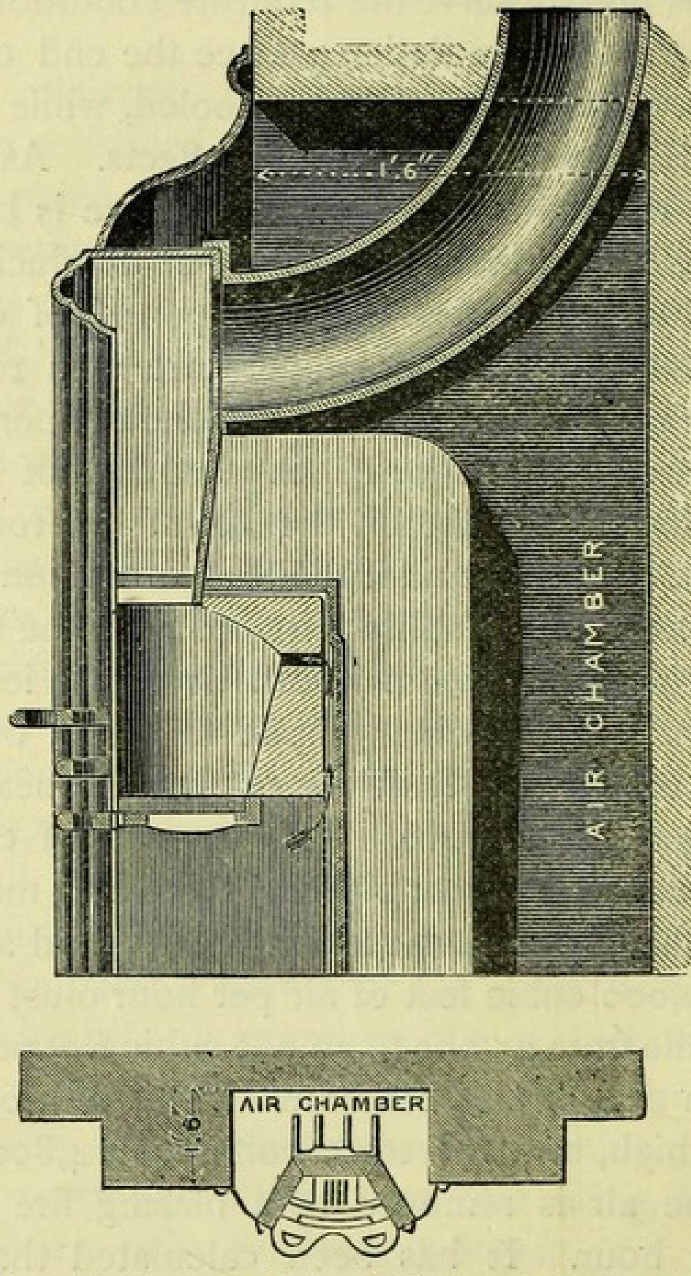
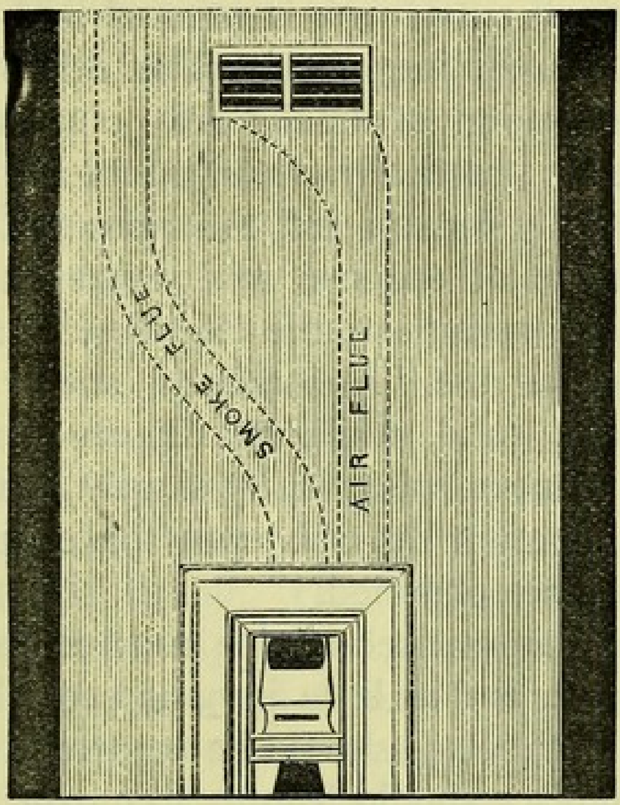


FIG. 46.—Section and plan of Captain Galton's grate.

the evils of the latter are lessened, the air thus admitted mingling with the upward current, and finally becoming one with the air of the room.

Various improvements on grates have been from time to time designed with the view of modifying the faults and of increasing the excellences of the open grate. Captain Galton's open fireplace, or stove (figs. 46 and 47), is a well-known form of such apparatus. Here fresh air is



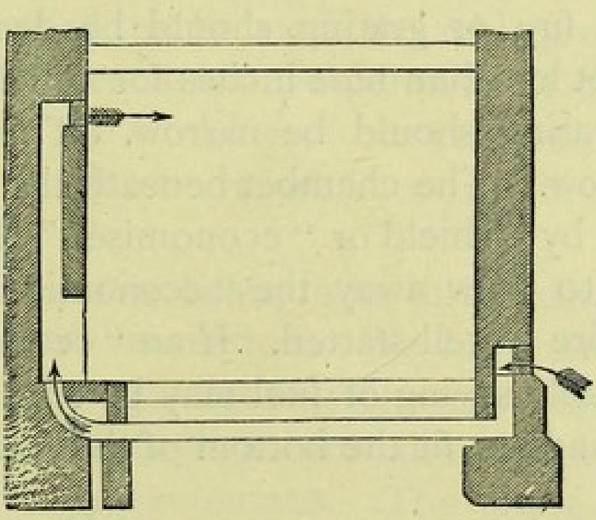


FIG. 47.—Elevation of Captain Galton's grate and section of room showing air-duct and flues.

admitted to a chamber placed at the back of the grate, and after being warmed therein, is carried by a special flue to the upper part of the room, where it mingles with the air-currents of the apartment. The draught of the grate is limited below, while warm air is supplied to the top of the fuel at the back of the fire. 'Boyle's Ventilating Grates' likewise provide for the entrance of heated air at the top of the grate. 'Shorland's Manchester Grate' is a third contrivance in which outside air is warmed and conveyed into the room by the chimney-shelf. The economising of fuel and the consumption of smoke are points which may be noticed as being practically contrived in the case of other grates. As usually constructed, the open grate admits cold air to the centre of the fire, and causes an up-draught which carries the warmth up the chimney, as already noted. In such grates as the 'Abbotsford' and 'Parson's' the bottom is made solid, while Mr. Teale has recently described a contrivance, wherein, by simply adapting an iron shield or 'economiser' to the open space below the grate, excellent results are obtained.

Mr. Teale's summarised advice runs as follows :—'Use as much firebrick, and as little iron, as possible. The back and sides of the fireplace should be made of firebrick. The back of the fireplace should lean or arch over the fire. The bottom of the fire, or grating, should be deep from before backwards—not less than nine inches for a small room. The slits in the grating should be narrow. The bars in front should be narrow. The chamber beneath the fire should be closed in front by a shield or "economiser." In lighting the fire it is well to draw away the "economiser" for a short time until the fire is well started. If an "economiser" is not used, considerable saving of fuel may be effected by having an iron plate made to fit the bottom of the grate, and laid on the bars.'

One important advantage of any means which effects the more complete combustion of fuel, is the diminution in the quantity of smoke emitted by the chimney. The 'smoke nuisance' is one of such real character that all attempts to check it should be encouraged to the full.

In the case of *stoves*, the fuel is consumed in a closed chamber, and a larger amount of heat is therefore given off as compared with that which passes from an open fireplace. About 24 per cent., as a rule, of the total heat generated by stoves passes up the flue. Stoves have always been objected to on the ground of their tendency to render the air extremely dry, although expedients are in vogue which remedy this evil in many instances. Stoves made of brick are bad conductors of heat when compared with iron stoves, although, when well heated, the former class give off a high temperature. In choosing a stove, the preference should be given to one which possesses efficient means of ventilation. 'Doulton's German Stove' is, in this and other respects, one of the best made. Where *gas heating* is practised, great care must be taken to ensure efficient ventilation of the apartments thus heated. Gas stoves and kitchen apparatus have grown greatly in public favour. The 'Calorigen Stove' is an example of a handy description of gas-ventilating stoves. Whatever be the means adopted, it may lastly be noted that a temperature of from 55° to 65° F. in rooms occupied by day is that which it is desirable to maintain. The temperature of bedrooms need not be made the subject of too much anxiety, seeing that the lower temperature of the night is provided against by the clothing of our couches, while such decrease is more readily borne while resting in bed than in the working hours.

The subject of *lighting* bears, in its turn, a direct relation both to warming and ventilation. We have already noted the effects of ordinary gas-lighting on ventilation, but the influences of ordinary daylight are also worthy of being taken into account by sanitarians. The abuse of light is productive of very decided consequences both in the animal and plant worlds. Ordinary green plants grown in the dark are feeble, do not develop colour, and remain blanched or *etiolated.* With animals—except in the case of those forms which have become habituated to life in dark places—the case is similar. The vital powers languish and become enfeebled, and the health of the organisms undergoes general deterioration where absence of light is experienced. The influence of light on health is by no means so widely recognised as it should be ; although at present the tendency is to admit the necessity of light as an essential element in the full development of the body. Any tendency, architectural, æsthetic or otherwise, which advises and countenances a return to the small windows of our forefathers, or which cuts off a full supply of sunlight from our homes, ought, on health grounds, to be rigidly resisted. The size of window space is required, in the rules of the Local Government Board, to equal one-tenth of the floor area of the apartment, but this estimate is by no means over-adequate.

With regard to the supply of light in an ordinary room, it has been pointed out that for the preservation of the eyes, a direct facing light is to be regarded as prejudicial to the sight. Probably the best position is that of writing or sewing with the side to the light, and preferably with the left hand towards the light, so that no shadow is cast upon the work or paper.

Artificial lighting is usually carried out in our homes by means of candles, lamps, or gas. In all these expedients, the light is produced by the combustion of carbon or hydrogen gases. The hydro-carbon compound unites with the oxygen of the air, is decomposed thereby, and evolves heat and light. The result of more or less imperfect combustion is also to liberate solid carbon particles, constituting the 'soot' of the lights in question. Another result of such combustion is the production of carbonic acid and water ; hence, as already pointed out, the presence of lights in a room adds to the air impurities which it is the aim of ventilation to disperse. The particles of carbon are chiefly consumed at the edge of the flame, but where the combustion is imperfect, they escape in quantity into the air. It should be borne in mind, however, that the brightness of flame is really due to the combustion of the carbon particles in question, the gas itself, which is evolved, preserving little power of illumination. Carbonic oxide gas is also produced as the result of imperfect combustion, and this gas, it need not be remarked, is a highly poisonous compound. In the case of candles, the hydro-carbon gas is really burnt in the flame as it is produced; the oily matters of the candle supply the carbon and hydrogen for the combustion. In lamps, the strong air-current which is produced by the glass chimney causes perfect combustion of the materials, the difference between the lamp flame before and after the application of the chimney being, as everyone knows, of very marked character.

As regards lighting by means of candles, the improvements which have taken place both in the manufacture of the wicks and of the combustible materials, have placed lights of clear character at our command. 'Sperm Candles,' used in gas-testing, consume each 120 grains of their material per hour, and cost 2*s.* 6*d.* per lb. weighing 7,000 grains. Calculations made regarding the relative cost of lighting show that twenty sperm candles burning for 100 hours and costing £4 5*s.* 9*d.* would be equalled in this work and period by Ozokerit candles costing only £1 14*s.* 3*d.* If colza oil is reckoned to burn at the rate of 49 grains per hour per candle light, 98,000 grains would equal the consumption of twenty candles for 100 hours, and the expense of the oil (at 9 lbs. to the gallon, and 3*s.* 6*d.* per gallon), would only amount to 7*s.* 2*d.* Petroleum oil, well burned, and consumed at the rate of 48 grains per hour per candle light (giving 84,000 grains for twenty candles for 100 hours) would cost 2*s.* at 1*s.* 4*d.* a gallon of 8 lbs. The cost of candles is therefore seen to vastly exceed that of oil-lamps. The harder makes of candles are the best; the substances of which they consist not having the same tendency to imperfect combustion as the tallow and softer kinds. In the case of lamps, burners like those used in the 'Silber' lamps are probably the best. Useful lamps, with two or three wicks, are now commonly sold.

Gas-lighting forms, however, the principal means of artificial illumination in common use. The gas is distilled from coal in retorts, leaving coke as the residue ; while the distilled matters include tar, ammonia, the coal gas, and other substances tending to render gas impure, and have, therefore, to be removed by purifying processes. The special dangers attending the use of gas are its liability, in case of escape, to form an explosive mixture with air ; and its own poisonous properties, which depend chiefly on the carbonic oxide it contains. Another source of health-danger and air-impurity combined, is found in the varying pressures at which the gas enters our houses. If the pressure is great and uncontrolled, more gas is forced through the burners than can be properly and fully consumed. Waste of gas and increased gas bills, together with ill-health, are the results of this accident, which, however, can be thoroughly remedied by the use of a 'gas governor' attached to the meter, and which regulates the amount of gas passing into the house pipes. Of such 'governors' by far the best is Stott's, of Oldham, and 174 Fleet Street, London. This 'governor' is automatic in its action ; and, from personal experience of its use, the writer can attest its high value in preventing air-impurity. It is not liable to fall out of order, and it is cheap and easily applied to the meter. So beneficial are the effects of this ingenious contrivance, and so great is the saving on gas bills it effects, that the nuisance of flaming jets and unconsumed gas in our houses, should no longer be suffered by anyone desirous of abating these evils.

The defect of gas-lighting, as commonly practised in our private houses, is the want of adequate means of carrying off the waste products of combustion. In this respect, fire and gas are widely different ; since the fire possesses the chimney as a channel whereby the waste products are removed. Attempts have been made to imitate the principle of the fire and its flue in the case of gas lights. Thus in large gas lights (as in the case of a sun-burner) there is usually provided a special exit leading directly to the air. In globe lights, the burners are enclosed in a glass globe, and are thus completely shut off from the room, the waste matter being carried to the air by a special shaft or flue. The full development of electric lighting in its application to our houses, is no doubt a realisation of the near future. The application of this light would, of course, remove all nuisance from odours or combustion, burning as it may *in vacuo* ; while, as far as the effects of the electric light on the eyes are concerned, it would seem to be as suitable in every way as are the lights in ordinary use.

Passing now to consider the question of warmth from its personal aspect, the subject of *clothing* is brought under our attention. As is the case with the artificial warming of our houses, so with clothing, the primary object is to preserve an equable temperature of body. Of necessity, included under this head we find the consideration that clothing is designed for protection ; and this aim, along with that already mentioned, constitute, therefore, the true purport of clothing and dress at large. All other considerations, such as those which relate to style, fashion, and expense, are entirely subsidiary to the physiological use and purport of dress. These latter points may be important enough when regarded from a social point of view. From the all-important sanitary standpoint, they are not entitled to weight ; indeed, they may, as often as not, be subjected to severe criticism. With the suitability of clothes for their primary purposes, hygienic science has certainly much to do—science can, and does, suggest what is proper for the protection and warmth of the body; but it is obvious that happily it does not require to concern itself with the frivolities of fashion or the passing fancies of the hour in dress. It may legitimately speak of the necessity for proper clothing for the different seasons ; it is equally certain that it has no concern with such an excrescence as the 'crinolette' of ladies or the 'tall hat' of the male sex.

The *materials* which are utilised in the manufacture of clothes are very varied, and naturally show characteristic differences when race and climate, as well as the ranks and classes of society, are taken into consideration. Certain materials are bad 'conductors' of heat, and are therefore suitable for preserving the warmth of the body. Wool ranks in this category, to which may also be added down and fur. The use of a down quilt in winter can be readily justified on the grounds thus specified. Wool, it has been estimated, possesses just half the conducting properties of linen or calico.

Naturally, *colour* has much to do with influencing the choice of materials for clothing, but it is texture, and not colour, which gives to any material its conducting or non-conducting powers. When, on the other hand, the influence of external heat is considered, colour then rises in importance as a hygienic condition. That black clothes in summer are often unbearable, while white garments are cool, depends, not so much on the texture, as on the fact that the black garments absorb the greatest, and white the least, amount of heat. Texture has also to do with the evaporation of skin-moisture, and with the consequent cooling of the body's surface. The closer a texture, the less freely does it allow the moisture of the body to pass through its fibres, and *vice versa*.

As is well known, some fabrics absorb moisture readily, while others present an opposite effect. As, after periods of great exertion, we perspire freely, it becomes of importance that the clothing of the body's surface should possess a power of absorbing moisture and of thus removing it from the skin surface ; otherwise that surface, along with the clothing, simply remains wet, and chills and colds are thus apt to follow. The feeble conductors of heat—wool, down, and fur—are found to be those which possess the greatest moisture-absorbing, or *hygroscopic*, powers. Cotton and linen absorb freely; silk ranking above the latter materials in this respect. The teachings of experience have, therefore, selected wool or flannel as the material most suitable for wearing next the skin, and as that which most effectively protects the body from chill. It is also found that wool or flannel allows air to pass through it much more readily than does linen, and this property is one of no small value in assisting the ready drying of such materials.

In connection with the absorption of moisture by fabrics, the subject of protection against wet naturally falls to be considered. Waterproof clothing is that commonly used for this purpose; but objections to waterproof articles have been commonly entertained owing to their impermeability, and to the consequent retention of perspiration they exhibit, and liability to cold they engender. These objections can only apply to cases where the waterproof clothing is worn for long periods, or where the underclothing is of unsuitable character as regards the absorption of the skin moisture. The French soldier is not allowed to use a waterproof on account of the alleged unsanitary nature of these garments; but the waterproof clothing constructed by Messrs. Mandleberg & Co., of Manchester, obviates the objections to the use of this material, in that the manufactures in question are ingeniously ventilated.

The liability of different kinds of clothing to become readily ignited varies greatly. Wool and silk char but do not blaze, whilst cotton and linen readily take fire. To render dress materials uninflammable, and to prevent their sudden ignition, is often a necessary and advantageous procedure where liability to the accident of ignition exists. Tungstate of soda, which is unaffected by the ironing and dressing to which fabrics may be subjected, is perhaps the most preferable substance. A fireproof starch, invented by Mr. Nicoll, contains tungstate of soda, and can be used in dressing the fabrics to be protected.

For *underclothing*, wool is the material which, on all grounds, must be regarded as the most suitable. Wool, as we have seen, is a poor conductor; it readily absorbs moisture, and it is permeable enough to permit of evaporation taking place. Hence, in a climate which is subject to frequent and often great changes in temperature—and, indeed, in all climates, hot or cold—the use of wool underclothing is to be thoroughly approved. The underclothing should be of loose description, and never tight-fitting; among other reasons for this recommendation is the fact that the presence of air between the garment and body aids the non-conducting properties of the former. As regards the attire suitable for night wear, the preference is given to linen or cotton articles. The conditions under which we rest in bed are so different from those represented in our waking life, that the need for attending to considerations of warmth, &c., as regards the body-clothing, no longer causes us anxiety. In the very young, and in the old, light woollen underclothing should be worn at night.

Our clothing naturally becomes adapted to *age* as well as to climate and season. In *infancy*, when the heat-producing and heat-conserving powers are not thoroughly developed, great need exists for the preservation of an equable temperature; hence, the chief point requiring attention in the case of the child is the preservation of an equable degree of warmth, together with the avoidance of extreme heat, which leads to restlessness and enfeeblement. There is no greater delusion in the treatment of infants—unless, indeed, one may find such in the frequent errors of their feeding—than that which tends to expose young children to cold by way of enabling them to undergo some mysterious process to which the name of 'hardening' is given. Again, the practice of literally swathing infants in tight-fitting clothes, after the fashion of miniature mummies, is to be earnestly deprecated on every score of health, present and future. The infant should, above all, be freely and loosely clad. The ordinary 'binder' is useless and mischievous in its effects ; its tight character alone is a serious fault. It tends to induce a highly unequal temperature in the lower part of the body, it obstructs muscular action, and it is the certain cause of many of the commoner and trifling ailments which infants exhibit. When Professor Humphry termed the binder 'those mischievous two yards of calico,' he did not overrate the evil of the garment in question. 'A more pernicious device,' he adds, 'can scarcely be conceived than this relic of ancient nursedom ; and it is impossible to estimate the number of deformed or pigeon-chests, of hampered stomachs, livers, lungs, and hearts, with their varied attendant life-enduring infirmities and curtailment of life, that must result from the use of these "swathers," as they are called, for which there is not the slightest necessity.'

Regarding the faults of infants' clothes, Dr. Day observes that they are too long and too heavy, that they do not properly fit the neck, that they require the child to be turned over in dressing, and that they are made to pass over the child's head, and to fasten with hooks and buttons. The dressing of an infant should be carried out without the child being turned over and over, as is commonly the case. Garments designed by Dr. Day, and opening in front, so that the infant may simply be laid in them, and thus dressed readily and without injurious movement, are now made, and can be readily obtained. Illustrations and descriptions of these garments appeared in the second volume of '*Health.*' [1] While the infant's clothes should be loose, the extreme in this direction must, of course, be avoided. No dress should be so loose as to allow the back, for example, to be seen on pulling away the clothes ever so lightly, and it is almost needless to remark that all waistbands or other constructions are not only unnecessary, but highly injurious. Excess of clothing is, lastly, to be decried. As a rule, the most common error of infants' clothes is illustrated by this latter

[1] Published by Messrs. Wyman & Sons, 74 Great Queen Street, London, W.C.

point; and the long cloaks and other garments in which young children are so often swathed, are therefore to be objected to as needless and productive of risk of cold. A point of importance, likewise, in the clothing of young children consists in attention being paid to the covering of the head, neck, and arms. These parts are too frequently left bare, with disastrous results as far as colds and chills are concerned. The head of the young child should be kept cool, on account of the changes in the structural elements of the skull, which are a feature of early life, and for this reason, also, heavy head-gear in infants should never be permitted.

The *dress of adults* is a matter concerning which only a few remarks are permissible, since the subject in itself is almost endless, and capable of being considered from multifarious points of view. As regards male attire, the dictates of fashion reign supreme, in much the same manner as in the case of female dress. The great aim should be to dress so as to find adequate protection from cold, and at the same time to avoid unnecessary excess of clothing. The neck should be well protected, but all constriction should be avoided, and of the chest the same remark holds good. All tight bands round the body are injurious, and braces form the only hygienic support to the body. There are various makes of braces now sold of which easy accommodation to all the movements of the body is made a distinct feature. The head attire is important, in that for health's sake we require that the head should be kept warm, and not overheated, and that injurious pressure should be avoided. The ordinary 'tall hat' is an indefensible piece of clothing on any ground, but its use appears to be perennially sanctioned by fashion, and so it survives as an infliction of the male sex. The white straw hat of summer, equally with the pith helmet of the soldier in the tropics, are examples of head-gear in which attention to hygienic rules has been paid. What are required in a hat, are the qualities of coolness, shade, and a sufficiency of ventilation. These desirable items are apparently far removed as yet from practical realisation. In health, no caps or other head-gear at night are necessary.

The eccentricities of *female dress* have formed subject-matter for remark in every age; but, as regards the hygienic aspects of this question, the rules which apply to the dress of the male sex are also those which should regulate female attire. Absence of all injurious pressure, lightness combined with warmth, avoidance of all constriction, and the abolition of unnecessary appendages and extravagances in the costume, are the chief points at which female dress-reform is being aimed. Recent reforms have had for their objects the remodelling of the usually cumbrous petticoats and under-garments by the adoption of such a contrivance as 'the divided skirt,' in which each limb is separately clad in its own 'skirt,' as in the case of male attire; the divided garments being concealed by the dress, and thus rendered inconspicuous. It is claimed, and with good reason, for this costume, that it obviates the necessity for the many garments at present in use, while it secures lightness and greater freedom of movement than is possible under the ordinary fashion. Tight sleeves, like tight waists, are decidedly injurious, and the reaction against the latter enormities has come none too soon.

Tight-lacing is a very ancient fashion, no doubt, but its ill-effects have been, and are, proportionate to its venerable character. With preconceived notions of beauty of form or outline, the sanitarian has no concern. It is his duty to insist upon the recognition of the great law, that departures from the normal standard of health are injurious, and that all such lapses are certain, sooner or later, to prove exceedingly serious in their effects, not merely upon the health of the existing generation, but upon that of future generations also. Hence, when a waist whose normal circumference—taking that of the average woman—is from 25 to 26 or 27 inches, is constricted to 22 or even 20 inches, the dress reformer can find no difficulty in showing that a pathological criterion of 'beauty' has been set up in place of a standard of health. The form of the normal chest is that of a cone (fig. 48), which has its apex above and its base below. In tight-lacing the apex and base (fig. 49) are literally reversed. The waist, drawn in to an excessive degree, becomes widened above and narrowed below. The results of this compression are highly characteristic. Displacement of important organs — liver, stomach &c. — naturally follows (figs. 50, 51, and 52), constriction and deformity are found, the breathing capacity is seriously diminished, exercise and freedom of movement become impossibilities, health - disturbances become common, and very serious results accrue, as in the case of child-bearing, in the after-life of the subject.

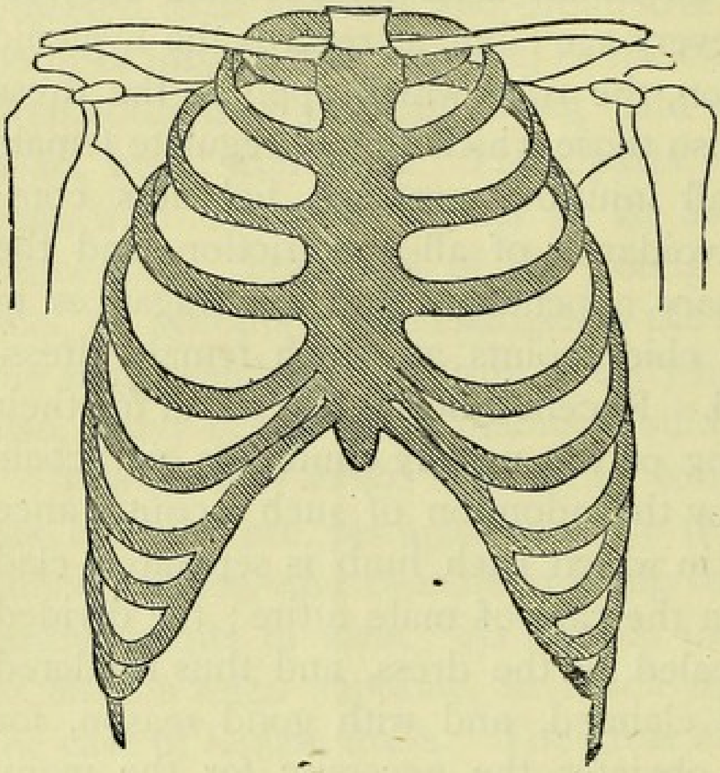


FIG. 48.—The natural form of the chest.

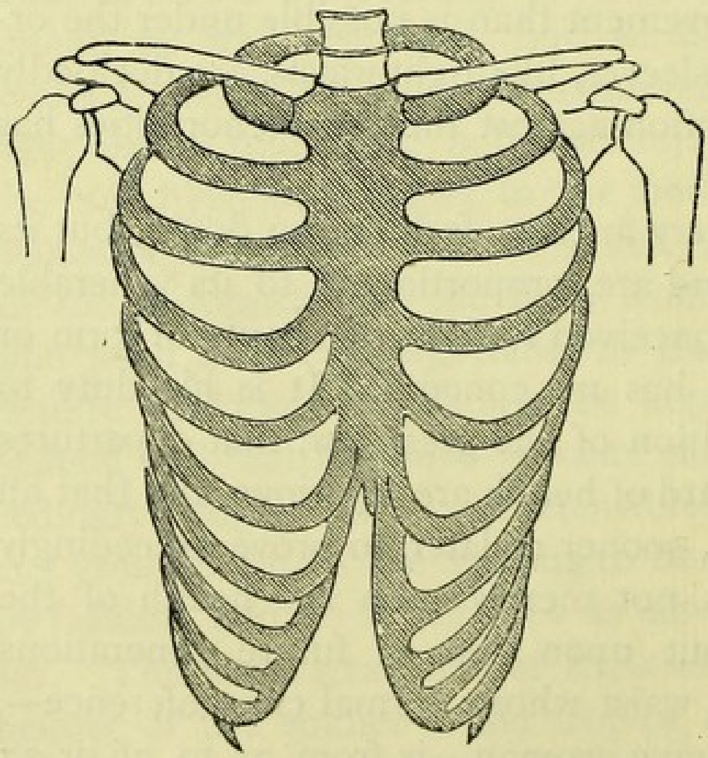


FIG. 49.—The chest deformed by tight-lacing.

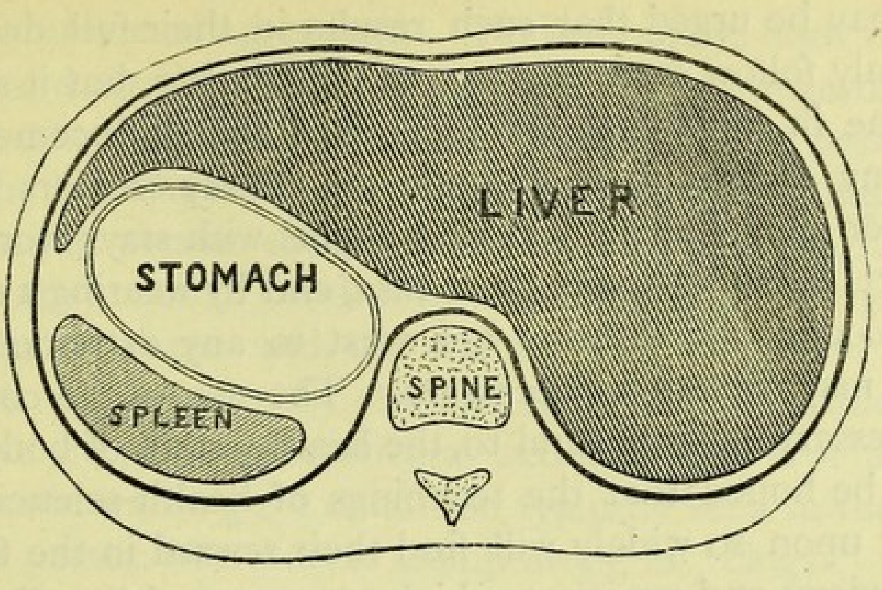


FIG. 50.—Section of a natural waist.

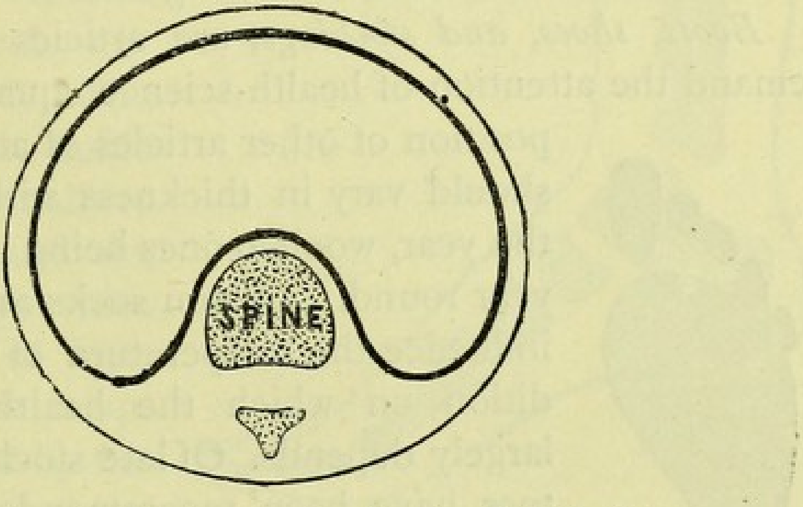


FIG. 51.—Section of a tight-laced waist, showing diminished space.

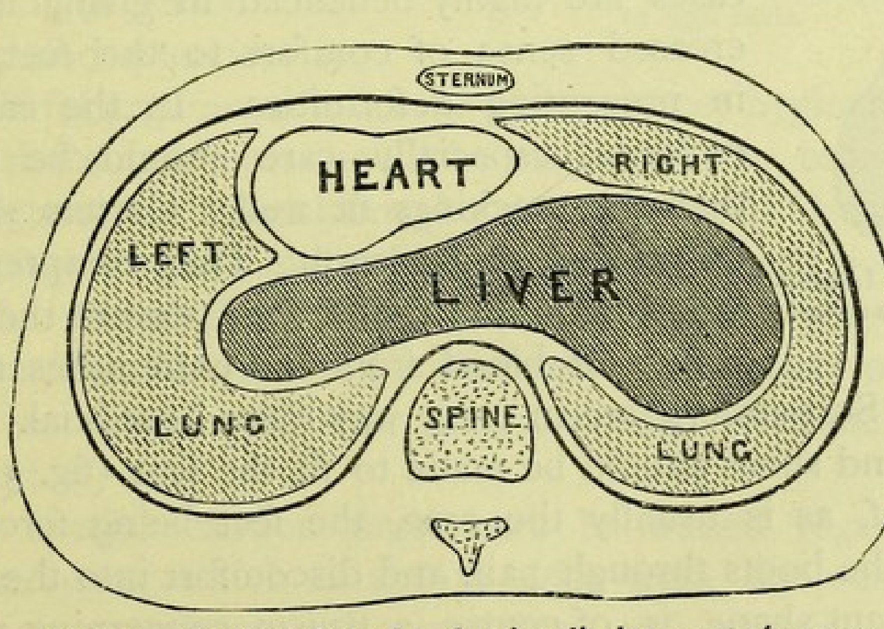


FIG. 52.—Section of a waist, showing displacement of organs.

It may be urged that such results in their full development only follow extreme cases of tight-lacing, but it should be borne in mind that the incentives and inducements to carry any fashion to an extreme are merely matters of degree after all. The subject who begins with stays worn as a 'support' may, with very great ease, end by wearing a corset, so as to crib and confine her waist to any extreme which fashion may dictate as necessary. The use of the corset is not necessary in, or natural to, the healthy state of body, and it is to be hoped that the teachings of health-science now insisted upon so widely will find their reward in the formation of views and practices which may powerfully affect the generations of the future for their good.

Boots, shoes, and stockings, are articles of attire which demand the attention of health-science equally with the disposition of other articles of attire. Stockings should vary in thickness with the season of the year, woollen ones being preferable all the year round. Cotton socks are apt to unduly influence the temperature of the feet, a condition on which the health of the body largely depends. Of late stockings made with toes have been recommended, and in many cases are highly beneficial in giving an increased sense of comfort to the feet, and in preventing deformities. In the case of children, especially, care should be taken that the stockings fit well. Garters should on no account be worn. They compress the veins of the limb, and thus prevent the easy return of blood from the extremities to the heart. 'Suspenders' are in every way more beneficial. That boots and shoes should be made to fit the feet (fig. 53) instead of, as is usually the case, the feet being forced to mould the boots through pain and discomfort into the most convenient shape, is, of course, a truism concerning which

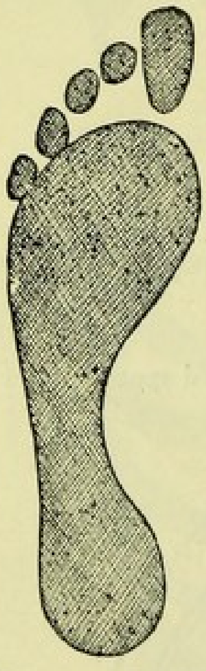


FIG. 53.—Impression of a natural foot.

there is universal agreement. Unfortunately, however, very many and varying opinions are entertained regarding the best method of effecting this desirable end. The pointed toe and the high heel (fig. 54) are equally abnormalities which no sensible person should endure. The toes are distorted by the first-named condition, while the arch of the foot is put out of shape and the natural gait destroyed by the second. Again, perfectly stiff and rigid soles are undesirable, because they limit the natural action of the foot and leg-muscles in walking ; a condition typically seen in the unfortunate person who has to tramp along in 'clogs.' Elastic-sided boots may prove injurious if the veins of the foot are thereby unduly compressed. The shoe is, perhaps, liable to fewer abnormalities than the boot, and the former usually provides for a freedom of foot-circulation which is apt to be constricted by the latter. The fact that the shoe is preferred for games and exercises is a powerful argument in favour of its greater hygienic value. Both shoes and boots should be made with low, broad heels, and square, or at least broad toes. 'Rational' bootmakers will refuse to make either high-heeled or pointed boots. It may be added that of late the 'reversible' principle of boot-making has found its advocates ; the boots or shoes being so constructed that they are worn alternately right and left.

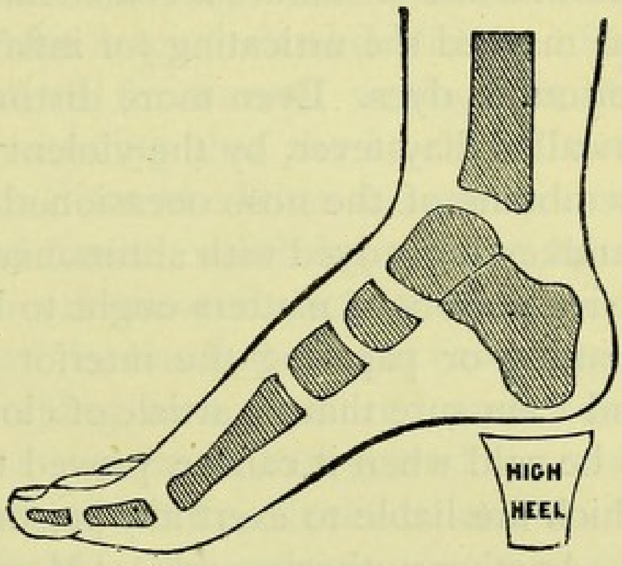


FIG. 54.—The bones of the foot in relation to high heels.

A special caution must here be added regarding a health-danger which is apt to arise from the wearing of materials containing poisonous dyes, and especially aniline colours. As in the case of arsenical paperhangings, such articles of dress may cause ailments which become all the more dangerous because their source is unsuspected. The following remarks may be perused with interest, as bearing on this danger to health :—

Dr. Bartlett says : 'I should class with preventible dangers the aniline-dyed taffeta gloves and silk handkerchiefs, of which I have had a large number of specimens submitted to me for analysis. Severe irritation of the hands of delicate women and children has accompanied the wearing of gloves dyed with aniline salts, arsenic, and vanadium, and in some instances a considerable vesication of the skin has marked the urticating (or inflammatory) nature of these poisonous dyes. Even more distinct is the simulation of the so-called hay-fever, by the violent irritation of the mucous membrane of the nose occasioned by the application of silk handkerchiefs dyed with antimonial salts of aniline. All diffusive poisonous matters ought to be prohibited from use in painting or papering the interior of domestic habitations; and I am sure that no article of clothing should be permitted to be sold when it can be proved to be dyed with materials which are liable to exert any poisonous influence.'

Another authority adds : 'Most unpleasant consequences not uncommonly arise from the improper use of the aniline colours. It is well known that arsenic is largely used in their preparation, but under proper management none of the arsenic passes into the "finished" dye. The painfully irritant effects which have been frequently observed from stockings, gloves, &c., dyed with aniline colours cannot, therefore, be attributed to any other source than the dyes themselves, the secret of the mischief probably being that the colours have not been properly "fixed." Aniline itself, taken internally, is a strong narcotic poison, and its external action is that of a local irritant. It is not difficult, therefore, to understand that in its numerous chemical derivatives the aniline dyes may partake of its irritant properties. Aniline colours are now largely used in artificial-flower making, not merely for brilliant colours, but on sombre leaves, bunches of berries, and dyed grasses. It is thus an unquestionable fact that our house furniture, decorations, and dress materials are, to a great extent, charged with deleterious poisons.'

Mr. Carr gives, among such cases, 'that of a young woman, a cutter-out of dyed goods; of others poisoned by gloves, shirts, socks, shoe-lining, &c. The evil effects of the socks are especially well-known to the public. A young lady, lately suffering in her feet, came under the care of Dr. Myrtle, of Harrogate. Her case is reported as follows: She had for some time been wearing stockings of a deep red colour, and suffered from large inflamed blisters. She was under medical treatment for several weeks, but the blisters remained, notwithstanding that the stockings were discarded. Dr. Myrtle then discovered that she was wearing slippers lined with magenta flannel, which kept up the irritation. When this lining also was removed she soon recovered.'

Dr. Myrtle remarks that 'he has had several cases where mauve-dyed articles of clothing have produced great local irritation, which, in one or two cases, has proved not only painful, but most difficult of cure. Neckties and socks have furnished obstinate forms of an eruption of an herpetic character, the base of each vesicle being painful and greatly inflamed. The eruption has, in appearance and nature, resembled shingles more than anything else, although it is, as far as my observation goes, a distinct form of cutaneous disease.'

Another case was reported by Dr. Robert Blair, of Goole, in which gloves formed the source of infection.

In this case a lady bought a pair of 'bronze green' silk gloves. 'After wearing them a day or two she was attacked with a peculiar blistering and swelling of both hands, which increased to such an extent that for three weeks she was compelled to carry her hands in a sling, suffering acute pain, and being unable to feed or dress herself.'

It is, therefore, evident that great care requires to be exercised in the selection of materials for clothing on account of the dangers above noted. Many otherwise mysterious cases of illness are readily explained when an analysis of suspected articles has been made. The occurrence of such cases shows the necessity for increased attention being paid by the Legislature to the topic of poisonous materials in dress, artificial flowers, wall-papers, sweets, and the like.

Dr. Parkes summed up the chief facts relative to clothing in a concise form under the following heads :—

'*Protection against Cold.*—For equal thickness, wool is much superior to either cotton or linen, and should be worn for all underclothing. In case of extreme cold, besides wool, leather or waterproof clothing is useful. Cotton and linen are nearly equal.

'*Protection against Heat.*—Texture has nothing to do with protection from the direct solar rays. This depends entirely on colour. White is the best colour, then grey, yellow, pink, blue, black. In hot countries, therefore, white or light grey clothing should be chosen. In the shade the effect of colour is not marked. The thickness and the conducting power of the material are the conditions (especially the former) which influence heat.

'*Protection against Cold Winds.*—For equal thickness leather and indiarubber take the first rank, wool the second, cotton and linen about equal.

'*Absorption of Perspiration.*—Wool has more than double the power of cotton and linen.

'*Absorption of Odours.*—This partly depends on colour, and Stark's observations show that the power of absorption is in this order—black, blue, red, green, yellow, white. As far as texture is concerned, the absorption is in proportion to the hygroscopic property, and wool therefore absorbs more than cotton or linen.

'*Protection against Malaria* (or poisonous influences arising from marshy soils).—It has been supposed that wearing flannel next the skin lessens the risk of malaria. As it is generally supposed that the poison of malaria enters either by the lungs or stomach, it is difficult to see how protection to the skin can prevent its action, except indirectly, by preventing chill in persons who have already suffered from ague. But the very great authority of Andrew Combe, drawn from experience at Rome, is in favour of its having some influence; and it has been used on the West Coast of Africa for this purpose, with apparently good results.'

CHAPTER X.

PERSONAL HEALTH—THE CARE OF THE BODY.

As the interests of a nation, in a political sense, are ruled through the co-operation of communities, and as these again are influenced by individual actions and opinions, so in the matter of health the welfare of the nation is emphatically the outcome of individual strivings after a wisely ordered life. The great problem of health-progress, it should never be forgotten, is only to be solved on the basis of the personal culture of health. Sanitation can never progress in the mass, save through the effects of the units which compose the mass. Hence, attention to personal health and an eagerness on the part of each individual to avail himself or herself of the ways and means of healthy living, is the first condition for the successful advance of the welfare of the people at large.

Turning, then, to the brief consideration of the main points involved in what may be called personal hygiene, we may begin by noting how the gradual growth of the human body necessitates the observation of special rules for its physical guidance at the various stages or periods of life's journey. Such periods are well marked in the birth, growth, development, maturity, decline, and death of the individual frame. The period of *infancy*, as we have seen, demands its own special conditions for the preservation of health. The regulation of the infant's feeding, its dress, and other conditions, is forcibly made a special study by parents, just as the diseases of childhood form a special and distinct province of the science of medicine. But the period of *youth* possesses, likewise, its own special traits and characteristics. This is the stage of preparation for adult life. It is the period when the constitution is being formed for good or evil in a physical, as in a moral, sense. Growth is taking place during youth, and hence, on the full discharge of the functions of nutrition and on the proper selection of foods, as well as on attention to the rules of healthy living at large, the well-being of the adult frame must depend. The child is truly 'father to the man' in this physiological sense. He inherits, it is true, the frame and features of his ancestry; but these features, it can readily be shown, are susceptible of modification, wherever such a process is desirable, by the methods of hygienic control.

For example, let us suppose that the child of a consumptive stock is under consideration. Under ordinary circumstances, the physical outlook of such a subject would be of a singularly despairing kind. He has inherited a grave constitutional malady, which, if not modified by health influences, is well-nigh certain to show itself later on in all its deplorable fulness and strength. Now, statistical and medical experience together show, that if a child born of consumptive parents is carefully tended, guarded against cold, warmly clad, well fed, overstrain avoided, and made to breathe a pure and wholesome atmosphere, such a being will not only pass safely in most cases through the ailments of youth, but has the best possible chance of living healthily past the particular period (namely, thirty-six years of age), which constitutes the Rubicon of his health. This period or age being safely passed, he possesses the probable prospect of surviving to ordinary old age. Nor is this a solitary instance of what may be done in the way of modifying disease through care and attention being paid to the laws of personal health. The child who inherits gout may, by attention being paid to plain living, healthy exercise, and other points, escape the malady to which it is heir. The child born of parents who have exhibited insane tendencies may similarly, by a well-controlled system of education and restraint, together with attention to physical health, become as useful and as long-lived a member of society as the child born free of such inherited taint.

We thus see that although diseases 'run in the blood,' and although 'like begets like' as a primary rule of nature, there is another law—that of evolution and modification—which operates in the direction of producing, under favourable conditions, departures in the direction of health from the parental line. This is really the problem of *heredity* or *inheritance*—how to correct, by judicious attention to the laws of health, the errors and mistakes of the past—how best to lay, through such attention and culture, the foundations of health where otherwise the 'dead sea fruit' of disease would inevitably appear. The lessons which the subject of heredity in its health-bearings teach us with great clearness, are those showing anew the wisdom of the personal culture of health. In an era when wise marriages, the careful upbringing of children, and the personal care of the body are made subjects of education and practice, the loss of life through hereditary disease will dwindle to a minimum which seems at present entirely outside the reach and scope of our strongest aspirations. Marriage engaged in either too early or too late in life; children neglected in their most vital interests; and the duties of ordinary life in relation to health slurred over, are causes which bring about a terrible day of reckoning to very many of the units of which society is composed. The awakening to a knowledge of the truth that disease may be both diminished and prevented, will be the signal for a new departure in the direction of advance in national health and of a largely diminished death rate.

The period of youth is marked by many changes, amongst which stand conspicuous those collectively known under the name of *puberty*, when the boy, 'putting away childish things,' blossoms forth into manhood, and when the girl similarly develops into the woman-stage of her career. At this period of life, there is great need for the exercise of care in all the duties pertaining to personal health. Over-strain, physical and mental alike, is carefully to be avoided. The nutrition of the body should be rigidly supervised, and habits of regularity encouraged in every aspect and department of personal life.

In *old age*, on the other hand, when the powers of life begin to fail, the care which tended the hours of childhood begins once again to find an appropriate sphere of duty. There is now greater need for warmth and for light food, easy of digestion. The periods of rest require to be of longer duration, and work and labour, if indulged in at all, require to be of a light and non-exacting character. Life may be prolonged for many years in the aged by attention to the ordinary rules of healthy living; modified as these rules must be, for the special care of the 'flickering flame' which carelessness of any kind may only too readily extinguish.

Respecting the general question of *habits*, in relation to personal health, the primary condition for observation is that of *regularity*. This condition reigns paramount throughout every question of personal hygiene, from that of sleep and exercise, to food and the action of the bowels. The gravest errors of health are those of which irregularity forms the chief feature, and the difference between lives which are well ordered and the reverse, is often found to consist less in the amount of food required or taken, and less in the nature of the habits, than in the regularity with which periods of work, recreation, and rest succeed one another from day to day.

What is true of the health which follows the regularity of the action of the heart, for example, as contrasted with irregularity of its work, holds good of the work and life of the body as a whole.

Amongst the habits, in the exercise of which regularity tells with marked effect on the physical and mental health, questions of work, exercise, and recreation, meals, sleep, and rest stand out in conspicuous array. *Work*, as a primary condition, demands for its perfect performance regularity of its periods. The experience of every-day life goes against giving credit to 'spurts' of work, and the fable of the hare and the tortoise includes a physiological as well as a moral application. As a matter of fact, the trades and professions in which break-down from overstrain most frequently occurs, are not those involving hard application, but those entailing severe temporary strains. A hard and laborious occupation may, *cæteris paribus*, be healthy enough, provided the work is performed with regularity, and does not in itself involve unhealthy conditions. Contrariwise, an easy occupation, indulged in under conditions of strain, may become thoroughly prejudicial to the health of the worker. This much can readily be accepted without need of details.

With *exercise* and other forms of *recreation*, the case is similar. The development of physical education in schools and colleges, and the extension of means of recreation among all classes of society, is beginning to effect a much needed reform in the direction of health. As a means of developing the bodily powers in youth, physical exercise of a well-ordered kind is invaluable, and it is also gratifying to observe that such exercises are now made available for girls as well as for boys. The value of such exercises as are included in 'Ling's System of Gymnastics,' consists not only in the mere development of bone and muscle, but in a certain mental training and self-reliance which the practice of gymnastics tends to foster and encourage. The great aim and end of exercise is to provide relief from the accustomed duties and toils of the day. The schoolboy's games are the antitheses of his school work, just as the walk of the merchant, the rowing or tricycling expeditions of the sedentary student, or the volunteering practice of the clerk or shopkeeper form an agreeable contrast to his ordinary avocation. It is this feature of alternation of occupation, combined with the bringing into play of a new set of muscles or thoughts, which constitutes the beneficial aspect of all recreation. Even the desire for alternation which prompts the student of science to amuse himself with a novel, is an apt illustration of this truth.

Those interested in the wide subject of physical education may consult with advantage the works of the late Mr. Maclaren of Oxford, in which are detailed very fully and completely the various ways and means in which exercise may become subservient to healthy growth and activity. It may be added that special exercises have been devised for the cure of deformities and for the wants of those for whom ordinary recreation is unsuitable. Of such exercises Dr. Zander's system presents the best-known example. At the English Institute conducted on Zander's system at Soho Square, London, the various machines and appliances employed in the practice of this form of physical education may be inspected; while, as a means of ordinary exercise, there are many features in the Zander system worthy of examination.

The question of *regularity in the periods of eating and drinking* is a highly important one. It may safely be said that no condition more forcibly than this contributes to welfare of body; while, conversely, the neglect of such rules is the most common cause of health-disturbance. The importance of regularity of meal hours is only equalled by the dictum that rest and relaxation after food are necessary for the healthy performance of the digestive function. No more common cause of dyspepsia, or indigestion, for example, exists, than the habit of indulging in exertion immediately after taking food. The process of digestion, involving as it does an exercise of muscular and nervous power, demands rest as an essential factor for the healthy discharge of its functions. Hence, to regularity in meal-taking should be added rest after meals, as an essential condition of health. The aphorism, 'After dinner sit awhile,' is approved by physiological reasoning of sound nature.

No less important is the subject of *sleep*. Sancho Panza's famous declaration regarding the blessedness of sleep, was doubtless founded on an acute perception of the value of sound rest as an essential condition for healthy wakefulness. The *periodicity* which life everywhere exhibits, is nowhere better exemplified than in the alternation between rest and repose which not only the body at large, but its individual organs, exhibit in the natural course of their existence. For example, the heart pulsates between brief spells of work and short intervals of rest; of the work of the lungs, the same remark holds good. The muscular system demands repose. And if we turn to the world of plant life, we may find the alternations between activity and rest to be as abundantly illustrated as in the animal world. Living nature seems to abhor continuous action. Alternation of labour and repose, and not continuity of work, forms the unwritten law of the living constitution.

The duration of the period required for sleep naturally varies with the age of the individual. In adult life, about a third of existence is spent in sleep; in infancy, life is almost a continuous period of sleep, until, indeed, the awakening consciousness begins to arouse the child from the birth-slumber in which its earliest weeks are passed. In old age, the individual demands a greater amount of sleep than in adult life, and an approach to the period of infancy is seen in the well-nigh continuous somnolence of the extremely old. It has been calculated that at 4 years of age about 12 hours sleep are required; at 7 years of age, 11 hours; at 9, 10½ hours; at 14, 10 hours; at 17, 9½ hours; at 21, 9 hours; and at 28, 8 hours. The latter amount may, therefore, be taken as a fair average amount for the healthy adult. As regards the intensity of sleep, experiment would seem to indicate that the greatest depth of sleep is attained within the first hour of repose. This deduction is probably in accord with physiological notions of the value of, and necessity for, intense and perfect repose during the early epoch of rest, and therefore during that which lies nearest to the toils and labour which have passed. The activity of brain during sleep, which is manifested in dreams, is probably due to the wakefulness of certain lower centres of the organ of mind, the higher, or intellectual, centres being quiescent. As a rule, dream-sleep of marked kind is the result of over-exertion mental or physical, of digestive disturbance, and of unwise participation in 'late suppers.' The practice of eating late at night is, in any case, an injurious one; although persistent wakefulness is sometimes cured by the subject of the disturbance eating some very light food shortly before retiring to rest. Under this latter designation, it is needless to add, the ordinary 'supper' is not included. Occasionally bathing the face with cold water will induce sleep, and the coolness of a pillow is a well-known incentive to drowsiness. But all sleep-producing doses and narcotics are to be indelibly branded as utterly harmful, and to be eschewed save under medical advice. Apart from the absolute danger to life to which the morphia tippler and the chloral drinker are subject, the use of such drugs only increases the evil they are believed to cure. They produce in time an irritability of brain which is simply fatal to the enjoyment of all natural rest. Children drugged, as they too often are, with 'soothers,' grow up weakly and irritable; and no mother who values the health of her offspring will consent for a moment to employ such means of inducing what, at the best, is not 'sleep,' but a condition of 'narcotism.'

Personal habits in the care of health and of the waking life include attention to the teeth, hair, skin, and bowels as fixed points in the category of bodily functions. To each of these points we may therefore devote a few words.

The care of the *teeth* is an essential duty in view of the preservation of health. Neglected teeth imply careless mastication of food; and this latter condition constitutes the commencement of indigestion, and of the many evils carried in its train. Composed (see chap. ii.) of *dentine*, or 'ivory' coated with enamel, and provided internally with a pulp containing nerves and blood-vessels, a tooth is thus a living structure, which grows from the gum, and which is therefore related, not to the bones, but to the hair and nails, as skin appendages, the 'gum' itself being simply modified skin. Teeth are subject to various diseases, among which *caries*, or 'decay,' is the most frequent. To obviate decay, and to cleanse the teeth from the food-particles which induce fermentative changes and the development of acids causing tooth destruction, it is necessary that they should be well cleaned. The teeth should be brushed night and morning. A moderately hard and broad brush should be used; and, as fluids are of no avail in cleansing the teeth, a powder must be employed. The fine precipitated chalk, or magnesia, commonly known as 'camphorated chalk,' forms a safe, agreeable, and efficient dentifrice. Where the gums are tender, a little tincture of myrrh may be added to water and used as a mouth-wash. The 'Dento-Phenolene' of Messrs. Calvert, an elegant preparation of carbolic acid, or the 'Phenate of Soda Solution' of Messrs. Woolley, Sons & Co., will also be found serviceable as a mouthwash. It is needless to add that smokers require to pay very special attention to the care of the teeth. Where the teeth are decayed, the dentist's help is necessary; and no hesitation or delay should be allowed to prevent our procuring efficient artificial substitutes where the teeth are unfit to perform their highly necessary work in the division of the food.

The care of the *hair* is a duty which, not only on the score of cleanliness, but on that of beauty and personal appearance, demands notice and attention. A hair, like a tooth or nail, grows from a *papilla*, or soft projection, and consists essentially of skin-cells moulded on a shaft, to form the well-known filament. The hair should be washed at least once a week. Too frequent washing of the head, is as injurious to the hair, as the opposite practice of neglect. Yolk of egg, a pure soap, and hot water, or 'Quillai bark,' or 'soap bark'—a Chilian product, which makes a natural lather when dissolved in water—may be used for washing the hair. A solution of bi-carbonate of soda in distilled water, with vanilla essence added, is also recommended for this purpose. Wilson's shampooing liquid, useful where scurf exists, may be made as follows :—

℞	Sapo animalis (B. P.) . . .	½ ounce
	Aqua Coloniæ	8 drachms
	Liquor ammoniæ (B. P.) . .	8 drachms
	Aquæ destill.	To make up 10 ounces. Mix.

A wine-glassful may be used as a shampooing fluid.

The use of oil or pomade in strict moderation is not injurious, and in some cases is a necessity for the health of the hair. Dr. Beigel recommends an oil made as follows :—

Provence oil	3 ounces
Ess. oil of almonds . .	2 drops of each
Oil of roses	2 drops of each
Orange oil	5 drops
Lemon oil	10 drops

This may be coloured by digesting a little alkanet root in it for a few days. Pomatum may be made by melting together two parts hog's lard and one part beef suet : being some essential oil added by way of scenting it. A 'Macassar oil' may be made as follows :—

Oil of almonds (reddened)	. .	1 pint
,, rosemary	. . . .	of each 1 drachm
,, origanum	. . . .	
,, nutmeg	. . . .	of each 15 drops
,, roses	. . . .	
,, neroli	. . . . .	6 drops
Essence of musk	. . . .	3 or 4 drops

These ingredients are to be mixed, and alcohol to be added drop by drop, the mixture being agitated until about two fluid ounces have been so added. The bandoline used for 'fixing' the hair consists of gum-tragacanth and distilled water digested for five or six hours. These materials are then strained through muslin, pressed, and alcohol and rose-water added.

The hair should be kept short; for children of both sexes, this practice is desirable. A hard brush should never be used; it induces scurf, and only increases, instead of curing, that evil; and the small-tooth comb is an enormity which should be banished from every well-regulated household. Crimping the hair is injurious, while singeing serves no end which cutting is not equal to effecting. Where the hair has a tendency to grow thin, the parting should be changed. In the case of baldness, not depending on any parasitic disease, such as ringworm and the like, the following washes are recommended by Dr. Robinson. The first, or alkaline wash, is to be used for a week, and to be well rubbed into the scalp, while the acid hair wash is to be substituted in the following week.

Alkaline Hair Wash.

℞ Boracis	. . . . .	1 drachm
Glycerini	. . . . .	2 drachms
Tinct. cantharidis	. . . .	6 drachms
Liq. ammoniæ (B. P.)	. . .	1 ounce
Ol. Lauri-nobilis essent.	. .	4 minims
Aquæ ad	. . . . .	6 ounces. Mix.

Acid Hair Wash.

℞	Acet. aromatici	2 drachms
	Glycerini	2 drachms
	Sp. vini rect.	1 ounce
	Liq. epispastici	1 drachm
	Aquæ flor. aurantii	2 ounces
	Aquæ rosæ ad	6 ounces. Mix.

It should, lastly, be borne in mind that the hair sympathises very strongly with the bodily health at large. Many conditions of hair-weakness are therefore cured by simple attention to the general health of body, and by the use of tonics and other means indicated for the restoration of the normal state. 'Hair dyes' mostly contain lead and other injurious ingredients, and should be eschewed by all who value health of body and hair.

The care of the *skin* is not secondary to any other health duty, inasmuch as the skin not merely serves as a covering to the body, but is an organ of *excretion*, and (see chap. ii.), as such, is concerned with the removal of waste matters from the blood. The duty of skin-cleanliness thus becomes apparent when we reflect that from four to twenty or more pounds of matter may be poured out from the sweat and other glands of the skin in the course of a single day. Furthermore, as the skin is always acting, the need for constant attention to this surface can readily be justified. The use of *baths*, carried out to such an extent among the Greeks and Romans, is a necessity for cleanliness of skin, and therefore for health.

Baths range in their temperature from 85° to 95° for *tepid baths* ; from 95° to 104° for warm baths ; and for hot baths from 102° to 110° F. The *cold bath* acts as a mere stimulant. It favours tissue-change, and thus aids the body in casting off effete matters, but it does not cleanse the skin —in other words, it has no *detergent* properties. Sea-bathing only differs from a cold bath in the stimulating effect of the plunge and in the influence of the salt contained in the water. The test of ability to bear a cold bath is the feeling of warm glow and reaction after the bath. If this sensation is not present, and the bather feels chilled, even after brisk friction with a towel, the bath had better be omitted. The head should not, as a rule, be wetted in taking the morning sponge bath, which is an immense aid to health and vigour in those with whom it agrees. In its action, it at first drives the blood from the surface, the recovery of the circulation being followed by the warm glow already described.

The *tepid bath* seems to possess no decided effect beyond imparting a feeling of ease after exertion; but the warm bath favours tissue-change, and acts as a cleansing measure to the skin in a thoroughly efficient manner when aided by the detergent action of soap. On the warm baths we must, therefore, depend for cleansing properties.

Hot air or *vapour baths* also act in promoting excretion, through the copious skin action they induce. As much as three pounds of weight have been lost after a hot air bath; but care and caution must be exercised in the use of such baths, owing to the depressing effect they may exert on the heart and blood-vessels. The ordinary warm bath, as is well known, is a highly refreshing agent after exertion has been undergone. It aids the weary muscles in recovering their tone and in parting with their waste. Napoleon the Great is said to have recuperated his powers after great exertion and mental fatigue on the battlefield, by indulging in a warm bath, instead of recruiting himself in sleep.

Attention to the *action of the bowels* must rank highly as an aid in the preservation of health. No condition more than the regular action of this part of the economy possesses direct influence on the physical well-being; and the beginning of many serious ailments may be said to date from the neglect to ensure the regular action of the alimentary canal in this respect. Habits of regularity of such action, should be inculcated in children from their infancy upwards. Such habits grow to become a part of the normal organisation of the digestive system, and obviate the necessity for the practice of perennial drugging with aperient medicines which is so lamentable a feature of our age. Where the action of the bowels is irregular, the eating of fruits and vegetables should be resorted to as a simple means of cure. The eating of 'whole meal bread' and the avoidance of tea and coffee are also hints worth bearing in mind for the treatment of such irregularity; while swallowing a glass of cold water on rising in the morning, often tends to promote such action. Possibly, of all remedies for constipation, the most satisfactory is that of giving 20 drops of the Cascara Cordial (of Messrs. Parke & Davis) in water, an hour before meals, twice daily; but it is needless to add this remedy is only intended for use as a preliminary to that wise dietetic treatment which alone can permanently cure such ailments. Where there is marked irregularity in the action of the intestines, medical advice should be obtained. The practice of swallowing aperients, like that of chloral-drinking to procure sleep, only serves to intensify the evil it is intended or supposed to cure.

CHAPTER XI.

AMBULANCE WORK, OR 'FIRST AID' TO THE INJURED.

THE treatment, by the educated bystander, of those who have been injured by accident of any kind has come to form an essential part of the training of even schoolboys and schoolgirls. Owing to the efforts of the St. John's Ambulance Association of London, and to the endeavours of kindred bodies elsewhere, information of this kind has been dispensed to ambulance classes throughout the length and breadth of the land. The value of such instruction requires no explanation. The duty of rendering efficient aid in cases of injury is, in the first place, one which lies incumbent upon all the members of a civilised community. In the second place, it is evident that the bystander, from his proximity to the sufferer, may be, and very frequently is, enabled to render an amount of assistance which far exceeds that the medical man can afford when afterwards he appears on the scene. 'First aid,' in other words, promptly applied may save life, when the most efficient surgical or medical aid, rendered later on, can be of no assistance. In a case of apparent drowning, of poisoning, of severe bleeding from a wound, or of choking, for example, the ready aid of the bystander suffices to tide the sufferer over the danger, or may at least place him in circumstances in which he may safely wait the arrival of a medical man. The pith of the motto, 'He gives twice who gives quickly,' is emphatically illustrated in ambulance work; and when we add that, for the most part, the details of such work are easily acquired by all who possess even a rudimentary knowledge of anatomy and physiology, we have enumerated the chief points which demand notice in treating the subject of ambulance aid.

The treatment of *wounds and bleeding* may first be described as dealing with a topic which deserves notice from the frequency with which such accidents occur. There are three kinds of blood-vessels (see chapter ii. p. 30 *et seq.*) in the human body. These are *arteries*, *veins*, and *capillaries.* The first-named vessels, as already noted, carry pure blood, of light red colour, *from the heart to the body.* The *veins* carry dark purple or impure blood *from the body to heart and lungs for purification.* The *capillaries* are the minute vessels in which arteries end and veins begin. In the case of injury of an artery (1) the blood escapes in jets from the wound, the jets corresponding to the impulses of the left side of the heart, with which the artery is of course in direct communication; while (2) the blood is light red in colour. It is clear, therefore, that in such a case pressure must be made *between the wound and the heart*, so as to arrest the flow of blood which is being propelled outwards from the heart. The importance of the instant treatment of arterial bleeding becomes evident, when we reflect that death may result in a few minutes from the exhaustion of blood. The prompt treatment of such an injury consists, therefore, (1) in compressing the artery between the wound and heart, the blood-vessel being pressed firmly against the adjacent bone; (2) in applying a ligature of one kind or another between the wound and heart—this ligature being technically known as a *tourniquet*.

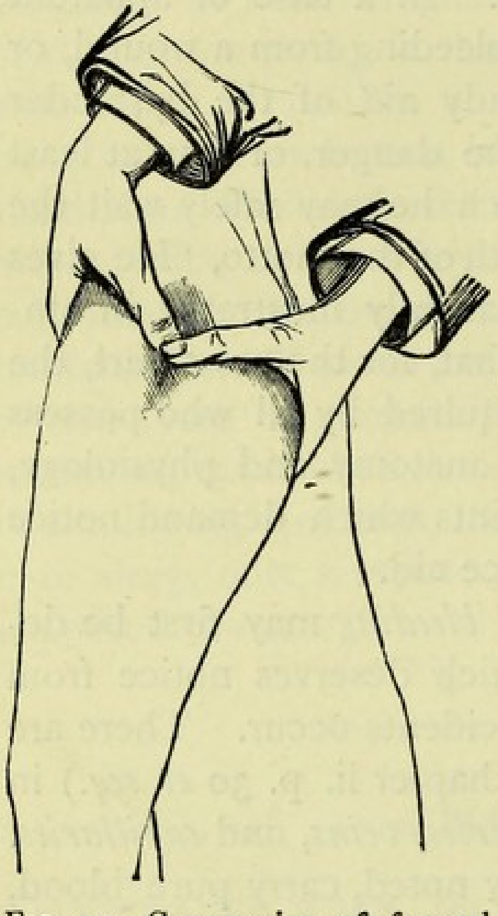


Fig. 55:—Compression of femoral artery in upper part of the thigh.

The pressure must be made firmly, with fingers or thumbs as the case may be. Thus, in the case of a wound of the *femoral artery* (or that of the thigh), or of its continuation (the *popliteal artery*) at the back of the knee joint, or ham, the compression can be readily made, as shown in the adjoining figure (fig. 55). If the wound is in the leg, the femoral artery may be compressed, as above noted, in the first instance. In the case of wounds of the upper limb, we may compress the *subclavian artery* against the first rib, by placing the thumb into the hollow space which is seen at the root of the neck on each side above the collar-bone. Lower down in the arm, the *brachial artery* can be compressed against the *humerus*, or bone of the upper arm—the artery running a course in the upper arm nearly indicated by the inner seam of the coat sleeve. At the wrist, the *radial artery* (or that in which the pulse is usually felt) can be compressed against the *radius* bone of the forearm, and the *ulnar artery* (on the opposite or little-finger side of the wrist) may similarly be compressed against its corresponding bone. In the case of the *carotid arteries*, or those of the neck, pressure would be made, between the heart and wound as before, against the spine or windpipe.

Compression, which can be applied at once, must be supplemented by the application of a *tourniquet*. This may be improvised, as shown in fig. 56, by using a handkerchief or other form of bandage, by placing a pad of some kind—a cork, stone, and folded handkerchief will suffice—upon the artery between the heart and wound (*i.e.* where compression is applied), by tying the bandage tightly over the pad, and by, lastly, twisting the bandage with a piece of stick, if need be, as a drayman uses his rack-pin to tighten his ropes, so as to exert pressure sufficient to control the bleeding. In the case of the brachial artery of the arm the figure (fig. 57) shows a bandage similarly applied, with the pad in position; while the stick, as shown in the figure, must be tied in position, so as to maintain the pressure until the surgeon arrives.

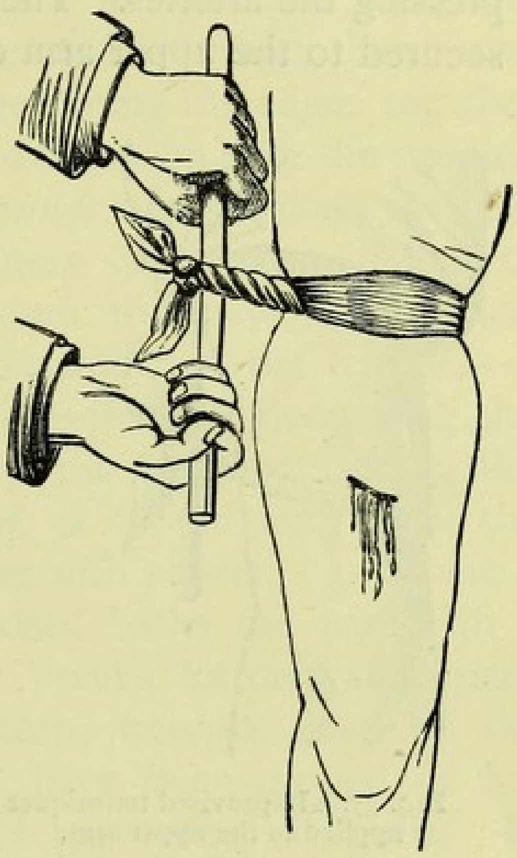


FIG. 56.—Application of an improvised tourniquet (handkerchief and stick) to the thigh for wound below.

Various forms of tourniquets are sold for ordinary use. Thus in fig. 58, two of these appliances are shown in position, so as to control the *femoral artery*. The left leg is encircled by the tourniquet of Petit, consisting of a strap, pad, and buckle attached to a brass or metal frame, which, by the movement of a screw, can be so adjusted, as to exercise great pressure by the tightening of the band. The right leg is guarded by an Esmarch's tourniquet, which is merely an india-rubber band, that can be wound tightly around the limb and secured thereafter in a catch, as shown in the figure. These elastic bands should be kept ready for use at all railway stations and other public places.

Other methods for arresting arterial bleeding consist in placing pads in the hollow of elbow and knee, or ham, respectively, in bending the forearm or leg, and in thus compressing the arteries. The forearm or leg is thereafter to be secured to the upper arm or thigh, as the case may be, by a

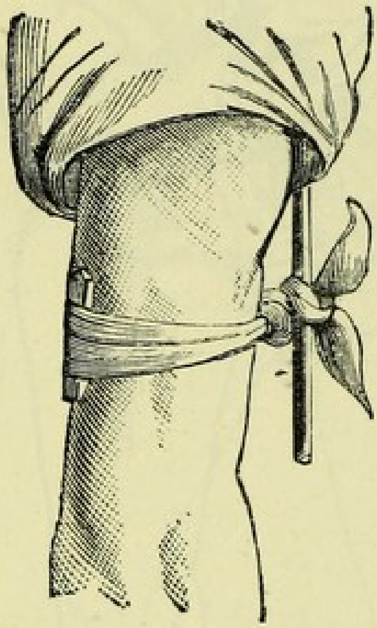


FIG. 57.—Improvised tourniquet applied to the upper arm.

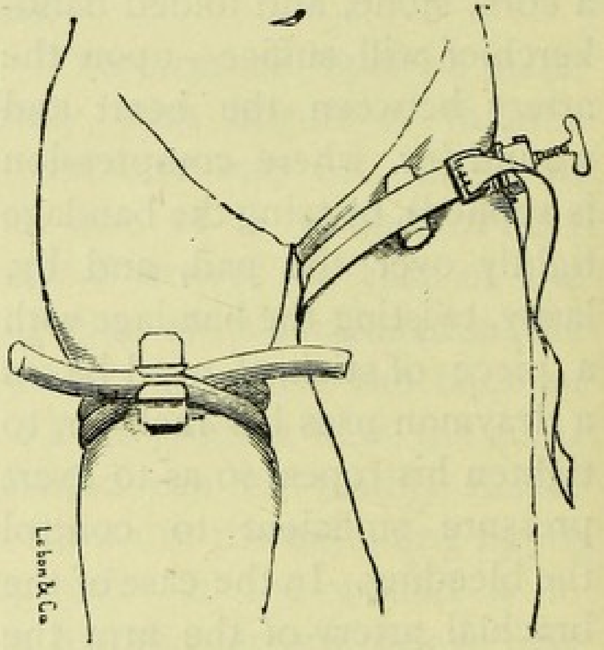


FIG. 58.—Tourniquets in position—that of Petit on the left, and that of Esmarch on the right thigh.

bandage. Bleeding *in the face* may be checked by compressing the facial artery where it passes over the edge of the lower jaw to reach the face.

Bleeding from a *vein* is indicated by the dark purple colour of the blood, and by its oozing from the wound, instead of 'spurting,' as in the case of the artery. In such a case, press on the bleeding point, place a pad and bandage thereon; and, if bleeding continues, compress or bandage *below* the wound. Elevation of the limb, it should be remembered, is an important part of the procedure in cases of bleeding. *Capillary bleeding*, or hæmorrhage, is familiarly seen in a simple scratch or superficial cut. The blood is red, and flows generally from the surface. The treatment consists of cold and pressure, or applying cotton wool, which is cleaner than cobwebs, and serves the same purpose, namely, that of clotting the blood. Tincture of the perchloride of iron ('steel drops') may be applied on a piece of cotton wool. This method is useful in the often troublesome bleeding following leech-bites. If, in the latter case, the bleeding still persists, pass a fine needle through the skin so as to transfix the wound, and then bring the edges together by passing a thread in a figure-of-8 fashion over the needle.

The *general treatment of wounds* resolves itself into the following axioms :—1. If faintness supervenes on loss of blood, lay the person flat, loosen the neck-clothes, but otherwise do not disturb him, inasmuch as the faintness—unless much blood has been lost—through decreasing the heart's action, will tend to limit the bleeding. 2. In the case of a simple *incised wound*, or 'clean cut,' wash the part and bring the edges together with plaster. 3. Where a *contused* (or bruised) *wound* exists, bathe the part with a lotion of spirits and water, or Pond's Extract and water (1 to 3). 4. In *lacerated* (or torn) wounds, wrap up the injured part in flannels which have been dipped in hot water, and if necessary give hot tea, coffee, or spirits. In such wounds there is rarely any serious bleeding, owing to the contraction of the vessels.

For *internal hæmorrhage* from the stomach or lungs, keep the patient quiet, in the lying posture, and give iced drinks, or ice to suck. *Bleeding from the nose* (*epistaxis*) may be controlled by cold applied to the forehead, by syringing the nose with alum and cold water, or by sniffing up powdered galls. Cold to the spine is also useful in such cases—hence the reason of the common remedy of placing a key or other cold body down the patient's back.

It should be remembered that free exposure of a wound to the air will often arrest bleeding. The exact nature of the wound should be seen; but where a clot has formed, care should be taken that it is not disturbed.

A class of injuries known as *poisoned wounds* may here be noted. Thus the bite of a 'mad' or 'rabid' dog, the sting of a wasp or serpent, and a scratch with a rusty nail (producing a suppurating finger), illustrate various forms of 'poisoned wounds.' The indications for treatment here consist in the removal of poison from the wound by suction; in the instant destruction of the poison (where fatal results may be apprehended, as in the case of serpent bite or that of a rabid dog) by excision of the part, by burning with a red-hot iron or a glowing cinder, by caustics, &c.; and in the prevention of the spread of the poison by the placing of a ligature between the wound and the heart. In the case of serpent bites, strong stimulants must be administered to the patient. The poisons which act by their diffusion through the blood may be safely enough sucked out of a wound by the mouth, provided the mucous membrane of the mouth is intact. In the case of the bite of a so-called 'mad' dog, do not destroy the animal. The dog should be tied up and carefully watched, so as to ascertain whether or not it is really rabid. Much vexation and pain may be saved in this way by the discovery that the animal has not been 'rabid,' but has simply bitten the person in a fit of ordinary anger.

Burns and scalds should be treated by placing the burnt part in warm water—the clothes should not be roughly pulled off for fear of injuring the skin—and by soaking rags in 'carron oil' (a mixture of equal parts of olive oil and linseed oil and lime water), and covering the part with cotton wool. Where collapse and faintness ensue from the shock, hot drinks should be given, and the patient should be kept warm. Carbonate of soda dissolved in water, and applied as a lotion, relieves the pain of a burn. With regard to the blisters which may form after burning, these may, as a rule, be punctured and the fluid allowed to escape.

Painting the burn with the *Collodion Flexile* of the druggist, is an excellent method of dressing such injuries.

What is known popularly as a *fit* may arise from a variety of causes. In the *simple fainting fit* (or *syncope*), the patient is pale and the heart's action feeble. The treatment is to loosen all neck-clothing, to remove the patient to the open air, and to keep the head low. People commonly raise such a person to the upright position; this is an erroneous method. As an authority has remarked, 'If people will lift up anything, let them lift the heels, not the head, of a fainting person.' The *hysterical fit* usually occurs in women. They require no treatment, save perhaps the wholesome method of 'neglect.' The *epileptic fit* is popularly described as 'convulsions.' The patient is usually unconscious, and his body is contorted; he bites his tongue as a rule, and blood on this account issues from the mouth. He is to have neck-clothes loosened, to be laid on the floor on a mattress, and simply to be prevented from injuring himself. Epilepsy is a nervous disease, and nothing more can therefore be done by the bystander. In the *apoplectic fit*, the face is flushed as a rule, and the breathing is of a stertorous or snoring character, while the one side of the body may be paralysed. Loosen the neck-clothing and raise the head.

Allied to *fits* is the subject of *unconsciousness*. A man or woman found in an unconscious state, should have the neck-clothing loosened at once, and the exact cause of the loss of consciousness investigated. This may be due to—(1) *drunkenness*, when the breath smells of liquor; although, it must be remembered, a man who had been struck with apoplexy after drinking, might exhibit this symptom; (2) *apoplexy*, the symptoms of which have been already noted; (3) *epilepsy*, the symptoms of which have been detailed above; (4) *fainting*, or *syncope*, already mentioned; (5) simple *shock*, where small quantities of stimulants may be given, and the patient is to be kept warm; (6) *injuries to head or brain*, wounds of head to be looked for, and patient to be kept quiet in a darkened room; no stimulants are to be given here; (7) *uræmia*, or blood-poisoning from kidney ailment, which may closely resemble the symptoms of apoplexy, &c.; (8) *poisoning by narcotics* (e.g. opium). The diagnosis of this latter condition is highly difficult. The history of the case, where this can be ascertained, is in all instances the best guide.

In the case of *sunstroke*, or *heat-apoplexy*, cold water should be poured on the head, and the patient removed to a cool place. The body should be sponged with cold water; ice to the head, if obtainable, should be used. Light stimulants (e.g. ammonia and ether) may be given, and the bowels should be specially attended to.

The treatment of the *apparently drowned* is a topic of highly important character, inasmuch as persons have been restored to consciousness after several hours' hard work on the part of bystanders or medical men. The points to be aimed at are, first, to restore breathing, to stimulate the heart's action, and to induce warmth. The body should never be rolled in casks or held up by the feet, and should never be placed in a warm bath, save under medical orders. All clothing is to be removed from the chest. The mouth is to be cleansed from all foreign matter; this may be done by placing the patient on his face with his arm bent under the head so as to keep the face off the ground, and so as to allow water to flow out of the mouth. The tongue is also to be pulled well forward, and secured by an elastic band passed over the tongue and under the chin.

Artificial respiration is then to be begun. Sylvester's method is as follows:—The body is laid on its back, with the shoulders raised on a firm cushion. The operator, standing behind the patient, grasps the arms above the elbows and draws them steadily upwards above the head (fig. 59). They are to be kept so stretched for two seconds. The arms are next turned down and pressed firmly against the sides of the chest for the same period of time—two seconds (fig. 60). These movements are to be repeated sixteen or seventeen times per minute, and are to be continued for two or three hours if necessary. If an assistant is present, he should press the lower ribs together at the time when the chest is compressed, as shown in fig. 60, to imitate the act of expiration. The former procedure (fig. 59) imitates the act of inspiration. The nostrils may be also excited with snuff or smelling-salts, by way of accelerating the restoration of breathing.

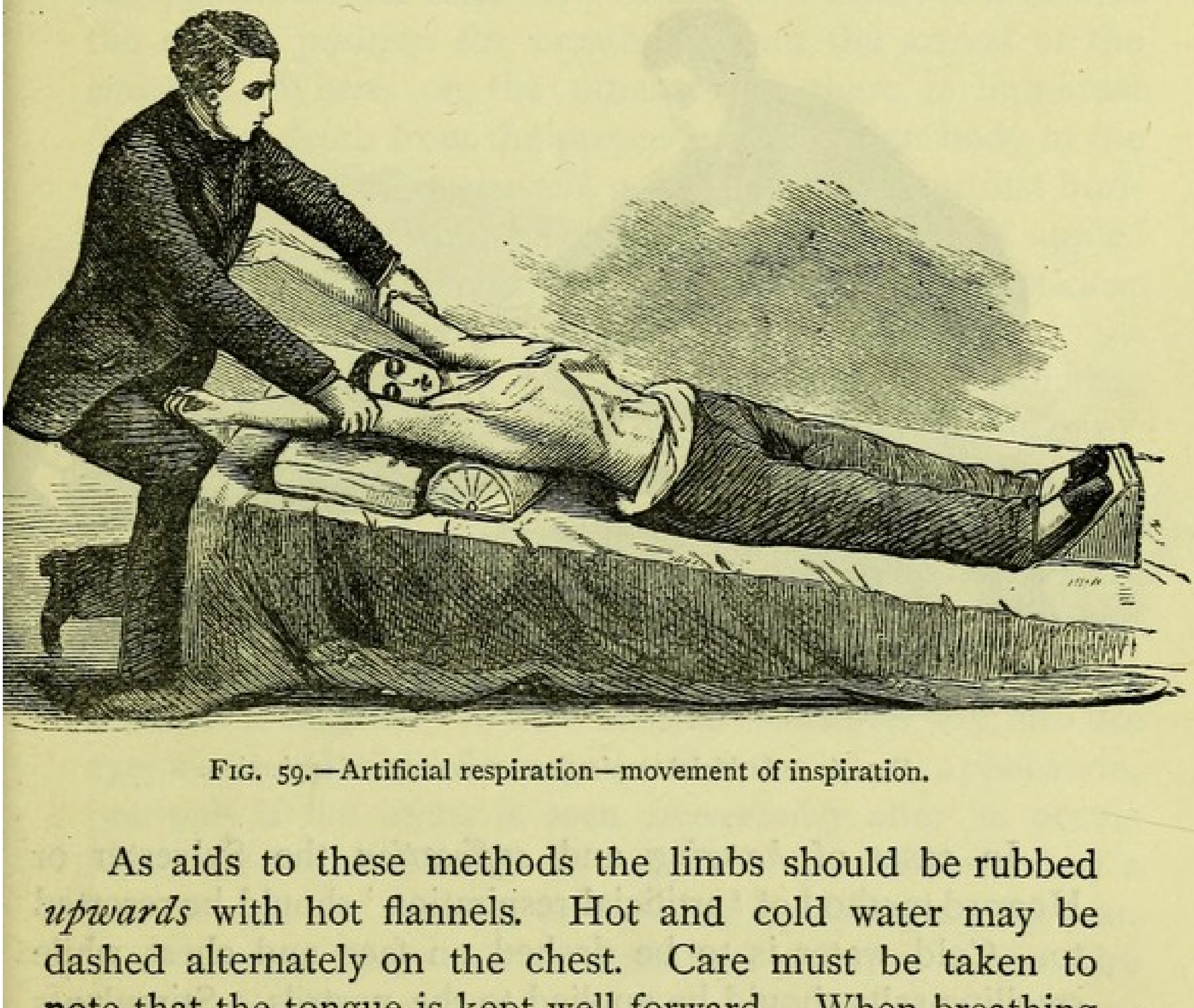


FIG. 59.—Artificial respiration—movement of inspiration.

As aids to these methods the limbs should be rubbed *upwards* with hot flannels. Hot and cold water may be dashed alternately on the chest. Care must be taken to note that the tongue is kept well forward. When breathing is established, the patient is to be removed to a warm bed in a well-ventilated room. Great care should be taken in giving any fluids by the mouth ; an enema of brandy and beef-tea may be given if necessary.

In Howard's method, the stomach is cleared of water and the tongue is kept well forward, while an assistant pulls the arms above the head and holds them in a crossed position. The operator now kneels astride the body. He places his fingers in the lower spaces between the ribs on each side, and compresses the lower ribs by bending forward over the body of the patient. This act imitates expiration, while inspiration is produced by the recoil of the ribs when the operator looses his hold, and is assisted by the position in which the arms are being held.

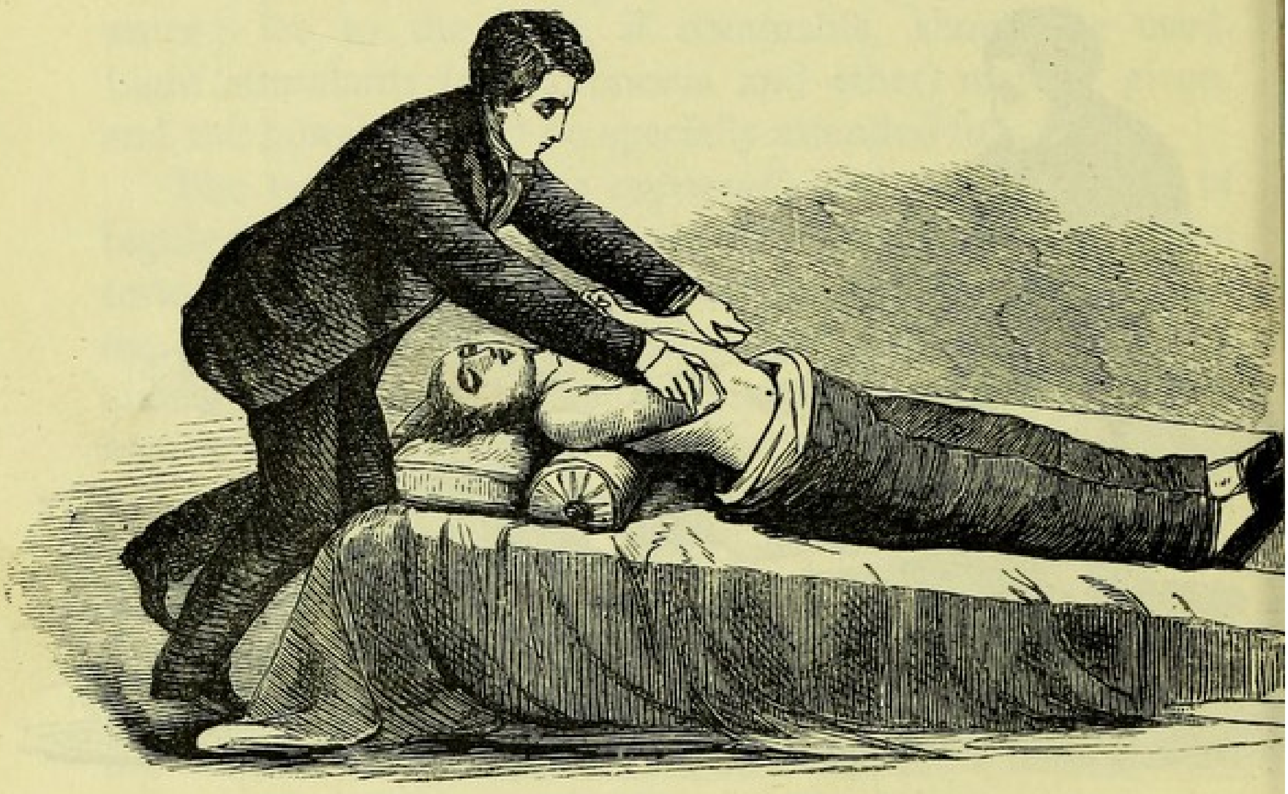


FIG. 60.—Artificial respiration—movement of expiration.

In cases of *hanging* and *suffocation* the Sylvester or Howard method of 'artificial respiration' should be resorted to. Cold water is to be dashed on face and chest, while smelling-salts should be applied to the nostrils. Stimulants may be given when the person has recovered consciousness.

In a case of *frostbite* the patient should never be taken into a warm room or near a fire. Rub the part with snow in a cold place, or bathe with very cold water, so as gradually to restore warmth. Stimulants may be given later on.

Where *choking* occurs from the lodgment of meat, &c. in the throat, the patient should be placed at once in a reclining posture, the teeth separated by a gag of some kind, and the forefinger, or forefinger and thumb passed into the back of the mouth and swept round so as to hook forward or seize the object. The old-fashioned remedy of a slap on the back should be tried; while in the case of a child it should be held up by the heels or treated as above indicated. Where these means fail to relieve the obstruction, the patient should shift his position, and discover thus wise the easiest position for breathing, until the arrival of the surgeon. Where, on the other hand, there is imminent danger of death from the presence of a foreign body in the larynx or organ of voice itself, a penknife may be thrust horizontally into the windpipe an inch below 'Adam's apple.' This opening is to be enlarged, a tube inserted, and kept clear with a feather or camel's-hair brush.

Foreign bodies in the eye may be removed by blowing the nose sharply, by drawing the upper eyelid over the lower, by everting the upper eyelid over a probe or slim pen which is to be laid on the upper eyelid; the lid being then drawn upwards by the eyelashes, over the pen or probe. If a piece of steel or 'fire' is fixed in the eye, simply pour olive oil into the eye, bandage the eye so as to keep it at rest, and send for a surgeon. Where lime has found its way into the eye, use a solution of vinegar and water as an application, but only if the injury is seen *immediately* after its occurrence. *Foreign bodies in the ear* can only be extracted by a pair of delicate forceps, or by carefully syringing the ear. A 'Waverley Pen,' with its turned-up point, or a fine wire bent at the tip, may also be used in such cases. Great care should be taken that the drum of the ear is not injured. In the case of the *nose*, substances impacted in the nostrils can, as a rule, be easily dislodged by violent sneezing, or by the use of forceps.

The subject of *poisoning* is one admitting of general directions only being given in the present case. In the first place, if the poison is known or believed to be a corrosive (such as vitriol or other acid), or if stains are seen on the lips and mouth, *no emetic* (or *vomit*) *must be given.* To administer such, would be tantamount to destroying the already injured stomach. In such a case, we give olive oil, salad oil, linseed, cod-liver or castor oil. The patient is put to bed, smelling-salts are used, and when signs of choking appear, hot fomentations are applied to the throat.

When, on the other hand, no stains are found about the mouth or lips, and when the poison, instead of being a corrosive acid, is probably a mineral or narcotic poison, we *give an emetic* (or *vomit*) *at once*, so as to empty the stomach. Thus, 20 grains sulphate of zinc given in water will produce vomiting, while one ounce of ipecacuanha wine serves the same end. Mustard and warm water, salt and warm water, and tickling the throat with a feather, are also well-known methods of producing vomiting.

In addition to such means we ought to give strong black tea or strong black coffee, especially if the poison swallowed is opium in any shape; in which case, also, we should keep the patient awake by every means in our power. Eggs beaten up, milk, or flour and water should also be given. These act as mechanical antidotes; the white of egg being the chemical antidote to corrosive sublimate. When vomiting ceases, the patient is to be put to bed and hot tea administered. Oils may be given in all cases of poisoning, except where phosphorus (commonly taken as rat-paste) has been swallowed, and where oil would favour the absorption of the poison.

The symptoms of poisoning are generally marked by their sudden onset, while they supervene usually after food or medicine has been taken. Chemical antidotes to poisons require the exercise of special memory and special knowledge for their successful use. Thus, for *acids*, alkalies are given; the safest alkalies are chalk and magnesia. For poisoning by *caustic alkalies* (potash, soda, lime, &c.) lemon-juice or vinegar is given; while oil is also indicated, and milk. For *corrosive sublimate*, as already noted, after vomiting has been induced, we give white of egg; for *opium*, tannic acid, strong tea, and strong coffee; for *antimony*, tannic acid, strong tea, nut-galls, and milk; for *arsenic*, milk and raw egg, and salad or olive oil; for *sugar of lead*, &c. Epsom salts; for *phosphorus*, magnesia or chalk and water (no oil); for *oxalic acid*, chalk or magnesia in milk. Scrape the ceiling and administer the matter scraped off, if no other remedy can be got. For *prussic acid*, cold douche to head and face and back at once, as there is no time for the use of emetics in this case, while artificial respiration is to be tried, and smelling-salts used; for *strychnia*, animal charcoal; for *carbolic acid*, raw eggs, followed by olive oil, or olive and castor oil combined with magnesia, while stimulants are necessary in collapse; for *chloral*, an emetic, stimulants, and artificial respiration. In the cases above noted the stomach is to be emptied, save, as already stated, where acids have been taken, and where the lips are stained. In certain other cases (e.g. oxalic acid poisoning) it is not advisable to give an emetic at first.

In *dislocations*, the head of a bone is usually forced out of its socket, or a bone is otherwise displaced from its normal position. Of all dislocations the most common is that of the *humerus*, or upper arm-bone, from its socket in the shoulder-blade. In the absence of help, a person may be able to reduce such a dislocation, as shown in the figure (fig. 61), by passing his arm over a gate, and by grasping the lowest bar he can reach, so as to exert pressure on the head of the bone by means of the top bar.

The treatment of *fractures* includes the wide subjects of the conveyance of injured persons, and of bandaging and the adjustment of splints. A *fracture*, or breakage of bone, is known to have occurred by the symptoms of pain, by deformity of the limb, by the part swelling, by loss of power of movement, and by *crepitus*, or the grating together of the broken ends of the bone. *When a person has broken a bone, it is highly dangerous to move him until the fracture has been properly 'put up' in splints.* The broken ends of the bone, in a case of *simple fracture*, may thus be forced by movement, through the skin, converting the injury into a *compound fracture*. Hence, the fractured bone should be dressed as the patient lies. Splints are to be put on each side of the limb: these are to be secured by handkerchiefs or bandages, and, in the case of the legs, the sound leg is, in turn, to be bandaged to the injured limb. The object

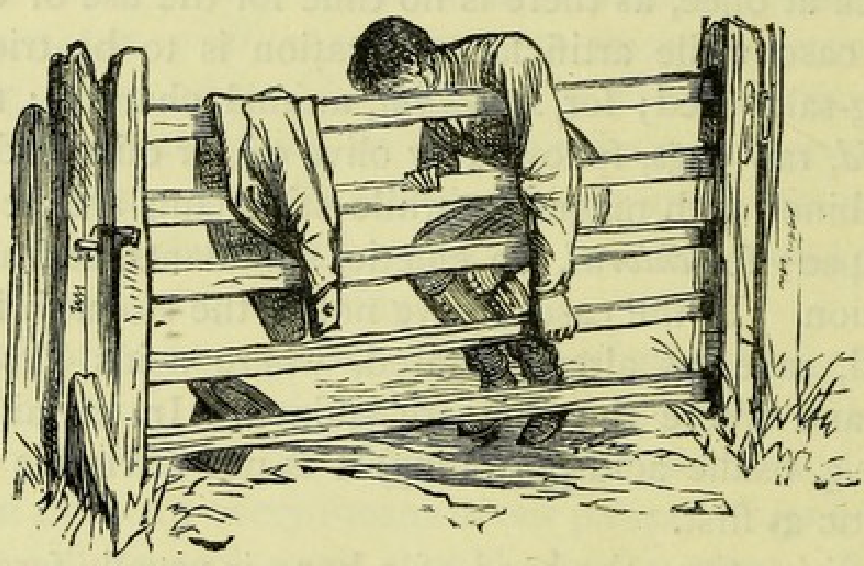


FIG. 61.—Self-reduction of shoulder-dislocation.

of applying splints is to prevent movement of the injured limb and further displacement of the bones. Splints may be made of many and varied objects—the boards of books, a coat rolled up so as to swathe the limb, an umbrella, a broom-handle, and other objects, can all be pressed into ambulance service.

The *carriage* of the injured person is an important matter. He may be carried, under certain circumstances, in the well-known fashion of the 'lady's chair,' by two bearers (fig. 62), or he may be transported upon a stretcher, formed of a gate taken off its hinges; while other forms of conveyance may be extemporised with a blanket and two poles, or four poles, as shown in fig. 63. Another very excellent form of stretcher is the rope-stretcher, formed, as the accompanying illustration shows, by two poles with a rope twisted round them, so as to support the body, which

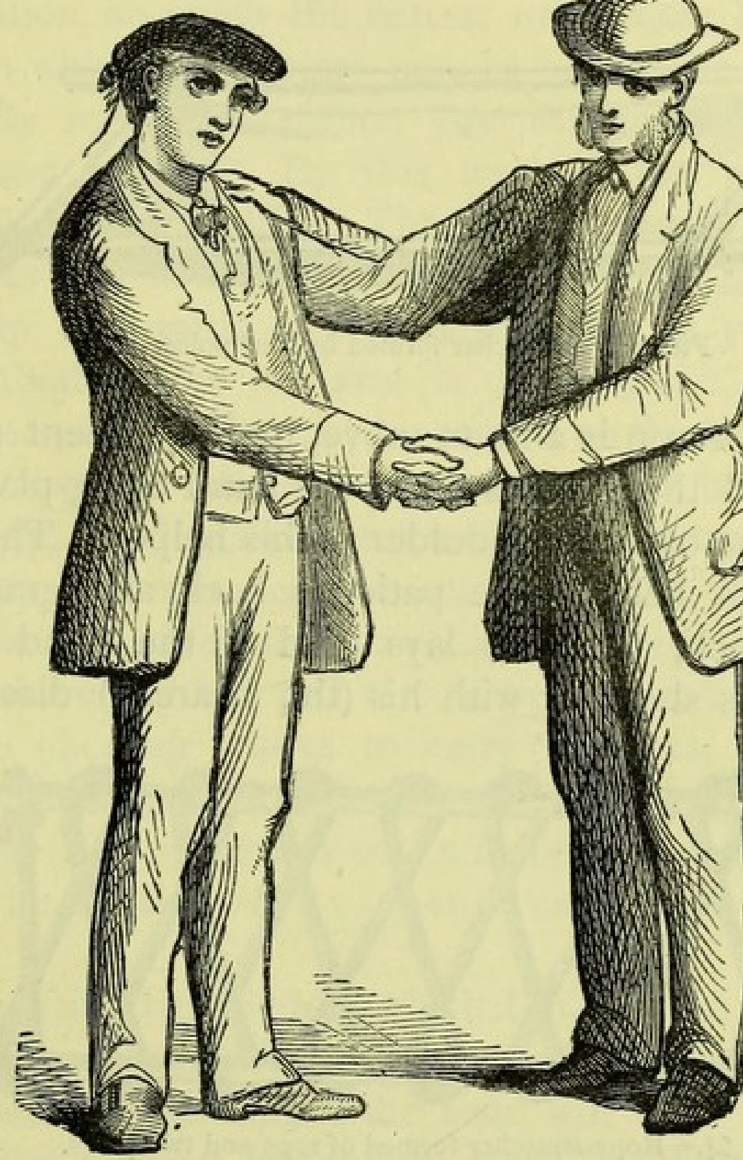


FIG. 62.—Carriage of the injured by two bearers.

would rest on coats, blankets, or rugs placed above the rope.

The bearers of an injured person should not walk in step. If the front bearer steps off with his left foot, the hind bearer should step off with his right foot. A stretcher should never be carried on the shoulders. In going up hill, the patient's head is to be in front, except when the leg is broken, when the position is reversed. In going down hill the patient's head is behind, except where the leg is broken, when he must be carried in the reverse order.

The conveyance of an injured or unconscious person by one bearer is a matter of moment. Usually this is con-

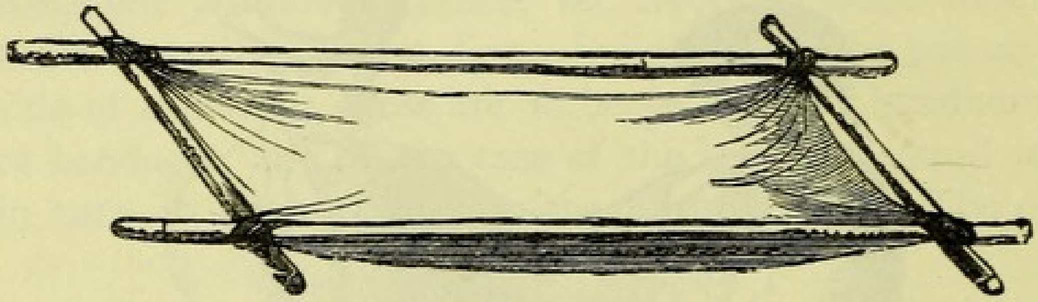


FIG. 63.—Stretcher formed by our poles.

trived, if the person is able to move, by the patient placing one arm round the bearer's neck, the hand being placed on the front of the opposite shoulder of his helper. The latter places his arm behind the patient's back and grasps his opposite haunch, while he lays hold of the hand of the patient on his shoulder with his (the bearer's) disengaged

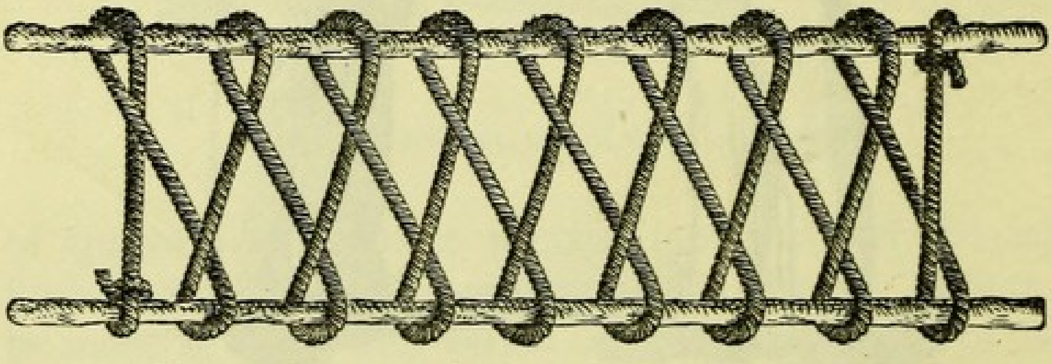


FIG. 64.—Rope-stretcher formed of rope and two poles.

hand. In this way, and by pushing his hip behind that of the patient which is next him, slow progress may be made.

A correspondent of the 'Lancet' has contributed the following interesting particulars on the transport of an unconscious person by one bearer :—

'Turn the individual upon his face, with the arms extended in a line with the body. Raise the trunk until he be in a kneeling position. Place yourself under him, so that his stomach rests on your right shoulder. Pass your right arm between the thighs and behind his right thigh. With your left arm draw his left hand forwards under your left, and grasp the wrist with your right hand: then raise yourself to an erect position. If you can obtain assistance in this operation, so much the better; or if there be a bed or table upon which the subject may be placed, he will be the more easily raised, or, rather, you will more easily raise yourself and burden. By this method the weight falls directly on your shoulders. The person carried cannot slip forwards, as you have his hand grasped from behind; nor can he slip backwards or off the shoulder, as your arm is over the thigh. The left arm is disengaged. Or, by reversing the operation, he may be carried on the left shoulder, in which case the left arm is passed behind his left thigh and his right hand grasped from behind. Your right arm is then free. This is very advantageous; as, for example, going down a ladder from an upper storey of a burning building where the rescued one is overcome by smoke, or where the operator wishes to carry weapons, &c. off the field of battle. The situation of the subject as above described may not be devoid of its inconveniences; but that need not be considered . . . nor in certain other cases, as apoplexy.

'Here is another method which I have seen employed:—Seat the subject with the legs flexed on the thighs, and these flexed on the trunk; the head will then rest on the knees. Pass a broad continuous strap (a soldier's belt, for example) behind the thighs at the popliteal spaces (behind the knees) and under his arms. Crouch down behind him, *dos à dos*, pass the strap over your forehead, and raise yourself. The strap should be short enough to allow the weight to fall upon the shoulders and upper part of your back while you are bent slightly forwards. The head may drop backwards; but if so it falls on the top of yours. The strap, being under his arms, prevents him from falling through. Both your arms are comparatively free. By means of this strap I have seen Indians carry 300 pounds in weight (a barrel of pork) farther than one probably would care to believe.'

The art of *bandaging* can only be acquired, of course, by practical study and under direct tuition ; but a few illus-

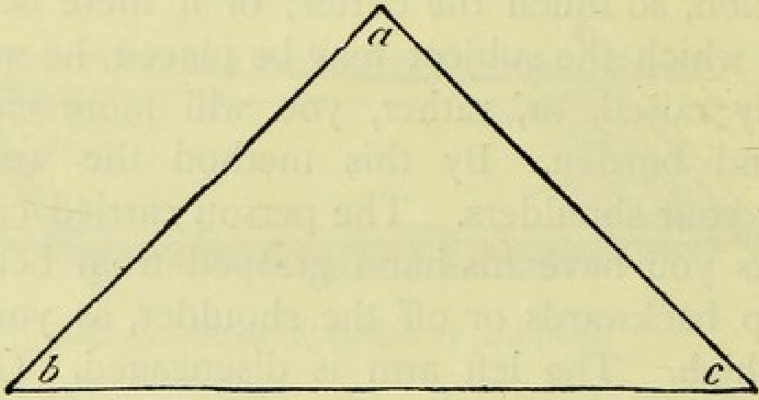


FIG. 65.—The Esmarch triangular bandage.

trations of some common forms of bandage may not prove out of place in the present instance.

Esmarch's 'Triangular Bandage' (fig. 65) is one of the most useful of all forms of ambulance apparatus. A piece

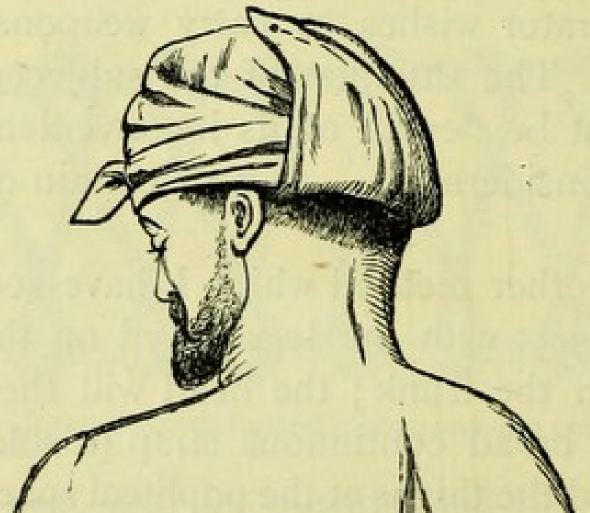


FIG. 66.—Esmarch bandage applied to the head.

of calico, unbleached, is cut into a triangle which has a 'lower' border (*b c*), and 'side' borders (*a c* and *a b*), a 'point' (*a*), and 'ends' (*b* and *c*). Applied to the head (fig. 66), the lower border is laid across the forehead, while the point hangs over the nape of the neck. The two ends are carried back above the ears, crossed behind, brought forwards, and tied in front of the forehead. The point is then turned upwards, and fastened with a pin above.

A sling for the arm (fig. 67) is instantly made by throwing one end over the uninjured shoulder, by bending the arm across the middle of the bandage, by bringing the other

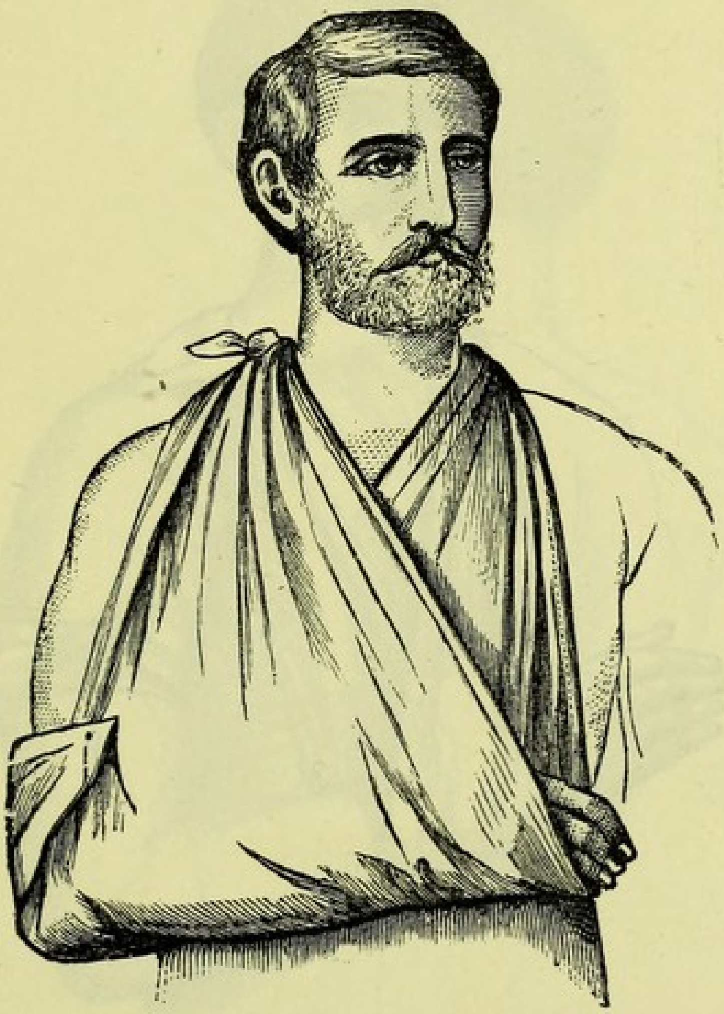


FIG. 67.—Esmarch bandage forming sling for the arm.

end to meet the first, and by tying the ends at the nape of the neck. The point is then drawn forward and pinned. Another form of shoulder bandage is made by cutting the cloth in halves, one half being used to make a sling (fig. 68), while the other half, as shown in the figure, has its lower border placed on the middle of the outside of the upper arm, 'the point lying upon the side of the neck.

Carry the two ends round the inside of the arm, cross, bring forward, and tie on the outer side. Slip the point under the sling, fold it back on itself, and fasten with a pin.'

In applying the triangular bandage to the chest, the lower border (fig. 69) is to be placed across the chest

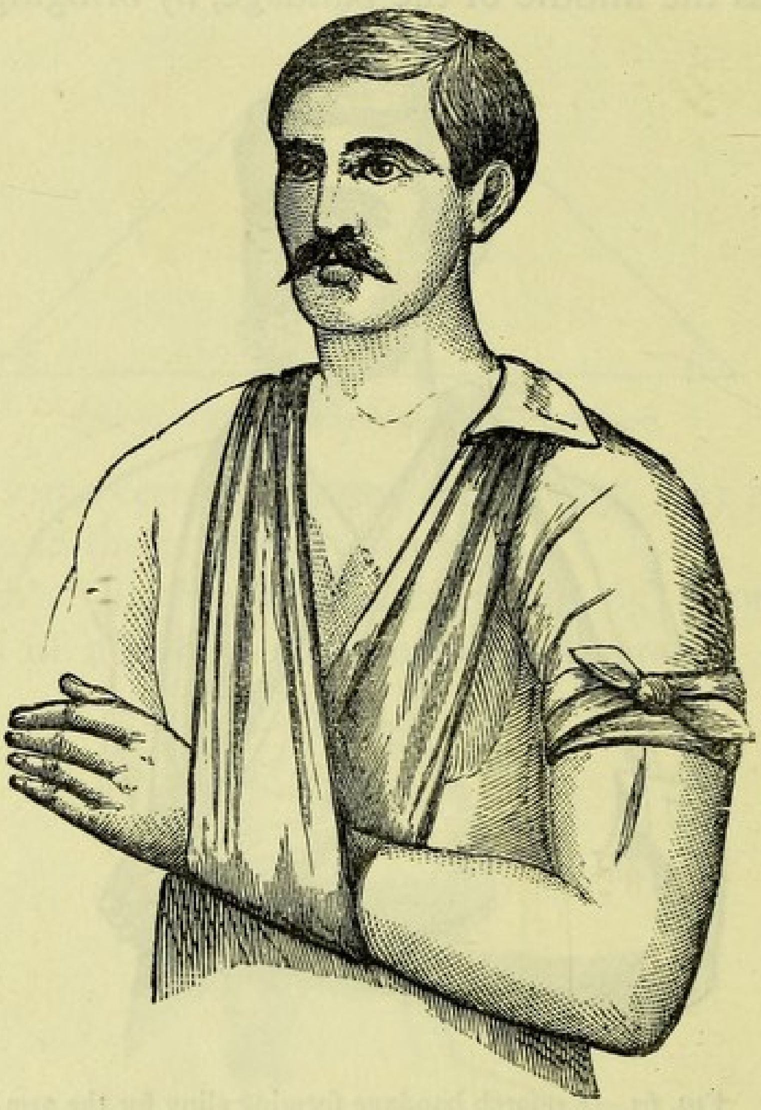


FIG. 68.—Bandage or injuries of shoulder.

below, the point being thrown over one shoulder. The two ends are next carried backwards and pinned together over the spine. The point is then drawn down, passed under the two ends, folded on itself, and pinned. In the figure the point is represented as tied.

The triangular bandage, in its multifarious uses, can be applied to the hand (fig. 70) or foot. Only half a cloth is to be employed. Place the centre of the lower border across the wrist, then turn the point upwards and over the fingers on the back of the forearm, and tie the ends. For the foot (fig. 71) the sole is placed in the middle of the cloth, and the point is carried over the toes, while the ends are passed round the ankle and tied on the sole.

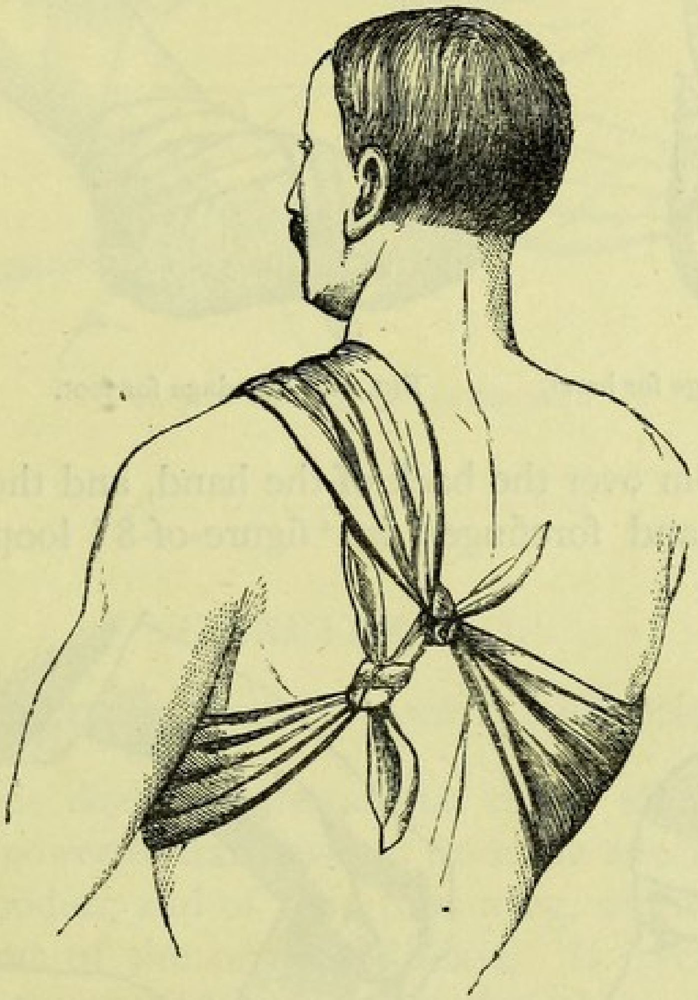


FIG. 69.—Bandage for the chest.

In bandaging the head, as ordinarily practised according to another method (fig. 72), the roller-bandage is taken in one or two turns round the front and back of the head. These are secured with a pin, while the succeeding turns are made beneath the chin and over the top of the head, thus securing the former turns.

The use of the roller-bandage in the case of the hand is well shown in figs. 73 and 74. Where the palm of the hand has to be protected (fig. 73), the first turn is taken

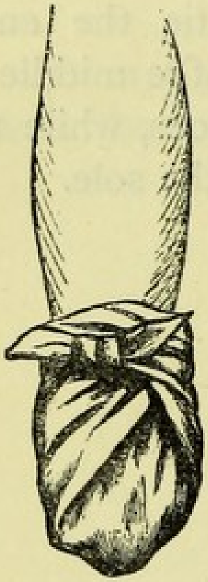


FIG. 70.—Bandage for hand.

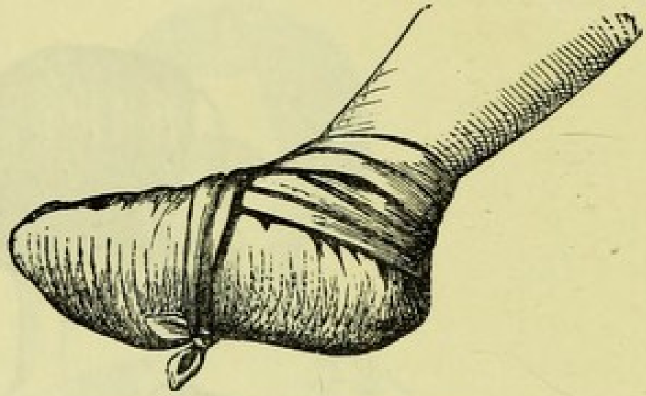


FIG. 71.—Bandage for foot.

from the palm over the back of the hand, and then between the thumb and forefinger, in 'figure-of-8' loops, so as to

FIG. 72.—Bandage for head.

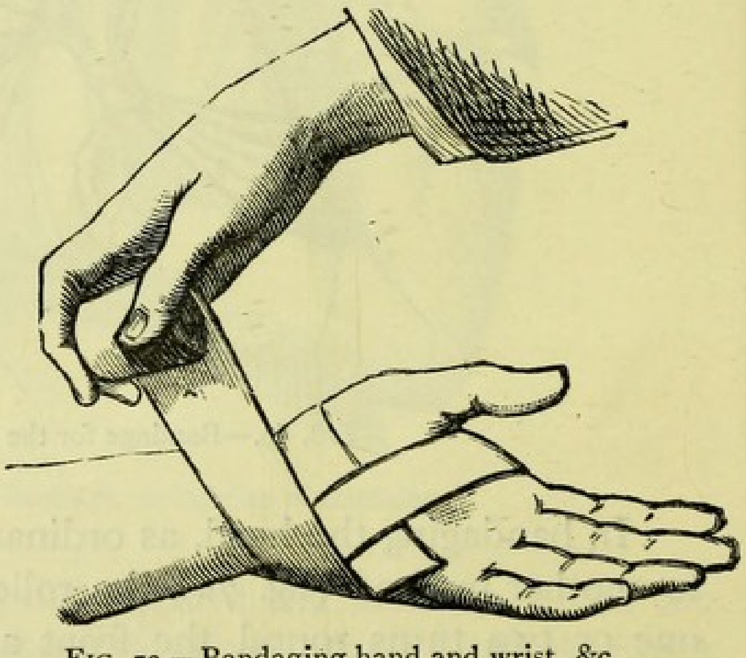


FIG. 73.—Bandaging hand and wrist, &c.

exercise pressure on the palm. Where the forearm has also to be bandaged (as shown in fig. 74), the bandage is simply carried up the forearm and turned down or reversed as depicted, so as to cause it to conform closely to the shape of the limb.

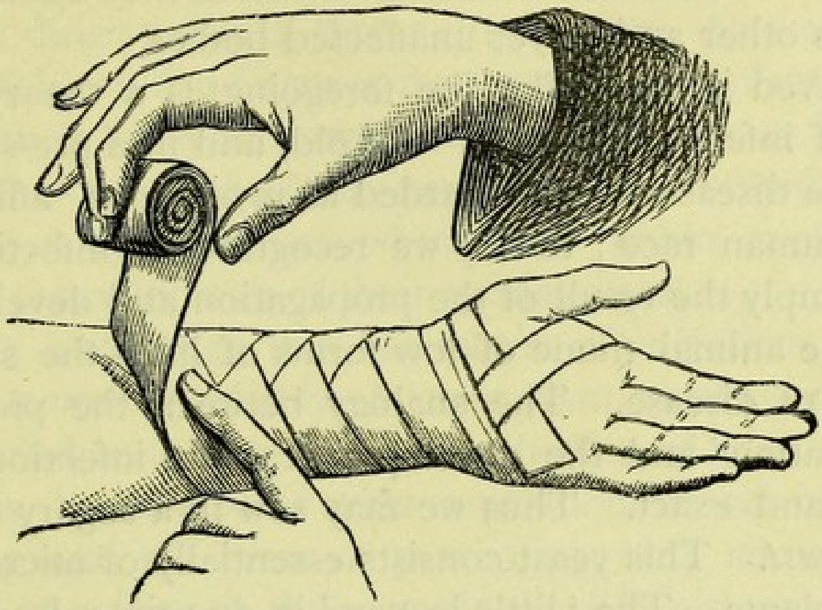


FIG. 74.—Bandage for the forearm.

CHAPTER XII.

INFECTIOUS DISEASES AND DISINFECTION.

BY infectious diseases, are meant those ailments which possess the power of transmission from the affected subjects to healthy bodies, and of thus producing, within the latter, the symptoms of the original disease. It is clear, if this definition be accepted as correct, that these diseases are propagated by a process analogous to the sowing of seed. There exists first the *materies morbi*—the matter or *virus* of the disease. This matter is derived from the affected body. In the second place, it requires a soil, or condition represented by another body, capable of receiving and harbouring the diseased matter. In the third place, there appears for consideration the process of the reproduction and growth of the original disease which has thus been sown within the body. The latter represents a new field wherein the disease grows, and it lastly becomes, in its turn, a new focus of material whence the disease may spread to other and as yet unaffected bodies.

Involved in facts like the foregoing, is a theory of the nature of infectious disease. Of old, and in a pre-scientific age, these diseases were regarded as mysterious 'afflictions' of the human race; to-day we recognise in infectious ailments simply the result of the propagation and development within the animal frame of low forms of life—the so-called 'germs' of disease. The analogy between the process of 'fermentation' and the development of an infectious fever is close and exact. Thus we may sow in a sugary solution a little *yeast*. This yeast consists essentially of microscopic, cellular plants. The 'little leaven,' in due time, leavens the 'whole lump.' Fermentation begins and ends. The sugar is split up into carbonic acid gas, which flies off, and alcohol, which remains. But at the same time, an enormous increase has taken place in the number of yeast-plants. From the few which were originally sown in the sugary fluid, thousands have sprung. The multiplication of yeast-plants has proceeded contemporaneously with the fermenting process. 'Fermentation,' to be more exact, is merely the result of the reproduction and growth of yeast-plants within their appropriate medium or soil.

Substitute for the yeast-plants the germs of disease—of typhus, scarlet fever, smallpox, measles, or other infectious ailment—and replace the sugary solution by the human body, and the analogy between fermentation and disease production is, in one sense, perfect and complete. A little vaccine lymph introduced into the blood of the infant, produces in a few days the characteristic fever and pustule of 'vaccination.' Here the lymph-germs sown in the blood, have multiplied and produced countless others, and the succeeding fever and local symptoms are merely the results of that multiplication affecting the body as a whole. In like manner, the germs of disease are sown within their appropriate soil. They multiply and produce countless other germs resembling themselves. The symptoms of the fever are the direct result of this multiplication. As a corollary to this result, we also discover that as new yeast-plants, ready to begin their fermenting work, are produced as we have seen, so, in the case of the fever, new germs are formed, ready, in their turn, to reproduce, when sown within another body, all the characteristics of their special disease.

The knowledge that the matter of infectious disease is *living matter*—probably of lower plant nature—and that it grows and multiplies within the bodies of men and lower animals, has effected a wide revolution in our methods of treating, and still more of preventing, such ailments. The course of a fever is thus simply the life history of a lower plant, being worked out before our eyes in the body of the man. The fever, as a living product, has its period of development or *incubation*, its height or acme, and its decline and death. Again, like other living things, each germ of disease possesses its own sphere and conditions of vitality. 'Yellow fever' is only found in tropical regions; ague breeds in the neighbourhood of marshes; typhus germs multiply amid the foul air of unventilated places; while typhoid fever has its home in sewage matter. Nor has the microscope been behind in demonstrating the actual existence of disease-germs. The modern activity of medicine may be said, in truth, to be largely concerned with the discovery of the actual matters which cause disease through their development within the living frame; and although much remains to be accomplished in this direction, the facts which have already been demonstrated, leave the 'germ origin' of infectious disease no mere theory, but a stable fact in the history of medical and sanitary science.

The term *zymotic diseases* (from *zymosis*, a ferment) has been applied to indicate the infectious group of ailments;

the phrase *epidemic diseases* has been also applied to these ailments in allusion to their spread from place to place or from one person to another; while the expression *endemic disease* indicates the opposite condition, and refers to ailments which are characteristic of a locality, and which do not spread abroad. The chief *zymotic diseases* are cholera, smallpox, typhus fever, typhoid (or enteric) fever, scarlet fever, measles, whooping-cough, relapsing fever, and the like. To these may be added diphtheria, chicken-pox, and erysipelas. 'Mumps' may also be included in the list of contagious disorders.

Each of these diseases has its own and special characters. Thus, *cholera*, like *typhoid fever*, appears to attack the digestive canal especially. Hence the matters passed from the intestine of a patient affected with these diseases, are naturally regarded as containing their infective matter in its typical development. As already remarked in the section on water-supply, infection of such a supply, by the bowel-discharges from typhoid-fever cases, is the common source of this disease. In the case of *typhus fever*, on the other hand, overcrowding, deficient ventilation, the presence of the organic matter exhaled from skin and lungs, destitution and want, and a moderate temperature, are the conditions which are known to be associated with the spread of this disorder. With *relapsing fever*, or *famine fever*, as it is also named, the case is different. It is in seasons of want and destitution that this fever is chiefly seen, and it is among the poor and ill-fed that it is typically developed. Of *smallpox*, *scarlet fever*, and *measles*, less that is definite is known. The conditions which are favourable to the multiplication of the germs of these diseases are by no means so well ascertained as in the preceding cases. Dirt, want of ventilation, improper feeding, overcrowding, and like conditions, no doubt predispose to the inroad of these diseases; but that special circumstances of more special nature may favour their direct development is an idea that admits of no dispute. *Diphtheria* seems to be conveyed by polluted drinking water and by the foul air of drains, &c., while by some authorities, a damp condition of surroundings is credited with a large share in its production. *Whooping-cough* resembles scarlet fever in the uncertainty of its exact generation.

A point of importance in the history of infectious diseases is that which notes the fact, that one attack of a disease generally protects the sufferer from a second invasion. This is not an universal rule by any means, but it is one of fairly general character. It would therefore seem as if the inroad of a fever so altered the chemical and physical constitution of the body that it became less predisposed to harbour or develop any germs of the disease in question. Many curious facts, which space will not permit of being noticed, might be cited in addition by way of showing how peculiar in their action on the living body are the effects of the diseases under consideration. Thus, while the mortality from certain of these diseases may be great enough among civilised nations, on savage races they appear to exercise a singularly malign influence. To the question, how or why the civilised frame has become inured to the attack of these ailments, while the savage races succumb in such a high degree, no satisfactory reply can be given, except, perhaps, that which looks to heredity and to the modifications of inheritance as the causes of such differences between savage and civilised men.

The *duration* of the infectious diseases varies greatly, as also does the period of *incubation*. Taking average periods, we may thus tabulate the period of incubation (or development) and the period during which the patient is liable to be a source of infection :—

Disease	Period of Incubation	Period of Infection
Cholera	1 to 5 days	2 or 3 weeks
Smallpox	12 ,,	6 weeks
Typhoid fever	8 to 14 ,,	6 ,,
Typhus fever	6 ,, 14 ,,	4 ,,
Scarlet fever	1 ,, 6 ,,	6 ,,
Diphtheria	1 ,, 8 ,,	6 ,,
Measles	8 ,, 20 ,,	4 ,,
German measles . .	6 ,, 14 ,,	3 ,,
Relapsing fever . . .	2 ,, 16 ,,	4 ,,
Whooping-cough . .	4 ,, 14 ,,	8 ,,
Chicken-pox	10 ,, 14 ,,	3 ,,
Mumps	14 ,, 22 ,,	3 ,,

It should be clearly borne in mind that the above periods merely indicate the *average* periods of incubation and duration of infectiousness as demonstrated by experience; but many, and in some cases singular, exceptions are found to the foregoing rules in respect of rapidity of development and other phases of fever history.

With regard to *the modes and methods of infection*, like variations are experienced. Infection may be direct, as for example when a person acquires the germs of an infectious disease from contact with the body, breath, or secretions of a patient affected by the ailment. In many cases, it would appear that fever-germs are carried by the air, and develop their action wherever a suitable soil is encountered. That the matter of disease can be conveyed by clothes, letters, banknotes, books, toys, &c. are facts abundantly proved by medical experience. Perhaps the only safe rule to be followed in respect of the prevention of infectious disease is that which regards the patient as capable of giving off infective matter from the time when the first symptoms of the disease have appeared to the period when all the symptoms have disappeared. It should, however, be borne in mind that much of the infectious disease which occurs around us is the result of the ignorance and carelessness which, when such ailments occur, fail so to guard the patients, that no infective matters shall be allowed to escape into healthy homes, or to come in contact with sound bodies. The person who fails to disinfect the stools of a typhoid-fever patient, who neglects to disinfect the clothing of a smallpox or scarlet-fever case, who forgets that diphtheritic matter from the throat of a patient should be carried off on rags and immediately burned instead of being allowed to pass to a laundry on handkerchiefs; or who sends children to mingle at school, or elsewhere, with others before they are freed from the infective power of scarlet fever, measles, or mumps—exemplifies in each case a plain violation of rules which, when rigidly attended to, limit the spread of serious ailments and save chances of pain, misery, or even death, to, it may be, hundreds of innocent and unsuspecting persons.

The rules for the conduct of cases of infectious disease are by no means difficult of apprehension. When infectious ailment invades a house, the first and primary duty of those in charge is to isolate and to separate the patient from the rest of the household. The bedroom of the patient should practically be converted into a fever hospital of one bed. All communication with the house should be as far and as completely as possible cut off, and a special attendant appointed as nurse. A room on the upper or top flat of a house is preferable for the treatment of such a case, on account of the lessening of liability to contamination of the surroundings, and of the lessened risk of infecting the air of the domicile. The room itself should be screened off from other apartments by means of a sheet suspended across the door of the room and saturated with some volatile disinfectant. It should be airy and well ventilated. Every unnecessary article of furniture should be removed from the apartment. The carpet should be taken up, bed-hangings and curtains abolished, and stuffed chairs should be superseded by wooden ones, susceptible of being readily cleansed, As regards the articles—vessels, cups, spoons, &c.—used in the room, the strictest cleanliness should be observed; and articles of this kind should not be allowed to pass between the room and kitchen or other parts of the house. All such articles should, at least, be thoroughly disinfected before they are sent from the apartment. The dress of the nurse is important. No woollen garments, such as are likely to harbour disease-germs, should be worn. Linen is a preferable material; and it need hardly be added that the clothes of the attendant, like those of the patient, must be considered as liable to convey infection, and must accordingly be treated as such. The patient's body-clothes and bed-clothes should never be removed from the room without first having been disinfected by being plunged into a solution of disinfecting material immediately on being removed from the body or bed; while such clothes should always be well boiled and washed separately from other linen.

The same rigid care must be observed in the treatment of all matters belonging to the more personal history of the fever patient. Thus, all discharges from mouth and nose should be wiped away with pieces of rag, which should be immediately thereafter burned. The bowel-discharges in typhoid fever, cholera, and other diseases, are to be carefully and thoroughly disinfected before being allowed to pass into drains. In such diseases as smallpox and scarlet fever, where the infective matter is contained in the skin-particles which are freely given off—especially during the period of convalescence—the care of the skin becomes an important matter in the light of the freedom with which infection may occur from this source. The body in such cases will require to be anointed with disinfecting oils, as the medical attendant may direct, by way of preventing the spreading of the diseased material through the air. A good oil for this purpose is made by adding ½ oz. of camphor to 1 pint of olive oil.

The use of *disinfectants* has been alluded to as an essential detail in the treatment of the cases of infectious disease. A 'disinfectant,' speaking broadly but correctly as regards the true significance of the name, is a substance possessing the power of destroying the matter of disease. The phrase 'germicide,' or 'germ-killer,' is perhaps more exact in its nature, but possesses the disadvantage of technicality; while the term 'antiseptic,' apart from its pure chemical or physical meanings, may be regarded as equivalent in its scope to the word 'disinfectant.' Discarding technical quibbling over terms, it is sufficient for our present purpose, as it is indisputably correct from a practical standpoint, to regard a 'disinfectant' as a substance or means of destroying disease-matter. It is certainly in this latter phase alone, that any disinfectant is bought and used in the actual practice of sanitary work.

The subject of 'disinfection,' it should, however, be added, is a highly difficult one; and is moreover in a somewhat transition state at the present time. We are still in need of decisive experiments by way of accurately settling the place and power of many substances used for the destruction of disease-materials. One general caution, which common sense dictates, and which has need of due enforcement, consists in the advice to avoid *undue dilution* of any disinfectant which may be used. There exists a tendency, fostered doubtless by commercial competition, to exaggerate the powers of many substances used in disinfection. The cheapness of a fluid or medium is frequently a consideration; and it is often asserted in addition, that this or that substance is effective in all cases, when diluted with so many times its bulk of water. All statements of this kind should be discountenanced, for the plain reason that as no experiments have been carried out in sufficient detail on the matter of every fever, it is impossible, as well as absurd, to lay down a general rule of effectiveness for any one disinfectant and for all cases of disinfection. There are many substances which doubtless possess the power of destroying disease-material; but in all cases it is wiser to err on the side of safety, and to use disinfectants in a high degree of strength, than to attempt rough experiments in the way of diluting them. Such dilution may prove to be the most false economy, in face of the fact that a solution which is trusted to destroy disease-matter only paralyses it, so to speak, for a time, and leaves it to waken up, later on, into all its pristine vitality, imbued with the power of imparting disease. Better far no disinfection whatever, than an imperfect process of this kind, is a motto which we cannot too clearly bear in mind.

The disinfectants in common use are—1. *Heat* and *cold.* The burning of a rag laden with disease-matter illustrates the effective disposal of such matter by heat. On a scientific scale, by means of 'disinfecting stoves' (e.g. those of Dr. Ransome, of Bradford & Co., and of Dr. Scott), infected articles are purified by being exposed to hot air. Steam is also used to purify carpets, bedding, &c. It has been found that the spores, or young germs, of the germs of *charbon* or *anthrax* (see fig. 25), which are notable for their high powers of resisting destruction, are killed after two minutes' boiling (Koch). Hence the practical deduction from this fact remains, that by thoroughly boiling bed linen and other garments and articles of attire, disinfection may be readily and thoroughly carried out. In the case of *dry* heat, these spores were only killed after exposure for three hours to a temperature of 284° Fahr., this fact showing the superiority of steam and boiling to dry heat in the matter of disinfection. *Cold* is rarely if ever used in disinfection, the vitality of many forms of life, of by no means the lowest grade, having been proved to survive prolonged exposure to a very low temperature.

2. The vapour of *chlorine* is regarded as a powerful disinfectant, but is highly irritating to the lungs. It is made for disinfecting rooms by adding to equal parts of common salt and binoxide of manganese 2 parts of water and 2

parts of strong sulphuric acid ; or by adding 1 part sulphuric acid to 3 parts of bleaching powder. A little hydrochloric acid added to Condy's fluid evolves this gas. Mr. Wynter Blyth gives the following directions for fumigating a room by means of chlorine :—

First, make the room as much as possible like an hermetically sealed box by closing securely the chimney, windows, doors, &c. Three lbs. of chloride of lime and 3 lbs. of hydrochloric acid are to be used for every 1,000 cubic feet of space. The chloride of lime is to be divided into several distinct parts in deep vessels, and to be placed as high in the room as possible ; the hydrochloric acid is then mixed with the chloride of lime gradually, in the manner described by Fischer and Proskauer. These scientists, it may be mentioned, found that 6 oz. of chloride of lime and 10 oz. of hydrochloric acid should be used for each cubic yard the room contains. This procedure costs about *2d.* per cubic yard. The room is kept closed for twenty-four hours. All things in the room capable of being submitted to a moist heat are to be taken away to a suitable apparatus. The floor is lastly to be washed with a solution of corrosive sublimate (1 in 1,000 of water).

3. *Animal charcoal* has been employed as a disinfectant, but its power appears to be limited to the absorption and deodorising of foul gases. Over disease germs, there is no evidence that it exerts any specific influence. 4. *Sulphurous acid gas*, given off from burning sulphur, is a very effective and cheap method of disinfecting a room after occupancy by a fever case. One pound sulphur is used for each 1,000 cubic feet the apartment contains. The room is emptied of its contents, and all its openings and crevices closed ; the sulphur being then placed in an appropriate vessel, set alight, and the door kept closed for a number of hours. Thereafter the woodwork, floors, &c. are to be washed with hot water and carbolised soft soap, or other similar detergent. The paper should be stripped off the

walls and renewed, the ceiling whitewashed, and the woodwork repainted.

5. *Carbolic acid* has acquired a high and just reputation as a disinfectant. It possesses an irritating odour, is highly poisonous, and must therefore be used with great caution, and duly labelled as a dangerous substance. It should be used, as already indicated, without undue dilution. Probably a solution of Calvert's No. 4 carbolic acid in the proportion of $\frac{1}{4}$ pint to the gallon of water is a fairly representative mixture ; while in the case of disinfecting excretions, it is safer to use the acid pure, or but feebly diluted. 6. *Condy's fluid* is a solution of permanganate of potash. It acts by oxidising decaying matters (see p. 82), is non-poisonous, and inodorous. It is a valuable disinfectant, but is inapplicable where it is desired to impregnate the atmosphere with any disinfecting material, and where a volatile substance is therefore required. 7. *Sanitas* is a non-poisonous, volatile substance, possessing a pleasant odour, and belonging to the turpentine class of compounds. It possesses valuable properties as a disinfectant, and is admirably adapted for use in purifying clothes, which should be immersed in a tub of water to which 'Sanitas' has been added in sufficient quantity. 8. *Chloralum* is regarded by some authorities as a disinfectant of high value. It is not volatile, but can be employed with advantage in the disinfection of clothes and discharges of all kinds. 9. *Chloride of lime* has probably been greatly over-rated as a disinfectant. As commonly used, by being merely sprinkled over decaying matter, &c. it can have no effect in preventing the dissemination of disease. 10. *Sulphate of copper*, and (11) *Sulphate of iron* each possess powerful qualities in the destruction of diseased material. The objections to the former rest chiefly in its high price, and in the fact that it is a poisonous salt ; but it is said to be highly effective as an antiseptic and disinfectant, and has acquired a special reputation as a destroyer of the poison of choleraic and typhoid discharges.

Sulphate of iron, or 'green copperas,' is used in the proportion of 1 lb. to the gallon of water, and is recommended as highly effective by Pettenkofer and other sanitarians. 12. *Jeye's disinfectant* is an excellent medium, as also is (13) the *Thymo-cresol*, of Ness & Co. In all cases the precaution of avoiding over-dilution of these disinfectants must be rigidly attended to. 14. *Chloride of zinc*, as the principle of 'Burnett's disinfecting fluid,' must be also included in the list of disinfecting agents. About 25 grains of the chloride of zinc is contained in each fluid drachm. This disinfectant will therefore bear dilution with about eight times its bulk of water, and in such a state will be found highly serviceable for all ordinary purposes. 15. *Corrosive sublimate* (or *bichloride of mercury*) has of late come into repute as a disinfectant, in consequence of the researches of Dr. Koch, who found that a solution of this salt of the strength of 1 in 5,000 of water killed most germs, while a solution of 1 to 1,000 of water (that is, about 1 ounce to 6 gallons of water) killed every germ experimented upon. This salt is, no doubt, a very powerful disinfectant, but it is highly poisonous, and cannot be used with safety save by a medical man. 16. Of *Thymol*, it may be said that 1 part in 80,000 of water has been found to prevent development of the spores of *anthrax* or *splenic fever*.

In the case of *death* from infectious disease, the body should be washed with a disinfecting fluid, and should be coffined as soon as possible ; while some disinfectant in the form of powder—e.g. 'Sanitas' powder or carbolic powder—should be placed in the coffin, and that receptacle screwed down without delay. Our duty to the living should be the paramount thought in the discharge of the last offices to the dead.

In reference to the subject of infectious disease, it may be well to add that should *cremation* as a form of burial become adopted, the risks of infection from the polluted soil or air of cemeteries would thereby be abolished. It is much to be desired in the interests of health that the sentimental objections which are entertained to cremation should disappear. Already there are signs that the rapid incineration of the dead body is making headway as a thoroughly sanitary and reasonable practice. The Cremation Society of England has established a crematorium at St. John's, Woking, near London, and this apparatus has been successfully utilised in the rapid disposal of the dead. The body buried in the earth, goes slowly to decay. Putrefactive change, accomplished tediously in the ground, is, after all, only a form of slow burning, or oxidation. Far more in accordance with the dictates of reason and health, is the work of the crematorium, which, in impressive silence, quickly and completely resolves all that was once a living frame into the ashes which have ever been typical of our final dissolution.

The question of *protection against the attack of infectious disease* may be finally alluded to. We have seen that in nature, one attack of a fever as a rule protects against a second invasion. Man has sought to imitate nature and to protect himself against disease by inoculating himself with the germs of a modified form of the ailment he fears. The mild germs induce a form of illness which, by experience, is found generally to protect the body against the more serious illness. The well-known case of *vaccination* illustrates this procedure. Here the vaccine *lymph*, or matter from the *cow-pox vesicle* of the cow, is used to protect man against smallpox—a fact only explicable on the theory that the cow-pox is simply produced by the inoculation of the lower animal with the matter of the smallpox of man. The passage of this smallpox matter through the organisation of the cow, appears to modify and alter the character of the *virus*, and to render it fitted for producing in man the mild fever of vaccination, which in turn gives immunity from the graver and original disease.

The opposition to vaccination is founded upon various grounds, of which the chief are inefficient or careless vaccination, altered or inoperative lymph, failure or neglect of re-vaccination, and insusceptibility of the body to the influence of the lymph. No one, however, who thoroughly examines the evidence at hand, can fail to believe that, given vaccination, well performed with good lymph, and excluding special constitutional peculiarities on the part of individuals, it is thoroughly protective against smallpox. It has been shown, for example, that the comparative smallpox death-rates for London (vaccinated and unvaccinated cases respectively) for the fifty-two weeks ending May 29, 1881, were as follows:—

Death-rate of people of ages noted below	Per million of each age of the Vaccinated class	Per million of each age of the Unvaccinated class
All ages . .	90	3,350
Under 20 years .	61	4,520
Under 5 years .	40½	5,950

These figures speak for themselves.

Recently Dr. Gayton, whose experience in the care of smallpox cases has been of an exceptionally wide nature, in a pamphlet on the value of vaccination, as shown by an analysis of 10,403 cases of smallpox, clearly proves that '*the severity of the disease decreases in proportion to the efficiency of the vaccination.*' He shows that 'vaccination,' as commonly practised, is one thing; while real, thorough, and effective vaccination, as shown by the marks, is quite another matter. The so-called 'failure of vaccination' to protect against smallpox, of which so much is made by anti-vaccination agitators, is in reality the natural failure of imperfect vaccination. Of the 10,403 cases, 8,234 were said to be vaccinated, against 2,169 unvaccinated. But while 2,085 were found to present 'good marks' only 907 were discovered to be '"protected" in such a way as to warrant their being classified as "well vaccinated."' Dr. Gayton proves conclusively that in the light of recent experience, while ordinary vaccination will prevent smallpox from assuming a severe form in cases in which the disease appears, the partially or imperfectly vaccinated person when attacked by the disease suffers severely, or may die. The lesson which is taught by such researches, is the necessity for thorough and careful vaccination in infancy, and for re-vaccination at puberty (or between the ages of thirteen and fifteen in females, and fourteen and sixteen in males), by way of protection against smallpox.

The experience of smallpox hospitals shows, also, that the nurses rarely, if ever, contract the disease, owing to their efficient vaccination. An additional fact, which should be borne in mind, is that elicited by the late Mr. Marson, to the effect, that if an unvaccinated person inhaled smallpox germs on a Monday, and were vaccinated on the Wednesday, the vaccination would prevent the development of the disease. If the vaccination were delayed till the Thursday smallpox would appear, but in a modified form ; while, if vaccinated on Friday, the disease would develop fully, owing to the failure of the vaccine matter to fully affect the system before the smallpox poison had done its work.

Despite much ingenuous but mistaken argument on the side of the anti-vaccinationist party—argument which, as a rule, fails to take a wide and comprehensive view of the whole facts and bearings of the subject—we must conclude that in vaccination, performed carefully and according to the light of matured experience of its action and nature, we have a means of protecting our race against the ravages of a terrible disease. Smallpox has been robbed of its terrors in this way. It remains to be seen whether, in the higher and future era of medical progress, what has been done in the way of protection against smallpox, will be accomplished for other diseases to-day afflicting the populations of the world, and presenting year by year to view the terrible roll of preventable mortality, which it is the aim of hygiene to limit and finally abolish altogether.

QUESTIONS.

1. GIVE a definition of 'health.' Support your answer by examples.

2. Show, by examples, how sanitary science has progressed within the past and present centuries.

3. Mention some of the plagues and epidemic diseases which have been abolished. To what is their disappearance to be ascribed?

4. With what discoveries are the names of Howard, Cook, and Jenner associated?

5. Sketch out the various requirements necessary for the pursuit of sanitary science.

6. Define *physiology* and *anatomy* respectively. Describe the general type or plan of Vertebrated animals. Show how man conforms to this type.

7. Describe the essential nature of a digestive system.

8. What is digestion? Name the actions effected upon the food in the mouth.

9. Describe the development and structure of a tooth, and the arrangement of the teeth in the 'milk' and 'permanent' sets, respectively.

10. What is saliva? How is it formed, and what are its uses? Why should starchy foods be avoided in the case of young infants?

11. Describe the mechanism of swallowing.

12. Give an account of the structure of the stomach. What organs are situated near it?

13. What is gastric juice, and how is it secreted? What changes does it effect on the food?

14. Give a short description of the liver and its functions.

15. What is the sweetbread? What is the function of the pancreatic juice?

16. Describe the process of absorption. What is lymph? and what part does it play in the nutrition of the body?

17. What are the blood-corpuscles?

18. Describe the circulation of the blood in man.

19. How do the valves of the heart act?

20. What are the characters of arteries, veins, and capillaries respectively?

21. What quantity of blood is an adult man believed to possess?

22. What is excretion? How is it performed?

23. Describe the lungs. How do we breathe? What functions are discharged by breathing?

24. Give an account of the structure of the skin. What are its duties?

25. Describe the essential features seen in the structure of the kidney. What are the functions of the kidneys?

26. How may the work of the body be calculated?

27. What is food? Show the necessity for taking food.

28. What is the scientific classification of foods?

29. Which foods, or groups of foods, are required for the support of the body? Give proofs in support of your answer.

30. Give an account of the exact functions of nitrogenous and non-nitrogenous foods in the work and support of the body.

31. Quote the experiments of Fick and Wislicenus, and explain the facts proved by these experiments.

32. What is the place of gelatin in the list of foods?

33. What are the functions (1) of fats and oils, (2) of starches and sugars?

34. Show how water forms an all-important food.

35. Mention the principal minerals necessary for food.

36. Is vegetarianism reasonable? If so, on what grounds? Quote facts in support of your answer.

37. Give examples of dietaries for different amounts of work. Show how sex, age, &c., influence diet.

38. How is corpulency produced and cured?

39. Describe the phenomena seen in starvation. What is the mode of death in starvation?

40. Give an account of the common parasites liable to be found in the food of man.

41. What are the characters of pure milk?

42. Compare, in point of nutritive power, our common vegetable foods.

43. Contrast the action of boiling, frying, baking, stewing, and roasting our foods.

44. What is protoplasm?

45. Describe the chemical composition of water.

46. Compare rain, spring, and well waters in point of purity and liability to contamination. What is 'hard' and 'soft' water respectively?

47. How can water be distilled and aërated?

48. Give the characters of a pure water.

49. Give an account of the chief impurities—(1) mineral, (2) animal, and (3) vegetable—which are liable to occur in water. Mention the chief diseases liable to follow the use of impure water.

50. What quantity of water should be supplied to a city per day?

51. Show how cisterns should be treated to ensure a healthy water-supply.

52. Describe the chief methods of purifying water. Note how filters should be attended to.

53. How does permanganate of potash serve as a test for water-purity?

54. Describe the nature and uses of tea, coffee, and cocoa.

55. What is the true place of alcohol in the list of foods?

56. Describe the composition of pure air, and note the accidental matters air is liable to contain.

57. What is ozone? How is its presence detected?

58. What changes happen to the air after being breathed?

59. What proportions of carbonic acid, &c., render air unsuitable for breathing? How would you calculate the amount of space needed to accommodate a number of persons suitably, as regards healthy breathing?

60. Show how the wind becomes available for ventilating purposes. What is meant by 'diffusion of gases'?

61. How does the principle of the 'expansion of gases' affect ventilation?

62. What is (1) perflation? (2) aspiration?

63. Give an account of the impurities of air and their sources.

64. What diseases are liable to be produced by various 'dusts'? Give examples.

65. How is it proved that the germs of disease are carried by the air?

66. Mention the means you would rely upon for the improvement of unhealthy trades.

67. Describe the nature and sources of carbonic acid gas, and show how this gas acts injuriously on animal life.

68. Describe the principal means of ventilating an ordinary room—(1) without effecting changes in its structure; (2) by changing or altering its structure.

69. What is the principle on which McKinnell's ventilator acts?

70. Give a test for the purity of air.

71. Describe the manufacture of soap.

72. How may sewage be disposed of? Criticise cesspools, and show the dangers of imperfect drainage arrangements.

73. What are earth-closets? Note their advantages.

74. Are sewage farms sanitarily advisable? Give reasons for your answer.

75. What is the principle on which all house drains should be connected to sewers?

76. What is a trap? What is a syphon-trap? What essential points should be found in a trustworthy trap?

77. How should (1) cistern overflows, and (2) sink-discharging pipes, be treated?

78. How are drains ordinarily tested?

79. Describe the structure and show the objections to the pan-closet.

80. Give an account of any researches which show how soils influence human health.

81. Describe fit and unfit soils for houses.

82. What influence has vegetation on health?

83. How may dampness be avoided in houses?

84. What is meant by the 'porosity' of building materials?

85. Give a sketch of a satisfactory arrangement of the rooms of a house, with special reference to the position, &c., of closets and bath-rooms.

86. How would you test a wall-paper for arsenic? What symptoms would lead you to suspect poisoning from this source?

87. Describe the circulation of air which takes place in a room heated by an open grate.

88. Note the amount of wasted heat which the use of an open grate entails.

89. Describe Galton's grate.

90. What is Teale's 'economiser'? How is it used?

91. What are the principles on which stoves act?

92. Compare candles, gas, and lamps as to cost, &c., in the matter of lighting.

93. What is a gas governor?

94. What 'colours' and 'materials' of clothing should be selected for summer and winter wear, and why?

95. How is clothing rendered fireproof?

96. Describe suitable materials for underclothing.

97. How should infants be clothed? Criticise prevalent errors in the dress of young children.

98. Show how tight lacing is injurious.

99. What are the chief points to be attended to in the manufacture of healthy boots and shoes?

100. What are the baneful effects of aniline dyes?

101. Show how inherited diseases may be avoided by care and hygienic precautions.

102. Quote examples in proof of the healthy influences (1) of regularity in work; (2) in foods; (3) in exercise and play.

103. Give an account of the periods required for sleep at different ages.

104. How should the teeth be treated?

105. Give directions for the care (1) of the healthy hair; (2) where hair weakness is apparent.

106. How do cold, tepid, and hot baths act respectively?

107. Show how attention to the bowels is a necessity for health. What are the best means of curing constipation apart from complex medical treatment?

108. How would you know an artery had been wounded? and how would you treat such a wound (1) in the thigh; (2) in the upper arm; (3) in the forearm?

109. What expedients would you use (1) in the instant manufacture of a tourniquet; (2) for the instant making of splints for a broken leg?

110. How would you treat (1) bleeding from the nose; (2) bleeding from lungs or stomach; (3) bleeding from a vein?

111. A dog bites a man; what would you do (1) for the man; (2) in the case of the dog? and why?

112. What is the treatment of snake-bite?

113. How would you treat a serious burn?

114. How would you recognise and treat (1) a fainting fit; (2) an apoplectic fit; (3) an epileptic fit?

115. Show how you would attempt to discover the cause of unconsciousness in a man found insensible by the wayside?

116. What would you do (1) in a case of sunstroke, and (2) frostbite, respectively?

117. Show how a case of drowning should be treated in its various stages.

118. What is to be done in a case of choking?

119. How would you remove a foreign body from eye and ear respectively?

120. Mention the symptoms, treatment, and antidotes in poisoning (1) by opium; (2) by phosphorus; (3) by oxalic acid; (4) by prussic acid; (5) by corrosive sublimate; (6) by arsenic; (7) by chloral.

121. What are the rules for the treatment of a fracture?

122. Show how an injured person may be carried by one bearer and by several bearers respectively.

123. What is an Esmarch bandage?

124. What are 'infectious' diseases? Name the chief 'zymotic' diseases, and explain the meanings of the terms 'zymotic,' 'epidemic,' and 'endemic' diseases.

125. What is the 'germ theory' of disease? Give illustrations in support of your answer.

126. Note the chief characters of cholera, typhus fever, and typhoid fever respectively. What are the common sources of infection in each case?

127. What is meant by the 'incubation' of an infectious disease?

128. How may 'infection' be conveyed?

129. Describe how a patient and a household respectively, should be treated when infectious disease occurs in a dwelling.

130. Mention some of the best-known disinfectants. State their character, and show how they should be used.

131. What should be done when death occurs from an infectious disease?

132. How would you disinfect a room after its occupancy by a fever patient?

133. Why should cremation be encouraged from a sanitary aspect?

134. What is the nature of vaccination? Quote arguments in its favour, and show the most frequent and remediable causes of its failure.

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