LESSONS

IN

ELEMENTARY PHYSIOLO

BY

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NEW EDITION

London:

MACMILLAN AND CO.

1879.

LONDON:
R. CLAY, SONS, AND TAYLOR,
BREAD STREET HILL.

PREFACE TO THE SIXTH EDITION.

A CONSIDERABLE number of illustrations have been added to this edition; and several of them have been taken, not from the Human subject, but from the Rabbit, the Sheep, the Dog, and the Frog, in order to aid those, who, in accordance with the recommendation contained in the Preface to the Second Edition, attempt to make their knowledge real, by acquiring some practical acquaintance with the facts of Anatomy and Physiology.

My thanks are again due to my friend Dr. Foster, F.R.S., for many valuable suggestions, and, more especially, for the trouble he has taken in superintending the execution of the new woodcuts.

LONDON, *September* 1872.

PREFACE TO THE SECOND EDITION.

THE present edition of the "Lessons in Elementary Physiology," has been very carefully revised. A few woodcuts have been added; others have been replaced by better ones, as in the case of the figures of the retina, which embody the results of Schultze's latest researches.

Some additions (but as few as possible, lest the book should insensibly lose its elementary character) have been made; among the most important I count the very useful "Table of Anatomical and Physiological Constants" drawn up for me by Dr. Michael Foster, for whose friendly aid I am again glad to express my thanks.

It will be well for those who attempt to study Elementary Physiology, to bear in mind the important truth that the knowledge of science which is attainable by mere reading, though infinitely better than ignorance, is knowledge of a very different kind from that which arises from direct contact with fact;

and that the worth of the pursuit of science as an intellectual discipline is almost lost by those who seek it only in books.

As the majority of the readers of these Lessons will assuredly have no opportunity of studying anatomy or physiology upon the human subject, these remarks may seem discouraging. But they are not so in reality. For the purpose of acquiring a practical, though elementary, acquaintance with physiological anatomy and histology, the organs and tissues of the commonest domestic animals afford ample materials. The principal points in the structure and mechanism of the heart, the lungs, the kidneys, or the eye, of man, may be perfectly illustrated by the corresponding parts of a sheep; while the phenomena of the circulation, and many of the most important properties of living tissues, are better shown by the common frog than by any of the higher animals.

Under these circumstances there really is no reason why the teaching of elementary physiology should not be made perfectly sound and thorough. But it should be remembered that, unless the learner has previously acquired a knowledge of the elements of Physics and of Chemistry, his path will be beset with difficulties and delays.

T. H. H.

LONDON, *July* 1868.

PREFACE TO THE FIRST EDITION.

THE following "Lessons in Elementary Physiology" are primarily intended to serve the purpose of a text-book for teachers and learners in boys' and girls' schools.

My object in writing them has been to set down, in plain and concise language, that which any person who desires to become acquainted with the principles of Human Physiology may learn, with a fair prospect of having but little to unlearn as our knowledge widens.

It is only by inadvertence, or from an error in judgment, therefore, that the book contains any statement, or doctrine, which cannot be regarded as the common property of all physiologists. I have endeavoured simply to play the part of a sieve, and to separate the well-established and essential from the doubtful and the unimportant portions of the vast mass of knowledge and opinion we call Human Physiology.

The originals of the woodcuts are, for the most part, to be found in the works of Bourgery, Gray, Henle, and Kölliker. A few are new.

I am particularly indebted to my accomplished friend, Dr. Michael Foster, for the pains and trouble he has bestowed upon the Lessons in their passage through the press.

THE ROYAL SCHOOL OF MINES, LONDON,
October 1866.

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LESSONS

IN

ELEMENTARY PHYSIOLOGY.

LESSON I.

A GENERAL VIEW OF THE STRUCTURE AND FUNCTIONS OF THE HUMAN BODY.

1. THE body of a living man performs a great diversity of actions, some of which are quite obvious; others require more or less careful observation; and yet others can be detected only by the employment of the most delicate appliances of science.

Thus, some part of the body of a living man is plainly always in motion. Even in sleep, when the limbs, head, and eyelids may be still, the incessant rise and fall of the chest continue to remind us that we are viewing slumber and not death.

More careful observation, however, is needed to detect the motion of the heart; or the pulsation of the arteries; or the changes in the size of the pupil of the eye with varying light; or to ascertain that the air which is breathed out of the body is hotter and damper than the air which is taken in by breathing.

And lastly, when we try to ascertain what happens in the eye when that organ is adjusted to different distances:

or what in a nerve when it is excited: or of what materials flesh and blood are made: or in virtue of what mechanism it is that a sudden pain makes one start—we have to call into operation all the methods of inductive and deductive logic; all the resources of physics and chemistry; and all the delicacies of the art of experiment.

2. The sum of the facts and generalizations at which we arrive by these various modes of inquiry, be they simple or be they refined, concerning the actions of the body and the manner in which those actions are brought about, constitutes the science of Human Physiology. An elementary outline of this science, and of so much anatomy as is incidentally necessary, is the subject of the following Lessons; of which I shall devote the present to an account of so much of the structure and such of the actions (or, as they are technically called, "functions") of the body, as can be ascertained by easy observation; or might be so ascertained if the bodies of men were as easily procured, examined, and subjected to experiment, as those of animals.

3. Suppose a chamber with walls of ice, through which a current of pure ice-cold air passes; the walls of the chamber will of course remain unmelted.

Now, having weighed a healthy living man with great care, let him walk up and down the chamber for an hour. In doing this he will obviously exercise a great amount of mechanical force; as much, at least, as would be required to lift his weight as high and as often as he has raised himself at every step. But, in addition, a certain quantity of the ice will be melted, or converted into water; showing that the man has given off heat in abundance. Furthermore, if the air which enters the chamber be made to pass through lime-water, it will cause no cloudy white precipitate of carbonate of lime, because the quantity of carbonic acid in ordinary air is so small as to be inappreciable in this way. But if the air which passes out is made to take the same course, the lime-water will soon become milky, from the precipitation of carbonate of lime, showing the presence of carbonic acid, which, like the heat, is given off by the man.

Again, even if the air be quite dry as it enters the chamber (and the chamber be lined with some material so as to shut out all vapour from the melting ice walls), that which is breathed out of the man, and that which is given off from his skin, will exhibit clouds of vapour; which vapour, therefore, is derived from the body.

After the expiration of the hour during which the experiment has lasted, let the man be released and weighed once more. He will be found to have lost weight.

Thus a living, active, man constantly exerts *mechanical force*, gives off *heat*, evolves *carbonic acid* and *water*, and undergoes a *loss of substance*.

4. Plainly, this state of things could not continue for an unlimited period, or the man would dwindle to nothing. But long before the effects of this gradual diminution of substance become apparent to a bystander, they are felt by the subject of the experiment in the form of the two imperious sensations called hunger and thirst. To still these cravings, to restore the weight of the body to its former amount, to enable it to continue giving out heat, water and carbonic acid, at the same rate, for an indefinite period, it is absolutely necessary that the body should be supplied with each of three things, and with three only. These are, firstly, fresh air; secondly, drink—consisting of water in some shape or other, however much it may be adulterated; thirdly, food. That compound known to chemists as *proteid* matter, and which contains carbon, hydrogen, oxygen, and nitrogen, must form a part of this food, if it is to sustain life indefinitely; and fatty, starchy, or saccharine matters ought to be contained in the food, if it is to sustain life conveniently.

5. A certain proportion of the matter taken in as food either cannot be, or at any rate is not, used; and leaves the body, as *excrementitious matter*, having simply passed through the alimentary canal without undergoing much change, and without ever being incorporated with the actual substance of the body. But, under healthy conditions, and when only so much food as is necessary is taken, no important proportion of either proteid matter, or fat, or starchy or saccharine food, passes out of the body as such. Almost all real food leaves the body in the form either of *water*, or of *carbonic acid*, or of a third substance called *urea*, or of certain *saline* compounds.

Chemists have determined that these products which are thrown out of the body and are called *excretions*, contain, if taken altogether, far more oxygen than the food and water taken into the body. Now, the only possible source whence the body can obtain oxygen, except from food and water, is the air which surrounds it.[1] And careful investigation of the air which leaves the chamber in the imaginary experiment described above would show, not only that it has gained carbonic acid *from* the man, but that it has lost *oxygen* in equal or rather greater amount *to* him.

6. Thus, if a man is neither gaining nor losing weight, the sum of the weights of all the substances above enumerated which leave the body ought to be exactly equal to the weight of the food and water which enter it, together with that of the oxygen which it absorbs from the air. And this is proved to be the case.

Hence it follows that a man in health, and "neither gaining nor losing flesh," is *incessantly* oxidating and wasting away, and *periodically* making good the loss. So that if, in his average condition, he could be confined in the scale-pan of a delicate spring balance, like that used for weighing letters, the scale-pan would descend at every meal, and ascend in the intervals, oscillating to equal distances on each side of the average position, which would never be maintained for longer than a few minutes. There is, therefore, no such thing as a stationary condition of the weight of the body, and what we call such is simply a condition of variation within narrow limits—a condition in which the gains and losses of the numerous daily transactions of the economy balance one another.

7. Suppose this diurnally-balanced physiological state to be reached, it can be maintained only so long as the quantity of the mechanical work done, and of heat, or other force evolved, remains absolutely unchanged.

Let such a physiologically-balanced man lift a heavy body from the ground, and the loss of weight which he would have undergone without that exertion will be immediately increased by a definite amount, which cannot be made good unless a proportionate amount of

[1] Fresh country air contains in every 100 parts nearly 21 of oxygen and 79 of nitrogen gas, together with a small fraction of a part of carbonic acid, a minute uncertain proportion of ammonia, and a variable quantity of watery vapour. (See Lesson IV. § 11.)

extra food be supplied to him. Let the temperature of the air fall, and the same result will occur, if his body remains as warm as before.

On the other hand, diminish his exertion and lower his production of heat, and either he will gain weight, or some of his food will remain unused.

Thus, in a properly nourished man, a stream of food is constantly entering the body in the shape of complex compounds containing comparatively little oxygen.; as constantly, the elements of the food (whether before or after they have formed part of the living substance) are leaving the body, combined with more oxygen. And the incessant breaking down and oxidation of the complex compounds which enter the body are definitely proportioned to the amount of force the body exerts, whether in the shape of heat or otherwise; just in the same way as the amount of work to be got out of a steam-engine, and the amount of heat it and its furnace give off, bear a strict proportion to its consumption of fuel.

8. From these general considerations regarding the nature of life, considered as physiological work, we may turn for the purpose of taking a like broad survey of the apparatus which does the work. We have seen the general performance of the engine, we may now look at its build.

The human body is obviously separable into *head*, *trunk*, and *limbs*. In the head, the brain-case or *skull* is distinguishable from the *face*. The trunk is naturally divided into the chest or *thorax*, and the belly or *abdomen*. Of the limbs there are two pairs—the upper, or *arms*, and the lower, or *legs*; and legs and arms again are subdivided by their joints into parts which obviously exhibit a rough correspondence—*thigh* and *upper arm*, *leg* and *fore-arm*, *ankle* and *wrist*, *fingers* and *toes*, plainly answering to one another. And the two last, in fact, are so similar that they receive the same name of *digits*; while the several joints of the fingers and toes have the common denomination of *phalanges*.

The whole body thus composed (without the viscera) is seen to be bilaterally symmetrical; that is to say, if it were split lengthways by a great knife, which should be made to pass along the middle line of both the dorsal and ventral (or back and front) aspects, the two halves would almost exactly resemble one another.

9. One-half of the body, divided in the manner described (Fig. 1, A), would exhibit, in the trunk, the cut faces of thirty-three bones, joined together by a very strong and tough substance into a long column, which lies much nearer the *dorsal* (or back) than the *ventral* (or front) aspect of the body. The bones thus cut through are called the *bodies* of the *vertebræ*. They separate a long, narrow canal, called the *spinal canal*, which is placed upon their dorsal side, from the spacious chamber of the chest and abdomen, which lies upon their ventral side. There is no direct communication between the dorsal canal and the ventral cavity.

The spinal canal contains a long white cord—the *spinal cord*—which is an important part of the nervous system. The ventral chamber is divided into the two subordinate cavities of the thorax and abdomen by a remarkable, partly fleshy and partly membranous, partition, the *diaphragm* (Fig. 1, *D*), which is concave towards the abdomen, and convex towards the thorax. The *alimentary canal* (Fig. 1, *Al.*) traverses these cavities from one end to the other, piercing the diaphragm. So does a long double series of distinct masses of nervous substance, which are called *ganglia*, are connected together by nervous cords, and constitute the so-called *sympathetic* (Fig. 1, *Sy.*). The abdomen contains, in addition to these parts, the two *kidneys*, one placed against each side of the vertebral column, the *liver*, the *pancreas* or "sweetbread," and the *spleen*. The thorax encloses, besides its segment of the alimentary canal and of the sympathetic, the *heart* and the two *lungs*. The latter are placed one on each side of the heart, which lies nearly in the middle of the thorax.

Where the body is succeeded by the head, the uppermost of the thirty-three vertebral bodies is followed by a continuous mass of bone, which extends through the whole length of the head, and, like the spinal column, separates a dorsal chamber from a ventral one. The dorsal chamber, or *cavity of the skull*, opens into the spinal canal. It contains a mass of nervous matter called the *brain*, which is continuous with the spinal cord, the brain and the spinal cord together constituting what is termed the *cerebro-spinal*

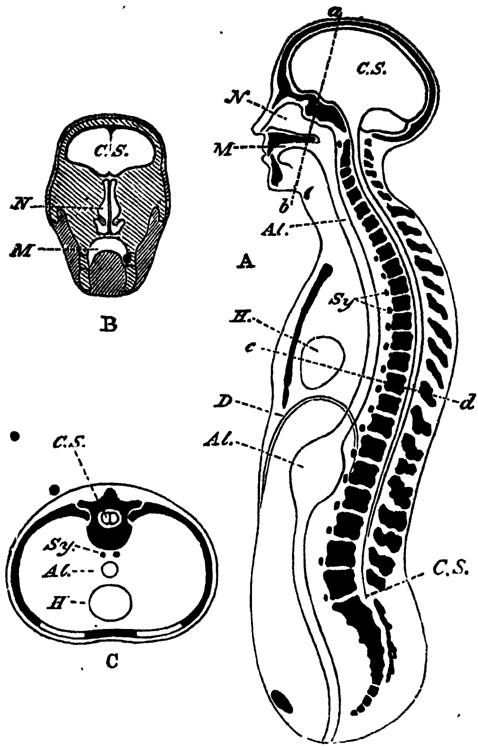

FIG. I.

A. A diagrammatic section of the human body taken vertically through the median plane. *C.S.* the cerebro-spinal nervous system; *N*, the cavity of the nose; *M*, that of the mouth; *Al. Al.* the alimentary canal represented as a simple straight tube; *H*, the heart; *D*, the diaphragm; *Sy.* the sympathetic ganglia.

B. A transverse vertical section of the head taken along the line *a b*; letters as before.

C. A transverse section taken along the line *c d*; letters as before.

axis (Fig. 1, *C.S.*, *C.S.*). The ventral chamber, or *cavity of the face*, is almost entirely occupied by the *mouth* and *pharynx*, into which last the upper end of the alimentary canal (called gullet or *œsophagus*) opens.

10. Thus, the study of a longitudinal section shows us that the human body is a double tube, the two tubes being completely separated by the spinal column and the bony axis of the skull, which form the floor of the one tube and the roof of the other. The dorsal tube contains the cerebro-spinal axis; the ventral, the alimentary canal, the sympathetic nervous system, and the heart, besides other organs.

Transverse sections, taken perpendicularly to the axis of the vertebral column, or to that of the skull, show still more clearly that this is the fundamental structure of the human body, and that the great apparent difference between the head and the trunk is due to the different size of the dorsal cavity relatively to the ventral. In the head the former cavity is very large in proportion to the size of the latter (Fig. 1, B); in the thorax, or abdomen, it is very small (Fig. 1, C).

The limbs contain no such chambers as are found in the body and the head; but, with the exception of certain branching tubes filled with fluid, which are called *blood-vessels* and *lymphatics*, are solid or semi-solid, throughout.

11. Such being the general character and arrangement of the parts of the human body, it will next be well to consider into what constituents it may be separated by the aid of no better means of discrimination than the eye and the anatomist's knife.

With no more elaborate aids than these, it becomes easy to separate that tough membrane which invests the whole body, and is called the skin, or *integument*, from the parts which lie beneath it. Furthermore, it is readily enough ascertained that this integument consists of two portions: a superficial layer, which is constantly being shed in the form of powder or scales, composed of minute particles of horny matter, and is called the *epidermis*; and the deeper part, the *dermis*, which is dense and fibrous (Fig. 32). The epidermis, if wounded, neither gives rise to pain nor bleeds. The dermis, under like circumstances, is very tender, and bleeds freely. A practical distinction is drawn between the two in shaving, in the course of which operation the razor ought to cut only epidermic structures; for if it go a shade deeper, it gives rise to pain and bleeding.

The skin can be readily enough removed from all parts of the exterior, but at the margins of the apertures of the body it seems to stop, and to be replaced by a layer which is much redder, more sensitive, bleeds more readily, and which keeps itself continually moist by giving out a more or less tenacious fluid, called *mucus*. Hence, at these apertures, the skin is said to stop, and to be replaced by *mucous membrane*, which lines all those interior cavities, such as the alimentary canal, into which the apertures open. But, in truth, the skin does not really come to an end at these points, but is directly continued into the mucous membrane, which last is simply an integument of greater delicacy, but consisting fundamentally of the same two layers,—a deep, fibrous layer, containing blood-vessels and nerves, and a superficial, insensible, and bloodless one, now called the *epithelium*. Thus every part of the body might be said to be contained between the walls of a double bag, formed by the epidermis, which invests the outside of the body, and the epithelium, its continuation, which lines the internal cavities.

12. The dermis, and the deep, sanguine layer, which answers to it in the mucous membranes, are chiefly made up of a filamentous substance, which yields abundant *gelatine* on being boiled, and is the matter which tans when hide is made into leather. This is called *areolar*, *fibrous*, or, better, *connective* tissue.[1] The last name is the best, because this tissue is the great connecting medium by which the different parts of the body are held together. Thus it passes from the dermis between all the other organs, ensheathing the muscles, coating the bones and cartilages, and eventually reaching and entering into the mucous membranes. And so completely and thoroughly does the connective tissue permeate almost all parts of the body, that if every other tissue could be dissected away, a complete model of all the organs would be left composed of this tissue. Connective tissue varies very

[1] Every such constituent of the body, as epidermis, cartilage, or muscle, is called a "tissue." (See Lesson XII.)

much in character; sometimes being very soft and tender, at others—as in the tendons and ligaments, which are almost wholly composed of it—attaining great strength and density.

13. Among the most important of the tissues imbedded in and ensheathed by the connective tissue, are some the presence and action of which can be readily determined during life.

If the upper arm of a man whose arm is stretched out be tightly grasped by another person, the latter, as the former bends up his fore-arm, will feel a great soft mass which lies at the fore part of the upper arm, swell, harden, and become prominent. As the arm is extended again, the swelling and hardness vanish.

On removing the skin, the body which thus changes its configuration is found to be a mass of red flesh, sheathed in connective tissue. The sheath is continued at each end into a tendon, by which the muscle is attached, on the one hand, to the shoulder-bone, and, on the other, to one of the bones of the fore-arm. This mass of flesh is the *muscle* called *biceps*, and it has the peculiar property of changing its dimensions—shortening and becoming thick in proportion to its decrease in length—when influenced by the will as well as by some other causes,[1] and of returning to its original form when let alone. This temporary change in the dimensions of a muscle, this shortening and becoming thick, is spoken of as its *contraction*. It is by reason of this property that muscular tissue becomes the great motor agent of the body; the muscles being so disposed between the systems of levers which support the body, that their contraction necessitates the motion of one lever upon another.

14. These levers form part of the system of hard tissues which constitute the *skeleton*. The less hard of these are the *cartilages*, composed of a dense, firm substance, ordinarily known as "gristle." The harder are the *bones*, which are masses either of cartilage, or of connective tissue, hardened by being impregnated with *phosphate* and *carbonate of lime*. They are animal tissues which have become, in a manner, naturally petrified; and when the salts of lime are extracted, as they may be, by the

[1] Such causes are called *stimuli*.

action of acids, a model of the bone in soft and flexible animal matter remains.

More than 200 separate bones are ordinarily reckoned in the human body, though the actual number of distinct bones varies at different periods of life, many bones which are separate in youth becoming united together in old age. Thus there are originally, as we have seen, thirty-three separate bodies of vertebræ in the spinal column, and the upper twenty-four of these commonly remain distinct throughout life. But the twenty-fifth, twenty-sixth, twenty-seventh, twenty-eighth, and twenty-ninth early unite into one great bone, called the *sacrum;* and the four remaining vertebræ often run into one bony mass called the *coccyx*. In early adult life, the skull contains twenty-two naturally separate bones, but in youth the number is much greater, and in old age far less. Twenty-four ribs bound the chest laterally, twelve on each side, and most of them are connected by cartilages with the breast-bone. In the girdle which supports the shoulder, two bones are always distinguishable as the *scapula* and the *clavicle*. The *pelvis*, to which the legs are attached, consists of two separate bones called the *ossa innominata* in the adult; but each *os innominatum* is separable into three (called *pubis*, *ischium*, and *ilium*) in the young. There are thirty bones in each of the arms, and the same number in each of the legs, counting the *patella*, or knee pan.

All these bones are fastened together by ligaments, or by cartilages; and where they play freely over one another, a coat of cartilage furnishes the surfaces which come into contact. The cartilages which thus form part of a joint are called *articular* cartilages, and their free surfaces, by which they rub against each other, are lined by a delicate *synovial* membrane, which secretes a lubricating fluid—the *synovia*.

15. Though the bones of the skeleton are all strongly enough connected together by ligaments and cartilages, the joints play so freely, and the centre of gravity of the body, when erect, is so high up, that it is impossible to make a skeleton or a dead body support itself in the upright position. That position, easy as it seems, is the result of the contraction of a multitude of muscles which oppose and balance one another. Thus, the foot affording

the surface of support, the muscles of the calf (Fig. 2, I) must contract, or the legs and body would fall forward.

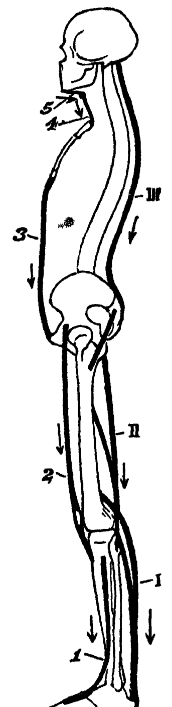

FIG. 2.—A DIAGRAM ILLUSTRATING THE ATTACHMENTS OF SOME OF THE MOST IMPORTANT MUSCLES WHICH KEEP THE BODY IN THE ERECT POSTURE.

I. The muscles of the calf. II. Those of the back of the thigh. III. Those of the spine. These tend to keep the body from falling forward.
1. The muscles of the front of the leg. 2. Those of the front of the thigh. 3. Those of the front of the abdomen. 4, 5. Those of the front of the neck. These tend to keep the body from falling backwards. The arrows indicate the direction of action of the muscles, the foot being fixed.

But this action tends to bend the leg; and to neutralize this and keep the leg straight, the great muscles in front of the thigh (Fig. 2, 2) must come into play. But these, by the same action, tend to bend the body forward on the legs; and if the body is to be kept straight, they must be neutralized by the action of the muscles of the buttocks and of the back (Fig. 2, III).

The erect position, then, which we assume so easily and without thinking about it, is the result of the combined and accurately proportioned action of a vast number of muscles. What is it that makes them work together in this way?

16. Let any person in the erect position receive a violent blow on the head, and you know what occurs. On the instant he drops prostrate, in a heap, with his limbs relaxed and powerless. What has happened to him? The blow may have been so inflicted as not to touch a single muscle of the body; it may not cause the loss of a drop of blood: and, indeed, if the "concussion," as it is called, has not been too severe, the sufferer, after a few moments of unconsciousness, will come to himself, and be as well as ever again. Clearly, therefore, no permanent injury has been done to any part of the body, least of all to the muscles, but an influence has been exerted upon a something which governs the muscles. And this influence may be the effect of very subtle causes. A strong mental emotion, and even a very bad smell, will, in some people, produce the same effect as a blow.

These observations might lead to the conclusion that it is the mind which directly governs the muscles, but a little further inquiry will show that such is not the case. For people have been so stabbed, or shot in the back, as to cut the spinal cord, without any considerable injury to other parts: and then they have lost the power of standing upright as much as before, though their minds may have remained perfectly clear. And not only have they lost the power of standing upright under these circumstances, but they no longer retain any power of either feeling what is going on in their legs, or, by an act of their volition, causing motion in them.

17. And yet, though the mind is thus cut off from the

lower limbs, a controlling and governing power over them still remains in the body. For, if the soles of the disabled feet be tickled, though no sensation will reach the body, the legs will be jerked up, just as would be the case in an uninjured person. Again, if a series of galvanic shocks be sent along the spinal cord, the legs will perform movements even more powerful than those which the will could produce in an uninjured person. And, finally, if the injury is of such a nature that the cord is crushed or profoundly disorganized, all these phenomena cease; tickling the soles, or sending galvanic shocks along the spine, will produce no effect upon the legs.

By examinations of this kind carried still further, we arrive at the remarkable result that the brain is the seat of all sensation and mental action, and the primary source of all voluntary muscular contractions; while the spinal cord is capable of receiving an impression from the exterior, and converting it not only into a simple muscular contraction, but into a combination of such actions.

Thus, in general terms, we may say of the cerebro-spinal nervous centres, that they have the power, when they receive certain impressions from without, of giving rise to simple or combined muscular contractions.

18. But you will further note that these impressions from without are of very different characters. Any part of the surface of the body may be so affected as to give rise to the sensations of contact, or of heat or cold; and any or every substance is able, under certain circumstances, to produce these sensations. But only very few and comparatively small portions of the bodily framework are competent to be affected, in such a manner as to cause the sensations of taste or of smell, of sight or of hearing: and only a few substances, or particular kinds of vibrations, are able so to affect those regions. These very limited parts of the body, which put us in relation with particular kinds of substances, or forms of force, are what are termed *sensory organs*. There are two such organs for sight, two for hearing, two for smell, and one, or more strictly speaking two, for taste.

19. And now that we have taken this brief view of the structure of the body, of the organs which support it,

of the organs which move it, and of the organs which put it in relation with the surrounding world, or, in other words, enable it to move in harmony with influences from without, we must consider the means by which all this wonderful apparatus is kept in working order.

All work, as we have seen, implies waste. The work of the nervous system and that of the muscles, therefore, implies consumption either of their own substance, or of something else. And as the organism can make nothing, it must possess the means of obtaining from without that which it wants, and of throwing off from itself that which it wastes; and we have seen that, in the gross, it does these things. The body feeds, and it excretes. But we must now pass from the broad fact to the mechanism by which the fact is brought about. The organs which convert food into nutriment are the organs of *alimentation;* those which distribute nutriment all over the body are organs of *circulation;* those which get rid of the waste products are organs of *excretion.*

20. The organs of alimentation are the mouth, pharynx, gullet, stomach, and intestines, with their appendages. What they do is, first to receive and grind the food. They then act upon it with chemical agents, of which they possess a store which is renewed as fast as it is wasted; and in this way separate it into a fluid containing nutritious matters in solution or suspension, and innutritious dregs or *fæces.*

21. A system of minute tubes, with very thin walls, termed *capillaries*, is distributed through the whole organism except the epidermis and its products, the epithelium, the cartilages, and the substance of the teeth. On all sides, these tubes pass into others, which are called *arteries* and *veins;* while these, becoming larger and larger, at length open into the *heart*, an organ which, as we have seen, is placed in the thorax. During life, these tubes and the chambers of the heart, with which they are connected, are all full of liquid, which is, for the most part, that red fluid with which we are all familiar as *blood.*

The walls of the heart are muscular, and contract rhythmically, or at regular intervals. By means of these contractions the blood which its cavities contain is driven in jets out of these cavities into the arteries, and thence into the capillaries, whence it returns by the veins back into the heart.

This is the *circulation of the blood.*

22. Now the fluid containing the dissolved or suspended nutritive matters which are the result of the process of digestion, traverses the very thin layer of soft and permeable tissue which separates the cavity of the alimentary canal from the cavities of the innumerable capillary vessels which lie in the walls of that canal, and so enters the blood, with which those capillaries are filled. Whirled away by the torrent of the circulation, the blood, thus charged with nutritive matter, enters the heart, and is thence propelled into the organs of the body. To these organs it supplies the nutriment with which it is charged; from them it takes their waste products, and, finally, returns by the veins, loaded with useless and injurious excretions, which sooner or later take the form of water, carbonic acid, and urea.

23. These excretionary matters are separated from the blood by the *excretory organs*, of which there are three—the *skin*, the *lungs*, and the *kidneys.*

Different as these organs may be in appearance, they are constructed upon one and the same principle. Each, in ultimate analysis, consists of a very thin sheet of tissue, like so much delicate blotting-paper, the one face of which is free, or lines a cavity in communication with the exterior of the body, while the other is in contact with the blood which has to be purified.

The excreted matters are, as it were, strained from the blood, through this delicate layer of filtering-tissue, and on to its free surface, whence they make their escape.

Each of these organs is especially concerned in the elimination of one of the chief waste products—water, carbonic acid, and urea—though it may at the same time be a means of escape for the others. Thus the lungs are especially busied in getting rid of carbonic acid, but at the same time they give off a good deal of water. The duty of the kidneys is to excrete urea (together with other saline matters), but at the same time they pass away a large quantity of water and a trifling amount of carbonic acid; while the skin gives off much water, some amount of carbonic acid, and a certain quantity of saline matter, among which urea is, at all events, sometimes present.

24. Finally, the lungs play a double part, being not merely eliminators of waste, or excretionary, products, but importers into the economy of a substance which is not exactly either food or drink, but something as important as either,—to wit, *oxygen*. It is oxygen which is the great sweeper of the economy. Introduced by the blood, into which it is absorbed, into all corners of the organism, it seizes upon those organic molecules which are disposable, lays hold of their elements, and combines with them into the new and simpler forms, carbonic acid, water, and urea.

The oxidation, or, in other words, the *burning* of these matters, gives rise to an amount of heat which is as efficient as a fire to raise the blood to a temperature of about 100°; and this hot fluid, incessantly renewed in all parts of the economy by the torrent of the circulation, warms the body, as a house is warmed by a hot-water apparatus.

25. But these alimentary, distributive or circulatory, excretory, and combustive processes would be worse than useless if they were not kept in strict proportion one to another. If the state of physiological balance is to be maintained, not only must the quantity of aliment taken be at least equivalent to the quantity of matter excreted; but that aliment must be distributed with due rapidity to the seat of each local waste. The circulatory system is the commissariat of the physiological army.

Again, if the body is to be maintained at a tolerably even temperature, while that of the air is constantly varying, the condition of the hot-water apparatus must be most carefully regulated.

In other words, a *combining organ* must be added to the organs already mentioned, and this is found in the nervous system, which not only possesses the function already described of enabling us to move our bodies and to know what is going on in the external world; but makes us aware of the need of food, enables us to discriminate nutritious from innutritious matters, and to exert the muscular actions needful for seizing, killing, and cooking; guides the hand to the mouth, and governs all the movements of the jaws and of the alimentary canal. By it, the working of the heart is properly adjusted and the calibres of the distributing pipes are regulated, so as indirectly to govern the excretory and combustive processes. And these are more directly affected by other actions of the nervous system.

26. The various functions which have been thus briefly indicated constitute the greater part of what are called the *vital actions* of the human body, and, so long as they are performed, the body is said to possess *life*. The cessation of the performance of these functions is what is ordinarily called *death*.

But there are really several kinds of death, which may, in the first place, be distinguished from one another under the two heads of *local* and of *general* death.

27. *Local death* is going on at every moment, and in most, if not in all, parts of the living body. Individual cells of the epidermis and of the epithelium are incessantly dying and being cast off, to be replaced by others which are, as constantly, coming into separate existence. The like is true of blood-corpuscles, and probably of many other elements of the tissues.

This form of local death is insensible to ourselves, and is essential to the due maintenance of life. But, occasionally, local death occurs on a larger scale, as the result of injury, or as the consequence of disease. A burn, for example, may suddenly kill more or less of the skin; or part of the tissues of the skin may die, as in the case of the slough which lies in the midst of a boil; or a whole limb may die, and exhibit the strange phenomena of *mortification*.

The local death of some tissues is followed by their regeneration. Not only all the forms of epidermis and epithelium, but nerve, connective tissue, bone, and, at any rate, some muscles, may be thus reproduced, even on a large scale. Cartilage once destroyed is said not to be restored.

28. *General death* is of two kinds, *death of the body as a whole*, and *death of the tissues*. By the former term is implied the absolute cessation of the functions of the brain, of the circulatory, and of the respiratory organs; by the latter, the entire disappearance of the vital actions of the ultimate structural constituents of the body.

When death takes place, the body, as a whole, dies first, the death of the tissues sometimes not occurring until after a considerable interval.

Hence it is that, for some little time after what is ordinarily called death, the muscles of an executed criminal may be made to contract by the application of proper stimuli. The muscles are not dead, though the man is.

29. The modes in which death is brought about appear at first sight to be extremely varied. We speak of natural death by old age, or by some of the endless forms of disease; of violent death by starvation, or by the innumerable varieties of injury, or poison. But, in reality, the immediate cause of death is always the stoppage of the functions of one of three organs; the cerebro-spinal nervous centre, the lungs, or the heart. Thus, a man may be instantly killed by such an injury to a part of the brain which is called the *medulla oblongata* (see Lesson XI.) as may be produced by hanging, or breaking the neck.

Or death may be the immediate result of suffocation by strangulation, smothering, or drowning,—or, in other words, of stoppage of the respiratory functions.

Or, finally, death ensues at once when the heart ceases to propel blood. These three organs—the brain, the lungs, and the heart—have been fancifully termed the *tripod of life*.

In ultimate analysis, however, life has but two legs to stand upon, the lungs and the heart, for death through the brain is always the effect of the secondary action of the injury to that organ upon the lungs or the heart. The functions of the brain cease, when either respiration or circulation is at an end. But if circulation and respiration are kept up artificially, the brain may be removed without causing death. On the other hand, if the blood be not aërated, its circulation by the heart cannot preserve life; and, if the circulation be at an end, mere aëration of the blood in the lungs is equally ineffectual for the prevention of death.

30. With the cessation of life, the everyday forces of the inorganic world no longer remain the servants of the bodily frame, as they were during life, but become its masters. Oxygen, the sweeper of the living organism, becomes the lord of the dead body. Atom by atom, the

complex molecules of the tissues are taken to pieces and reduced to simpler and more oxidized substances, until the soft parts are dissipated chiefly in the form of carbonic acid, ammonia, water, and soluble salts, and the bones and teeth alone remain. But not even these dense and earthy structures are competent to offer a permanent resistance to water and air. Sooner or later the animal basis which holds together the earthy salts decomposes and dissolves—the solid structures become friable, and break down into powder. Finally, they dissolve and are diffused among the waters of the surface of the globe, just as the gaseous products of decomposition are dissipated through its atmosphere.

It is impossible to follow, with any degree of certainty, wanderings more varied and more extensive than those imagined by the ancient sages who held the doctrine of transmigration; but the chances are that sooner or later, some, if not all, of the scattered atoms will be gathered into new forms of life.

The sun's rays, acting through the vegetable world, build up some of the wandering molecules of carbonic acid, of water, of ammonia, and of salts, into the fabric of plants. The plants are devoured by animals; animals devour one another, man devours both plants and other animals; and hence it is very possible that atoms which once formed an integral part of the busy brain of Julius Cæsar may now enter into the composition of Cæsar the negro in Alabama, and of Cæsar the house-dog in an English homestead.

And thus there is sober truth in the words which Shakespeare puts into the mouth of Hamlet—

> "Imperial Cæsar, dead and turned to clay,
> Might stop a hole to keep the cold away;
> Oh that that earth, which kept the world in awe,
> Should patch a wall, t' expel the winter's flaw!"

LESSON II.

THE VASCULAR SYSTEM AND THE CIRCULATION.

1. ALMOST all parts of the body are *vascular;* that is to say, they are traversed by minute and very close-set canals, which open into one another so as to constitute a small-meshed network, and confer upon these parts a spongy texture. The canals, or rather tubes, are provided with distinct but very delicate walls, composed of a structureless membrane (Fig. 3 A, *a*), in which at intervals small oval bodies (Fig. 3 A, *b*), termed *nuclei* (see Lesson XII. § 2), are imbedded.

These tubes are the *capillaries.* They vary in diameter from $\frac{1}{2000}$th to $\frac{1}{1500}$th of an inch; they are sometimes disposed in loops, sometimes in long, sometimes in wide, sometimes in narrow meshes: and the diameters of these meshes, or, in other words, the interspaces between the capillaries, are sometimes hardly wider than the diameter of a capillary, sometimes many times as wide (see Figs. 16, 20, 32, 33, and 37). These interspaces are occupied by the substance of the tissue which the capillaries permeate (Fig. 3 A, *c*), so that the ultimate anatomical components of every part of the body are, strictly speaking, outside the vessels, or *extra-vascular.*

But there are certain parts which, in another and broader sense, are also said to be extra-vascular or non-vascular. These are the epidermis and epithelium, the nails and hairs, the substance of the teeth, and the cartilages; which may and do attain a very considerable thickness or length, and yet contain no vessels. However, as we have seen that all the tissues are really extra-vascular, these differ only in degree from the rest. The circumstance that all the tissues are outside the vessels by no means interferes with their being bathed by the fluid which is inside the vessels. In fact, the walls of the

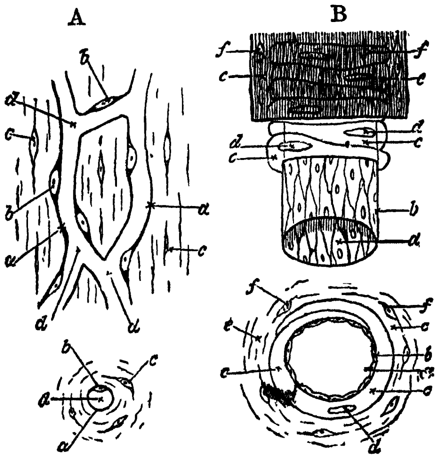

FIG. 3.

A. Diagrammatic representation of a capillary seen from above and in section: *a*, the wall of the capillary with *b*, the nuclei; *c*, nuclei belonging to the connective tissue in which the capillary is supposed to be lying; *d*, the canal of the capillary.

B. Diagrammatic representation of the structure of a small artery: *a*, epithelium; *b*, the so-called basement membrane; *c*, the circular non-striated muscular fibres, each with nucleus *d*; *e*, the coat of fibrous tissue with nuclei *f*.

capillaries are so exceedingly thin that their fluid contents readily exude through the delicate membrane of which they are composed, and irrigate the tissues in which they lie.

2. Of the capillary tubes thus described, one kind contains, during life, the red fluid, *blood*, while the ot[her is] filled with a pale, watery, or milky fluid, termed [lymph] or *chyle*. The capillaries, which contain blood, are con-

tinued on different sides into somewhat larger tubes, with thicker walls, which are the smallest *arteries* and *veins*.

The mere fact that the walls of these vessels are thicker than those of the capillaries constitutes an important difference between the capillaries and the small arteries and veins; for the walls of the latter are thus rendered far less permeable to fluids, and that thorough irrigation of the tissues, which is effected by the capillaries, cannot be performed by them.

The most important difference between these vessels and the capillaries, however, lies in the circumstance that their walls are not only thicker, but also more complex, being composed of several coats, one, at least, of which is muscular. The number, arrangement, and even nature of these coats differ according to the size of the vessels, and are not the same in the veins as in the arteries, though the smallest veins and arteries tend to resemble each other.

If we take one of the smallest arteries, we find, first, a very delicate lining of cells constituting a sort of epithelium (Fig. 3 B, *a*). Outside this (separated from it by a structureless membrane, Fig. 3 B, *b*) comes the muscular coat of the kind called *plain* or *non-striated* muscle (see Lesson XII.), made up of flattened spindle-shape bands or fibres which are wrapped round the vessel (Fig. 3 B, *c*).

Outside the muscular coat is a sheath of fibrous or connective tissue (Fig. 3 B, *f*).

In the smallest arteries there is but a single layer of these muscular fibres encircling the vessel like a series of rings; but in the larger arteries there are several layers of circular muscular fibres variously bound together with fibrous and elastic tissue, though as the vessels get larger the quantity of muscular tissue in them gets *relatively* less.

Now these plain muscular fibres possess that same power of contraction, or shortening in the long, and broadening in the narrow, directions which, as was stated in the preceding Lesson, is the special property of muscular tissue. And when they exercise this power, they, of course, narrow the calibre of the vessel, just as squeezing it in any other way would do; and this contraction may go so far as, in some cases, to reduce the cavity of the vessel almost to nothing, and to render it practically impervious.

The state of contraction of these muscles of the small arteries and veins is regulated, like that of other muscles, by their nerves; or, in other words, the nerves supplied to the vessels determine whether the passage through these tubes should be wide and free, or narrow and obstructed. Thus while the small arteries and veins lose the function, which the capillaries possess, of directly irrigating the tissues by transudation, they gain that of regulating the supply of fluid to the irrigators, or capillaries themselves. The contraction, or dilatation, of the arteries which supply a set of capillaries, comes to the same result as lowering or raising the sluice-gates of a system of irrigation-canals.

3. The smaller arteries and veins severally unite into, or are branches of, larger arterial or venous trunks, which again spring from or unite into still larger ones, and these, at length, communicate by a few principal arterial and venous trunks with the heart.

The smallest arteries and veins, as we have seen, are similar in structure, but the larger arteries and veins differ widely; for the larger arteries have walls so thick and stout that they do not sink together when empty; and this thickness and stoutness arises from the circumstance that not only is the muscular coat very thick, but that, in addition, and more especially, several layers of a highly elastic, strong, fibrous substance become mixed up with the muscular layers. Thus, when a large artery is pulled out and let go, it stretches and returns to its primitive dimensions almost like a piece of india-rubber.

The larger veins, on the other hand, contain but little of either elastic or muscular tissue. Hence, their walls are thin, and they collapse when empty.

This is one great difference between the larger arteries and the veins; the other is the presence of what are [illegible] r in a great many of the veins, especially in those which lie in muscular parts of the body. They are absent in the largest trunks, and in the smallest branches, and in all the divisions of the portal, pulmonary, and cerebral veins.

4. These valves are pouch-like folds of the inner wall

of the vein. The bottom of the pouch is turned towards those capillaries from which the vein springs. The free edge of the pouch is directed the other way, or towards the heart. The action of these pouches is to impede the passage of any fluid from the heart towards the capillaries, while they do not interfere with fluid passing in the opposite direction (Fig. 4). The working of some of these valves may be very easily demonstrated in the living body. When the arm is bared, blue veins may be seen running from the hand, under the skin, to the upper arm. The diameter of these veins is pretty even, and diminishes regularly towards the hand, so long as the current of the blood, which is running in them, from the hand to the upper arm, is uninterrupted.

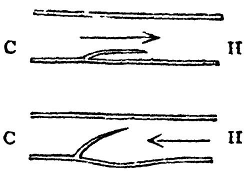

FIG. 4.—DIAGRAMMATIC SECTIONS OF VEINS WITH VALVES.

In the upper, the blood is supposed to be flowing in the direction of the arrow, towards the heart; in the lower, the reverse way. C, capillary side; H, heart side.

But if a finger be pressed upon the upper part of one of these veins, and then passed downwards along it, so as to drive the blood which it contains backwards, sundry swellings, like little knots, will suddenly make their appearance at several points in the length of the vein, where nothing of the kind was visible before. These swellings are simply dilatations of the wall of the vein, caused by the pressure of the blood on that wall, above a valve which opposes its backward progress. The moment the backward impulse ceases the blood flows on again; the valve, swinging back towards the wall of the vein, affords obstacle to its progress, and the distension caused its pressure disappears (Fig. 4).

The only arteries which possess valves are the primary trunks—the aorta and pulmonary artery—which spring from the heart, and they will be best considered with the latter organ.

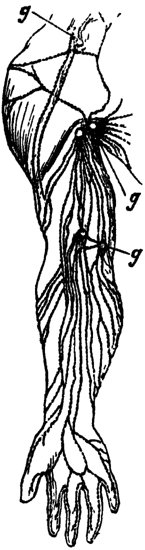

Fig. 5.—The Lymphatics of the Front of the Right Arm.

g Lymphatic glands, or *ganglia*, as they are sometimes called. These *ganglia* are not to be confounded with nervous *ganglia*.

5. Besides the capillary network and the trunks connected with it, which constitute the blood-vascular system, all parts of the body which possess blood capillaries — except the brain [illegible] spinal cord, the eyeball, the [illegible]s, tendons, and perhaps the bones[1]—also contain another set of what are termed *lymphatic* capillaries, mixed up with those of the blood-vascular system, but not directly communicating with them, and, in addition, differing from the blood capillaries in being connected with larger vessels of only one kind. That is to say, they open only into trunks which carry fluid away from them, there being no large vessels which bring anything to them.

These trunks further resemble the small veins in being [illegible]vided with valves which freely [illegible] of the passage of liquid from the lymphatic capillaries, but obstruct the flow of anything the other way. But the lymphatic trunks differ from the veins, in that they do not rapidly unite into larger and larger trunks, which present a continually increasing calibre, and allow of a flow without interruption to the heart.

On the contrary, remaining nearly of the same size, they, at intervals, enter and ramify in rounded bodies called *lymphatic glands*, whence new lymphatic trunks arise (Fig. 5). In these glands the

[1] It is probable that these exceptions are apparent rather than real, but the question is not yet satisfactorily decided.

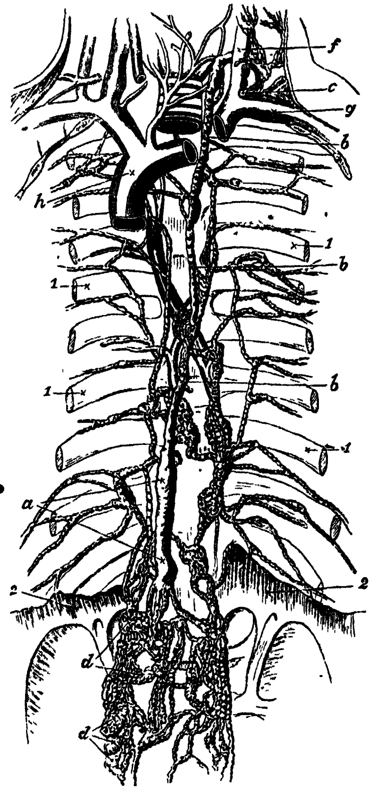

FIG. 6—THE THORACIC DUCT.

The Thoracic Duct occupies the middle of the figure. It lies upon the spinal column, at the sides of which are seen portions of the ribs (*1*).

a, the receptacle of the chyle; *b*, the trunk of the thoracic duct, opening at *c* into the junction of the left jugular (*f*) and subclavian (*g*) veins as they unite into the left innominate vein, which has been cut across to show the thoracic duct running behind it; *d*, lymphatic glands placed in the lumbar regions; *h*, the superior vena cava formed by the junction of the right and left innominate veins.

lymphatic capillaries and passages are closely interlaced with blood capillaries.

Sooner or later, however, the great majority of the smaller lymphatic trunks pour their contents into a tube, which is about as large as a crow-quill, lies in front of the backbone, and is called the *thoracic duct.* This opens at the root of the neck into the conjoined trunks of the great veins which bring back the blood from the left side of the head and the left arm (Fig. 6). The remaining lymphatics are connected by a common canal with the corresponding vein on the right side.

Where the principal trunks of the lymphatic system open into the veins, valves are placed, which allow of the passage of fluid only from the lymphatic to the vein. Thus the lymphatic vessels are, as it were, a part of the venous system, though, by reason of these valves, the fluid which is contained in the veins cannot get into the lymphatics. On the other hand, every facility is afforded for the passage into the veins of the fluid contained in the lymphatics. Indeed, in consequence of the numerous valves in the lymphatics, every pressure on, and contraction of, their walls, not being able to send the fluid backward, must drive it more or less forward, towards the veins.

6. The lower part of the thoracic duct is dilated, and is termed the *receptacle*, or *cistern*, of the *chyle* (*a*, Fig. 6). In fact, it receives the lymphatics of the intestines, which, though they differ in no essential respect from other lymphatics, are called *lacteals*, because, after a meal con- [illegible] fatty matter, they are filled with a milky [illegible] termed the *chyle*. The lacteals, or lymphatics of the small intestine, not only form networks in its walls, but send blind prolongations into the little velvety processes termed *villi*, with which the mucous membrane of that intestine is beset (see Lesson VI.). The trunks which open into the network lie in the *mesentery* (or membrane which suspends the small intestine to the back wall of the abdomen), and the glands through which these trunks lead are hence termed the *mesenteric glands.*

7. It will now be desirable to take a general view of the arrangement of all these different vessels, and of their

relations to the great central organ of the vascular system —the heart (Fig. 7).

All the veins of every part of the body, except the lungs, the heart itself, and certain viscera of the abdomen, join together into larger veins, which, sooner or later, open into one of two great trunks (Fig. 7, *V.C.S. V.C.I.*) termed the *superior* and the *inferior vena cava*, which debouch into the upper, or broad end of the right half of the heart.

All the arteries of every part of the body, except the lungs, are more or less remote branches of one great trunk—the *aorta* (Fig. 7, *Ao.*), which springs from the lower division of the left half of the heart.

The arteries of the lungs are branches of a great trunk (Fig. 7, *P.A.*) springing from the lower division of the right side of the heart. The veins of the lungs, on the contrary, open by four trunks into the upper part of the left side of the heart (Fig. 7, *P.V.*).

Thus the venous trunks open into the upper division of each half of the heart—those of the body in general into that of the right half; those of the lungs into that of the left half: while the arterial trunks spring from the lower moieties of each half of the heart—that for the body in general from the left side, and that for the lungs from the right side.

Hence it follows that the great artery of the body, and the great veins of the body, are connected with opposite sides of the heart; and the great artery of the lungs and the great veins of the lungs also with opposite sides of that organ. On the other hand, the veins of the body open into the same side of the heart as the artery of the lungs, and the veins of the lungs open into the same side of the heart as the artery of the body.

The arteries which open into the capillaries of the substance of the heart are called *coronary arteries*, and arise, like the other arteries, from the aorta, but quite close to its origin, just beyond the semilunar valves. But the *coronary vein*, which is formed by the union of the small veins which arise from the capillaries of the heart, does not open into either of the venæ cavæ, but pours the blood which it contains directly into the division of the heart into which these cavæ open—that is to say, into the [illegible] 14 *b*).

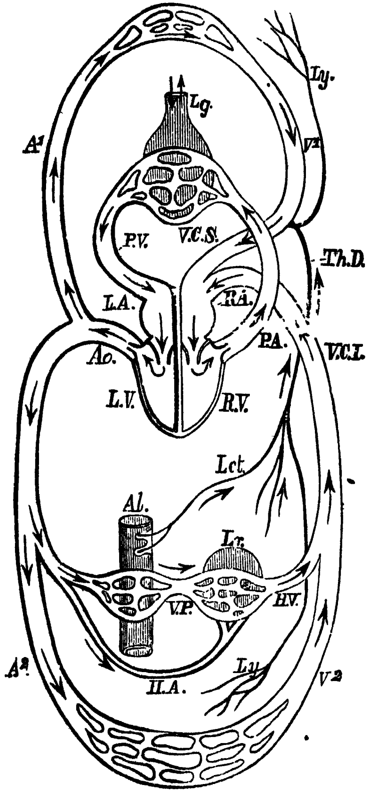

FIG. 7.—DIAGRAM OF THE HEART AND VESSELS, WITH THE COURSE OF THE CIRCULATION, VIEWED FROM BEHIND SO THAT THE PROPER LEFT OF THE OBSERVER CORRESPONDS WITH THE LEFT SIDE OF THE HEART IN THE DIAGRAM.

L.A. left auricle; *L.V.* left ventricle; *Ao.* aorta; A^1. arteries to the upper part of the body; A^2. arteries to the lower part of the body; *H.A.* hepatic artery, which supplies the liver with part of its blood; V^1. veins of the upper

The abdominal viscera referred to above, the veins of which do not take the usual course, are the stomach, the intestines, the spleen, and the pancreas. These veins all [illegible] into a single trunk, which [illegible] *portæ* (Fig. 7, *V.P.*), but this trunk does not open into the *vena cava inferior.* On the contrary, having reached th[e] liver, it enters the substance of that organ, and breaks u[p] into an immense multitude of capillaries, which ramif[y] through the liver, and become connected with those int[o] which the artery of the liver, called the *hepatic arter[y]* (Fig. 7, *H.A.*), branches. From this common capillar[y] mesh-work veins arise, and unite, at length, into a single trunk, the *hepatic vein* (Fig. 7, *H.V.*), which emerges from the liver, and opens into the *inferior vena cava.* The portal vein is the only great vein in the body which branches out and becomes continuous with the capillaries of an organ, like an artery.

8. The heart (Figs. 8 and 10), to which all the vessels in the body have now been directly or indirectly traced, is an organ, the size of which is usually roughly estimated as equal to that of the closed fist of the person to whom it belongs, and which has a broad end turned upwards and backwards, and rather to the right side, called its *base:* and a pointed end which is called its *apex,* turned downwards and forwards, and to the left side, so as to lie opposite the interval between the fifth and sixth ribs.

It is lodged between the lungs, nearer the front than the back wall of the chest, and is enclosed in a sort of double bag—the *pericardium* (Fig. 9, *p.*). One-half of the double bag is closely adherent to the heart itself, forming a thin coat upon its outer surface. At the base of the heart, this half of the bag passes on to the great vessels which spring from, or open into, that organ; and becomes continuous with the other half, which loosely envelopes the heart and the adherent half of the bag. Between the two

part of the body; *V*[2]. veins of the lower part of the body; *V.P.* vena portæ; *H.V.* hepatic vein; *V.C.I.* inferior vena cava; *V.C.S.* superior vena cava; *R.A.* right auricle; *R.V.* right ventricle; *P.A.* pulmonary artery; *Lg.* lung; *P.V.* pulmonary vein; *Lct.* lacteals; *Ly.* lymphatics; *Th.D.* thoracic duct; *Al.* alimentary canal; *Lr.* liver. The arrows indicate the course of the blood, lymph, and chyle. The vessels which contain arterial blood have dark contours, while those which carry venous blood have light contours.

FIG. 8.—HEART OF SHEEP, AS SEEN AFTER REMOVAL FROM THE BODY, LYING UPON THE TWO LUNGS. THE PERICARDIUM HAS BEEN CUT AWAY, BUT NO OTHER DISSECTION MADE.

R.A. Auricular appendage of right auricle; *L.A.* auricular appendage of left auricle; *R.V.* right ventricle; *L.V.* left ventricle; *S.V.C.* superior vena cava; *I.V.C.* inferior vena cava; *P A.* pulmonary artery; *Ao*, aorta; *A'o'*, innominate branch from aorta dividing into subclavian and carotid arteries;

layers of the pericardium, consequently, there is a completely closed, narrow cavity, lined by an epithelium, and secreting into its interior a small quantity of clear fluid.[1] The outer layer of the pericardium is firmly connected surface of the diaphragm.

But the heart cannot be said to depend altogether upon the diaphragm for support, inasmuch as the great vessels which issue from or enter it—and for the most part pass

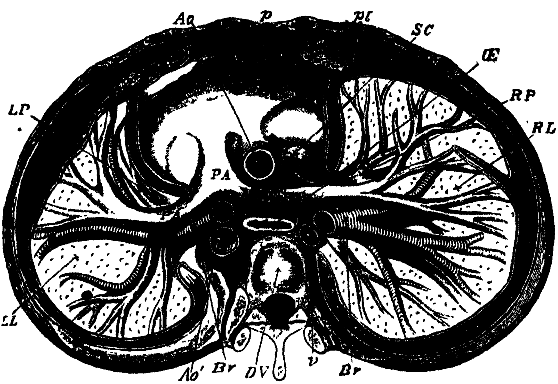

FIG. 9.—TRANSVERSE SECTION OF THE CHEST, WITH THE HEART AND LUNGS IN PLACE. (A little diagrammatic.)

D.V. dorsal vertebra, or joint of the backbone; *Ao. Ao'.* aorta, the top of its arch being cut away in this section; *S.C.* superior vena cava; *P.A.* pulmonary artery, divided into a branch for each lung; *L.P. R.P.* left and right pulmonary veins; *Br.* Bronchi; *R.L.L.L.* right and left lungs; *Œ.* the gullet or œsophagus; *p*, outer bag of pericardium; *pl*, the two layers of pleura; *v*, azygos vein.

L. lung; *Tr.* trachea. 1, solid cord often present, the remnant of a once open communication between the pulmonary artery and aorta. 2, masses of fat at the bases of the ventricle hiding from view the greater part of the auricles. 3, line of fat marking the division between the two ventricles. 4, mass of fat covering end of trachea.

[1] This fluid, like that contained in the peritoneum, pleura, and other shut sacs of a similar character to the pericardium, is sometimes called *serum*; whence the membranes forming the walls of these sacs are frequently termed *serous membranes*.

upwards from its base—help to suspend and keep it in place.

Thus the heart is coated, outside, by one layer of the pericardium. Inside, it contains two great cavities or "divisions," as they have been termed above, completely separated by a fixed partition which extends from the base to the apex of the heart; and, consequently, having no direct communication with one another. Each of these two great cavities is further subdivided, not longitudinally

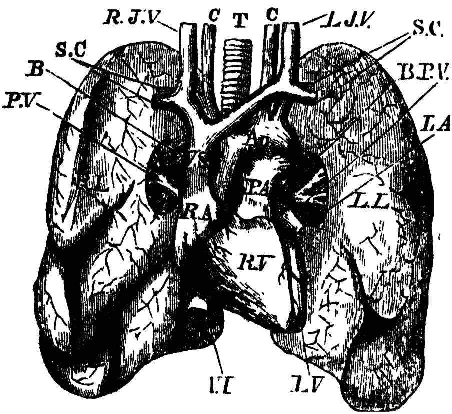

FIG. 10.—THE HEART, GREAT VESSELS, AND LUNGS. (FRONT VIEW.)

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

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

but transversely, by a moveable partition. The cavity above the transverse partition, on each side, is called the *auricle;* the cavity below, the *ventricle*—right or left as the case may be.

Each of the four cavities has the same capacity, and is capable of containing from 4 to 6 cubic inches of water

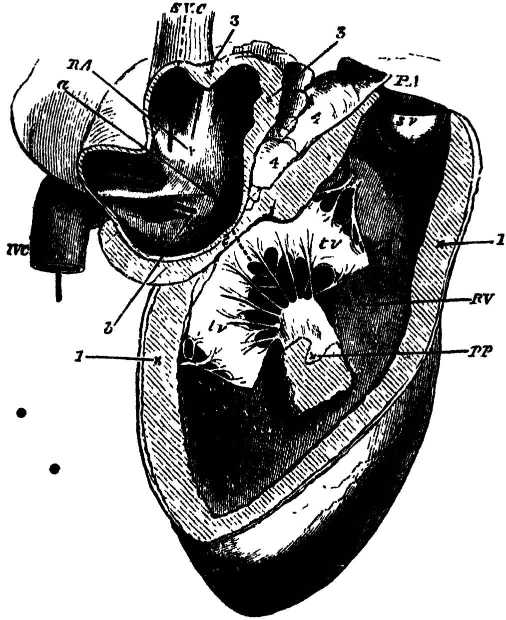

Fig. 11.—Right Side of the Heart of a Sheep.

R.A. cavity of right auricle; *S.V.C.* superior vena cava, *I.V.C.* inferior vena cava; (a style has been passed through each of these;) *a*, a style passed from the auricle to the ventricle through the auriculo-ventricular orifice; *b*, a style passed into the coronary vein.

R.V. cavity of right ventricle; *tv*, *tv*, two flaps of the tricuspid valve: the third is dimly seen behind them, the style *a* passing between the three. Between the two flaps, and attached to them by *chordæ tendineæ*, is seen a papillary muscle, *pp*, cut away from its attachment to that portion of the wall of the ventricle which has been removed. Above, the ventricle terminates somewhat like a funnel in the pulmonary artery, *P.A.* One of the pockets of the semilunar valve, *sv*, is seen in its entirety, another partially.

1, the wall of the ventricle cut across; 2, the position of the auriculo-ventricular ring; 3, the wall of the auricle; 4, masses of fat lodged between the auricle and pulmonary artery.

The walls of the auricles are much thinner than those of the ventricles. The wall of the left ventricle is much thicker than that of the right ventricle; but no such difference is perceptible between the two auricles (Figs. 11 and 12, 1 and 3).

9. In fact, as we shall see, the ventricles have more work to do than the auricles, and the left ventricle more to do than the right. Hence the ventricles have more muscular substance than the auricles, and the left ventricle than the right; and it is this excess of muscular substance which gives rise to the excess of thickness observed in the left ventricle.

The muscular fibres of the heart are not smooth, nucleated bands, like those of the vessels, but are bundles of transversely-striped fibres, and resemble those of the chief muscles of the body, except that they have no sheath, or *sarcolemma*, such as we shall find to exist in the latter.

Almost the whole mass of the heart is made up of these muscular fibres, which have a very remarkable and complex arrangement. There is, however, an internal membranous and epithelial lining, called the *endocardium;* and at the junction between the auricles and ventricles, the apertures of communication between their cavities, called the *auriculo-ventricular apertures*, are strengthened by *fibrous rings*. To these rings the moveable partitions, or *valves*, between the auricles and ventricles, the arrangement of which must next be considered, are attached.

10. There are three of these partitions attached to the circumference of the right auriculo-ventricular aperture, and two to that of the left (Figs. 11, 12, 13, 14, *t v*, *m v*). Each is a broad, thin, but very tough and strong triangular fold of the endocardium, attached by its base, which joins on to its fellow, to the auriculo-ventricular fibrous ring; and hanging with its point downwards into the ventricular cavity. On the right side there are, therefore, three of these broad, pointed membranes, whence the whole apparatus is called the *tricuspid valve*. On the left side, there are but two, which, when detached from all their connexions but the auriculo-ventricular ring, look something like a bishop's mitre, and hence bear the name of the *mitral valve*.

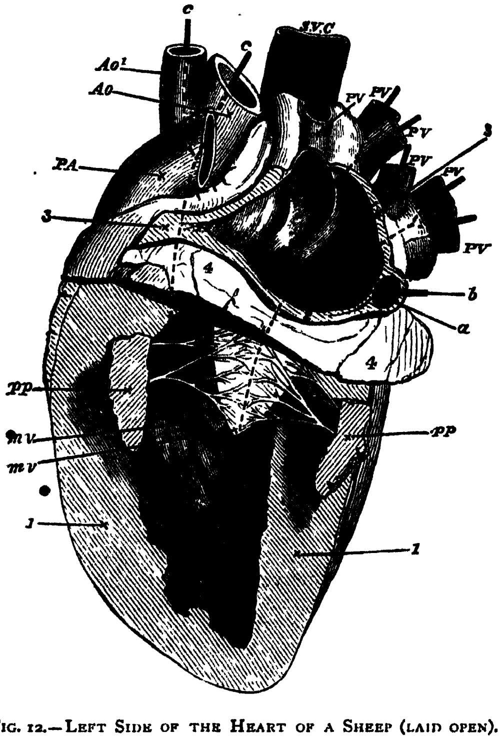

FIG. 12.—LEFT SIDE OF THE HEART OF A SHEEP (LAID OPEN).

P. V. pulmonary veins opening into the left auricle by four openings, as shown by the styles: *a*, a style passed from auricle into ventricle through the auriculo-ventricular orifice; *b*, a style passed into the coronary vein, which, though it has no connection with the left auricle, is, from its position, necessarily cut across in thus laying open the auricle.
M. V. the two flaps of the mitral valve (drawn somewhat diagrammatically): *pp*, papillary muscles, belonging as before to the part of the ventricle cut away; *c*, a style passed from ventricle in *Ao.* aorta; *Ao*¹. branch of aorta (see Fig. 8, *A'o'*); *P.A.* pulmonary artery; *S V.C.* superior vena cava.
1, wall of ventricle cut across; 2, wall of auricle cut away around auriculo-ventricular orifice; 3, other portions of auricular wall cut across; 4, mass of fat around base of ventricle (see Fig. 8, 2).

The edges and apices of the valves are not completely free and loose. On the contrary, a number of fine, but strong, tendinous cords, called *chordæ tendineæ*, connect them with some column-like elevations of the fleshy substance of the walls of the ventricle, which are termed *papillary muscles* (Figs. 11 and 12, *pp*); similar column-like elevations of the walls of the ventricles, but having no *chordæ tendineæ* attached to them, are called *columnæ carneæ*.

It follows, from this arrangement, that the valves oppose no obstacle to the passage of fluid from the auricles to the ventricles; but if any should be forced the other way, it will at once get between the valve and the wall of the heart, and drive the valve backwards and upwards. Partly because they soon meet in the middle and oppose one another's action, and partly because the *chordæ tendineæ* hold their edges and prevent them from going back too far, the valves, thus forced back, give rise to the formation of a complete transverse partition between the ventricle and the auricle, through which no fluid can pass.

Where the aorta opens into the left ventricle and where the pulmonary artery opens into the right ventricle, another valvular apparatus is placed, consisting in each case of three pouch-like valves, called the *semilunar valves* (Fig. 11, *s.v.*; Figs. 13 and 14, *Ao. P.A.*), which are similar to those of the veins. But as they are placed on the same level and meet in the middle line, they completely stop the passage when any fluid is forced along the artery towards the heart. On the other hand, these valves flap back and allow any fluid to pass from the heart into the artery, with the utmost readiness.

The action of the auriculo-ventricular valves may be demonstrated with great ease on a sheep's heart, in which the aorta and pulmonary artery have been tied and the greater part of the auricles cut away, by pouring water into the ventricles through the auriculo-ventricular aperture. The tricuspid and mitral valves then usually become closed by the upward pressure of the water which gets behind them. Or, if the ventricles be nearly filled, the valves may be made to come together at once by gently squeezing the ventricles. In like manner, if the base of the aorta, or pulmonary artery, be cut out of the heart, so as not to injure the semilunar valves, water poured into the upper ends of the vessel will cause its valves to close tightly, and allow nothing to flow out after the first moment.

Thus the arrangement of the auriculo-ventricular valves is such, that any fluid contained in the chambers of the heart can be made to pass through the auriculo-ventricular apertures in only one direction : that is to say, from the

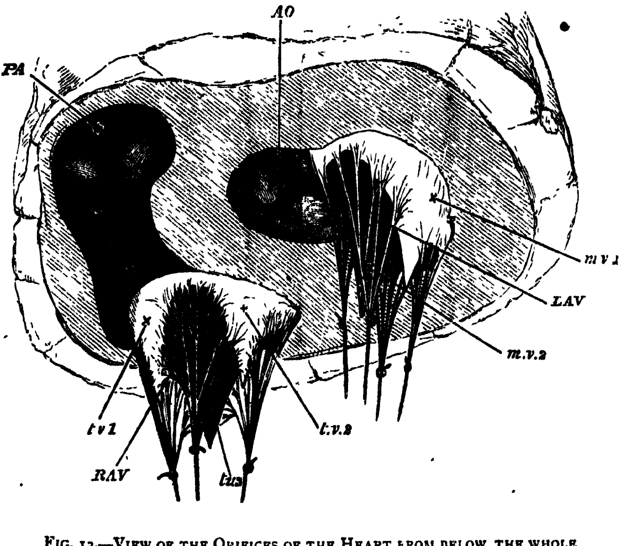

FIG. 13.—VIEW OF THE ORIFICES OF THE HEART FROM BELOW, THE WHOLE OF THE VENTRICLES HAVING BEEN CUT AWAY.

R.A.V. right auriculo-ventricular orifice surrounded by the three flaps *t.v.* 1, *t.v.* 2, *t.v.* 3, of the tricuspid valve, these are stretched by weights attached to the *chordæ tendineæ*.
L.A.V. left auriculo-ventricular orifice surrounded in same way by the two flaps, *m.v.* 1, *m.v.* 2, of mitral valve; *P.A* the orifice of pulmonary artery, the semilunar valves having met and closed together; *Ao* the orifice of the aorta with its semilunar valves. The shaded portion, leading from *R.A.V.* to *P.A.*, represents the funnel seen in Fig. 11.

auricles to the ventricles. On the other hand, the arrangement of the semilunar valves is such that the fluid contents of the ventricles pass easily into the aorta and pulmonary artery, while none can be made to travel the other way from the arterial trunks to the ventricles.

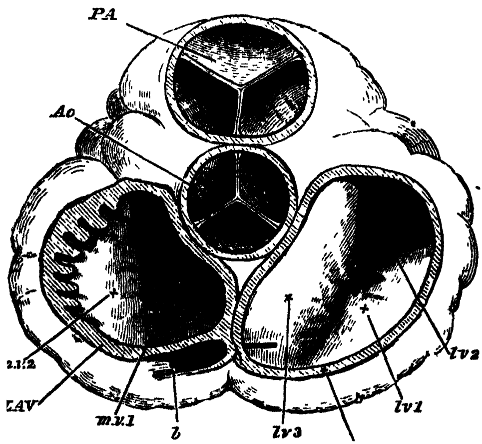

FIG. 14.—THE ORIFICES OF THE HEART SEEN FROM ABOVE, THE AURICLES AND GREAT VESSELS BEING CUT AWAY.

P.A. pulmonary artery, with its semilunar valves ; *Ao.* aorta, do.
R.A.V. right auriculo-ventricular orifice with the three flaps (*lv.* 1, 2, 3) of tricuspid valve.
L.A.V. left auriculo-ventricular orifice, with *m.v.* 1 and 2, flaps of mitral valve ; *b*, style passed into coronary vein. On the left part of *L.A.V.*, the section of the auricle is carried through the auricular appendage ; hence the toothed appearance due to the portions in relief cut across.

11. Like all other muscular tissues, the substance of the heart is contractile ; but, unlike most muscles, the heart contains within itself a something which causes its different parts to contract in a definite succession and at regular intervals.

If the heart of a living animal be removed from the body, it will go on pulsating for a longer or shorter time, much as it did while in the body. And careful attention to these pulsations will show that they consist of:—(1) A simultaneous contraction of the walls of both auricles. (2) Immediately following this, a simultaneous contraction of the walls of both ventricles. (3) Then comes a pause, or state of rest; after which the auricles and ventricles contract again in the same order as before, and their contractions are followed by the same pause as before.

If the auricular contraction be represented by A˘, the ventricular by V˘, and the pauses by —, the series of actions will be as follows: A˘ V˘ —; A˘ V˘ —; A˘ V˘ —; &c. Thus, the contraction of the heart is *rhythmical*, two short contractions of its upper and lower halves respectively being followed by a pause of the whole, which occupies about as much time as the two contractions.

The state of contraction of the ventricle or auricle is called its *systole*; the state of relaxation, during which it undergoes dilatation, its *diastole*.

12. Having now acquired a notion of the arrangement of the different pipes and reservoirs of the circulatory system, of the position of the valves, and of the rhythmical contractions of the heart, it will be easy to comprehend what must happen if, when the whole apparatus is full of blood, the first step in the pulsation of the heart occurs and the auricles contract.

By this action each auricle tends to squeeze the fluid which it contains out of itself in two directions—the one towards the great veins, the other towards ntricl and the direction which the blood, as a whole, will take, will depend upon the relative resistance offered to it in these two directions. Towards the great veins it is resisted by the mass of the blood contained in the veins. Towards the ventricles, on the contrary, there is no resistance worth mentioning, inasmuch as the valves are open, the walls of the ventricles, in their uncontracted state, are flaccid and easily distended, and the entire pressure of the arterial blood is taken off by the semilunar valves, which are necessarily closed.

Therefore, when the auricles contract, only a very little of the fluid which they contain will flow back into the veins, and the great proportion will pass into and distend the ventricles. As the ventricles fill and begin to resist further distension, the blood, getting behind the auriculo-ventricular valves, will push them towards one another, and almost shut them. The auricles now cease to contract, and immediately that their walls relax, fresh blood flows from the great veins and slowly distends them again.

But the moment the auricular systole is over, the ventricular systole begins. The walls of each ventricle contract vigorously; and the first effect of that contraction is to shut the auriculo-ventricular valves completely and to stop all egress towards the auricle. The pressure upon the valves becomes very considerable, and they might even be driven upwards, if it were not for the *chordæ tendineæ* which hold down their edges.

As the contraction continues and the capacities of the ventricles become diminished, the points of the wall of the heart to which the *chordæ tendineæ* are attached approach the edges of the valves; and thus there is a tendency to allow of a slackening of these cords, which, if it really took place, might permit the edges of the valves to flap back and so destroy their utility. This tendency, however, is counteracted by the *chordæ tendineæ* being connected, not directly to the walls of the heart, but to those muscular pillars, the papillary muscles, which stand out from its substance. These muscular pillars shorten at the same time as the substance of the heart contracts; and thus, just so far as the contraction of the walls of the ventricles brings the papillary muscles nearer the valves, do they, by their own contraction, pull the *chordæ tendineæ* as tight as before.

By the means which have now been described, the fluid in the ventricle is debarred from passing back into the auricle; the whole force of the contraction of the ventricular walls is therefore expended in overcoming the resistance presented by the semilunar valves. This resistance has several sources, being the result, partly, of the weight of the vertical column of blood which the valves support; partly, of the reaction of the distended elastic walls of the great arteries, and partly, of the friction and inertia of the blood contained in the vessels.

It now becomes obvious why the ventricles have so much more to do than the auricles, and why valves are needed between the auricles and ventricles, while none are wanted between the auricles and the veins.

All that the auricles have to do is to fill the ventricles, which offer no active resistance to that process. Hence the thinness of the walls of the auricles, and hence the [illegible]e, the resistance on the side of the ventricle being so insignificant that it gives way, at once, before the pressure of the blood in the veins.

On the other hand, the ventricles have to overcome a great resistance in order to force fluid into elastic tubes which are already full ; and if there were no auriculo-ventricular valves, the fluid in the ventricles would meet with less obstacle in pushing its way backward into the auricles and thence into the veins, than in separating the semilunar valves. Hence the necessity, firstly, of the auriculo-ventricular valves ; and, secondly, of the thickness and strength of the walls of the ventricles. And since the aorta, systemic arteries, capillaries, and veins form a much larger system of tubes, containing more fluid and offering more resistance than the pulmonary arteries, capillaries, and veins, it follows that the left ventricle needs a thicker muscular wall than the right.

13. Thus, at every systole of the auricles, the ventricles are filled and the auricles emptied, the latter being slowly refilled by the pressure of the fluid in the great veins, which is amply sufficient to overcome the passive resistance of the relaxed auricular walls. And, at every systole of the ventricles, the arterial systems of the body and lungs receive the contents of these ventricles, and the nearly emptied ventricles remain ready to be refilled by the auricles.

We must now consider what happens in the arteries. When the contents of the ventricles are suddenly forced into these tubes (which, it must be recollected, are already full), a shock is given to the entire mass of fluid which they contain. This shock is propagated almost instantaneously throughout the fluid, becoming fainter and fainter in proportion to the increase of the mass of the blood in the capillaries, until it finally ceases to be discernible.

If the vessels were tubes of a rigid material, like gas-pipes, the fluid which the arteries contain would be transported forward as far as this impulse was competent to carry it, at the same instant as the shock, throughout their whole extent. And, as the arteries open into the capillaries, the capillaries into the veins, and these into the heart, a quantity of fluid exactly equal to that driven out of the ventricles would be returned to the auricles, almost at the same moment that the ventricles contract.

However, the vessels are not rigid, but, on the contrary, very yielding tubes; and the great arteries, as we have seen, have especially elastic walls. What happens, then, when the ventricular systole takes place, is—firstly, the production of the general slight and sudden shock already mentioned; and, secondly, the dilatation of the great arteries by the pressure of the increased quantity of blood forced into them.

But, when the systole is over, the force stored up in the dilated arterial walls, in the shape of elastic tension, comes into play and exerts a pressure on the fluid—the first effect of which is to shut the semilunar valves; the second, to drive a certain quantity of the fluid from the larger arteries along the smaller ones. These it dilates in the same fashion. The fluid at length passing into the capillaries, the ejection of a corresponding quantity of fluid from them into the veins, and finally from the veins into the heart, is the ultimate result of the ventricular systole.

14. Several of the practical results of the working of the heart and arteries just described now become intelligible. For example, between the fifth and sixth ribs, on the left side, a certain movement is perceptible by the finger and by the eye, which is known as the *beating* of the heart. It is the result of the striking of the apex of the heart against the pericardium, and through it, on the inner wall of the chest, at this point, at the moment of the systole of the ventricles. When the systole occurs, in fact, two things happen: in the first place, as a result of the manner in which the muscular fibres of the heart are disposed, its apex bends upwards sharply; and, in the second place, its front face is thrown a little downwards and forwards, in consequence of the stretching and elongation of the aorta by the blood which is thrown into it.

The result of one or other, or both of these actions combined, is the upward and forward blow of the apex of the heart which we feel.

15. Secondly, if the ear be applied over the heart, certain *sounds* are heard, which recur with great regularity, at intervals corresponding with those between every two beats. First comes a longish dull sound; then a short sharp sound; then a pause; then the long, then the sharp sound, then another pause; and so on. There are many different opinions as to the cause of the first sound, and perhaps physiologists are not yet at the bottom of the matter; though the more probable view is, that part of it is a muscular sound caused by the contraction of the muscular fibres of the ventricle, and part is due to the tension of the auriculo-ventricular valves; but the second sound is, without doubt, caused by the sudden closure of the semilunar valves when the ventricular systole ends. That such is the case has been proved experimentally, by hooking back the semilunar valves in a living animal, when the second sound ceases at once.

16. Thirdly, if the finger be placed upon an artery, such as that at the wrist, what is termed the *pulse* will be felt; that is to say, the elastic artery dilates somewhat, at regular intervals, which answer to the beatings of the heart. The pulse which is felt by the finger, however, does not correspond precisely with the beat of the heart, but takes place a little after it, and the interval is longer the greater the distance of the artery from the heart. The beat in the artery on the inner side of the ankle, for example, is a little later than the beat of the artery in the temple.

The reason of this is that the sense of touch by finger is only delicate enough to distinguish the dilatation of the artery by the wave of blood, which is driven along it by the elastic reaction of the aorta, and is not competent to perceive the first shock caused by the systole. But if, instead of the fingers, sufficiently delicate levers were made to rest upon any two arteries, it would be found that the pulse really begins at the same time in both, the shock of the systole making itself felt all over the vascular system at once; and that it is only the actual dilatation of the arterial walls, which, travelling in the form of a wave from the larger to the smaller arteries, takes longer to reach and distend the more distant branch.

17. Fourthly, when an artery is cut, the outflow of the fluid which it contains is increased by *jerks*, the intervals of which correspond with the intervals of the beats of the heart. The cause of this is plainly the same as that of the pulse; the force which would be employed in distending the walls of the artery, were the latter entire, is spent in jerking the fluid out when the artery is cut.

18. Fifthly, under ordinary circumstances, the pulse is no longer to be detected in the capillaries, or in the veins. This arises from several circumstances. One of them is that the capacity of the branches of an artery is greater than the capacity of its trunk, and the capacity of the capillaries, as a whole, is greater than that of all the small arteries put together. Hence, supposing the capacity of the trunk to be 10, that of its branches 50, and that of the capillaries into which these open 100, it is clear that a quantity of fluid thrown into the trunk, sufficient to dilate it by one-tenth, and to produce a very considerable and obvious effect, could not distend each branch by more than $\frac{1}{50}$th, and each capillary by $\frac{1}{100}$th of its volume, an effect which might be quite imperceptible.

19. But this is not all. Did the pulse merely become indistinguishable on account of its division and dispersion among so many capillaries, it ought to be felt again when the blood is once more gathered up into a few large venous trunks. But it is not. The pulse is definitely lost at the capillaries. There is, under ordinary circumstances, no pulse whatever in the veins, except sometimes a backward pulse from the heart along the great venous trunks; but this is quite another matter.

This actual loss, or rather transformation of the pulse, is effected by means of the elasticity of the arterial walls, in the following manner.

In the first place it must be borne in mind that, owing to the minute size of the capillaries and small arteries, the amount of friction taking place in their channels when the blood is passing through them is very great; in other words, they offer a very great resistance to the passage of the blood.

The consequence of this is, that the blood cannot get through the capillaries, in spite of the fact that their total area is so much greater than that of the aorta, into the veins so fast as it is thrown into the arteries by the heart. The whole arterial system, therefore, becomes over distended with blood.

Now we know by experiment that under such conditions as these, an elastic tube has the power, if long enough and elastic enough, to change a jerked impulse into a continuous flow. If a syringe (or one of the elastic bottles now so frequently in use) be fastened to one end of a long glass tube, and water be pumped through the tube, it will flow from the far end in jerks, corresponding to the jerks of the syringe. This will be the case whether the tube be quite open at the far end, or drawn out to a fine point so as to offer great resistance to the outflow of the water. The glass tube is a rigid tube, and there is no elasticity to be brought into play. If now a long india-rubber tube be substituted for the glass tube, it will be found to act differently, according as the opening at the far end is wide or narrow.

If it is wide, the water flows out in jerks, nearly as distinct as those from the glass tube. There is little resistance to the flow, little distension of the india-rubber tube, little elasticity brought into play.

If, however, the opening be narrowed, as by fastening to it a stopcock or a glass tube drawn to a point, or if a piece of sponge be thrust into the end of the tube; if, in fact, in any way resistance be offered to the outflow of the water, the tube becomes distended, its elasticity is brought into play, and the water flows out from the end, not in jerks but in a stream, which is more and more completely continuous the longer and more elastic the tube.

Substitute for the syringe the heart, for the stopcock or sponge the capillaries and small arteries, for the india-rubber tube the whole arterial system, and you have exactly the same result in the living body. Through the action of the elastic arterial walls the separate jets from the heart are blended into one continuous stream. The whole force of each blow of the heart is not at once spent in driving a quantity of blood out of the capillaries; a part only is thus spent, the rest goes to distend the elastic arteries. But during the interval between that beat and the next the distended arteries are narrowing again, by virtue of their elasticity, and so are pressing the blood on into the capillaries with as much force as they were themselves distended by the heart. Then comes another beat, and the same process is repeated. At each stroke the elastic arteries shelter the capillaries from part of the sudden blow, and then quietly and steadily pass on that part of the blow to the capillaries during the interval between the strokes.

The larger the amount of elastic arterial wall thus brought into play, *i. e.* the greater the distance from the heart, the greater is the fraction of each heart's stroke which is thus converted into a steady elastic pressure between the beats. Thus the pulse becomes less and less marked the farther you go from the heart; any given length of the arterial system, so to speak, being sheltered by the lengths between it and the heart.

Every inch of the arterial system may, in fact, be con- [illegible] a small fraction of the heart's jerk into a steady pressure, and when all these fractions are summed up together in the total length of the arterial system no trace of the jerk is left.

As the effect of each systole becomes diminished in the smaller vessels by the causes above mentioned, that of this constant pressure becomes more obvious, and gives rise to a steady passage of the fluid from the arteries towards the veins. In this way, in fact, the arteries perform the same functions as the air-reservoir of a fire-engine, which converts the jerking impulse given by the pumps into the steady flow of the delivery hose.

20. Such is the general result of the mechanical conditions of the organs of the circulation combined with the rhythmical activity of the heart. This activity drives the fluid contained in these organs out of the heart into the arteries, thence to the capillaries, and from them through the veins back to the heart. And in the course of these operations it gives rise, incidentally, to the beating of the heart, the sounds of the heart, and the pulse.

It has been found, by experiment, that in the horse it takes about half a minute for any substance, as for instance a chemical body, whose presence in the blood can easily be recognized, to complete the circuit, *ex. gr.* to pass from the jugular vein down through the right side of the heart, the lungs, the left side of the heart, up through the arteries of the head and neck, and so back to the jugular vein.

By far the greater portion of this half minute is taken up by the passage through the capillaries, where the blood moves, it is estimated, at the rate only of about one and a half inches in a *minute*, whereas through the carotid a dog it flies along at the rate of about ten inches in a *second*.

Of course to complete the circuit of the circulation, a blood-corpuscle need not have to go through so much as half of an inch of capillaries in either the lungs or any of the tissues of the body.

Inasmuch the force which drives the blood on is (putting the other comparatively slight helps on one side) the beat of the heart and that alone, however much it may be modified, as we have seen, in character, it is obvious that the velocity with which the blood moves must be greatest in the aorta and diminish towards the capillaries.

For with each branching of the arteries the total area of the arterial system is increased, the total width of the capillary tubes if they were all put together side by side being very much greater than that of the aorta. Hence the blood, or a corpuscle, for instance, of the blood being driven by the same force, viz. the heart's beat, over the whole body, must pass much more rapidly through the aorta than through the capillary system or any part of that system.

It is not that the greater friction in any capillary causes the blood to flow more slowly there and there only. The resistance caused by the friction in the capillaries is thrown back upon the aorta, which indeed feels the resistance of the whole vascular system; and it is this total resistance which has to be overcome by the heart before the blood can move on at all.

The blood driven everywhere by the same force simply moves more and more slowly as it passes into wider and wider channels. When it is in the capillaries it is slowest; after escaping from the capillaries, as the veins unite into larger and larger trunks, and hence as the total venous area is getting less and less, the blood moves again faster and faster for just the same reason that in the arteries it moved slower and slower.

A very similar case is that of a river widening out in a plain into a lake and then contracting into a narrow stream again. The water is driven by one force throughout (that of gravity). The current is much slower in the lake than in the narrower river either before or behind.

21. It is now necessary to trace the exact course of the circulation as a whole. And we may conveniently commence with the portion of the blood contained at any moment in the right auricle. The contraction of the right auricle drives that fluid into the right ventricle; the ventricle then contracts and forces it into the pulmonary artery; from hence it passes into the capillaries of the lungs. Leaving these, it returns by the four pulmonary veins to the left auricle; and the contraction of the left auricle drives it into the left ventricle.

The systole of the left ventricle forces the blood into the aorta. The branches of the aorta convey it into all parts of the body except the lungs; and from the capillaries of all these parts, except from those of the intestines and certain other viscera in the abdomen, it is conveyed, by vessels which gradually unite into larger and larger trunks, into either the superior or the inferior *vena cava*, which carry it to the right auricle once more.

But the blood brought to the capillaries of the stomach and intestines, spleen and pancreas, is gathered into veins which unite into a single trunk—the *vena portæ*. The vena portæ distributes its blood to the liver, mingling with that supplied to the capillaries of the same organ by the hepatic artery. From these capillaries it is conveyed by small veins, which unite into a large trunk—the *hepatic vein*, which opens into the inferior vena cava. The flow of the blood from the abdominal viscera, through the liver, to the hepatic vein, is called the *portal circulation*.

The heart itself is supplied with blood by the two *coronary arteries* which spring from the root of the aorta just above two of the semilunar valves. The blood from the capillaries of the heart is carried back by the coronary vein, not to either vena cava, but to the right auricle. The opening of the coronary vein is protected by a valve, so as to prevent the right auricle from driving the venous blood which it contains back into the vessels of the heart.

22. Thus, the *shortest possible course* which any particle of the blood can take in order to pass from one side of the heart to the other, is to leave the aorta by one of the coronary arteries, and return to the right auricle by the coronary vein. And in order to pass through the *greatest possible number of capillaries* and return to the point from which it started, a particle of blood must leave the heart by the aorta and traverse the arteries which supply the alimentary canal, spleen, and pancreas. It then enters, 1stly, the capillaries of these organs; 2ndly, the capillaries of the liver; and, 3rdly, after passing through the right side of the heart, the capillaries of the lungs, from which it returns to the left side and eventually to the aorta.

Furthermore, from what has been said respecting the lymphatic system, it follows that any particle of matter which enters a lacteal of the intestine, will reach the right auricle by the superior cava, after passing through the lymph capillaries and channels of sundry lymphatic glands; while anything which enters the adjacent blood capillary in the wall of the intestine will reach the right auricle by the inferior cava, after passing through the blood capillaries of the liver.

23. It has been shown above (§ 2) that the small arteries may be directly affected by the nervous system, which controls the state of contraction of their muscular walls, and so regulates their calibre. The effect of this power of the nervous system is to give it a certain control over the circulation in particular spots, and to produce such a state of affairs that, although the force of the heart and the general condition of the vessels remain the same, the state of the circulation may be very different in different localities.

Blushing is a purely local modification of the circulation of this kind, and it will be instructive to consider how a blush is brought about. An emotion—sometimes pleasurable, sometimes painful—takes possession of the mind: thereupon a hot flush is felt, the skin grows red, and according to the intensity of the emotion these changes are confined to the cheeks only, or extend to the "roots of the hair," or "all over."

What is the cause of these changes? The blood is a red and a hot fluid; the skin reddens and grows hot, because its vessels contain an increased quantity of this red and hot fluid; and its vessels contain more, because the small arteries suddenly dilate, the natural moderate contraction of their muscles being superseded by a state of relaxation. In other words, the action of the nerves which cause this muscular contraction is suspended.

On the other hand, in many people, extreme terror causes the skin to grow cold, and the face to appear pale and pinched. Under these circumstances, in fact, the supply of blood to the skin is greatly diminished, in consequence of an excessive stimulation of the nerves of the small arteries, which causes them to contract and so to cut off the supply of blood more or less completely.

24. That this is the real state of the case may be proved experimentally upon rabbits. These animals may be made to blush artificially. If, in a rabbit, the sympathetic nerve which sends branches to the vessels of the head is cut, the ear of the rabbit, which is covered by so delicate an integument that the changes in its vessels can be readily perceived, at once blushes. That is to say, the vessels dilate, fill with blood, and the ear becomes red and hot. The reason of this is, that when the sympathetic is cut, the nervous stimulus which is ordinarily sent along its branches is interrupted, and the muscles of the small vessels, which were slightly contracted, become altogether relaxed.

And now it is quite possible to produce pallor and cold in the rabbit's ear. To do this it is only necessary to irritate the cut end of the sympathetic which remains connected with the vessels. The nerve then becomes excited, so that the muscular fibres of the vessels are thrown into a violent state of contraction, which diminishes their calibre so much that the blood can hardly make its way through them. Consequently, the ear becomes pale and cold.

25. The practical importance of this local control

exerted by the nervous system is immense. When exposure to cold gives a man catarrh, or inflammation of the lungs, or diarrhœa, or some still more serious affection of the abdominal viscera, the disease is brought about through the nervous system. The impression made by the cold on the skin is conveyed to the nervous centres, and so influences the *vaso-motor* nerves (as the nerves which govern the walls of the vessels are called) of the organ affected as to cause their partial paralysis, and produce that state of *congestion* (or undue distension of the vessels) which so commonly ends in inflammation. (See Lesson XI. § 15.)

26. Is the heart, in like manner, under the control of the central nervous system?

As we all know, it is not under the direct influence of the will, but everyone is no less familiar with the fact that the actions of the heart are wonderfully affected by all forms of emotion. Men and women often faint, and have sometimes been killed by sudden and violent joy or sorrow; and when they faint or die in this way, they do so because the perturbation of the brain gives rise to a something which arrests the heart as dead as you stop a stop-watch with a spring. On the other hand, other emotions cause that extreme rapidity and violence of action which we call palpitation.

Now there are three sets of nerves in the heart: one set are supplied by *ganglia*, or masses of nerve-cells, in its substance; another set come from the *sympathetic* nerve; a third set are branches of a remarkable nerve, which proceeds straight from the brain, and is called the *pneumogastric* nerve. There is every reason to believe that the regular rhythmical succession of the ordinary contractions of the heart depends upon the ganglia lodged in its substance. At any rate, it is certain that these movements depend neither on the sympathetic, nor on the pneumogastric, since they go on as well when the heart is removed from the body.

In the next place, there is much reason to believe that the influence which increases the rapidity of the heart's action is exerted through the sympathetic.

And lastly, it is quite certain that the influence which arrests the heart's action is supplied by the pneumogastric. This may be demonstrated in animals, such as frogs, with great ease.

27. If a frog be pithed, or its brain destroyed, so as to

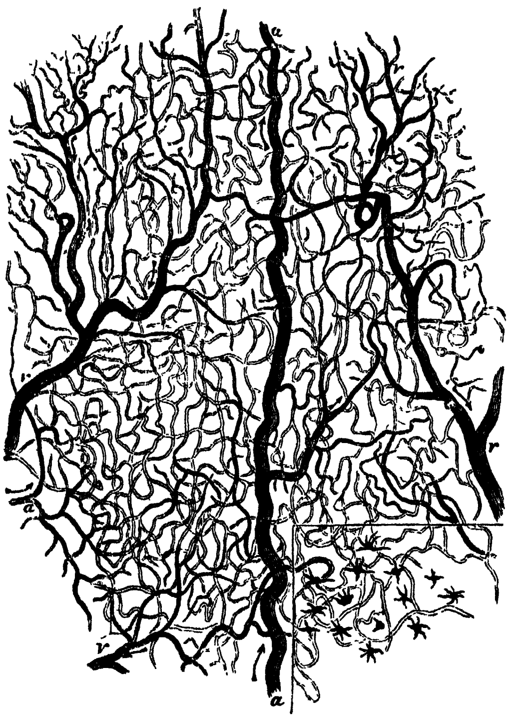

FIG. 15.—Portion of the web of a frog's foot seen under a low magnifying power, the blood-vessels only being represented except in the corner of the field, where in the portion marked off the pigment spots are also drawn.

a. small arteries; *v.* small veins: the minute tubes joining the arteries of the veins are the capillaries. The arrows denote the direction of the circulation. The larger artery running straight up in the middle line breaks up into capillaries at points higher up than can be shown in the drawing.

obliterate all sensibility, the animal will continue to live, and its circulation will go on perfectly well for an indefinite period. The body may be laid open without causing pain or other disturbance, and then the heart will be observed beating with great regularity. It is possible to make the heart move a long index backwards and forwards; and if frog and index are covered with a glass shade, the air under which is kept moist, the index will vibrate with great steadiness for a couple of days.

It is easy to adjust to the frog thus prepared a contrivance by which electrical shocks may be sent through the pneumogastric nerves, so as to irritate them. The moment this is done the index stops dead, and the heart will be found quiescent, with relaxed and distended walls. After a little time the influence of the pneumogastric passes off, the heart recommences its work as vigorously as before, and the index vibrates through the same arc as formerly. With careful management, this experiment may be repeated very many times; and after every arrest by the irritation of the pneumogastric, the heart resumes its work.

28. The evidence that the blood circulates in man, although perfectly conclusive, is almost all indirect. The most important points in the evidence are as follows:—

In the first place, the disposition and structure of the organs of circulation, and more especially the arrangement of the various valves, will not, as was shown by Harvey, permit the blood to flow in any other direction than in the one described above. Moreover, we can easily with a syringe inject a fluid from the vena cava, for instance, through the right side of the heart, the lungs, the left side of the heart, the arteries, and capillaries, back to the vena cava; but not the other way. In the second place, we know that in the living body the blood is continually flowing in the arteries towards the capillaries, because when an artery is tied, in a living body, it swells up and pulsates on the side of the ligature nearest the heart, whereas on the other side it becomes empty, and the tissues supplied by the artery become pale from the want of a supply of blood to their capillaries. And when we cut an artery the blood is pumped out in jerks from the cut end nearest the heart, whereas little or no blood

FIG. 16.—Very small portion of Fig. 15 very highly magnified.

A. walls of capillaries; *B*. tissue of web lying between the capillaries; *C*. cells of epidermis covering web (these are only shown in the right-hand from the other end. When, however, we tie a vein the state of things is reversed, the swelling taking place on the side farthest from the heart, &c. &c., showing that in the veins the blood flows from the capillaries to the heart.

But certain of the lower animals, the whole, or parts, of the body of which are transparent, readily afford direct proof of the circulation, the blood visibly rushing from the arteries into the capillaries, and from the capillaries into the veins, so long as the animal is alive and its heart is at work. The animal in which the circulation can be most conveniently observed is the frog. The web between its toes is very transparent, and the particles suspended in its blood are so large that they can be readily seen as they slip swiftly along with the stream of blood, when the toes are fastened out, and the intervening web is examined under even a low magnifying power (Figs. 15 and 16).

and lower part of the field; in the other parts of the field the focus of the microscope lies below the epidermis); *D.* nuclei of these epidermic cells; *E.* pigment cells contracted, not partially expanded as in Fig. 15; *F.* red blood corpuscle (oval in the frog) passing along capillary—nucleus not visible; *G.* another corpuscle squeezing its way through a capillary, the canal of which is smaller than its own transverse diameter; *H.* another bending as it slides round a corner; *K.* corpuscle in capillary seen through the epidermis; *I.* white blood-corpuscle.

LESSON III.

THE BLOOD AND THE LYMPH.

1. IN order to become properly acquainted with the characters of the blood it is necessary to examine it with a microscope magnifying at least three or four hundred diameters. Provided with this instrument, a hand lens, and some slips of thick and thin glass, the student will be enabled to follow the present Lesson.

The most convenient mode of obtaining small quantities of blood for examination is to twist a piece of string, pretty tightly, round the middle of the last joint of the middle, or ring finger, of the left hand. The end of the finger will immediately swell a little, and become darker coloured, in consequence of the obstruction to the return of the blood in the veins caused by the ligature. When in this condition, if it be slightly pricked with a sharp clean needle (an operation which causes hardly any pain), a good-sized drop of blood will at once exude. Let it be deposited on one of the slips of thick glass, and covered lightly and gently with a piece of the thin glass, so as to spread it out evenly into a thin layer. Let a second slide receive another drop, and, to keep it from drying, let it be put under an inverted watch-glass or wine-glass, with a bit of wet blotting-paper inside. Let a third drop be dealt with in the same way, a few granules of common salt being first added to the drop.

2. To the naked eye the layer of blood upon the first slide will appear of a pale reddish colour, and quite clear and homogeneous. But on viewing it with even a pocket lens its apparent homogeneity will disappear, and it will

look like a mixture of excessively fine yellowish-red particles, like sand, or dust, with a watery, almost colourless, fluid. Immediately after the blood is drawn, the particles will appear to be scattered very evenly through the fluid, but by degrees they aggregate into minute patches, and the layer of blood becomes more or less spotty.

The "particles" are what are termed the *corpuscles* of the blood; the nearly colourless fluid in which they are suspended is the *plasma.*

The second slide may now be examined. The drop of blood will be unaltered in form, and may perhaps seem to have undergone no change. But if the slide be inclined, it will be found that the drop no longer flows; and, indeed, the slide may be inverted without the disturbance of the drop, which has become solidified, and may be removed, with the point of a penknife, as a gelatinous mass. The mass is quite soft and moist, so that this setting, or *coagulation*, of a drop of blood is something very different from its drying.

On the third slide, this process of coagulation will be found not to have taken place, the blood remaining as fluid as it was when it left the body. The salt, therefore, has prevented the coagulation of the blood. Thus this very simple investigation teaches that blood is composed of a nearly colourless plasma, in which many coloured corpuscles are suspended; that it has a remarkable power of coagulating; and that this coagulation may be prevented by artificial means, such as the addition of salt.

3. If, instead of using the hand lens, the drop of blood on the first slide be placed under the microscope, the particles, or corpuscles, of the blood will be found to be bodies with very definite characters, and of two kinds, called respectively the *red corpuscles* and the *colourless corpuscles.* The former are much more numerous than the latter, and have a yellowish-red tinge; while the latter, somewhat larger than the red corpuscles, are, as their name implies, pale and devoid of coloration.

4. The corpuscles differ also in other and more important respects. The *red corpuscles* (Fig. 17) are flattened circular disks, on an average $\frac{1}{3200}$th of an inch in diameter, and having about one-fourth of that thickness. It follows that rather more than 10,000,000 of them will lie on a space

one inch square, and that the volume of each corpuscle does not exceed $\frac{1}{120000000000}$th of a cubic inch.

The broad faces of the disks are not flat, but somewhat concave, as if they were pushed in towards one another. Hence the corpuscle is thinner in the middle than at the

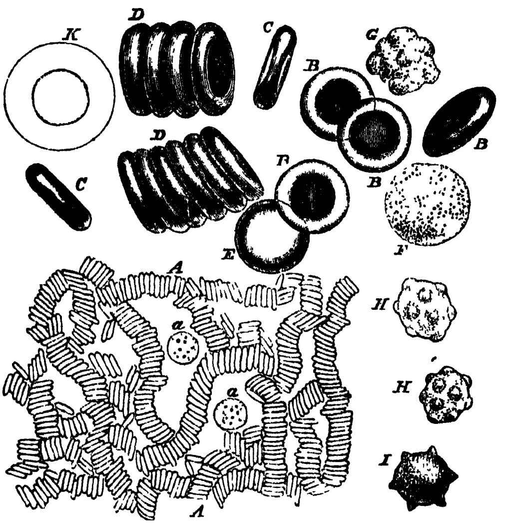

FIG. 17.—RED AND WHITE CORPUSCLES OF THE BLOOD MAGNIFIED.

A. Moderately magnified. The red corpuscles are seen lying in rouleaux; at *a* and *a* are seen two white corpuscles.
B. Red corpuscles much more highly magnified, seen in face; *C*. ditto, seen in profile; *D*. ditto, in rouleaux, rather more highly magnified; *E*. a red corpuscle swollen into a sphere by imbibition of water.
F. A white corpuscle magnified same as *B*.; *G*. ditto, throwing out some blunt processes; *K*. ditto, treated with acetic acid, and showing nucleus magnified same as *D*.
H. Red corpuscles puckered or crenate all over.
I. Ditto, at the edge only.

edges, and when viewed under the microscope, by transmitted light, looks clear in the middle and darker at the edges, or dark in the middle and clear at the edges, according to circumstances. When, on the other hand, the disks roll over and present their edges to the eye, they look like rods. All these varieties of appearance may be made intelligible by turning a round biscuit or muffin, bodies similar in shape to the red corpuscles, in various ways before the eye.

The red corpuscles are very soft, flexible, and elastic bodies, so that they readily squeeze through apertures and passages narrower than their own diameters, and immediately resume their proper shapes (Fig. 16, *G.H.*). The exterior of each corpuscle is denser than its interior, which contains a semi-fluid, or quite fluid matter, of a red colour, called *hæmoglobin*. By proper processes this may be resolved into an albuminous substance sometimes called *globulin*, and a peculiar colouring matter, which is called *hæmatin*. The interior substance presents no distinct structure.

From the density of the outer as compared with the inner substance of each corpuscle, they are, practically, small flattened bags, or sacs, the form of which may be changed by altering the density of the plasma. Thus, if it be made denser by dissolving saline substances, or sugar, in it, water is drawn from the contents of the corpuscle to the dense plasma, and the corpuscle becomes still more flattened and very often much wrinkled. On the other hand, if the plasma be diluted with water, the latter forces itself into and dilutes the contents of the corpuscle, causing the latter to swell out, and even become spherical; and, by adding dense and weak solutions alternately, the corpuscles may be made to become successively spheroidal and discoidal. Exposure to carbonic acid gas seems to cause the corpuscles to swell out; oxygen gas, on the contrary, appears to flatten them.

5. The *colourless corpuscles* (Fig. 17, *a a*, *F. G. K.*) are larger than the red corpuscles, their average diameter being $\frac{1}{2500}$th of an inch. They are further seen, at a glance, to differ from the red corpuscles by the extreme irregularity of their form, and by their tendency to attach themselves to the glass slide, while the red corpuscles float about and tumble freely over one another.

A still more remarkable feature of the colourless corpuscles than the irregularity of their form is the unceasing variation of shape which they exhibit. The form of a red corpuscle is changed only by influences from without, such as pressure, or the like; that of the colourless corpuscle is undergoing constant alteration, as the result of changes taking place in its own substance. To see these changes well, a microscope with a magnifying power of five or six hundred diameters is requisite; and, even then, they are so gradual that the best way to ascertain their existence is to make a drawing of a given colourless corpuscle at intervals of a minute or two. This is what has been done with the corpuscle represented in Fig. 18, in which *a* represents the form of the corpuscle when first observed; *b*, its form a minute afterwards; *c*, that at the end of the second; *d*, that at the end of the third; and *e*, that at the end of the fifth minute.

FIG. 18.—SUCCESSIVE FORMS ASSUMED BY COLOURLESS CORPUSCLES OF HUMAN BLOOD. (Magnified about 600 diameters.)

The interval between the forms *a*,*b*,*c*,*d*, was a minute; between *d* and *e* two minutes; so that the whole series of changes from *a* to *e* took five minutes.

Careful watching of a colourless corpuscle, in fact, shows that every part of its surface is constantly changing—undergoing active contraction, or being passively dilated by the contraction of other parts. It exhibits *contractility* in its lowest and most primitive form.

6. While they are thus living and active, no correct notion can be formed of the structure of the colourless corpuscles. By diluting the blood with water, or, still better, with water acidulated with acetic acid, the corpuscles are killed, and become distended, so that their real nature is shown. They are then seen to be spheroidal bags, or sacs, with very thin walls; and to contain in their interior a fluid which is either clear or granular, together with a spheroidal vesicular body, which is called

the *nucleus* (Fig. 17, *K*). It sometimes, though very rarely, happens that the nucleus has a red tint.

The sac-like colourless corpuscle, with its nucleus, is what is called a *nucleated cell*. It will be observed that it lives in a free state in the plasma of the blood, and that it exhibits an independent contractility. In fact, except that it is dependent for the conditions of its existence upon the plasma, it might be compared to one of those simple organisms which are met with in stagnant water, and are called *Amœbæ*.

7. That the red corpuscles are in some way or other derived from the colourless corpuscles may be regarded as certain : but the steps of the process have not been made out with perfect certainty. There is very great reason, however, for believing that the red corpuscle is simply the nucleus of the colourless corpuscle somewhat enlarged; flattened from side to side; changed, by development within its interior of a red colouring matter; and set free by the bursting of the sac or wall of the colourless corpuscle. In other words, the red corpuscle is a free nucleus.

The origin of the colourless corpuscles themselves is not certainly determined; but it is highly probable that they are constituent cells of particular parts of the solid substance of the body which have been detached and carried into the blood, and that this process is chiefly effected in what are called the *ductless glands* (Lesson V. § 27), from whence the detached cells pass, as *lymph-corpuscles*, directly or indirectly, into the blood.

The following facts are of importance in their bearing on the relation between the different kinds of corpuscles :—

(*a*) The invertebrate animals,[1] which have true blood-corpuscles, possess only such as resemble the colourless corpuscles of man.

(*b*) The lowest vertebrate animal, the Lancelet (*Amphioxus*), possesses only colourless corpuscles; and the very young embryos[2] of all vertebrate animals have only colourless and nucleated corpuscles.

[1] Invertebrate animals are animals devoid of backbones, such as insects, snails, sea-anemones, &c. Vertebrate animals are fishes, amphibia, reptiles, birds, and mammals.

[2] An embryo is the rudimentary unborn young of any creature

(*c*) All the vertebrated animals, the young of which are born from eggs,[1] have two kinds of corpuscles—colourless corpuscles, like those of man, and large red-coloured corpuscles, which are generally oval, and further differ from those of man in presenting a nucleus. In fact, they are simply the colourless corpuscles enlarged and coloured.

(*d*) All animals which suckle their young (or what are called mammals) have, like man, two kinds of corpuscles; colourless ones, and small coloured corpuscles—the latter being always flattened, and devoid of any nucleus. They are usually circular, but in the camel tribe they are elliptical. And it is worthy of remark that, in these animals, the nuclei of the colourless corpuscles become elliptical.

(*e*) The colourless corpuscles differ much less from one another in size and form, in the vertebrate series, than the coloured. The latter are smallest in the little Musk Deer, in which animal they are about a quarter as large as those of a man. On the other hand, the red corpuscles are largest in the *Amphibia* (or Frogs and Salamanders), in some of which animals they are ten times as long as in man.

8. As the blood dies, its several constituents, which have now been described, undergo marked changes.

The *colourless corpuscles* lose their contractility, but otherwise undergo little alteration. They tend to cohere neither with one another, nor with the red corpuscles, but adhere to the glass plate on which they are placed.

It is quite otherwise with the *red corpuscles*, which at first, as has been said, float about and roll, or slide, over each other quite freely. After a short time (the length of which varies in different persons, but usually amounts to two or three minutes), they seem, as it were, to become sticky, and tend to cohere; and this tendency increases until, at length, the great majority of them become applied face to face, so as to form long series, like rolls of coin. The end of one roll cohering with the sides of another, a network of various degrees of closeness is produced (Fig. 17, *A*.).

The corpuscles remain thus coherent for a certain length of time, but eventually separate and float freely

[1] These are fishes, amphibia, reptiles, and birds.

again. The addition of a little water, or dilute acids or saline solutions, will at once cause the rolls to break up.

It is from this running of the corpuscles together into patches of network that the change noted above in the appearances of the layer of blood, viewed with a lens, arises. So long as the corpuscles are separate, the sandy appearance lasts; but when they run together, the layer appears patchy or spotted.

The red corpuscles rarely, if ever, all run together into rolls, some always remaining free in the meshes of the net. In contact with air, or if subjected to pressure, many of the red corpuscles become covered with little knobs, so as to look like minute mulberries—an appearance which has been mistaken for a breaking up, or spontaneous division, of the corpuscles (Fig. 17, *H. H.*).

9. There is a still more remarkable change which the red blood-corpuscles occasionally undergo. Under certain circumstances, the peculiar red substance which forms the chief mass of their contents, and which has been called *hæmoglobin* (from its readily breaking up into globulin and hæmatin, § 6), separates in a crystalline form. In man, these crystals have the shape of prisms; in other animals they take other forms. Human blood crystallizes with difficulty, but that of the guinea-pig, rat, or dog much more easily. The best way to see these *blood-crystals* is to take a little rat's blood, from which the fibrin has been removed, shake it up with a little ether, and let it stand in the cold for some hours. A sediment will form at the bottom, which, when examined with the microscope, will be found to consist of long narrow crystals. Crystallization is much assisted by adding after the ether a small quantity of alcohol.

10. When the layer of blood has been drawn ten or fifteen minutes, the plasma will be seen to be no longer clear. It then exhibits multitudes of extremely delicate filaments of a substance called *Fibrin*, which have been deposited from it, and which traverse it in all directions, uniting with one another and with the corpuscles, and binding the whole into a semi-solid mass.

It is this deposition of fibrin which is the cause of the apparent solidification, or coagulation, of the drop upon the second slide; but the phenomena of coagulation, which are of very great importance, cannot be properly understood until the behaviour of the blood, when drawn in larger quantity than a drop, has been studied.

11. When, by the ordinary process of opening a vein with a lancet, a quantity of blood is collected into a basin, it is at first perfectly fluid: but in a very few minutes it becomes, through coagulation, a jelly-like mass, so solid that the basin may be turned upside down without any of the blood being spilt. At first the clot is a uniform red jelly, but very soon drops of a clear yellowish watery-looking fluid make their appearance on the surface of the clot, and on the sides of the basin. These drops increase in number, and run together, and after a while it has become apparent that the originally uniform jelly has separated into two very different constituents—the one a clear, yellowish liquid; the other a red, semi-solid mass, which lies in the liquid, and at the surface is paler in colour and firmer than in its deeper part.

The liquid is called the *serum;* the semi-solid mass the clot, or *crassamentum.* Now the clot obviously contains the corpuscles of the blood, bound together by some other substance; and this last, if a small part of the clot be examined microscopically, will be found to be that fibrous-looking matter, *fibrin*, which has been seen forming in the thin layer of blood. Thus the clot is equivalent to the corpuscles *plus* the fibrin of the plasma, while the serum is the plasma *minus* the fibrinous elements which it contained.

. The corpuscles of the blood are slightly heavier than the plasma, and therefore, when the blood is drawn, they sink very slowly towards the bottom. Hence the upper part of the clot contains fewer corpuscles, and is lighter in colour, than the lower part—there being fewer corpuscles left in the upper layer of plasma for the fibrin to catch when it sets. And there are some conditions of the blood in which the corpuscles run together much more rapidly and in denser masses than usual. Hence they more readily overcome the resistance of the plasma to their falling, just as feathers stuck together in masses fall much more rapidly through the air than the same feathers when loose. When this is the case, the upper stratum of plasma is quite free from red corpuscles before the fibrin forms in it; and, consequently, the uppermost layer of the clot is nearly white: it receives the name of the *buffy coat.*

After the clot is formed, the fibrin shrinks and squeezes out much of the serum contained within its meshes; and, other things being equal, it contracts the more the fewer corpuscles there are in the way of its shrinking. Hence, when the buffy coat is formed, it usually contracts so much as to give the clot a cup-like upper surface.

Thus the buffy coat is fibrin naturally separated from the red corpuscles; the same separation may be effected, artificially, by whipping the blood with twigs as soon as it is drawn, until its coagulation is complete. Under these circumstances the fibrin will collect upon the twigs, and a red fluid will be left behind, consisting of the serum *plus* the red corpuscles, and many of the colourless ones.

13. The coagulation of the blood is hastened, retarded, or temporarily prevented by many circumstances.

(*a*) *Temperature.*—A high temperature accelerates the coagulation of the blood; a low one retards it very greatly; and some experimenters have stated that, when kept at a sufficiently low temperature, it does not coagulate at all.

(*b*) *The addition of soluble matter to the blood.*—Many saline substances, and more especially sulphate of soda and common salt, dissolved in the blood in sufficient quantity, prevent its coagulation; but coagulation sets in when water is added, so as to dilute the saline solution.

(*c*) *Contact with living or not living matter.*—Contact with not living matter promotes the coagulation of the blood. Thus, blood drawn into a basin begins to coagulate first where it is in contact with the sides of the basin; and a wire introduced into a living vein will become coated with fibrin, although perfectly fluid blood surrounds it.

On the other hand, direct contact with living matter retards, or altogether prevents, the coagulation of the blood. Thus blood remains fluid for a very long time in a portion of a vein which is tied at each end.

The heart of a turtle remains alive for a lengthened period (many hours or even days) after it is extracted from the body; and, so long as it remains alive, the blood contained in it will not coagulate, though, if a portion of the same blood be removed from the heart, it will coagulate in a few minutes.

Blood taken from the body of the turtle, and kept from coagulating by cold for some time, may be poured into the separated, but still living, heart. and then will not coagulate.

Freshly deposited fibrin acts somewhat like living matter, coagulable blood remaining fluid for a long time in tubes coated with such fibrin.

14. The coagulation of the blood is an altogether physico-chemical process, dependent upon the properties of certain of the constituents of the plasma, apart from the vitality of that fluid. This is proved by the fact that if blood-plasma be prevented from coagulating by cold, and greatly diluted, a current of carbonic acid passed through it will throw down a white powdery substance. If this white substance be dissolved in a weak solution of common salt, or in an extremely weak solution of potash or soda, it, after a while, coagulates, and yields a clot of true pure fibrin. It would be absurd to suppose that a substance which has been precipitated from its solution, and redissolved, still remains alive.

There are reasons for believing that this white substance consists of two constituents of very similar composition, which exist separately in living blood, and the union of which is the cause of the act of coagulation. These reasons may be briefly stated thus:—The pericardium and other serous cavities in the body contain a clear fluid, which has exuded from the blood-vessels, and contains the elements of the blood without the blood-corpuscles. This fluid sometimes coagulates spontaneously, as the blood plasma would do, but very often shows no disposition to spontaneous coagulation. When this is the case, it may nevertheless be made to coagulate, and yield a true fibrinous clot, by adding to it a little serum of blood.

Now, if serum of blood be largely diluted with water and a current of carbonic acid be gas passed through it, a white powdery substance will be thrown down; this, redissolved in a dilute saline, or extremely dilute alkaline, solution will, when added to the pericardial fluid, produce even as good a clot as that obtained with the original serum.

This white substance has been called *globulin*. It exists not only in serum, but also, though in smaller quantities, in connective tissue, in the cornea, in the humours of the eye, and in some other fluids of the body.

It possesses the same general chemical properties as the albuminous substance which enters so largely into the composition of the red corpuscles (§ 4), and hence, at present, bears the same name. But when treated with chemical reagents, even with such as do not produce any appreciable effect on its chemical composition, it very speedily loses its peculiar power of causing serous fluids to coagulate. For instance, this power is destroyed by an excess of alkali, or by the presence of acids.

Hence, though there is great reason to believe that the *fibrino-plastic globulin* (as it has been called) which exists in serum does really come from the red corpuscles, the globulin which is obtained in large quantities from these bodies, by the use of powerful reagents, has no coagulating effect at all on pericardial or other serous fluids.

Though globulin is so susceptible of change when in solution, it may be dried at a low temperature and kept in the form of powder for many months, without losing its coagulating power.

Thus *globulin*, added, under proper conditions, to serous effusion, is a coagulator of that effusion, giving rise to the development of fibrin in it.

It does so by its interaction with a substance contained in the serous effusion, which can be extracted by itself, and then plays just the same part towards a solution of globulin, as globulin does towards its solution. This substance has been called *fibrinogen*. It is exceedingly like globulin, and may be thrown down from serous exudation by carbonic acid, just as globulin may be precipitated from the serum of the blood. When redissolved in an alkaline solution, and added to any fluid containing globulin, it acts as a coagulator of that fluid, and gives rise to the development of a clot of fibrin in it. In accordance with what has just been stated, serum of blood which has completely coagulated may be kept in one vessel, and pericardial fluid in another, for an indefinite period, if spontaneous decomposition be prevented, without the coagulation of either. But let them be mixed, and coagulation sets in.

Thus it seems to be clear, that the coagulation of the blood, and the formation of fibrin, are caused primarily by the interaction of two substances (or two modifications of the same substance), *globulin or fibrinoplastin* and *fibrinogen*, the former of which may be obtained from the serum of the blood, and from some tissues of the body; while the latter is known, at present, only in the plasma of the blood, of the lymph, and of the chyle, and in fluids derived from them.

15. The proverb that "blood is thicker than water" is literally true, as the blood is not only "thickened" by the corpuscles, of which it has been calculated that no fewer than 70,000,000,000 (eighty times the number of the human population of the globe) are contained in a cubic inch, but is rendered slightly viscid by the solid matters dissolved in the plasma. The blood is thus rendered heavier than water, its specific gravity being about 1055. In other words, twenty cubic inches of blood have about the same weight as twenty-one cubic inches of water.

The corpuscles are heavier than the plasma, and their volume is usually somewhat less than that of the plasma. Of colourless corpuscles there are usually not more than three or four for every thousand of red corpuscles; but the number varies very much, increasing shortly after food is taken, and diminishing in the intervals between meals.

The blood is hot, its temperature being about 100° Fahrenheit.

16. Considered chemically, the blood is an alkaline fluid, consisting of water, of solid and of gaseous matters.

The proportions of these several constitutents vary according to age, sex, and condition, but the following statement holds good on the average :—

In every 100 parts of the blood there are 79 parts of water and 21 parts of dry solids; in other words, the water and the solids of the blood stand to one another in about the same proportion as the nitrogen and the oxygen of the air. Roughly speaking, one quarter of the blood is dry, solid matter; three quarters water. Of the 21 parts of dry solids, 12 ($=\frac{4}{7}$ths) belong to the corpuscles. The remaining 9 are about two-thirds (6·7 parts $=\frac{2}{7}$ths) albumin (a substance like white of egg, coagulating by heat), and one-third ($=\frac{1}{7}$th of the whole solid matter) a mixture of saline, fatty, and saccharine matters, sundry products of the waste of the body, and fibrin. The quantity of the latter constituent is remarkably small in relation to the conspicuous part it plays in the act of coagulation. Healthy blood, in fact, yields in coagulating not more than from two to four parts in a thousand of its weight of fibrin.

The total quantity of gaseous matter contained in the blood is equal to rather less than half the *volume* of the blood; that is to say, 100 cubic inches of blood will contain rather less than 50 cubic inches of gases. These gaseous matters are carbonic acid, oxygen, and nitrogen; or, in other words, the same gases as those which exist in the atmosphere, but in totally different proportions; for whereas air contains nearly three-fourths nitrogen, one-fourth oxygen, and a mere trace of carbonic acid, the average composition of the blood gases is nearly two-thirds carbonic acid, rather less than one-third oxygen, and not one-tenth nitrogen.

It is important to observe that blood contains much more oxygen gas than could be held in solution by pure water at the same temperature and pressure. This power of holding oxygen appears in some way to depend upon the corpuscles, firstly, because mere serum has no greater power of absorbing oxygen than pure water has; and secondly, because red corpuscles suspended in water instead of serum absorb oxygen very readily. The oxygen thus held by the red corpuscles is readily given up by them for purposes of oxidation, and indeed can be removed from them by means of a mercurial gas pump. It would appear that the connection between the oxygen and the red corpuscles is of a peculiar nature, being a sort of loose chemical combination with one of their constituents, that constituent being the hæmoglobin; for solutions of hæmoglobin behave towards oxygen exactly as blood does.

The corpuscles differ chemically from the plasma, in containing a large proportion of the fats and phosphates, all the iron, and almost all the potash, of the blood; while the plasma, on the other hand, contains by far the greater part of the chlorine and the soda.

17. The blood of adults contains a larger proportion of solid constituents than that of children, and that of men more than that of women; but the difference of sex is hardly at all exhibited by persons of flabby, or what is called lymphatic, constitution.

Animal diet tends to increase the quantity of the red corpuscles; a vegetable diet and abstinence to diminish them. Bleeding exercises the same influence in a still more marked degree, the quantity of red corpuscles being diminished thereby in a much greater proportion than that of the other solid constituents of the blood.

18. The total quantity of blood contained in the body varies at different times, and the precise ascertainment of its amount is very difficult. It may probably be estimated, on the average, at not less than one-thirteenth of the weight of the body.

19. The function of the blood is to supply nourishment to, and take away waste matters from, all parts of the body. It is absolutely essential to the life of every part of the body that it should be in such relation with a current of blood, that matters can pass freely from the blood to it, and from it to the blood, by transudation through the walls of the vessels in which the blood is contained. And this vivifying influence depends upon the corpuscles of the blood. The proof of these statements lies in the following experiments:—If the vessels of a limb of a living animal be tied in such a manner as to cut off the supply of blood from the limb, without affecting it in any other way, all the symptoms of death will set in. The limb will grow pale and cold, it will lose its sensibility, and volition will no longer have power over it; it will stiffen, and eventually mortify and decompose.

But, even when the death stiffening has begun to set in, if the ligatures be removed, and the blood be allowed to flow into the limb, the stiffening speedily ceases, the temperature of the part rises, the sensibility of the skin returns, the will regains power over the muscles, and, in short, the part returns to its normal condition.

If, instead of simply allowing the blood of the animal operated upon to flow again, such blood, deprived of its fibrin by whipping, but containing its corpuscles, be artificially passed through the vessels, it will be found as effectual a restorative as entire blood; while, on the other hand, the serum (which is equivalent to whipped blood without its corpuscles) has no such effect

It is not necessary that the blood thus artificially injected should be that of the subject of the experiment. Men, or dogs, bled to apparent death, may be at once and effectually revived by filling their veins with blood taken from another man, or dog; an operation which is known by the name of *transfusion.*

Nor is it absolutely necessary for the success of this operation that the blood used in transfusion should belong to an animal of the same species. The blood of a horse will permanently revive an ass, and, speaking generally, the blood of one animal may be replaced without injurious effects by that of another closely-allied species; while that of a very different animal will be more or less injurious, and may even cause immediate death.

20. The *Lymph*, which fills the lymphatic vessels, is, like the Blood, an alkaline fluid, consisting of a plasma and corpuscles, and coagulates by the separation of fibrin from the plasma. The lymph differs from the blood in its corpuscles being all of the colourless kind, and in the very small proportion of its solid constituents, which amount to only about 5 per cent. of its weight. Lymph may, in fact, be regarded as blood *minus* its red corpuscles, and diluted with water, so as to be somewhat less dense than the serum of blood, which contains about 8 per cent. of solid matters.

A quantity of fluid equal to that of the blood is probably poured into the blood, daily, from the lymphatic system. This fluid is in great measure the mere overflow of the blood itself—plasma which has exuded from the capillaries into the tissues, and which has not been taken up again into the venous current; the rest is due to the absorption of chyle from the alimentary canal.

LESSON IV.

RESPIRATION.

1. THE blood, the general nature and properties of which have been described in the preceding Lesson, is the highly complex product, not of any one organ or constituent of the body, but of all. Many of its features are doubtless given to it by its intrinsic and proper structural elements, the corpuscles; but the general character of the blood is also profoundly affected by the circumstance that every other part of the body takes something from the blood and pours something into it. The blood may be compared to a river, the nature of the contents of which is largely determined by that of the head waters, and by that of the animals which swim in it; but which is also very much affected by the soil over which it flows, by the water-weeds which cover its banks, and by affluents from distant regions; by irrigation works which are supplied from it, and by drain-pipes which flow into it.

2. One of the most remarkable and important of the changes effected in the blood is that which results, in most parts of the body, from its simply passing through capillaries, or, in other words, through vessels the walls of which are thin enough to permit a free exchange between the blood and the fluids which permeate the adjacent ti[illegible]; (Lesson II. § 1).

Thus, if blood be taken from the artery which supplies a limb, it will be found to have a bright scarlet colour; while blood drawn, at the same time, from the vein of the limb, will be of a purplish hue, so dark that it is comcalled "black blood." And as this contrast is met with in the contents of the arteries and veins in general (except the pulmonary artery and veins), the scarlet blood is commonly known as *arterial*, and the black blood as *venous*.

This conversion of arterial into venous blood takes place in most parts of the body, while life persists. Thus, if a limb be cut off and scarlet blood be forced into its arteries by a syringe, it will issue from the veins as black blood.

3. When specimens of venous and of arterial blood are subjected to chemical examination, the differences pre-

small and inconstant. As a rule, there is rather

and rather more fatty matter. But the gaseous contents of the two kinds of blood differ widely in the proportion which the carbonic acid gas bears to the oxygen; there being a smaller quantity of oxygen and a greater quantity of carbonic acid, in venous than in arterial blood.

And it may be experimentally demonstrated that this difference in their gaseous contents is the only essential difference between venous and arterial blood. For if venous blood be shaken up with oxygen, or even with air, it gains oxygen, loses carbonic acid, and takes on the colour and properties of arterial blood. Similarly, if arterial blood be treated with carbonic acid so as to be thoroughly saturated with that gas, it gains carbonic acid, loses oxygen, and acquires the true properties of venous blood; though, for a reason to be mentioned below, the

is not so complete in this case as in the former. The same result is attained, though more slowly, if the blood, in either case, be received into a bladder, and then placed in the carbonic acid, or oxygen gas; the thin moist animal membrane allowing the change to be effected with perfect ease, and offering no serious impediment to the passage of either gas.

4. The physico-chemical processes involved in the exchange of carbonic acid for oxygen when venous is converted into arterial blood, or the reverse, in the cases mentioned above, are not thoroughly understood, and are probably somewhat complex.

It is known (*a*) that gases, mechanically held by a fluid in a given proportion, ten
to which they are exposed, unti
sphere in corresponding proportions; and (*b*) that gases separated by a dry porous partition, or simply in contact, diffuse into one another with a rapidity which is inversely proportioned to the square roots of their densities. A knowledge of these physical principles does, in a rough way, lead us to see how the gases contained in the blood may effect an exchange with those in the air, whether the blood be freely exposed, or enclosed in a membrane.

But the application of these principles gives no more than this sort of general insight. For, in the first place, when arterialization takes place through the walls of a bladder, or any other thin animal membrane, the matter is complicated by the circumstance that moisture dissolves carbonic acid far more freely than it will oxygen; hence a wet bladder has a very different action upon carbonic acid from that which it has upon oxygen. A moist bladder, partially filled with oxygen, and suspended in carbonic acid gas, becomes rapidly distended, in consequence of the carbonic acid gas passing into it with much greater rapidity than the oxygen passes out. Secondly, the gases of the blood are not held in a merely mechanical way in it; the oxygen seems to be loosely combined with the red corpuscles (Lesson III. § 16), and there is reason to think that a great part, at least, of the carbonic acid, is chemically connected, in a similarly loose way, with certain saline constituents of the serum. Hence the arterialization of blood in the lungs seems to be a very mixed process, partly physical, and yet, to a certain extent chemical, and consequently very difficult to analyse.

The same may also be said of the change from arterial to venous blood in the tissues. Owing to the peculiar relation of oxygen to the red blood-corpuscles, the process which takes place in the tissues is not a simple interchange by diffusion of the oxygen of the blood for the carbonic acid of the tissues; on the contrary, the oxygen is given up for purposes of oxidation, the demand being determined by the supply of oxidizable materials in the tissue, while the blood, poor in carbonic acid, takes up, apparently by an independent action, a quantity of that gas from the tissues rich in it.

Hence venous blood is characterized not only by the large amount of carbonic acid present, but also by the fact that the red corpuscles have given up a good deal of their oxygen for the purposes of oxidation, or, as the chemists would say, have become reduced. This is the reason why arterial blood is not so easily converted into venous blood by exposure to carbonic acid as venous blood into arterial by exposure to oxygen. There is, in the former case, a want of some oxidizable substance to carry off the oxygen from and so to reduce the red corpuscles. When such an oxidizable substance is added (as, for instance, a salt of iron), the blood at once and immediately becomes completely venous.

Practically we may say that the most important difference between venous and arterial blood is not so much the relative quantities of carbonic acid as that the red corpuscles of venous blood have lost a good deal of oxygen, are reduced, and ready at once to take up any oxygen offered to them.

5. The cause of the change of colour of the blood—of its darkening when exposed to carbonic acid, and its brightening when under the influence of oxygen—is not thoroughly understood. There is reason to think, however, that the red corpuscles are rendered somewhat

4). Under the former circumstances they may, not improbably, reflect the light more strongly, so as to give a more distinct coloration to the blood; while, under the latter, they may reflect less light, and, in that way, allow the blood to appear darker and duller.

This, however, is not the whole of the matter; for solutions of hæmoglobin or of blood-crystals (Lesson III. § 9), even when perfectly free from actual blood-corpuscles, change in colour from scarlet to purple, according as they gain or lose oxygen. It has already been stated (Lesson III. § 16) that oxygen most probably exists in the blood in loose combination with hæmoglobin. But, further, there is evidence to show that a solution of hæmoglobin, when thus loosely combined with oxygen, has a scarlet colour, while a solution of hæmoglobin, deprived of oxygen, has a purplish hue. Hence arterial blood, in which the hæmoglobin is richly provided with oxygen, would naturally be scarlet, while venous blood, which not only contains an excess of carbonic acid, but whose hæmoglobin also has lost a great deal of its oxygen, would be purple.

6. Whatever may be their explanation, however, the facts are certain (1), that arterial blood, separated by only a thin membrane from carbonic acid, or from a fluid containing a greater amount of carbonic acid than itself, and also carrying certain oxidizable materials, becomes venous; and (2) that venous blood, separated by only a thin membrane from oxygen, or a fluid containing a greater proportion of free oxygen than itself, becomes arterial.

In these facts lies the explanation of the conversion of scarlet blood into dark blood as it passes through the [illegible] of the body, for the latter [illegible] juices of the tissues, which contain carbonic acid, the product of their waste and combustion, in excess, together with highly oxidizable matters. On the other hand, if we seek for the explanation of the conversion of the dark blood in the veins into the scarlet blood of the arteries, we find, 1st, that the blood remains dark in the right auricle, the right ventricle, and the pulmonary [illegible] 2nd, that it is scarlet not only in the aorta, but in [illegible] left ventricle, the left auricle, and the pulmonary veins. Obviously, then, the change from venous to arterial takes place in the pulmonary capillaries, for these are the sole channels of communication between the pulmonary arteries and the pulmonary veins.

7. But what are the physical conditions to which the blood is exposed in the pulmonary capillaries?

These vessels are very wide, thin walled, and closely set, so as to form a network with very small meshes, which is contained in the substance of an extremely thin membrane. This membrane is in contact with the air, so that the blood in each capillary of the lung is separated from the air by only a delicate pellicle formed by its own wall and the lung membrane. Hence an exchange very readily takes place between the blood and the air; the latter gaining moisture and carbonic acid, and losing oxygen (Lesson I. §§ 23, 24).[1]

This is the essential step in respiration: that it really takes place may be demonstrated very readily, by the experiment described in the first Lesson (§ 3), in which air expired was proved to differ from air inspired, by containing more heat, more water, more carbonic acid, and less oxygen; or, on the other hand, by putting a ligature on the windpipe of a living animal so as to prevent air from passing into, or out of, the lungs, and then examining the contents of the heart and great vessels. The blood on both sides of the heart, and in the pulmonary veins and aorta, will be found to be as completely venous as in the venæ cavæ and pulmonary artery.

But though the passage of carbonic acid gas and hot watery vapour out of the blood and of oxygen into it is the essence of the respiratory process—and thus a membrane with blood on one side, and air on the other, is all that is absolutely necessary to effect the purification of the blood—yet the accumulation of carbonic acid is so rapid, and the need for oxygen so incessant, in all parts of the human body, that the former could not be cleared away, nor the latter supplied, with adequate rapidity, without the aid of extensive and complicated accessory machinery—the arrangement and working of which must next be carefully studied.

8. The back of the mouth or *pharynx* communicates by two channels with the external air (see Fig. 40). One of these is formed by the nasal passages, which cannot be closed by any muscular apparatus of their own; the other is presented by the mouth, which can be shut or opened at will.

Immediately behind the tongue, at the lower and front part of the pharynx, is an aperture—the *glottis* (Fig. 19, *Gl.*)—capable of being closed by a sort of lid—the *epiglottis*—or by the shutting together of its side boundaries, formed by the so-called *vocal chords*. The glottis

[1] The student must guard himself against the idea that arterial blood contains no carbonic acid, and venous blood no oxygen. In passing through the lungs venous blood loses only a part of its carbonic acid; and arterial blood, in passing through the tissues, loses only a part of its oxygen. In blood, however venous, there is in health always some oxygen; and in even the brightest arterial blood there is actually more carbonic acid than oxygen.

opens into a chamber with cartilaginous walls — the *larynx;* and leading from the larynx downwards along the front part of the throat, where it may be very readily felt, is the *trachea*, or windpipe (Fig. 19, *Tr.*).

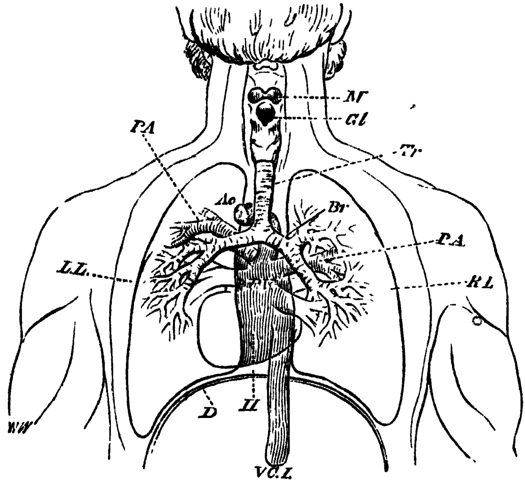

FIG 19.—BACK VIEW OF THE NECK AND THORAX OF A HUMAN SUBJECT FROM WHICH THE VERTEBRAL COLUMN AND WHOLE POSTERIOR WALL OF THE CHEST ARE SUPPOSED TO BE REMOVED.

M. mouth ; *Gl.* glottis ; *Tr.* trachea ; *L.L.* left lung ; *R.L.* right lung ; *Br.* bronchus ; *P.A.* pulmonary artery ; *P V.* pulmonary veins ; *Ao.* aorta ; *D.* diaphragm ; *H.* heart ; *V.C.I.* vena cava inferior.

If the trachea be handled through the skin, it will be found to be firm and resisting. Its walls are, in fact, strengthened by a series of cartilaginous hoops, which hoops are incomplete behind, their ends being united only by muscle and membrane, where the trachea comes into contact with the gullet, or *œsophagus.* The trachea passes into the thorax, and there divides into two branches, a right and a left, which are termed the *bronchi* (Fig. 19, *Br.*). Each bronchus enters the lung of its own side, and then breaks up into a great number of smaller branches, which are called the *bronchial tubes*. As these diminish in size, the cartilages, which are continued all through the bronchi and their large ramifications, become smaller and eventually disappear, so that the walls of the smallest bronchial tubes are entirely muscular or membranous. Thus while the trachea and bronchi are kept permanently open and pervious to air by their cartilages, the smaller bronchial tubes may be almost closed by the contraction of their muscular walls.

The finer bronchial tubes end at length in elongated dilatations, about $\frac{1}{70}$th of an inch in diameter on the average (Fig. 20, A). Each of these dilatations is beset with, or perhaps rather is made up of, little sacs, which open irregularly into the cavity of the dilatation. These sacs are the *air-cells*. The very thin walls (Fig. 20, B) which separate these air-cells are supported by much delicate and highly elastic tissue, and carry the wide and close-set capillaries into which the ultimate ramifications of the pulmonary artery pour its blood (Fig. 20, D). Thus, the blood contained in these capillaries is exposed on both sides to the air—being separated from the air-cell on either hand only by the very delicate pellicle which forms the wall of the capillary, and the lining of the air-sac.

9. Hence no conditions can be more favourable to a ready exchange between the gaseous contents of the blood and those of the air in the air-cells, than the arrangements which obtain in the pulmonary capillaries; and, thus far, the structure of the lung fully enables us to understand how it is that the large quantity of blood poured through the pulmonary circulation becomes exposed in very thin streams, over a large surface, to the air. But the only result of this arrangement would be, that the pulmonary air would very speedily lose all its oxygen, and become completely saturated with carbonic acid, if special provision were not made for its being incessantly renewed.

10. If an adult man, breathing calmly in the sitting position, be watched, the respiratory act will be observed to be repeated thirteen to fifteen times every minute. Each act consists of certain components which succeed one another in a regular rhythmical order. First, the breath is drawn in, or *inspired*; immediately afterwards

it is driven out, or *expired;* and these successive acts of *inspiration* and *expiration* are followed by a brief pause. Thus, just as in the rhythm of the heart the auricular systole, the ventricular systole, and then a pause follow in

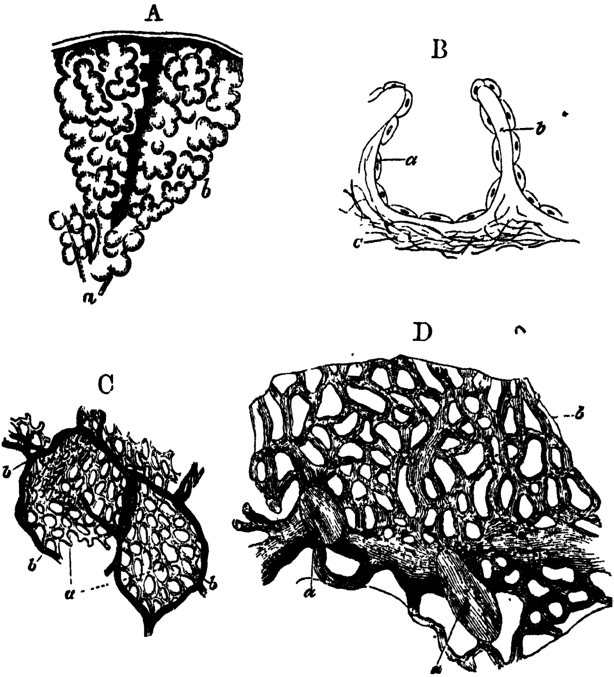

FIG. 20.

A. Two air-cells (*b*) with the ultimate bronchial tube (*a*) which opens into them. (Magnified 20 diameters.)

B. Diagrammatic view of an air-cell of A seen in section: *a*, epithelium; *b*, partition between two adjacent cells, in the thickness of which the capillaries run; *c*, fibres of elastic tissue

C. Portion of injected lung magnified: *a*, the capillaries spread over the walls of two adjacent air-cells; *b*, small branches of arteries and veins.

D. Portion still more highly magnified.

regular order; so in the chest, the inspiration, the expiration, and then a pause succeed one another. At each inspiration of an adult well-grown man about thirty cubic inches of air are inspired; and at each expiration the same, or a slightly smaller, volume (allowing for the increase of temperature of the air so expired) is given out of the body.

11. The expired air differs from the air inspired in the following particulars:—

(*a*) Whatever the temperature of the external air is, that expired is nearly as hot as the blood, or has a temperature between 98° and 100°.

(*b*) However dry the external air may be, that expired is quite, or nearly, saturated with watery vapour.

(*c*) Though ordinary air contains nearly 2,100 parts of oxygen, and 7,900 of nitrogen, with not more than 3 parts of carbonic acid, in 10,000 parts, expired air contains about 470 parts of carbonic acid, and only between 1,500 and 1,600 parts of oxygen; while the quantity of nitrogen suffers little or no change. Speaking roughly, air which has been breathed once has gained five per cent. of , and lost five per cent. of

The expired air contains, in addition, a greater or less quantity of animal matter of a highly decomposable character.

(*d*) Very close analysis of the expired air shows, firstly, that the quantity of oxygen which disappears is always slightly in excess of the quantity of carbonic acid supplied; and secondly, that the nitrogen is variable—the expired nitrogen being sometimes slightly in excess of, sometimes slightly less than that inspired, and sometimes remaining stationary.

12. From three hundred and fifty to four hundred cubic feet of air are thus passed through the lungs of an adult man taking little or no exercise, in the course of twenty-four hours; and are charged with carbonic acid, and deprived of oxygen, to the extent of nearly five

This amounts to about eighteen cubic feet of the one gas taken in, and of the other given out. Thus, if a man be shut up in a close room, having the form of a cube seven feet in the side, every particle of air in that room will have passed through his lungs in twenty-four hours, and a fourth of the oxygen it contained will be replaced by carbonic acid.

The quantity of carbon eliminated in the twenty-four hours is pretty nearly represented by a piece of pure charcoal weighing eight ounces.

The quantity of water given off from the lungs in the twenty-four hours varies very much, but may be taken on the average as rather less than half a pint, or about nine It may fall below this amount, or increase to double or treble the quantity.

13. The mechanical arrangements by which the respiratory movements, essential to the removal of the great mass of effete matters, and the importation of the large quantity of oxygen indicated, are effected, may be found in—(*a*) the elasticity of the lungs; (*b*) the mobility of the sides and bottom of the thoracic cavity in which the lungs are contained.

The thorax may be regarded as a completely shut conical box, with the small end turned upwards, the back of the box being formed by the spinal column, the sides by the ribs, the front by the breast-bone, the bottom by the diaphragm, and the top by the root of the neck (Fig. 19).

The two lungs occupy almost all the cavity of this box which is not taken up by the heart. Each is enclosed in its serous membrane, the *pleura*, a double bag (very similar to the pericardium, the chief difference being that the outer bag of each pleura is, over the greater part of its extent, quite firmly adherent to the walls of the chest and the diaphragm (see Fig. 9), while the outer bag of the pericardium is for the most part loose), the inner bag closely covering the lung and the outer forming a lining to the cavity of the chest. So long as the walls of the thorax are entire, the cavity of each pleura is practically obliterated, that layer of the pleura which covers the lung being in close contact with that which lines the wall of the chest; but if a small opening be made into the pleura, the lung at once shrinks to a comparatively small size, and thus develops a great cavity between the two layers of the pleura. If a pipe be now fitted into the bronchus, and air blown through it, the lung is very readily distended to its full size; but, on being left to itself, it collapses, the air being driven out again with some force.

The abundant elastic tissues of the walls of the air-cells are, in fact, so disposed as to be greatly stretched when the lungs are full; and, when the cause of the distension is removed, this elasticity comes into play and drives the greater part of the air out again.

The lungs are kept distended in the dead subject, so long as the walls of the chest are entire, by the pressure

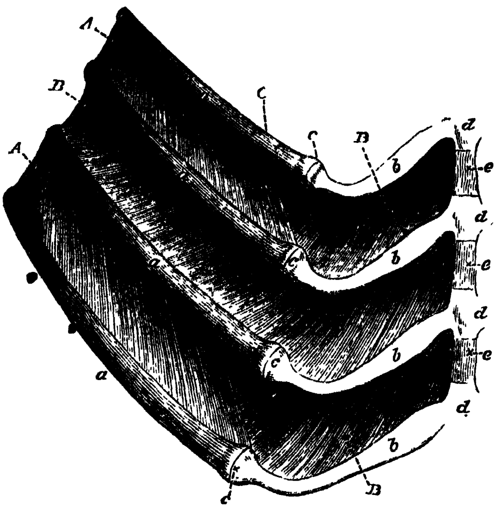

FIG. 21 —VIEW OF FOUR RIBS OF THE DOG WITH THE INTERCOSTAL MUSCLES.

a. The bony rib; *b*, the cartilage; *c*, the junction of bone and cartilage; *d*, unossified, *e*, ossified, portions of the sternum. *A*. External intercostal muscle. *B*. Internal intercostal muscle. In the middle interspace, the external intercostal has been removed to show the internal intercostal beneath it.

of the atmosphere. For though the elastic tissue is all the while pulling, as it were, at the layer of pleura which covers the lung, and attempting to separate it from that which lines the chest, it cannot produce such a separation without developing a vacuum between these two layers.

To effect this, the elastic tissue must pull with a force greater than that of the external air (or fifteen pounds to the square inch), an effort far beyond its powers, which do not equal more than one-fourth of a pound on the square inch. But the moment a hole is made in the pleura, the air enters into its cavity, the atmospheric pressure inside the lung is equalized by that outside it, and the elastic tissue, freed from its opponent, exerts its full power on the lung.

14. The lungs are elastic, whether alive or dead. During life the air which they contain may be further affected by the contractility of the muscular walls of the bronchial tubes. If water is poured into the lungs of a recently-killed animal, and a series of electric shocks is then sent through the bronchial tubes, the latter contract, and the water is forced out. Lastly, during life a further source of motion in the bronchial tubes is provided by the *cilia* —minute filaments attached to the epithelium of the tubes, which incessantly vibrate backwards and forwards, and work in such a manner as to sweep liquid and solid matters outwards, or towards the trachea.

15. The ribs are attached to the spine, so as to be freely moveable upon it; but when left to themselves they take a position which is inclined obliquely downwards and forwards.[1] Two sets of muscles, called *intercostals*, pass between the successive pairs of ribs on each side. The outer set, called *external intercostals* (Fig. 21, *A*), run from the rib above, obliquely downwards and forwards, to the rib below. The other set, *internal intercostals* (Fig. 21, *B*), cross these in direction, passing from the rib above, downwards and backwards, to the rib below.

The action of these muscles is somewhat puzzling at first, but is readily understood if the fact that *when a muscle contracts, it tends to make the distance between its two ends as short as possible*, be borne in mind. Let *a* and *b* in Fig. 22, A, be two parallel bars, moveable by their ends upon the upright *c*, which may be regarded as at the back of the apparatus, then a line directed from *x*

[1] I purposely neglect the consideration of the cartilages of the ribs, and some other points, in order not to complicate the question unnecessarily. It may, however, be stated that those fibres of the internal intercostals which are situate between the cartilages act like the external, and raise the ribs.

to *y* will be inclined downwards and forwards, and one from *w* to *z* will be directed downwards and backwards. Now it is obvious that there is one position of the rods, and one only, in which the points *x* and *y* are at the shortest possible distance, and one position only in which the points *w* and *z* are at the shortest possible distance; and these are, for *x* and *y* the position B, and for *w* and *z*

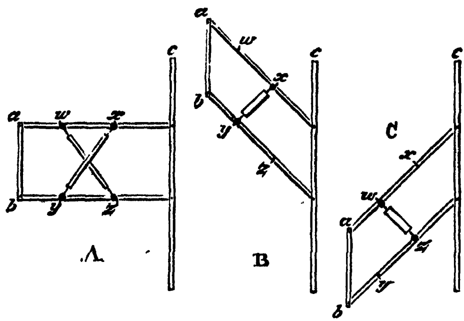

FIG. 22.—DIAGRAM OF MODELS ILLUSTRATING THE ACTION OF THE EXTERNAL AND INTERNAL INTERCOSTAL MUSCLES.

B, inspiratory elevation; C, expiratory depression.

the position C. These positions are respectively such that the points *x*, *y*, and *w*, *z*, are at the ends of straight lines perpendicular to both rods.

Thus, to bring *x* and *y* into this position, the parallel rods in A must move upwards; and to bring *w* and *z* into it, they must move in the opposite way.

If the simple apparatus just described be made of wood, hooks being placed at the points *x*, *y*, and *w*, *z*; and an elastic band, as long when left to itself as the shortest distance between these points, be provided with eyes which can be readily put on to or taken off these hooks: it will be found that when the bars are in the horizontal position, A, the elasticity of the band, when hooked on to *x* and *y*, will bring them up into the position shown in Fig. 22, B; while, if hooked on to *w* and *z*, it will force them down into the position shown in Fig. 22, C.

Substitute the contractility of the external and internal intercostal muscles for the elasticity of the band, and the latter will precisely exemplify their action; and it is thus proved that the external intercostals must raise, and the internal intercostals must depress, the bony ribs.

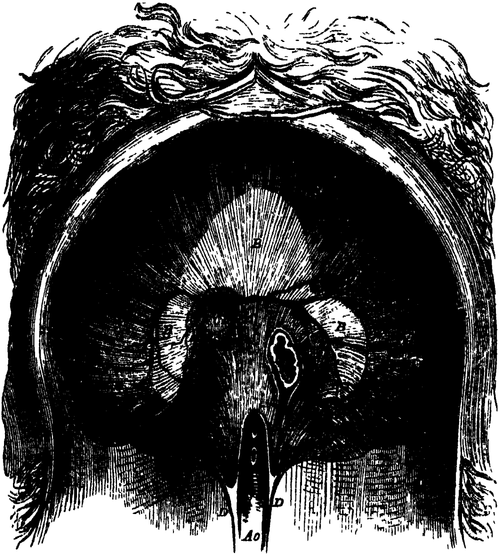

FIG. 23.—THE DIAPHRAGM OF A DOG VIEWED FROM THE LOWER OR ABDOMINAL SIDE.

V C.I. the vena cava inferior; *O.* the œsophagus; *Ao.* the aorta; the broad white tendinous middle (*B*) is easily distinguished from the radiating muscular fibres (*A*) which pass down to the ribs and into the pillars (*C D*) in front of the vertebræ.

16. The diaphragm is a great partition situated between the thorax and the abdomen, and always concave to the latter and convex to the former (Fig. 1, *D*). From its middle, which is tendinous, muscular fibres extend downwards and outwards to the ribs, and two, especially

strong masses, which are called the *pillars of the diaphragm*, to the spinal column (Fig. 23). When these muscular fibres contract, therefore, they tend to make the diaphragm flatter, and to increase the capacity of the thorax at the expense of that of the abdomen, by pulling down the bottom of the thoracic box (Fig. 24, *A*).

17. Let us now consider what would be the result of the action of the parts of the respiratory apparatus, which have been described, if the diaphragm alone should begin to contract at regular intervals.

When it contracts it increases the vertical dimensions of the thoracic cavity, and tends to pull away the lining of the bottom of the thoracic box from that which covers the bases of the lungs; but the air immediately rushing in at the trachea, proportionately increases the distension of the lungs, and prevents the formation of any vacuum between the two pleuræ of either lung in this region. When the diaphragm ceases to contract, so much of the elasticity of the lungs as was neutralized by the contraction of the diaphragm, comes into play, and the extra air taken in is driven out again. We have, in short, an *Inspiration* and an *Expiration*.

Suppose on the other hand that, the diaphragm being quiescent, the external intercostal muscles contract. The ribs will be raised from their oblique position, the antero-posterior dimensions of the thoracic cavity will be increased, and the lungs will be distended as before to balance the enlargement. If now the external intercostals relax, the action of gravity upon the ribs, the elasticity of the cartilages and more especially that of the lungs, will alone suffice to bring back the ribs to their previous positions and to drive out the extra air; but this expiratory action may be greatly aided by the contraction of the internal intercostals.

18. Thus it appears that we may have either *diaphragmatic respiration*, or *costal respiration*. As a general rule, however, not only do the two forms of respiration coincide and aid one another—the contraction of the diaphragm taking place at the same time with that of the external intercostals, and its relaxation with the contraction of the internal intercostals—but sundry other accessory agencies come into play. Thus, the muscles which connect the

ribs with parts of the spine above them, and with the shoulder, may, more or less extensively, assist inspiration; while those which connect the ribs and breastbone with the pelvis, and form the front and side walls of the abdomen, are powerful aids to expiration. In fact they assist expiration in two ways: first, directly, by pulling down the ribs; and next, indirectly, by pressing the viscera of the abdomen upwards against the under surface of the diaphragm, and so driving the floor of the thorax upwards.

It is for this reason that, whenever a violent expiratory effort is made, the walls of the abdomen are obviously flattened and driven towards the spine, the body being at the same time bent forwards.

In taking a deep inspiration, on the other hand, the walls of the abdomen are relaxed and become convex, the viscera being driven against them by the descent of the diaphragm—the spine is straightened, the head thrown back, and the shoulders outwards, so as to afford the greatest mechanical advantage to all the muscles which can elevate the ribs.

19. It is a remarkable circumstance that the mechanism of respiration is somewhat different in the two sexes. In men, the diaphragm takes the larger share in the process, the upper ribs moving comparatively little; in women, the reverse is the case, the respiratory act being more largely the result of the movement of the ribs.

Sighing is a deep and prolonged inspiration. "*Sniffing*" is a more rapid inspiratory act, in which the mouth is kept shut, and the air made to pass through the nose.

Coughing is a violent expiratory act. A deep inspiration being first taken, the glottis is closed and then burst open by the violent compression of the air contained in the lungs by the contraction of the expiratory muscles, the diaphragm being relaxed and the air driven through the mouth. In *sneezing*, on the contrary, the cavity of the mouth being shut off from the pharynx by the approximation of the soft palate and the base of the tongue, the air is forced through the nasal passages.

20. It thus appears that the thorax, the lungs, and the trachea constitute a sort of bellows without a valve, in which the thorax and the lungs represent the body of the bellows, while the trachea is the pipe; and the effect of

the respiratory movements is just the same as that of the approximation and separation of the handles of the bellows, which drive out and draw in the air through the pipe. There is, however, one difference between the bellows and the respiratory apparatus, of great importance in the theory of respiration, though frequently

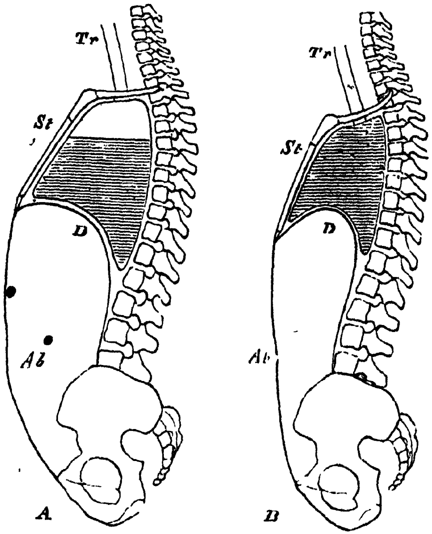

FIG. 24.—DIAGRAMMATIC SECTIONS OF THE BODY IN *A*. inspiration; *B*. expiration. *Tr* trachea; *St* sternum; *D* diaphragm; *Ab*. abdominal walls. The shading roughly indicates the stationary air.

overlooked; and that is, that the sides of the bellows can be brought close together so as to force out all, or nearly all, the air which they contain; while the walls of the chest, when approximated as much as possible, still enclose a very considerable cavity (Fig. 24, *B*); so that, even after the most violent expiratory effort, a very large quantity of air is left in the lungs.

The amount of this air which cannot be got rid of, and is called *Residual air*, is, on the average, from 75 to 100 cubic inches.

About as much more in addition to this remains in the chest after an ordinary expiration, and is called *Supplemental air.*

In ordinary breathing, 20 to 30 cubic inches of what is conveniently called *Tidal air* pass in and out. It follows that, after an ordinary inspiration, $100 + 100 + 30 = 230$ cubic inches, may be contained in the lungs. By taking the deepest possible inspiration, another 100 cubic inches, called *Complemental air*, may be added.

21. It results from these data that the lungs, after an ordinary inspiration, contain about 230 cubic inches of air, and that only about one-seventh to one-eighth of this amount is breathed out and taken in again at the next inspiration. Apart from the circumstance, then, that the fresh air inspired has to fill the cavities of the hinder part of the mouth, and the trachea, and the bronchi, if the lungs were mere bags fixed to the ends of the bronchi, the inspired air would descend so far only as to occupy that one-fourteenth to one-sixteenth part of each bag which was nearest to the bronchi, whence it would be driven out again at the next expiration. But as the bronchi branch out into a prodigious number of bronchial tubes, the inspired air can only penetrate for a certain distance along these, and can never reach the air-cells at all.

Thus the residual and supplemental air taken together are, under ordinary circumstances, *stationary*—that is to say, the air comprehended under these names merely shifts its outer limit in the bronchial tubes, as the chest dilates and contracts, without leaving the lungs; the *tidal* air, alone, being that which leaves the lungs and is renewed in ordinary respiration.

It is obvious, therefore, that the business of respiration is essentially transacted by the stationary air, which plays the part of a middleman between the two parties—the blood and the fresh tidal air—who desire to exchange their commodities, carbonic acid for oxygen, and oxygen for carbonic acid.

Now there is nothing interposed between the fresh tidal air and the stationary air; they are aëriform fluids, in complete contact and continuity, and hence the exchange between them must take place according to the ordinary laws of gaseous diffusion.

22. Thus, the stationary air in the air-cells gives up oxygen to the blood, and takes carbonic acid from it, though the exact mode in which the change is effected is not thoroughly understood. By this process it becomes loaded with carbonic acid, and deficient in oxygen, though to what precise extent is not known. But there must be a very much greater excess of the one, and deficiency of the other, than is exhibited by inspired air, seeing that the latter acquires its composition by diffusion in the short space of time (four to five seconds) during which it is in contact with the stationary air.

In accordance with these facts, it is found that the air expired during the first half of an expiration contains less carbonic acid than that expired during the second half. Further, when the frequency of respiration is increased without altering the volume of each inspiration, though the percentage of carbonic acid in each inspiration is diminished, it is not diminished in the same ratio as that in which the number of inspirations increases; and hence more carbonic acid is got rid of in a given time.

Thus, if the number of inspirations per minute is increased from fifteen to thirty, the percentage of carbonic acid evolved in the second case remains more than half of what it was in the first case, and hence the total evolution is greater.

23. Of the various mechanical aids to the respiratory process, the nature and workings of which have now been described, one, the elasticity of the lungs, is of the nature of a dead, constant force. The action of the rest of the apparatus is under the control of the nervous system, and varies from time to time.

As the nasal passages cannot be closed by their own action, air has always free access to the pharynx; but the glottis, or entrance to the windpipe, is completely under the control of the nervous system—the smallest irritation about the mucous membrane in its neighbourhood being conveyed, by its nerves, to that part of the cerebro-spinal axis which is called the *medulla oblongata* (see Lesson XI. § 16). The medulla oblongata, thus stimulated, gives rise, by a process which will be explained hereafter, termed *reflex action*, to the contraction of the muscles which close the glottis, and commonly, at the same time, to a violent contraction of the expiratory muscles, producing a cough (see § 19).

The muscular fibres of the smaller bronchial tubes, no less than the respiratory pump itself, formed by the walls and floor of the thorax, are under the complete control of the nerves which supply the muscles, and which are brought into action in consequence of impressions conveyed to that part of the brain which is called the medulla oblongata, by the pneumogastric and other nerves.

24. From what has been said, it is obvious that there are many analogies between the circulatory and the respiratory apparatus. Each consists, essentially, of a kind of pump which distributes a fluid (aëriform in the one case, liquid in the other) through a series of ramified distributing tubes to a system of cavities (capillaries or air-cells), the volume of the contents of which is greater than that of the tubes.

In each, the pump is the cause of the motion of the fluid, though that motion may be regulated, locally, by the contraction, or relaxation, of the muscular fibres contained in the walls of the distributing tubes. But, while the rhythmic movement of the heart chiefly depends upon a nervous apparatus placed within itself, that of the respiratory apparatus results mainly from the operation of a nervous centre lodged in the medulla oblongata.

25. As there are certain secondary phenomena which accompany, and are explained by, the action of the heart, so there are secondary phenomena which are similarly related to the working of the respiratory apparatus. These are—(*a*) the respiratory sounds, and (*b*) the effect of the inspiratory and expiratory movements upon the circulation.

26. The *respiratory sounds* or *murmurs* are audible when the ear is applied to any part of the chest which covers one or other of the lungs. They accompany inspiration and expiration, and very much resemble the sounds produced by breathing through the mouth, when the lips are so applied together as to leave a small

interval. Over the bronchi the sounds are louder than over the general surface. It would appear that these sounds are produced by the motion of the air along the air-passages.

27. In consequence of the elasticity of the lungs, a certain force must be expended in distending them, and this force is found experimentally to become greater and greater the more the lung is distended; just as, in stretching a piece of india-rubber, more force is required to stretch it a good deal than is needed to stretch it only a little. Hence, when inspiration takes place, and the lungs are distended with air, the heart and the great vessels in the chest are subjected to a less pressure than are the blood-vessels of the rest of the body.

For the pressure of the air contained in the lungs is exactly the same as that exerted by the atmosphere upon the surface of the body; that is to say, fifteen pounds on the square inch. But a certain amount of this pressure exerted by the air in the lungs is counterbalanced by the elasticity of the distended lungs. Say that in a given condition of inspiration a pound pressure on the square inch is needed to overcome this elasticity, then there will be only fourteen pounds pressure on every square inch of the heart and great vessels. And hence the pressure on the blood in these vessels will be one pound per square inch less than that on the veins and arteries on the rest of the body. If there were no aortic, or pulmonary, valves, and if the composition of the vessels, and the pressure upon the blood in them, were everywhere the same, the result of this excess of pressure on the surface would be, to drive all the blood from the arteries and veins of the rest of the body into the heart and great vessels contained in the thorax. And thus the diminution of the pressure upon the thoracic blood cavities produced by inspiration, would, practically, suck the blood from all parts of the body towards the thorax. But the suction thus exerted, while it hastened the flow of blood to the heart in the veins, would equally oppose the flow from the heart to the arteries, and the two effects would balance one another.

As a matter of fact, however, we know—

(1.) That the blood in the great arteries is constantly under a very considerable pressure, exerted by their elastic walls; while that of the veins is under little pressure.

(2.) That the walls of the arteries are strong and resisting, while those of the veins are weak and flabby.

(3.) That the veins have valves opening towards the heart; and that, during the diastole, there is no resistance of any moment to the free passage of blood into the heart; while, on the other hand, the cavity of the arteries is shut off from that of the ventricle during the diastole, by the closure of the semilunar valves.

Hence it follows that equal pressures applied to the surface of the veins and to that of the arteries must produce very different effects. In the veins the pressure is something which did not exist before; and, partly from the presence of valves, partly from the absence of resistance in the heart, partly from the presence of resistance in the capillaries, it all tends to accelerate the flow of blood *towards* the heart. In the arteries, on the other hand, the pressure is only a fractional addition to that which existed before; so that, during the systole, it only makes a comparatively small addition to the resistance which has to be overcome by the ventricle; and during the diastole, it superadds itself to the elasticity of the arterial walls in driving the blood onwards towards the capillaries, inasmuch as all progress in the opposite direction is stopped by the semilunar valves.

It is, therefore, clear that the inspiratory movement, on the whole, helps the heart, inasmuch as its general result is to drive the blood the way that the heart propels it.

28. In expiration, the difference between the pressure of the atmosphere on the surface, and that which it exerts on the contents of the thorax through the lungs, becomes less and less in proportion to the completeness of the expiration. Whenever, by the ascent of the diaphragm and the descent of the ribs, the cavity of the thorax is so far diminished that pressure is exerted on the great vessels, the veins, owing to the thinness of their walls, are especially affected, and a check is given to the flow of blood in them, which may become visible as a *venous pulse* in the great vessels of the neck. In its effect on the arterial trunks, expiration, like inspiration, is, on the whole, favourable to the circulation; the increased resistance to the

opening of the valves during the ventricular systole being more than balanced by the advantage gained in the addition of the expiratory pressure to the elastic reaction of the arterial walls during the diastole.

When the skull of a living animal is laid open and the brain exposed, the cerebral substance is seen to rise and fall synchronously with the respiratory movements; the rise corresponding with expiration, and being caused by the obstruction thereby offered to the flow of the blood in the veins of the head and neck.

29. Hitherto, I have supposed the air-passages to be freely open during the inspiratory and expiratory movements. But if, the lungs being distended, the mouth and nose are closed, and a strong expiratory effort is then made, the heart's action may be stopped altogether.[1] And the same result occurs if, the lungs being partially emptied, and the nose and mouth closed, a strong inspiratory effort is made. In the latter case the excessive distension of the right side of the heart, in consequence of the flow of blood into it, may be the cause of the arrest of the heart's action; but in the former, the reason of the stoppage is not very clear.

30. The activity of the respiratory process is greatly modified by the circumstances in which the body is placed. Thus, cold greatly increases the quantity of air which is breathed, the quantity of oxygen absorbed, and of carbonic acid expelled: exercise and the taking of food have a corresponding effect.

In proportion to the weight of the body, the activity of the respiratory process is far greatest in children, and diminishes gradually with age.

The excretion of carbonic acid is greatest during the day, and gradually sinks at night, attaining its minimum about midnight, or a little after.

Recent observations appear to show that the rule that the quantity of oxygen taken in by respiration is, approximately, equal to that given out by expiration, only holds good for the total result of twenty-four hours' respiration. Much more oxygen appears to be given out during the day-time (in combination with carbon as carbonic acid) than is absorbed; while, at night, much more oxygen is

[1] There is danger in attempting this experiment.

absorbed than is excreted as carbonic acid during the same period. And it is very probable that the deficiency of oxygen towards the end of the waking hours, which is thus produced, is one cause of the sense of fatigue which comes on at that time. This difference between day and night is, however, not constant, and appears to depend a good deal on the time when food is taken.

The quantity of oxygen which disappears in proportion to the carbonic acid given out, is greatest in carnivorous, least in herbivorous animals—greater in a man living on a flesh diet, than when the same man is feeding on vegetable matters.

31. When a man is strangled, drowned, or choked, or is, in any other way, prevented from inspiring or expiring sufficiently pure atmospheric air, what is called *asphyxia* comes on. He grows "black in the face;" the veins become turgid; insensibility, not unfrequently accompanied by convulsive movements, sets in, and he is dead in a few minutes.

But, in this asphyxiating process, two deadly influences of a distinct nature are co-operating; one is the *deprivation of oxygen*, the other is the *excessive accumulation of carbonic acid* in the blood. Oxygen starvation and carbonic acid poisoning, each of which may be fatal in itself, are at work together.

The effects of oxygen starvation may be studied separately, by placing a small animal under the receiver of an air-pump and exhausting the air; or by replacing the air by a stream of hydrogen or nitrogen gas. In these cases no accumulation of carbonic acid is permitted, but, on the other hand, the supply of oxygen soon becomes insufficient, and the animal quickly dies. And if the experiment be made in another way, by placing a small mammal, or bird, in air from which the carbonic acid is removed as soon as it is formed, the animal will nevertheless die as soon as the amount of oxygen is reduced to 10 per cent. or thereabouts.

The directly poisonous effect of carbonic acid, on the other hand, has been very much exaggerated. A very large quantity of pure carbonic acid (10 to 15 or 20 per cent.) may be contained in air, without producing any very serious immediate effect, if the quantity of oxygen be simultaneously increased. And it is possible that what appear to be the directly poisonous effects of carbonic acid may really arise from its taking up the room that ought to be occupied by oxygen. If this be the case, carbonic acid is a negative rather than a positive poison.

Whichever may be the more potent agency, the effect of the two, as combined in asphyxia, is to produce an obstruction, firstly, in the pulmonary circulation, and, secondly, in the veins of the body generally. The lungs and the right side of the heart, consequently, become gorged with blood, while the arteries and left side of the heart gradually empty themselves of the small supply of dark and unaërated blood which they receive. The heart becomes paralysed, partly by reason of the distension of its right side, but chiefly from being supplied with venous blood; and all the organs of the body gradually cease to act.

32. Sulphuretted hydrogen, so well known by its offensive smell, has long had the repute of being a positive poison. But its evil effects appear to arise chiefly, if not wholly, from the circumstance that its hydrogen combines with the oxygen carried by the blood-corpuscles, and thus gives rise, indirectly, to a form of oxygen starvation.

Carbonic oxide gas has a much more serious effect, as it turns out the oxygen from the blood-corpuscles, and forms a combination of its own with the hæmoglobin. The compound thus formed is only very gradually decomposed by fresh oxygen, so that if any large proportion of the blood-corpuscles be thus rendered useless, the animal dies before restoration can be effected.

Badly made common gas sometimes contains 20 to 30 per cent. of carbonic oxide; and, under these circumstances, a leakage of the pipes in a house may be extremely perilous to life.

33. It is not necessary, however, absolutely to strangle, or drown, a man, in order to asphyxiate him. As, other things being alike, the rapidity of diffusion between two gaseous mixtures depends on the difference of the proportions in which their constituents are mixed, it follows that the more nearly the composition of the tidal air approaches that of the stationary air, the slower will be the diffusion of carbonic acid outwards and of oxygen

inwards, and the more charged with carbonic acid and defective in oxygen will the air in the air-cells become. And, on diminishing the proportion of oxygen or increasing the proportion of carbonic acid in the tidal air, a point will at length be reached when the change effected in the stationary air is too slight to enable it to relieve the pulmonary blood of its carbonic acid, and to supply it with oxygen to the extent required for its arterialization. In this case the blood, which passes into the aorta, and is thence distributed to the heart and the body generally, being venous, all the symptoms of insensibility, loss of muscular power, and the like, which have been enumerated above as the results of supplying the brain and muscles with venous blood, will follow, and a stage of suffocation, or asphyxia, will supervene.

34. Asphyxia takes place whenever the proportion of carbonic acid in tidal air reaches 10 per cent. (the oxygen being diminished in like proportion). And it makes no difference whether this condition of the tidal air is brought about by shutting out fresh air, or by augmenting the number of persons who are consuming the same air; or by suffering combustion, in any shape, to carry off oxygen from the air.

But the deprivation of oxygen, and the accumulation of carbonic acid, cause injury, long before the asphyxiating point is reached. Uneasiness and headache arise when less than one per cent. of the oxygen of the air is replaced by other matters; while the persistent breathing of such air tends to lower all kinds of vital energy, and predisposes to disease.

Hence the necessity of sufficient air and of ventilation for every human being. To be supplied with respiratory air in a fair state of purity, every man ought to have at least 800 cubic feet of space[1] to himself, and that space ought to be freely accessible, by direct or indirect channels, to the atmosphere.

[1] A cubical room nine feet high, wide and long, contains only 729 cubic feet of air.

LESSON V.

THE SOURCES OF LOSS AND OF GAIN TO THE BLOOD.

1. THE blood which has been aërated, or arterialized, by the process described in the preceding Lesson, is carried from the lungs by the pulmonary veins to the left auricle, and is then forced by the auricle into the ventricle, and by the ventricle into the aorta. As that great vessel traverses the thorax, it gives off several large arteries, by means of which blood is distributed to the head, the arms, and the walls of the body. Passing through the diaphragm (Fig. 23), the aortic trunk enters the cavity of the abdomen, and becomes what is called the *abdominal aorta*, from which vessels are given off to the viscera of the abdomen. Finally, the main stream of blood flows into the *iliac* arteries, whence the viscera of the pelvis and the legs are supplied.

Having traversed the ultimate ramifications of the arteries, the blood, as we have seen, enters the capillaries. Here the products of the waste of the tissues constantly pour into it; and, as the blood is everywhere full of corpuscles, which, like all other living things, decay and die, the results of their decomposition everywhere accumulate in it. It follows that, if the blood is to be kept pure, the waste matters thus incessantly poured into, or generated in it, must be as constantly got rid of, or excreted.

2. Three distinct sets of organs are especially charged with this office of continually excreting carbonic acid, water, and urea. They are the *Lungs*, the *Kidneys*, and

the *Skin* (see Lesson I. § 23). These three great organs may therefore be regarded as so many drains from the blood—as so many channels by which it is constantly losing substance.

Further, the blood, as it passes through the capillaries, is constantly losing matter by exudation into the surrounding tissues.

Another kind of loss takes place from the surface of the body generally, and from the interior of the air-passages and lungs. Heat is constantly being given off from the former by radiation, evaporation, and conduction: from the latter, chiefly by evaporation.

3. The blood which enters the liver is constantly losing material to that organ; but the loss is only temporary, as almost all the matter lost, converted into sugar and into bile, re-enters the current of the circulation in the liver itself, or elsewhere.

Again, the loss of matter by the lungs in expiration is partially made good by the no less constant gain which results from the quantity of oxygen absorbed at each inspiration: while the combustion which is carried on in the tissues, by means of this oxygen, is the source not only of the heat which is given off through the lungs, but also of that which is carried away from the general surface of the body. And the loss by exudation from the capillaries is, in some degree, compensated by the gain from the lymphatics and ductless glands.

4. In the instances just mentioned the loss and gain are constant, and go on while life and health last. But there are certain other operations which cause either loss or gain to the blood, and which are not continuous, but take place at intervals.

These are, on the side of loss, the actions of the many *secretory glands*, which separate certain substances from the blood at recurrent periods, in the intervals of which they are quiescent.

On the side of gain are the contractions of the *muscles*, which, during their activity, cause a great quantity of waste materials to appear in the blood; and the operations of the *alimentary canal*, which, for a certain period after food has been taken, pour new materials into the blood.

Under some circumstances, the skin, by absorbing fluids, may become a source of gain.

5. The sources of loss and gain to the blood may be conveniently arranged in the following tabular form :—

A. INCESSANTLY ACTIVE SOURCES OF LOSS OR GAIN TO THE BLOOD.[1]

a. Sources of loss.

I. *Loss of matter.*

1. The lungs (carbonic acid, water).
2. The kidneys (urea, water, salines).
3. The skin (water, carbonic acid).
4. The liver (bile, glycogen).
5. The tissues generally (constructive material).

II. *Loss of heat.*

1. The free surfaces of the body.

b. Sources of gain.

I. *Gain of matter.*

1. The lungs (oxygen).
2. The liver (sugar, &c.).
3. The lymphatics (corpuscles, lymph).
4. The tissues generally (waste matters).
5. The spleen and other ductless glands.

II. *Gain of heat.*

1. The blood itself and the tissues generally.

B. INTERMITTENTLY ACTIVE SOURCES OF LOSS OR GAIN TO THE BLOOD.

a. Source of loss.

1. Many secreting glands (secretions).

b. Sources of gain.

1. The muscles (waste matters).
2. The alimentary canal (food some constituents of the bile).
3. The skin (absorption of liquids occasionally).

[1] The learner must be careful not to confound the losses and gains of the *blood* with the losses and gains of the *body* as a whole. The two differ in much the same way as the internal commerce of a country differs from its export and import trade.

according to the time of day; the temperature and moisture of the air; the fasting or replete condition of the alimentary canal; and t

Urea and uric acid are both composed of the elements carbon, hydrogen, oxygen, and nitrogen; but the urea is by far the more soluble in water, and greatly exceeds the uric acid in quantity.

An average healthy man excretes by the kidneys about fifty ounces, or 24,000 grains of water a day. In this are dissolved 500 grains of urea, but not more than 10 to 12 grains of uric acid.

The amount of other animal matters, and of saline substances, varies from one-third as much to nearly the same amount as the urea. The saline matters consist chiefly of common salt, phosphates and sulphates of potash, soda, lime, and magnesia. The gases are the same as those in the blood,—namely, carbonic acid, oxygen, and nitrogen. But the quantity is, proportionally, less than one-third as great; and the carbonic acid is in very large, while the oxygen is in very small, amount.

The average specific gravity does not differ very widely from that of blood serum, being 1·020.

8. The excretion of nitrogenous waste and water, with a little carbonic acid, by the kidneys, is thus strictly comparable to that of carbonic acid and water, by the lungs, in the air-cells of which carbonic acid and watery vapours are incessantly accumulating, to be periodically expelled by the act of expiration. But the operation of the renal apparatus differs from that of the respiratory organs, in the far longer intervals between the expulsory acts; and still more in the circumstance that, while the substance which the lungs take into the body is as important as those which they give out, the kidneys take in nothing.

9. It will be observed that all the chief constituents of the urine are already contained in the blood, and indeed, it might almost be said to be the blood devoid of its cor- ... albumin. Speaking broadly, it is such a fluid as might be separated from the blood by the help of any kind of filter which had the property of retaining these constituents, and letting the rest flow off. The filter required is found in the kidney, with the minute structure of which it is now necessary to become acquainted.

When a longitudinal section of a kidney is made (Fig. 26), the upper end of the ureter (*U*) seems to widen out into a basin-like cavity (*P*), which is called the *pelvis* of the kidney. Into this, sundry conical elevations, called

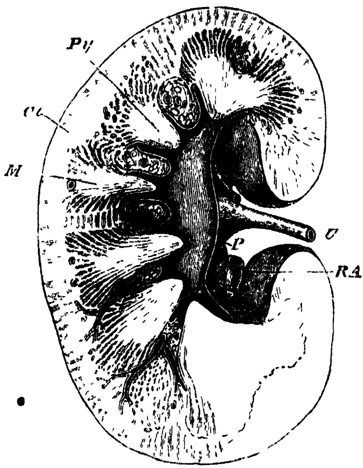

FIG. 26.—LONGITUDINAL SECTION OF THE HUMAN KIDNEY.

Ct, the cortical substance; *M*, the medullary substance; *P*, the pelvis of the kidney, *U*, the ureter; *RA*, the renal artery

the *pyramids* (*Py*) project; and their summits present multitudes of minute openings—the final terminations of the *tubuli*, of which the thickness of the kidney is chiefly made up. If the tubules be traced from their openings towards the outer surface, they are found, at first, to lie parallel with one another in bundles, which radiate towards the surface, and subdivide as they go; but at length they spread about irregularly, and become interlaced. From this circumstance, the middle, or *medullary*, part (marrow, *medulla*) of the kidney looks different from the superficial, or *cortical*, part (bark, *cortex*); but, in addition, the cortical part is more abundantly supplied with vessels than the medullary, and hence has a darker aspect. The great majority of the tubules after a very devious course ultimately terminate in dilatations (Fig. 28), which are called *Malpighian capsules.* Into the summit of each capsule, a small vessel (Figs. 28 and 29, *v.a*), one of the ultimate branches of the *renal artery* (Fig. 26, *RA*), enters (driving the thin wall of the capsule before it), and imme-

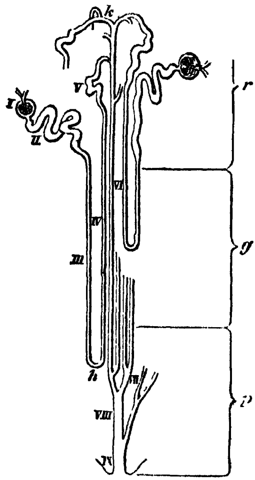

FIG. 27.—DIAGRAMMATIC VIEW OF THE COURSE OF THE TUBULES IN THE KIDNEY.

r, cortical portion answering to *Ct* in Fig. 26, *k* being close to the surface of the kidneys; *g*, *p*, medullary portion, *p* reaching to the summit of the pyramid.

IX, opening of tubule on the pyramid; *VIII*, *VII*, *VI*, the straight portion of the tubules; *V*– *II*, the twisted portion of the tubules; *I* the Malpighian capsule.

diately breaks up into a bunch of looped capillaries, called a *glomerulus* (Fig. 28, *g.l*), which nearly fills the cavity of the capsule. The blood is carried away from this *glomerulus* by a small vein (*v.e*), which does not, at once, join with other veins into a larger venous trunk, but opens into the network of capillaries (Fig. 29) which surrounds the tubule, thus repeating the portal circulation on a small scale.

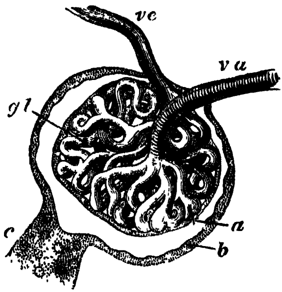

FIG. 28.—A MALPIGHIAN CAPSULE HIGHLY MAGNIFIED.

va, small branch of renal artery entering the capsule, breaking up into the glomerulus, *g l*, and finally joining again to form the vein, *v.e* *c*, the tubule; *a*, the epithelium over the glomerulus; *b*, the epithelium lining the capsule.

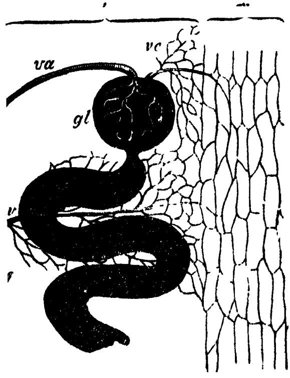

FIG. 29.—CIRCULATION IN THE KIDNEY.

ai, small branch of renal artery giving off the branch *va*, which enters glomerulus, issues as *ve*, and then breaks up into capillaries, which after surrounding the tubule find their way by *v* into *vi*, branch of the renal vein; *m*, capillaries around tubules in parts of the cortical substance where there are no g

The tubule has an epithelial lining (Fig. 28, *c*, and Fig 30, *a*), continuous with that of the pelvis of the kidney, and the urinary passages generally. The epithelium is thick and plain enough in the tubule, but it becomes very delicate, or even disappears, in the capsule and on the glomerulus (Fig. 28, *a*, *b*).

10. It is obvious from this description, that the surface of the glomerulus is, practically, free, or in direct communication with the exterior by means of the cavity of the tubule; and further, that, in each vessel of the glomerulus, a thin stream of blood constantly flows, only separated from the cavity of the tubule by the very delicate membrane of which the wall of the vessel is composed. The Malpighian capsule may, in fact, be regarded as a funnel, and the membranous walls of the glomerulus as a piece of very delicate filtering-paper, into which the blood is poured.

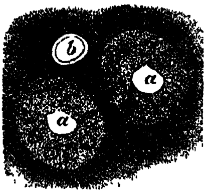

FIG. 30.—TRANSVERSE SECTION OF TWO TUBULES.
a.a. Canals of tubules surrounded by their epithelium.
b. A blood-vessel cut across.

11. The blood which supplies the kidneys is brought directly from the aorta by the renal arteries, so that it has but shortly left the heart. The venous blood which enters the heart, and is propelled to the lungs, charged with the nitrogenous, as well as with the other, products of waste, loses only an inappreciable quantity of the former in its course through the lungs; so that the arterial blood which fills the aorta is pure only as regards carbonaceous waste, while it is impure as regards urea and uric acid.

In the healthy condition, the walls of the minute renal arteries and veins are relaxed, so that the passage of the blood is very free; and but little waste, arising from muscular contraction in the walls of these vessels, is thrown into the renal blood. And as the urine which is separated from the renal blood contains proportionately less oxygen and more carbonic acid than the blood itself, any gain of carbonic acid from this source is probably at once counterbalanced. Hence, so long as the kidney is performing its functions properly, the blood which leaves the organ by the renal vein is as bright scarlet as that which enters it by the renal artery. Strictly speaking, it is the purest blood in the body, careful analysis having shown that it contains a sensibly smaller quantity of urea and of water than that of the left side of the heart. This difference is, of course, a necessary result of the excretion of the urinary fluid from the blood as it travels through the kidney.

As the renal veins pour their contents directly into the inferior vena cava (see Fig. 25), it follows that the blood in the upper part of this vein is so much the less impure, or venous, than that contained in the inferior vena cava, below the renal veins.

12. Irritation of the nerves which supply the walls of the vessels of the kidney has the immediate effect of stopping the excretion of urine, and rendering the renal blood dark and venous. The first effect would appear to be explicable by the diminution of the pressure exerted upon the blood in the Malpighian tufts, in consequence of the diminution in the size of the channels—the small arteries—by which the blood reaches them. And the second effect is probably, in part, a secondary result of the first—the excretion of carbonic acid by the urine ceasing with the suppression of that fluid; while, to a large extent, it is also the result of a pouring in of carbonic acid into the renal blood, in consequence of the work of the muscles of the small vessels, and the waste which results therefrom.

13. That the *skin* is a source of continual loss to the blood may be proved in various ways. If the whole body of a man, or one of his limbs, be enclosed in a caoutchouc bag, full of air, it will be found that this air undergoes changes which are similar in kind to those which take place in the air which is inspired into the lungs. That is to say, the air loses oxygen and gains carbonic acid; it also receives a great quantity of watery vapour, which condenses upon the sides of the bag, and may be drawn off by a properly disposed pipe.

Under ordinary circumstances no liquid water appears upon the surface of the integument, and the whole process receives the name of the *insensible perspiration*. But, when violent exercise is taken, or under some kinds of mental emotion, or when the body is exposed to a hot and moist atmosphere, the perspiration becomes *sensible;* that is, appears in the form of scattered drops upon the surface.

14. The quantity of *sweat*, or sensible perspiration, and also the total amount of both sensible and insensible perspiration, vary immensely, according to the temperature and other conditions of the air, and according to the state of the blood and of the nervous system. It is estimated that, as a general rule, the quantity of water excreted by the skin is about double that given out by the lungs in the same time. The quantity of carbonic acid is not above $\frac{1}{30}$th or $\frac{1}{40}$th of that excreted by the lungs; and it is not certain that in health any *appreciable* quantity of urea is given off.

In its normal state the sweat is acid, and contains fatty matters, even when obtained free from the fatty products of the *sebaceous glands*. Ordinarily, perspiration, as it collects upon the skin, is mixed with the fatty secretion of these glands; and, in addition, contains scales of the external layers of the epidermis, which are constantly being shed.

15. In analysing the process by which the perspiration is eliminated from the body, it must be recollected, in the first place, that the skin, even if there were no glandular structures connected with it, would be in the position of a moderately thick, permeable membrane, interposed between a hot fluid, the blood, and the atmosphere. Even in hot climates the air is, usually, far from being completely saturated with watery vapour, and in temperate climates it ceases to be so saturated the moment it comes into contact with the skin, the temperature of which is, ordinarily, twenty or thirty degrees above its own.

A bladder exhibits no sensible pores, but if filled with water and suspended in the air, the water will gradually ooze through the walls of the bladder, and disappear by evaporation. Now, in its relation to the blood, the skin is such a bladder full of hot fluid.

Thus, perspiration to a certain amount must always be going on through the substance of the integument; but what the amount of this perspiration may be cannot be accurately ascertained, because a second and very important source of the perspiration is to be found in what are

16. All over the body the integument presents minute apertures, the ends of channels excavated in the epidermis or scarf-skin, and each continuing the direction of a minute tube, usually about $\frac{1}{300}$th of an inch in diameter, and a quarter of an inch long, which is imbedded in the

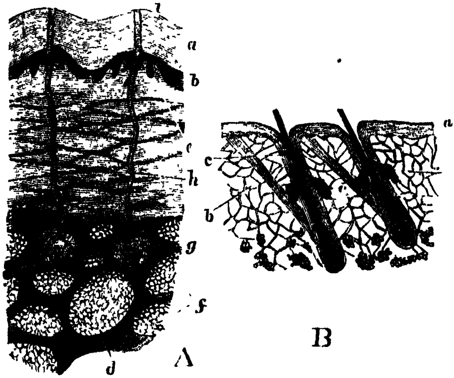

FIG. 31

A. Section of the skin showing the sweat-glands *a*, the epidermis; *b*, its deeper layer, the *rete Malpighii*; *c*,*d*, the dermis or true skin, *f*, fat cells; *g*, the coiled end of a sweat-gland, *h*, its duct, *i*, its opening on the surface of the epidermis

B. A section of the skin showing the roots of the hairs and the sebaceous glands. *b*, muscle of *c*, the hair sheath, on the left hand.

dermis. Each tube is lined with an epithelium continuous with the epidermis (Fig. 32, *e*). The tube sometimes divides, but, whether single or branched, its inner end or ends are blind, and coiled up into a sort of knot, interlaced with a meshwork of capillaries (Fig. 31, A *g*, and Fig. 33).

The blood in these capillaries is therefore separated from the cavity of the sweat-gland only by the thin walls of the capillaries, that of the glandular tube, and its epithelium, which, taken together, constitute but a very thin pellicle; and the arrangement, though different in

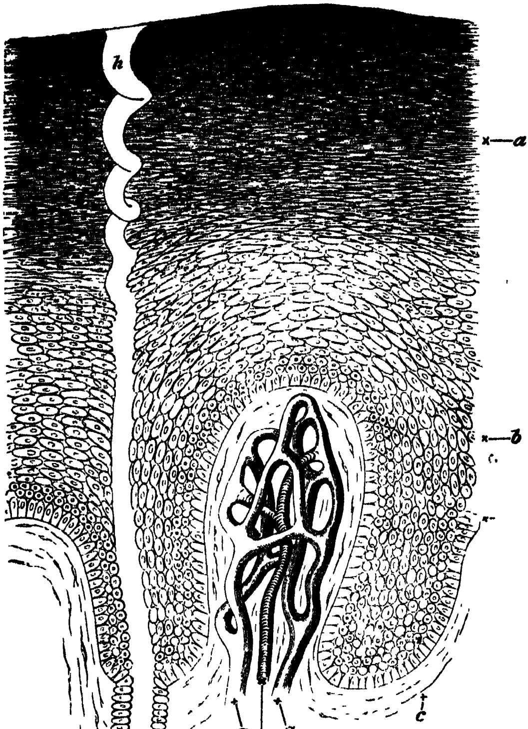

FIG. 32

Portion of Fig. 31, A, more highly magnified—somewhat diagrammatic. *a*, **horny epidermis**; *b*, softer layer, *rete Malpighii*; *c*, dermis; *d*, **lowermost vertical layer of** epidermic cells; *e*, cells lining the sweat duct **continuous with epidermic cells**, *h*, corkscrew canal of sweat duct. **To the right of the sweat duct the dermis** is raised into a papilla, **in which the small artery**, *f*, **breaks up into** capillaries, ultimately forming **the veins**, *g*.

detail, is similar in principle to that which obtains in the kidney. In the latter, the vessel makes a coil within the Malpighian capsule, which ends a tubule. Here the perspiratory tubule coils about, and among, the vessels. In both cases the same result is arrived at—namely, the exposure of the blood to a large, relatively free, surface, on to which certain of its contents transude.

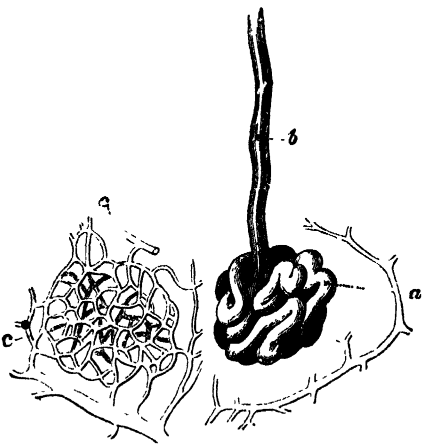

FIG. 33.

Coiled end of a sweat-gland (Fig. 31, *g*), epithelium not shown. *a*, the coil, *b*, the duct; *c*, network of capillaries, inside which the duct gland lies.

The number of these glands varies in different parts of the body. They are fewest in the back and neck, where their number is not much more than 400 to a square inch. They are more numerous on the skin of the palm and sole, where their apertures follow the ridges visible on the skin, and amount to between two and three thousand on the square inch. At a rough estimate, the whole integument probably possesses not fewer than from two millions and a quarter to two millions and a half of these tubules, which therefore must possess a very great aggregate secreting power.

17. The sweat-glands are greatly under the influence of the nervous system. This is proved, not merely by the well-known effects of mental emotion in sometimes suppressing the perspiration and sometimes causing it to be poured forth in immense abundance, but has been made a matter of direct experiment. There are some animals, such as the horse, which perspire very freely. If the sympathetic nerve of one side, in the neck of a horse, be cut, the same side of the head becomes injected with blood, and its temperature rises (see Lesson II. § 24); and, simultaneously, sweat is poured out abundantly over the whole surface thus affected. On irritating that end of the cut nerve which is in connection with the vessels, the muscular walls of the latter, to which the nerve is distributed, contract, the congestion ceases, and with it the perspiration.

18. The amount of matter which may be lost by perspiration, under certain circumstances, is very remarkable. Heat and severe labour, combined, may reduce the weight of a man two or three pounds in an hour, by means of the cutaneous perspiration alone; and, as there is some reason to believe that the quantity of solid matter carried off from the blood does not diminish with the increase of the amount of the perspiration, the total amount of solids which are eliminated by profuse sweating may be considerable.

The difference between blood which is coming from, and that which is going to, the skin, can only be concluded from the nature of the substances given out in the perspiration; but arterial blood is not rendered venous in the skin.

19. It will now be instructive to compare together in more detail than has been done in the first Lesson (§ 23), the three great organs—lungs, kidneys, and skin—which have been described.

In ultimate anatomical analysis, each of these organs consists of a moist animal membrane separating the blood from the atmosphere.

Water, carbonic acid, and solid matter pass out from the blood through the animal membrane in each organ, and constitute its secretion or excretion; but the three organs differ in the absolute and relative amounts of the constituents the escape of which they permit.

Taken by weight, water is the predominant excretion in all three: most solid matter is given off by the kidneys; most gaseous matter by the lungs.

The skin partakes of the nature of both lungs and kidneys, seeing that it absorbs oxygen and exhales carbonic acid and water, like the former, while it excretes organic and saline matter in solution, like the latter; but the skin is more closely related to the kidneys than to the lungs. Hence when the free action of the skin is interrupted, its work is usually thrown upon the kidneys, and *vice versâ*. In hot weather, when the excretion by the skin increases, that of the kidneys diminishes, and the reverse is observed in cold weather.

This power of mutual substitution, however, only goes a little way; for if the kidneys be extirpated, or their functions much interfered with, death ensues, however active the skin may be. And, on the other hand, if the skin be covered with an impenetrable varnish, the temperature of the body rapidly falls, and death takes place, though the lungs and kidneys remain active.

20. The *liver* is a constant source both of loss, and, in a sense, of gain, to the blood which passes through it. It gives rise to loss, because it separates a peculiar fluid, the *bile*, from the blood, and throws that fluid into the intestine. It is also in another way a source of loss because it elaborates from the blood passing through it a substance called *glycogen*, which is stored up sometimes in large, sometimes in small, quantities in the cells of the liver. This latter loss, however, is only temporary, and may be sooner or later converted into a gain, for this glycogen very readily passes into sugar, and either in that form or in some other way is carried off by the blood. In this respect, therefore, there is a gain to the blood of kind or quality though not of quantity of material. Finally, it the liver is one source of the colourless corpuscles of the blood.

The liver is the largest glandular organ in the body, ordinarily weighing about fifty or sixty ounces. It is a broad, dark, red-coloured organ, which lies on the right side of the body, immediately below the diaphragm, with which its upper surface is in contact, while its lower sur face touches the intestines and the right kidney.

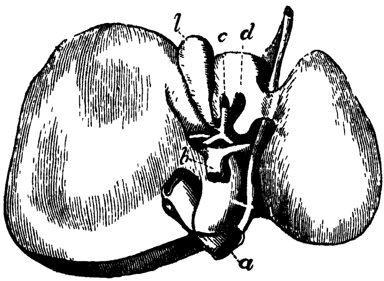

FIG. 34 – THE LIVER TURNED UP AND VIEWED FROM BELOW.

a, vena cava; *b*, vena portæ; *c*, bile duct; *d*, hepatic artery; *l*, gall-bladder. The termination of the hepatic vein in the vena cava is not seen, being covered by the piece of the vena cava.

The liver is invested by a coat of peritoneum, which keeps it in place. It is flattened from above downwards, and convex and smooth above, where it fits into the concavity of the lower surface of the diaphragm. Flat and irregular below (Fig. 34), it is thick behind, but ends in a thin edge in front.

Viewed from below, as in Fig. 34, the *inferior vena cava*, *a*, is seen to traverse a notch in the hinder edge of the liver as it passes from the abdomen to the thorax. At *b* the trunk of the *vena portæ* is observed dividing into the chief branches which enter into, and ramify through, the substance of the organ. At *d*, the *hepatic artery*, coming almost directly from the aorta, similarly divides, enters the liver, and ramifies through it; while at *c* is the single trunk of the duct, called the *hepatic duct*, which conveys away the bile brought to it by its right and left branches from the liver. Opening into the hepatic duct is seen the duct of a large oval sac, *l*, the *gall-bladder*. The duct is smaller than the artery, and the artery than the portal vein.

If the branches of the artery, the portal vein, and the bile duct be traced into the substance of the liver, they will be found to accompany one another, and to branch out and subdivide, becoming smaller and smaller. At

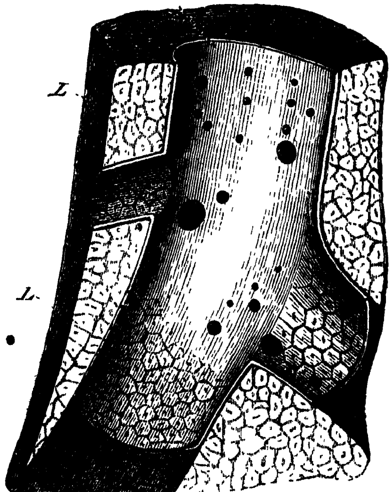

FIG 35.

A section of part of the liver to show *H V.*, a branch of the hepatic vein, with *L.*, the lobules or acini of the liver, seated upon its walls, and sending their intralobular veins into it.

length the portal vein and hepatic artery (Fig. 37, *V.P.*) will be found to end in the capillaries, which traverse, like a network, the substance of the smallest obvious subdivisions of the liver substance—polygonal masses of one-tenth of an inch in diameter, or less, which are termed the *lobules*. Every *lobule* is seated by its base upon one of the ramifications of a great vein—the *hepatic vein*—and the blood of the capillaries of the lobule is poured into that vein by a minute veinlet, called *intralobular* (Fig. 37, *H.V.*), which traverses the centre of the lobule, and pierces its base. Thus the venous blood of the portal vein and the arterial blood of the hepatic artery reach the surfaces of the lobules by the ultimate ramifications of that vein and artery, become mixed in the capillaries of each lobule, and are carried off by its *intralobular* veinlet, which pours its contents into one of the ramifications of the hepatic vein. These ramifications, joining together, form larger and larger trunks, which at length reach the hinder margin of the liver and finally open into the vena *cava inferior*, where it passes upwards in contact with that part of the organ.

Thus the blood with which the liver is supplied is a mixture of arterial and venous blood; the former brought

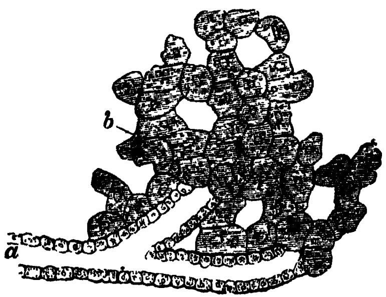

FIG. 36.

a, ultimate branches of the hepatic duct, *b*, liver cells.

by the hepatic artery directly from the aorta, the latter by the portal vein from the capillaries of the stomach, intestines, pancreas, and spleen.

What ultimately becomes of the ramifications of the hepatic duct is not certainly known.. Lined by an epithelium, which is continuous with that of the main duct, and thence with that of the intestines, into which the main duct opens, they may be traced to the very surface of the lobules. Their ultimate ramifications are not yet thoroughly determined: but recent investigations

A

B

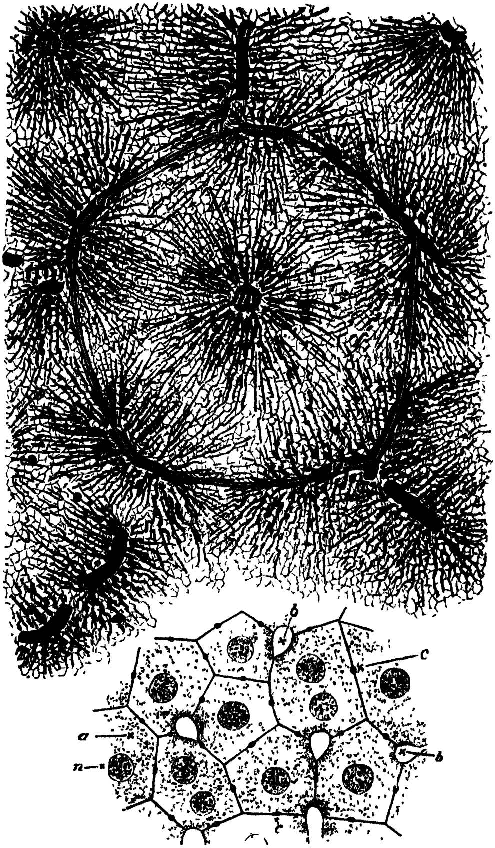

FIG. 37

A. Section of partially injected liver magnified. The artificial white line is introduced to mark the limits of a lobule. *V.P.* Branches of portal vein breaking up into capillaries, which run towards the centre of the lobule, and join *H V.*, the intralobular branch of the hepatic vein. The tend to show that they communicate with minute passages left between the hepatic cells, and traversing the lobule in the intervals left by the capillaries (Fig. 37, B.). However this may be, any fluid separated from the blood by the lobules must really find its way into them.

In the lobules themselves all the meshes of the blood-vessels are occupied by the liver cells. These are many-sided, minute bodies, each about $\frac{1}{1000}$th of an inch in diameter, possessing a nucleus in its interior, and frequently having larger and smaller granules of fatty matter distributed through its substance (Fig. 37, *a*). It is in the liver cells that the active powers of the liver are supposed to reside.

21. The nature of these active powers, so far as the liver is a source of loss to the blood which traverses it, is determined by ascertaining—

a. The character of that fluid, the bile, which incessantly flows down the biliary duct, and which, if digestion is not going on, and the passage into the intestine is closed, flows back into and fills the gall-bladder.

b. The difference between the blood which enters the liver and that which leaves it.

22. *a.* The total quantity of bile secreted in the twenty-four hours varies, but probably amounts to not less than from two to three pounds. It is a golden yellow, slightly alkaline, fluid, of extremely bitter taste, consisting of water with from 17 per cent. to half that quantity, of solid matter in solution. The solids consist in the first place of a somewhat complex substance which may be separated by crystallization, and has been called *bilin.* It is in reality a mixture of two acids, in combination with soda, one called *glycocholic*, and consisting of carbon, hydrogen, nitrogen, and oxygen, the other *taurocholic*, and containing in addition to the other elements a considerable quantity of sulphur. Besides the taurocholate and glycocholate of soda, or bile salts as they are sometimes called, the bile contains a remarkable crystalline substance, very fatty-

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outline of the liver cells are seen as a fine network of lines throughout the whole lobule.

B. Portion of lobule very highly magnified. *a*, liver cell with *n*, nucleus (two are often present); *b*, capillaries cut across; *c*, minute biliary passages between the cells, injected with colouring matter.

looking, but not really of a fatty nature, calle
one or more peculiar colouring matters probably related to the hæmatin of the blood, and certain saline matters.

b. Of these constituents of the bile the water, the cholesterin, and the saline matters, alone, are discoverable in the blood; and, though doubtless some difference obtains between the blood which enters the liver and that which leaves it, in respect of the proportional quantity of these constituents, great practical difficulties lie in the way of the precise ascertainment of the amount of that difference. The blood of the hepatic vein, however, is certainly poorer in water than that of the portal vein.

23. As the essential constituents of bile, the bile acids and the colouring matter, are not discoverable in the blood which enters the liver; they must be formed at the expense of the tissue of that organ itself, or of some constituent of the blood passing through it.

24. We must next consider the chief sources of constant gain to the blood; and, in the first place, *the sources of gain of matter.*

The lungs and skin are, as has been seen, two of the principal channels by which the body loses liquid and gaseous matter, but they are also the sole means by which one of the most important of all substances for the maintenance of life, *oxygen*, is introduced into the blood. It has already been pointed out that the volume of the oxygen taken into the blood by the lungs is rather greater than that of the carbonic acid given out. The absolute weight of oxygen thus absorbed may be estimated at 10,000 grains (see Lesson VI. § 2).

How much is taken in by the skin of man is not certainly known, but in some of the lower animals, such as the frog, the skin plays a very important part in the performance of the respiratory function.

25. The blood leaving the liver by the hepatic vein not only contains proportionally less water and fibrin, but proportionally more corpuscles, especially colourless corpuscles, and, what is still more important, under certain circumstances at least, a larger quantity of liver-sugar, or

glucose, than that brought to it by the portal veins anc hepatic artery.

That the blood leaving the liver should contain propor tionally less water and more corpuscles than that enterin; it, is no more than might be expected from the fact tha the formation of the bile, which is separated from thi blood, necessarily involves a loss of water and of som solid matters, while it does not abstract any of the cor puscles.

We do not know why less fibrin separates from the bloo of the hepatic vein than from the blood brought to the liver. But the reason why there may be more sugar in the blood leaving the liver than in that entering it; and why, in fact, there may be plenty of sugar in the blood o the hepatic vein even when none whatever is brought t it by the hepatic artery, or portal vein, has been made ou by careful and ingenious experimental research.

26. If an animal be fed upon purely animal food, the blood of the portal vein will contain no sugar, none having been absorbed by the walls of the alimentary canal, no will that of the hepatic artery contain any, or, at any rate, more than the merest trace. Nevertheless, plenty may be found, at the same time, in the blood of the [illegible] and in that of the vena cava, from the point at which it is joined by the hepatic vein, as far as the heart.

Secondly, if, from an animal so fed, the liver be ex tracted, and a current of cold water forced into the *vena portæ*, it will flow out by the hepatic vein, carrying with it all the blood of the organ, and will, after a time, come out colourless, and devoid of sugar. Nevertheless, if the organ be left to itself at a moderate temperature, suga will soon again become abundant in it.

Thirdly, from the liver, washed as above described, a substance may be extracted, by appropriate methods, which resembles starch or dextrine, in chemical composition, consisting as it does of carbon united with hydrogen and oxygen, the latter being in the same proportions as in water. This "amyloid" substance is the *glycogen* spoken of in § 20. It may be dried and kept for long periods without undergoing any change.

But, like the vegetable starch and dextrine, this animal amyloid, which must be formed in the liver, since it is certainly not contained either in the blood of the portal vein, or in that of the hepatic artery, is very readily changed by contact with certain matters, which act as ferments, into sugar.

Fourthly, it may be demonstrated that a ferment, competent to change the "amyloid" glycogen into saccharine "*glucose*," exists under ordinary circumstances in the liver.

Putting all these circumstances together, the following explanation of the riddle of the appearance of sugar in the blood of the hepatic vein and vena cava, when neither it, nor any compound out of which it is easily formed, exists in the blood brought to the liver, appears to have much probability; though it may possibly require modification, in some respects, hereafter.

The liver forms glycogen out of the blood with which it is supplied. The same blood supplies the ferment which, at the temperature of the body, very speedily converts the comparatively little soluble glycogen into very soluble sugar; and this sugar is dissolved and carried away by each intralobular vein to the hepatic vein, and thence to the vena cava.

Though after death a very considerable quantity of sugar accumulates in the hepatic vein, the amount which, *at any given moment*, can be detected during life is extremely small. This has led some physiologists to suppose that, in health, glycogen is not converted into sugar, but undergoes some other change. A very small quantity of sugar however, so small as to almost escape detection, thrown into the hepatic vein every instant, would amount to a considerable quantity in the twenty-four hours.

This formation of glycogen in the liver goes on in the total absence of starch or sugar from the food. It must, therefore, in such cases be formed at the expense of proteid material (see Lesson VI.). It appears, however, that the presence of starch or sugar in the food, though not essential, is very favourable to the production of glycogen in the liver.

27. The *lymphatic system* has been already mentioned as a feeder of the blood with a fluid which, in general, appears to be merely the superfluous drainage, as it were, of

the blood-vessels; though at intervals, as we shall see, the lacteals make substantial additions of new matter. It is very probable that the multitudinous *lymphatic glands* may effect some change in the fluid which traverses them, or may add to the number of corpuscles in the lymph.

Nothing *certain* is known of the functions of certain bodies which are sometimes called ductless glands, but have quite a different structure from ordinary secreting glands; and indeed do not resemble each other in structure. These are, the *thyroid* gland, which lies in the part of the throat below the larynx, and is that organ which, when enlarged by disease, gives rise to "Derbyshire neck" or "goître;" the *thymus* gland, situated at the base of the heart, largest in infants, and gradually disappearing in adult, or old, persons; and the *supra-renal* capsules, which lie above the kidneys.

28. We are as much in the dark respecting the office of the large viscus called the *spleen*, [illegible] side of the stomach in the abdominal cavity (Fig. 38). It is an elongated flattened red body, abundantly supplied with blood by an artery called the *splenic artery*, which proceeds almost directly from the aorta. The blood which has traversed the spleen is collected by the *splenic vein*, and is carried by it to the *vena portæ*, and so to the liver.

A section of the spleen shows a dark red spongy mass dotted over with minute whitish spots. Each of these last is the section of one of the spheroidal bodies called *corpuscles of the spleen*, which are scattered through its substance, and consist of a solid aggregation of minute bodies, like the white corpuscles of the blood, traversed by a capillary network, which is fed by a small twig of the splenic artery. The dark red part of the spleen, in which these corpuscles are embedded, is composed of fibrous and elastic tissue supporting a very spongy vascular network.

The elasticity of the splenic tissue allows the organ to be readily distended, and enables it to return to its former size after distension. It appears to change its dimensions with the state of the abdominal viscera, attaining its largest size about six hours after a full meal, and falling to its minimum bulk six or seven hours later, if no further supply of food be taken.

The blood of the splenic vein is found to contain proportionally fewer red corpuscles, but more colourless corpuscles and more fibrin, than that in the splenic artery; and it has been supposed that the spleen is one of those parts of the economy in which the colourless corpuscles of the blood are especially produced.

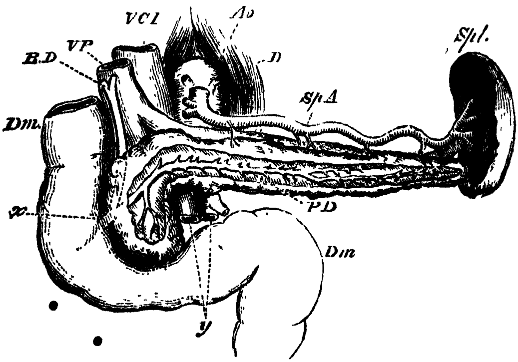

FIG. 38

The spleen (*Spl*) with the splenic artery (*SpA.*). Below this is seen the splenic vein running to help to form the vena portæ (*V.P*). *Ao.* the aorta; *D.* a pillar of the diaphragm, *P.D.* the pancreatic duct exposed by dissection in the substance of the pancreas; *Dm.* the duodenum, *B.D* the biliary duct uniting with the pancreatic duct into the common duct, *x*; *y*, the intestinal vessels.

29. It has been seen that *heat* is being constantly given off from the integument and from the air-passages; and everything that passes from the body carries away with it, in like manner, a certain quantity of heat. Furthermore, the surface of the body is much more exposed to cold than its interior. Nevertheless, the temperature of the body is maintained very evenly, at all times and in all parts, within the range of two degrees on either side of 99° Fahrenheit.

This is the result of three conditions:—The first, that heat is constantly being generated in the body; the second, that it is as constantly being distributed through the body; the third, that it is subject to incessant regulation.

Heat is generated whenever oxidation takes place; and hence, whenever proteid substances (see Lesson VI., § 4) or fats, or amyloidal matters, are being converted into the more highly oxidated waste products,—urea, carbonic acid, and water,—heat is necessarily evolved. But these processes are taking place in all parts of the body by which vital activity is manifested; and hence every capillary vessel and every extravascular islet of tissue is really a small fireplace in which heat is being evolved, in proportion to the activity of the chemical changes which are going on.

30. But as the vital activities of different parts of the body, and of the whole body, at different times, are very different; and as some parts of the body are so situated as to lose their heat by radiation and conduction much more easily than others, the temperature of the body would be very unequal in its different parts, and at different times, were it not for the arrangements by which the heat is distributed and regulated.

Whatever oxidation occurs in any part, raises the temperature of the blood which is in that part at the time to a proportional extent. But this blood is swiftly hurried away into other regions of the body, and rapidly gives up its increased temperature to them. On the other hand, the blood which by being carried to the vessels in the skin on the surface of the body begins to have its temperature lowered by evaporation, &c., is hurried away before it has time to get thoroughly cooled into the deeper organs; and in them it becomes warm by contact, as well as by the oxidating processes in which it takes a part. Thus the blood-vessels and their contents might be compared to a system of hot-water pipes, through which the warm water is kept constantly circulating by a pump; while it is heated, not by a great central boiler as usual, but by a multitude of minute gas jets, disposed beneath the pipes, not evenly, but more here and fewer there. It is obvious that, however much greater might be the heat applied to one part of the system of pipes than to another, the general temperature of the water would be even throughout, if it were kept moving with sufficient quickness by the pump.

31. If such a system were entirely composed of closed pipes, the temperature of the water might be raised to any extent by the gas jets. On the other hand, it might be kept down to any required degree by causing a larger, or smaller, portion of the pipes to be wetted with water, which should be able to evaporate freely—as, for example, by wrapping them in wet cloths. And the greater the quantity of water thus evaporated, the lower would be the temperature of the whole apparatus.

Now, the regulation of the temperature of the human body is effected on this principle. The vessels are closed pipes, but a greater number of them are enclosed in the skin and in the mucous membrane of the air-passages, which are, in a physical sense, wet cloths freely exposed to the air. It is the evaporation from these which exercises a more important influence than any other condition upon the regulation of the temperature of the blood, and, consequently, of the body.

But, as a further nicety of adjustment, the wetness of the regulator is itself determined by the state of the small vessels, inasmuch as exudation from these takes place more readily when the walls of the veins and arteries are relaxed, and the blood distends them and the capillaries. But the condition of the walls of the vessels depends upon the nerves by which they are supplied; and it so happens that cold so affects these nerves in such a manner as to give rise to contraction of the small vessels, while moderate warmth has the reverse effect.

Thus the supply of blood to the surface is lessened, and loss of heat is thereby checked, when the external temperature is low; while, when the external temperature is high, the supply of blood to the surface is increased, the fluid exuded from the vessels pours out by the sweat-glands, and the evaporation of this fluid checks the rise in the temperature of the superficial blood.

Hence it is that, so long as the surface of the body perspires freely, and the air-passages are abundantly moist, a man may remain with impunity, for a considerable time, in an oven in which meat is being cooked. The heat of the air is expended in converting this superabundant perspiration into vapour, and the temperature of the man's blood is hardly raised.

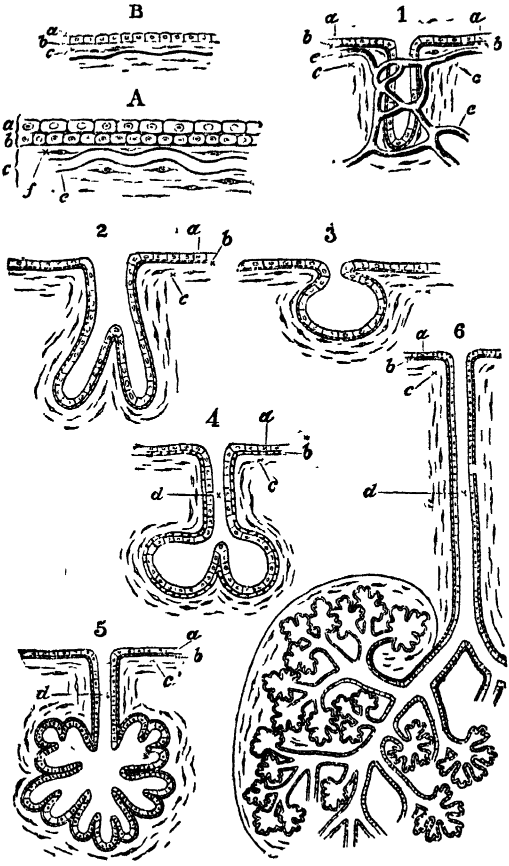

FIG 39 —A DIAGRAM TO ILLUSTRATE THE STRUCTURE OF GLANDS.

A. Typical structure of the mucous membrane. *a*, an upper, and *b*, a lower, layer of epithelium cells; *c*, the dermis with *e*, a blood-vessel, and *f*, connective tissue corpuscles.

32. The chief *intermittently active sources of loss* to the blood are found among the glands proper, all of which are, in principle, narrow pouches of the mucous membranes, or of the integument of the body, lined by a continuation of the epithelium, or of the epidermis. In the *glands of Lieberkuhn*, which exist in immense numbers in the walls of the small intestines, each gland is nothing more than a simple blind sac of the mucous membrane, shaped like a small test tube, with its closed end outwards, and its open end on the inner surface of the intestine (Fig. 39, 1). The sweat-glands of the skin, as we have already seen, are equally simple, blind, tube-like involutions of the integument, the ends of which become coiled up. The *sebaceous glands*, usually connected with the hair sacs, are shorter, and their blind ends are somewhat subdivided, so that the gland is divided into a narrow neck and a more dilated and sacculated end (Fig. 39, 5). The neck by which the gland communicates with the free surface is called its *duct*. More complicated glands are produced by the elongation of the duct into a long tube, and the division and subdivision of the blind end into multitudes of similar tubes, each of which ends in a dilatation (Fig. 39, 6). These dilatations, attached to their branched ducts, somewhat resemble a bunch of grapes. Glands of this kind are called *racemose*. The *salivary glands* and the *pancreas* are such glands.

Now, many of these glands, such as the salivary, and the pancreas (with the perspiratory, or sudoriparous glands, which it has been convenient to consider already), are only active when certain impressions on the nervous system give rise to a particular condition of the gland, or of its vessels, or of both.

Thus the sight or smell, or even the thought of food, will cause a flow of saliva into the mouth ; the previously

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B. The same, with only one layer of cells, *a* and *b*, the so-called basement membrane between the epithelium, *a*, and dermis, *c*.
1 A simple tubular gland
2. A tubular gland bifid at its base. In this and succeeding figures the blood-vessels are omitted.
3. A simple saccular gland
4. A divided saccular gland, with a duct, *d*.
5. A similar gland still more divided
6. A racemose gland, part only being drawn.

quiescent gland suddenly pouring out its fluid secretion, as a result of a change in the condition of the nervous system. And, in animals, the salivary glands can be made to secrete abundantly, by irritating a nerve which supplies the gland and its vessels. How far this effect is the result of the mechanical influence of the nerve on the state of the circulation, by widening the small arteries (see p. 51) and so supplying the gland with more blood, and how far it is the result of a more direct influence of the nerve upon the state of the tissue of the gland itself, making the *cells secrete*, just as a nerve when stimulated makes a muscle contract, is not at present finally determined.

The liquids poured out by the intermittent glands are always very poor in solid constituents, and consist chiefly of water. Those poured on to the surface of the body are lost, but those which are received by the alimentary canal are doubtless in a great measure re-absorbed.

33. The great *intermittent sources of gain of waste products* to the blood are the muscles, every contraction of which is accompanied by a pouring of certain products into the blood. That much of this waste is carbonic acid is certain from the facts (*a*) that the blood which leaves a contracting muscle is always highly venous, far more so than that which leaves a quiescent muscle; (*b*) that muscular exertion at once immensely increases the quantity of carbonic acid expired; but whether the amount of nitrogenous waste is increased under these circumstances, or not, is a point yet under discussion.

LESSON VI.

THE FUNCTION OF ALIMENTATION.

1. THE great source of gain to the blood, and, except the lungs, the only channel by which altogether new material is introduced into that fluid, putting aside the altogether exceptional case of absorption by the skin, is the *alimentary canal*, the totality of the operations of which constitutes the function of *alimentation*. It will be useful to consider the general nature and results of the performance of this function before studying its details.

2. A man daily takes into his mouth, and thereby introduces into his alimentary canal, a certain quantity of solid and liquid food, in the shape of meat, bread, butter, water, and the like. The amount of chemically dry, solid matter, which must thus be taken into the body, if a man of average size and activity is neither to lose, nor to gain, in weight, has been found to be about 8,000 grains. In addition to this, his blood absorbs by the lungs about 10,000 grains of oxygen gas, making a grand total of 18,000 grains (or nearly two pounds and three-quarters avoirdupois) of daily gain of dry, solid, and gaseous matter.

3. The weight of dry solid matter passed out from the alimentary canal does not, on the average, amount to more than one-tenth of that which is taken into it, or 800 grains. Now the alimentary canal is the only channel by which any appreciable amount of solid matter leaves the body in an undissolved condition. It follows, there-

fore, that in addition to the 10,000 grains of oxygen, 7,200 grains of dry, solid, matter must pass out of the body by the lungs, skin, or kidneys, either in the form of gas, or dissolved in the liquid excretions of those organs. Further, as the general composition of the body remains constant, it follows either that the elementary constituents of the solids taken into the body must be identical with those of the body itself: or that, in the course of the vital processes, the food alone is destroyed, the substance of the body remaining unchanged: or, finally, that both these alternatives hold good, and that food is, partly, identical with the wasting substance of the body, and replaces it; and, partly, differs from the wasting substance, and is consumed without replacing it.

4. As a matter of fact, all the substances which are used as food come under one of four heads. They are either what may be termed *Proteids*, or they are *Fats*, or they are *Amyloids*, or they are *Minerals*.

Proteids are composed of the four elements—carbon, hydrogen, oxygen, and nitrogen, sometimes united with sulphur and phosphorus.

Under this head come the *Gluten* of flour, the *Albumin* of white of egg, and blood serum; the *Fibrin* of the blood; the *Syntonin*, which is the chief constituent of muscle and flesh, and *Casein*, one of the chief constituents of cheese, and many other similar but less common bodies; while *Gelatin*, which is obtained by boiling from connective tissue, and *Chondrin*, which may be produced in the same way from cartilage, may be considered to be outlying members of the same group.

Fats are composed of carbon, hydrogen, and oxygen only, and contain more hydrogen than is enough to form water if united with the oxygen which they possess.

All vegetable and animal fatty matters and oils come under this division.

Amyloids are substances which also consist of carbon, hydrogen, and oxygen only. But they contain no more hydrogen than is just sufficient to produce water with their oxygen. These are the matters known as *Starch*, *Dextrine*, *Sugar*, and *Gum*.

It is the peculiarity of the three groups of food-stuffs just mentioned that they can only be obtained (at any rate, at present) by the activity of living beings, whether animals or plants, so that they may be conveniently termed *vital food-stuffs.*

Food-stuffs of the fourth class, on the other hand, or *Minerals*, are ~~to be procured as well from the not living~~, [illegible] *salts* of sundry alkalies, ~~earths, and~~ metals. To these, in strictness, *oxygen* ought to be added, though, as it is not taken in by the alimentary canal, it hardly comes within the ordinary acceptation of the word food.

5. In ultimate analysis, then, it appears that *vital food-stuffs* contain either three or four of the elements: carbon, hydrogen, oxygen, and nitrogen; and that *mineral food-stuffs* are water and salts. But the human body, in ultimate analysis, also proves to be composed of the same four elements, *plus* water, and the same saline matters as are found in food.

More than this, no substance can serve permanently for food—that is to say, can prevent loss of weight and change in the general composition of the body—unless it contains a certain amount of proteid matter in the shape of albumin, fibrin, syntonin, casein, &c., while, on the other hand, any substance which contains proteid matter in a readily assimilable shape, is competent to act as a permanent vital food-stuff.

The human body, as we have seen, contains a large quantity of proteid matter in one or other of the forms which have been enumerated; and, therefore, it turns out to be an indispensable condition, that every substance which is to serve permanently as food, must contain a sufficient quantity of the most important and complex component of the body ready made. It must also contain a sufficient quantity of the mineral ingredients which are required. Whether it contains either fats or amyloids, or both, its essential power of supporting the life and maintaining the weight and composition of the body remains unchanged.

6. The necessity of constantly renewing the supply of proteid matter arises from the circumstance that the secretion of urea from the body (and consequently the loss of nitrogen) goes on continually, whether the body is fed or not: while there is only one form in which

nitrogen (at any rate, in any considerable quantity) can be taken into the blood, and that is in the form of a solution of proteid matter. If proteid matter be not supplied, therefore, the body must needs waste, because there is nothing in the food competent to make good the loss of nitrogen.

On the other hand, if proteid matter be supplied, there can be no *absolute* necessity for any other but the mineral food-stuffs, because proteid matter contains carbon and hydrogen in abundance, and hence is competent to give origin to the other great products of waste, carbonic acid and water.

In fact, the final results of the oxidation of proteid matters are carbonic acid, water, and ammonia; and these, as we have seen, are the final shapes of the waste products of the human economy.

7. From what has been said, it becomes readily intelligible that, whether an animal be herbivorous or carnivorous, it begins to starve from the moment its vital food-stuffs consist of pure amyloids, or fats, or any mixture of them. It suffers from what may be called *nitrogen starvation*, and, sooner or later, will die.

In this case, and still more in that of an animal deprived of vital food altogether, the organism, so long as it continues to live, feeds upon itself. In the former case, those excretions which contain nitrogen, in the latter, all its waste products, are necessarily formed at the expense of its own body; whence it has been rightly enough observed that a starving sheep is as much a carnivore as a lion.

8. But though proteid matter is the essential element of food, and under certain circumstances may suffice, by itself, to maintain the body, it is a very disadvantageous and uneconomical food.

Albumen, which may be taken as the type of the proteids, contains about 53 parts of carbon and 15 of nitrogen in 100 parts. If a man were to be fed on white of egg, therefore, he would take in, speaking roughly, 3½ parts of carbon for every part of nitrogen.

But it is proved experimentally, that a healthy, full-grown man, keeping up his weight and heat, and taking a fair amount of exercise, eliminates 4,000 grains of carbon to only 300 grains of nitrogen, or, roughly, only needs one-thirteenth as much nitrogen as carbon. However, if he is to get his 4,000 grains of carbon out of albumen, he must eat 7,547 grains of that substance But 7,547 grains of albumen contain 1,132 grains of nitrogen, or nearly four times as much as he wants.

To put the case in another way, it takes about four pounds of fatless meat (which generally contains about one-fourth its weight of dry solid proteids) to yield 4,000 grains of carbon, whereas one pound will furnish 300 grains of nitrogen.

Thus a man confined to a purely proteid diet, must eat a prodigious quantity of it. This not only involves a great amount of physiological labour in comminuting the food and a great expenditure of power and time in dissolving and absorbing it; but throws a great quantity of wholly profitless labour upon those excretory organs, which have to get rid of the nitrogenous matter, three-fourths of which, as we have seen, is superfluous.

Unproductive labour is as much to be avoided in physiological, as in political, economy; and it is quite possible that an animal fed with perfectly nutritious, proteid matter should die of starvation: the loss of power in various operations required for its assimilation overbalancing the gain; or the time occupied in their performance being too great to check waste with sufficient rapidity. The body, under these circumstances, falls into the condition of a merchant who has abundant assets, but who cannot get in his debts in time to meet his creditors.

9. These considerations lead us to the physiological justification of the universal practice of mankind in adopting a mixed diet, in which proteids are mixed either with fats, or with amyloids, or with both.

Fats may be taken to contain about 80 per cent. of carbon, and amyloids about 40 per cent. Now it has been seen that there is enough nitrogen to supply the waste of that substance per diem, in a healthy man, in a pound of fatless meat; which also contains 1,000 grains of carbon, leaving a deficit of 3,000 grains of carbon. Rather more than half a pound of fat, or a pound of sugar, will supply this quantity of carbon. The former, if properly subdivided, the latter, by reason of its solubility, passes with great ease into the economy, the digestive labour of which is consequently reduced to a minimum.

10. Several apparently simple articles of food constitute a mixed diet in themselves. Thus butcher's meat commonly contains from 30 to 50 per cent. of fat. Bread, on the other hand, contains the proteid, gluten, and the amyloids, starch and sugar, with minute quantities of fat. But, from the proportion in which these proteid and other constituents exist in these substances, they are neither, taken alone, such physiologically economical foods as they are when combined in the proportion of about 200 to 75; or two pounds of bread to three-quarters of a pound of meat per diem.

11. It is quite certain that nine-tenths of the dry, solid food which is taken into the body sooner or later leaves it in the shape of carbonic acid, water, and urea (or uric acid); and it is also certain that the compounds which leave the body not only are more highly oxidized than those which enter it, but in them is carried away out of the body all the oxygen taken into the blood by the lungs.

The intermediate stages of this conversion are, however, by no means so clear. It is highly probable that the amyloids and fats are very frequently oxidized in the blood, without, properly speaking, ever forming an integral part of the substance of the body; but whether the proteids may undergo the same changes in the blood, or whether it is necessary for them first to be incorporated with the living tissue, is not positively known.

So, again, it is certain that, in becoming oxidized, the elements of the food must give off heat, and it is probable that this heat is sufficient to account for all that is given off by the body; but it is possible, and indeed probable, that there may be other minor sources of heat.

12. Food-stuffs have been divided into *heat-producers* and *tissue-formers*—the amyloids and fats constituting the former division, the proteids the latter. But this is a very misleading classification, inasmuch as it implies, on the one hand, that the oxidation of the proteids does not develop heat; and, on the other, that the amyloids and fats, as they oxidize, subserve only the production of heat.

Proteids are *tissue-formers*, inasmuch as no tissue can be produced without them; but they are also *heat-producers*, not only directly, but because, as we have seen (Lesson V. §§ 25, 26), that they are competent to give rise to amyloids by chemical metamorphosis within the body.

If it is worth while to make a special classification of the vital food-stuffs at all, it appears desirable to distinguish the *essential* food-stuffs, or proteids, from the *accessory* food-stuffs, or fats and amyloids—the former alone being, in the nature of things, necessary to life, while the latter, however important, are not absolutely necessary.

13. All food-stuffs being thus proteids, fats, amyloids, or mineral matters, pure or mixed up with other substances, the whole purpose of the alimentary apparatus is to separate these proteids, &c. from the innutritious residue, if there be any; and to reduce them into a condition either of solution or of excessively fine subdivision, in order that they may make their way through the delicate structures which form the walls of the vessels of the alimentary canal. To these ends food is taken into the mouth and masticated, is mixed with saliva, is swallowed, undergoes gastric digestion, passes into the intestine, and is subjected to the action of the secretions of the glands attached to that viscus; and, finally, after the more or less complete extraction of the nutritive constituents, the residue, mixed up with certain secretions of the intestines, leaves the body as the *fæces*.

The cavity of the mouth is a chamber with a fixed roof, formed by the hard *palate* (Fig. 40, *l*), and with a moveable floor, constituted by the lower jaw, and the tongue (*k*), which fills up the space between the two branches of the jaw. Arching round the margins of the upper and the lower jaws are the thirty-two teeth, sixteen above and sixteen below, and, external to these, the closure of the cavity of the mouth is completed by the cheeks at the sides, and, by the lips, in front.

When the mouth is shut, the back of the tongue comes into close contact with the palate; and, where the hard palate ends, the communication between the mouth and the back of the throat is still further impeded by a sort of fleshy curtain—the soft *palate* or *velum*—the middl which is produced into a prolongation, the *uvula* while its sides, skirting the sides of the passage, or *fau*

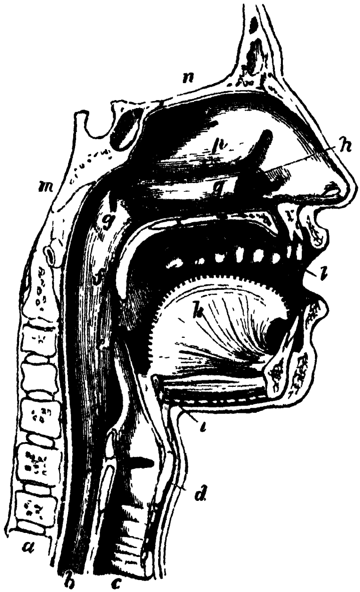

FIG. 40.

A SECTION OF THE MOUTH AND NOSE TAKEN VERTICALLY, A LITTLE TO THE LEFT OF THE MIDDLE LINE

a, the vertebral column; *b*, the gullet; *c*, the windpipe; *d*, the thyroid cartilage of the larynx; *e*, the epiglottis; *f*, the uvula; *g*, the opening of the left Eustachian tube; *h*, the opening of the left lachrymal duct; *i*, the hyoid bone; *k*, the tongue; *l*, the hard palate; *m*, *n*, the base of the skull; *o*, *p*, *q*, the superior, middle, and inferior turbinal bones. The letters *g*, *f*, *e* are placed in the pharynx.

form double muscular pillars, which are termed the *pillars of the fauces.* Between these the *tonsils* are situated, one on each side.

The velum with its uvula comes into contact below with the upper part of the back of the tongue, and with a sort of gristly, lid-like process connected with its base, the *epiglottis* (*e*).

Behind the partition thus formed lies the cavity of the *pharynx*, which may be described as a funnel-shaped bag with muscular walls, the upper margins of the slanting, wide end of which are attached to the base of the skull, while the lateral margins are continuous with the sides, and the lower with the floor, of the mouth. The narrow end of the pharyngeal bag passes into the gullet or œsophagus (*b*), a muscular tube, which affords a passage into the stomach.

There are no fewer than six distinct openings into the front part of the pharynx—four in pairs, and two single ones in the middle line. The two pairs are, in front, the hinder openings of the nasal cavities; and at the sides, close to these, the apertures of the *Eustachian tubes* (*g*). The two single apertures are, the hinder opening of the mouth between the soft palate and the epiglottis; and, behind the epiglottis, the upper aperture of the respiratory passage, or the *glottis*.

14. The mucous membrane which lines the mouth and the pharynx is beset with minute glands, the *buccal glands*; but the great glands from which the cavity of the mouth receives its chief secretion are the three pairs which, as has been already mentioned, are called *parotid*, *submaxillary*, *sublingual*, and which secrete the principal part of the saliva (Fig. 41).

Each parotid gland is placed just in front of the ear, and its duct passes forwards along the cheek, until it opens in the interior of the mouth, opposite the second upper grinding tooth.

The submaxillary and sublingual glands lie between the lower jaw and the floor of the mouth, the submaxillary being situated further back than the sublingual. Their ducts open in the floor of the mouth below the tip of the tongue. The secretion of these salivary glands, mixed with that of the small glands of the mouth, constitutes the *saliva*—a fluid which, though thin and watery, contains a small quantity of animal matter, called *Ptyalin*, which has certain very peculiar properties. It does not act upon proteid food-stuffs, nor upon fats; but if mixed with starch, and kept at a moderate warm temperature, it turns that starch into grape sugar. The importance of this operation becomes apparent when one reflects that

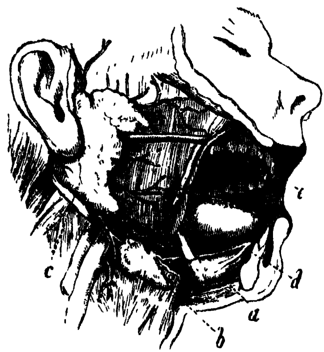

FIG 41.

A dissection of the right side of the face, showing *a*, the sublingual, *b*, the submaxillary glands, with their ducts opening beside the tongue in the floor of the mouth at *d*; *c*, the parotid gland and its duct, which opens on the side of the cheek at *e*.

starch is insoluble, and therefore, as such, useless as nutriment, while sugar is highly soluble, and readily oxidizable.

15. Each of the thirty-two teeth which have been mentioned consists of a *crown* which projects above the gum, and of one or more *fangs*, which are embedded in sockets, or what are called *alveoli*, in the jaws.

The eight teeth on opposite sides of the same jaw are constructed upon exactly similar patterns, while the eight teeth which are opposite to one another, and bite against one another above and below, though similar in kind, differ somewhat in the details of their patterns.

The two teeth in each eight which are nearest the middle line in the front of the jaw, have wide but sharp and chisel-like edges. Hence they are called *incisors*, or cutting teeth. The tooth which comes next is a tooth with a more conical and pointed crown. It answers to the great tearing and holding tooth of the dog, and is called the *canine* or eye-tooth. The next two teeth have broader crowns, with two cusps, or points, on each crown, one on the inside and one on the outside, whence they are termed *bicuspid* teeth, and sometimes false grinders. All these teeth have usually one fang each, except the bicuspid, the fangs of which may be more or less completely divided into two. The remaining teeth have two or three fangs each, and their crowns are much broader. As they crush and grind the matters which pass between them they are called *molars*, or true grinders. In the upper jaw their crowns present four points at the four corners, and a diagonal ridge connecting two of them. In the lower jaw the complete pattern is five-pointed, there being two cusps on the inner side and three on the outer.

The muscles of the parts which have been described have such a disposition that the lower jaw can be depressed, so as to open the mouth and separate the teeth; or raised, in such a manner as to bring the teeth together; or move obliquely from side to side, so as to cause the face of the grinding teeth and the edges of the cutting teeth to slide over one another. And the muscles which perform the elevating and sliding movements are of great strength, and confer a corresponding force upon the grinding and cutting actions of the teeth. In correspondence with the pressure they have to resist, the superficial substance of the crown of the teeth is of great hardness, being formed of *enamel*, which is the hardest substance in the body, so dense and hard, indeed, that it will strike fire with steel (see Lesson XII.). But notwithstanding its extreme hardness, it becomes worn down in old persons, and, at an earlier age, in savages who live on coarse food.

16. When solid food is taken into the mouth, it is cut and ground by the teeth, the fragments which ooze out upon the outer side of their crowns being pushed beneath them again by the muscular contractions of the cheeks and lips; while those which escape on the inner side are thrust back by the tongue, until the whole is thoroughly rubbed down.

While mastication is proceeding, the salivary glands pour out their secretion in great abundance, and the saliva mixes with the food, which thus becomes interpenetrated not only with the salivary fluid, but with the air which is entangled in the bubbles of the saliva.

When the food is sufficiently ground it is collected, enveloped, in saliva, into a mass or bolus, which rests upon the back of the tongue, and is carried backwards to the aperture which leads into the pharynx. Through this it is thrust, the soft palate being lifted and its pillars being brought together, while the backward movement of the tongue at once propels the mass and causes the epiglottis to incline backwards and downwards over the glottis and so to form a bridge by which the bolus can travel over the opening of the air-passage without any risk of tumbling into it. While the epiglottis directs the course of the mass of food below, and prevents it from passing into the trachea, the soft palate guides it above, keeps it out of the nasal chamber, and directs it downwards and backwards towards the lower part of the muscular pharyngeal funnel. By this the bolus is immediately seized and tightly held, and the muscular fibres contracting above it, while they are comparatively lax below, it is rapidly thrust into the œsophagus. By the muscular walls of this tube it is grasped and propelled onwards, in a similar fashion, until it reaches the stomach.

17. Drink is taken in exactly the same way. It does not fall down the pharynx and gullet, but each gulp is grasped and passed down. Hence it is that jugglers are able to drink standing upon their heads, and that a horse, or ox, drinks with its throat lower than its stomach, feats which would be impossible if fluid simply fell down the gullet into the gastric cavity.

During these processes of mastication, insalivation, and deglutition, what happens to the food is, first, that it is reduced to a coarser or finer pulp; secondly, that any matters it carries in solution are still more diluted by the water of the saliva; thirdly, that any starch it may contain begins to be changed into sugar by the peculiar constituent (ptyalin) of the saliva.

18. The stomach, like the gullet, consists of a tube with muscular walls composed of smooth muscular fibres

a id lined by an epithelium ; but it differs from the gullet in several circumstances. In the first place, its cavity is greatly larger, and its left end is produced into an enlargement which, because it is on the heart side of the body, is called the *cardiac* dilatation (Fig. 42, *b*). The opening of the gullet into the stomach, termed the *cardiac aperture*, is consequently nearly in the middle of the whole length of the organ, which presents a long, convex, *greater curvature*, along its front or under edge, and a short concave, *lesser curvature*, on its back or upper contour. Towards its right extremity the stomach narrows, and, where it passes into the intestine, the muscular fibres are so disposed as to form a sort of sphincter around the aperture of communication. This is called the *pylorus* (Fig. 42, *d*).

The mucous membrane lining the wall of the stomach is very delicate, and multitudes of small glands open upon its surface. Some of these are simple, but others (Fig. 43) possess a somewhat more complicated structure, their blind ends being subdivided. It is these glands, and more especially the more complicated ones, the so-called *peptic glands*, which, when food into the stomach, throw out a thin acid fluid, the *gastric* ...

When the stomach is empty, its mucous membrane is pale and hardly more than moist. Its small arteries are then in a state of contraction, and comparatively little blood is sent through it. On the entrance of food a nervous action is set up, which causes these small arteries to dilate ; the mucous membrane consequently receives a much larger quantity of blood, it becomes very red, little drops of fluid gather at the mouth of the glands, and finally run down as gastric juice. The process is very similar to the combined blushing and sweating which takes place when the sympathetic in the neck is divided.

Pure gastric juice appears to consist of little more than water, containing a few saline matters in solution, and its acidity is due to the presence of free hydrochloric acid it possesses, however, in addition a small quantity of a peculiar substance called *pepsin*, which seems to be not altogether dissimilar in chemical composition to, though very different in its effects from, *ptyalin* (§ 14).

Thus, when the food passes into the stomach, the contractions of that organ roll it about and mix it thoroughly with the gastric juice.

19. It is easy to ascertain the properties of gastric juice experimentally, by putting a small portion of that part of the mucous membrane which contains the peptic glands into acidulated water containing small pieces of meat,

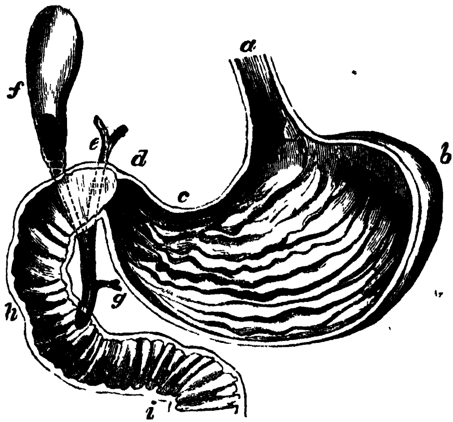

FIG. 42.—THE STOMACH LAID OPEN BEHIND.

a, the œsophagus; *b*, the cardiac dilatation; *c*, the lesser curvature; *d*, the pylorus, *e*, the biliary duct; *f*, the gall-bladder; *g*, the pancreatic duct, opening in common with the cystic duct opposite *h*; *h*, *i*, the duodenum.

hard-boiled egg, or other proteids, and keeping the mixture at a temperature of about 100°. After a few hours it will be found that the white of egg, if not in too great quantity, has become dissolved; while all that remains of the meat is a pulp, consisting chiefly of the connective tissue and fatty matters which it contained. This is *artificial digestion*, and it has been proved by experiment that precisely the same operation takes place when food undergoes natural digestion within the stomach of a living animal.

The proteid solution thus effected is called a *peptone*, and has pretty much the same characters, whatever the nature of the proteid which has been digested.

Peptone differs from all other proteids in its extreme solubility, and in the readiness with which it passes through animal membranes. Many proteids, as fibrin,

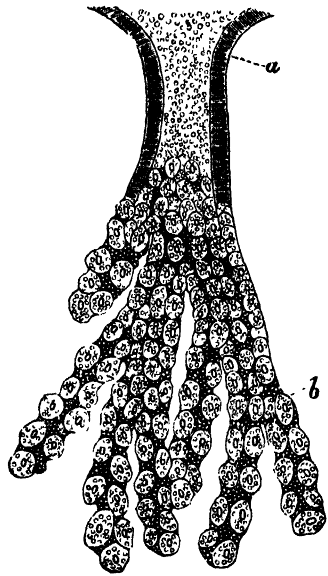

FIG. 43

One of the glands which secrete the gastric juice, magnified about 350 diameters.

are naturally insoluble in water, and others, such as white of egg, though apparently soluble, are not completely so, and can be rendered quite solid or coagulated by being simply heated, as when an egg is boiled. A solution of peptone however is perfectly fluid, does not become solid, and is not at all coagulated by boiling. Again, if a quantity of white of egg be tied up in a bladder, and the bladder immersed in water, very little of the proteid will pass through the bladder into the water, provided that there are no holes. If, however, peptone be used instead of albumin, a very large quantity will speedily pass through into the water, and a quantity of water will pass from the outside into the bladder, causing it to swell up. This process is called *osmosis*, and is evidently of great importance in the economy; and the purpose of the conversion of the various proteids by digestion into peptone seems to be, in part at least, to enable this class of food-stuff to pass readily into the blood through the thin partition formed by the walls of the mucous membrane of the intestine and the coats of the capillaries.

Similarly, starch, even when boiled, and so partially dissolved, will not pass through membranes, whereas sugar does so with the greatest ease. Hence the reason of the conversion of starch, by digestion, into sugar.

It takes a very long time (some days) for the dilute acid alone to dissolve proteid matters, and hence the solvent power of gastric juice must be chiefly attributed to the pepsin.

As far as we know gastric juice has no direct action on fats; by breaking up, however, the proteid framework in which animal and vegetable fats are imbedded, it sets these free, and so helps their digestion by exposing them to the action of other agents. It appears, too, that gastric juice has no direct action on amyloids; on the contrary, the conversion of the starch into sugar begun in the mouth appears to be wholly or partially arrested by the acidity of the contents of the stomach, ptyalin being active only in an alkaline or neutral mixture.

20. By continual rolling about, with constant additions of gastric juice, the food becomes reduced to the consistence of pea-soup, and is called *chyme*. In this state it is, in part, allowed to escape through the pylorus and to enter the duodenum; but a great deal of the fluid (consisting of peptone together with any saccharine fluids resulting from the partial conversion of starch, or otherwise) is at once absorbed, making its way, by imbibition, through the walls of the delicate and numerous vessels of

FIG. 44.—THE VISCERA OF A RABBIT AS SEEN UPON SIMPLY OPENING THE CAVITIES OF THE THORAX AND ABDOMEN WITHOUT ANY FURTHER DISSECTION.

A. Cavity of the thorax, pleural cavity of either side, *B*. Diaphragm ;

the stomach into the current of the blood, which is rushing though the gastric veins to the *vena portæ*.

21. The *intestines* form one long tube, with mucous and muscular coats, like the stomach; and, like it, they are enveloped in peritoneum. They are divided into two portions—the *small intestines* and the *large intestines;* the latter having a much greater diameter than the former. The small intestines again are subdivided into the *duodenum*, the *jejunum*, and the *ileum*, but there is no natural line of demarcation between these. The *duodenum*, however, is distinguishable as that part of the small intestine which immediately succeeds the stomach, and is bent upon itself and fastened by the peritoneum against the back wall of the abdomen, in the loop shown in Fig. 42. It is in this loop that the head of the pancreas lies (Fig. 38).

The ileum (Fig. 45, *a*) is no wider than the jejunum or duodenum, so that the transition from the small intestine to the large (*e*) is quite sudden. The opening of the small intestine into the large is provided with prominent lips which project into the cavity of the latter, and oppose the passage of matters from it into the small intestine, while they readily allow of a passage the other way. This is the *ileo-cæcal* valve (Fig. 45, *d*).

The large intestine forms a blind dilatation beyond the ileo-cæcal valve, which is called the *cæcum;* and from this an elongated, blind process is given off, which, from its shape, is called the *vermiform appendix* of the cæcum (Fig. 45, *b*).

The cæcum lies in the lower part of the right side of the abdominal cavity. The *colon*, or first part of the large intestine, passes upwards from it as the *ascending colon;* then making a sudden turn at a right angle, it passes across to the left side of the body, being called the

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C, ventricles of the heart; *D*, auricles; *E*, pulmonary artery; *F*, aorta; *G*, lungs, collapsed, and occupying only back part of chest; *H*, lateral portions of pleural membranes, *I*, cartilage at the end of sternum (ensiform cartilage); *K*, portion of the wall of body left between thorax and abdomen; *a*, cut ends of the ribs; *L*, the liver, in this case lying more to the left than the right of the body; *M*, the stomach, a large part of the greater curvature being shown; *N*, duodenum; *O*, small intestine; *P* the cæcum, so largely developed in this and other herbivorous animals; *Q*, the large intestine.

transverse colon in this part of its course; and next, suddenly bending backwards along the left side of the

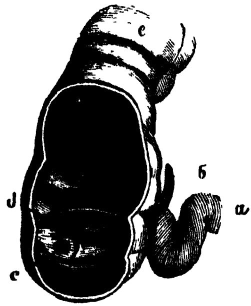

FIG. 45.

The termination of the ileum, *a*, in the cæcum, and the continuation of the latter into the colon, *c*; *d*, the ileo-cæcal valve, *e*, the aperture of the *appendix vermiformis* (*b*) into the cæcum.

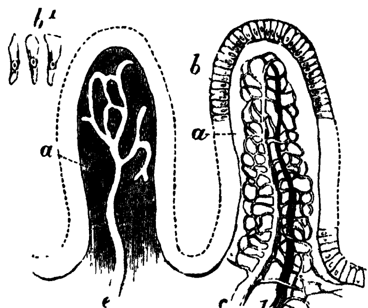

FIG. 46.—SEMI-DIAGRAMMATIC VIEW OF TWO VILLI OF THE SMALL INTESTINES. (Magnified about 50 diameters.)

a, substance of the villus; *b*, its epithelium, of which some cells are seen detached at b^1; *c d*, the artery and vein, with their connecting capillary network, which envelopes and hides *e*, the lacteal radicle which occupies the centre of the villus and opens into a network of lacteal vessels at its base.

abdomen, it becomes the *descending colon.* This reaches the middle line and becomes the *rectum*, which is that part of the large intestine which opens externally.

22. The mucous membrane of the whole intestine is provided with numerous small and simple glands (named after Lieberkuhn), which pour into it a secretion, the *intestinal juice*, the precise functions of which are unknown, though it appears in some creatures at least to possess the power of converting starch into sugar, and proteids into peptone. At the commencement of the duodenum are certain racemose glands, called the glands of Brunner, whose function is wholly unknown.

Structures peculiar to the small intestine are the *valvulæ conniventes*, transverse folds of the mucous membrane, which increase the surface; and the *villi*, which are minute thread-like processes of the mucous membrane on the *valvulæ conniventes* and elsewhere, set side by side, like the pile of velvet. Each villus is coated by epithelium, and contains in its interior the radicle, or commencement, of a lacteal vessel (Lesson II. § 6), between which and the epithelium lies a capillary n work with its afferent artery and efferent vein.

e intestines receive their blood almost directly from the aorta. Their veins carry the blood which has traversed the intestinal capillaries to the *vena portæ.*

The fibres of the muscular coat of the intestines (which lies between the mucous membrane and the serous, or peritoneal, investment) are disposed longitudinally and circularly; the longitudinal coat being much thinner, and placed outside the circular coat. Now the circular fibres of any part contract, successively, in such a manner that the lower fibres, or those on the side of the anus, contract after the upper ones, or those on the side of the pylorus. It follows from this so-called *peristaltic contraction*, that the contents of the intestines are constantly being propelled, by successive and progressive narrowing of their calibre, from their upper towards their lower parts.

The large intestine presents noteworthy peculiarities in the arrangement of the longitudinal muscular fibres of the colon into three bands, which are shorter than the walls of the intestine itself, so that the latter is thrown into puckers and pouches; and in the disposition of muscular fibres around the termination of the rectum into a ring-like sphincter muscle, which keeps the aperture firmly closed, except when defæcation takes place.

23. The only secretions, besides those of the proper intestinal glands, which enter the intestine, are those of the liver and the pancreas—the *bile* and the *pancreatic juice*. The ducts of these organs have a common opening in the middle of the bend of the duodenum; and, since the common duct passes obliquely through the coats of the intestine, its walls serve as a kind of valve, obstructing the flow of the contents of the duodenum into the duct, but readily permitting the passage of bile and pancreatic juice into the duodenum (Figs. 36, 38, 42).

Pancreatic juice is an alkaline fluid not unlike saliva in many respects; it differs, however, in containing a considerable quantity of proteid material. Bile we have already studied.

After gastric digestion has been going on some time, and the semi-digested food begins to pass on into the duodenum, the pancreas comes into activity, its blood-vessels dilate, it becomes red and full of blood, its cells secrete rapidly, and a copious flow of pancreatic juice takes place along its duct into the intestine.

The secretion of bile by the liver is much more continuous than that of the pancreas, and is not so markedly increased by the presence of food in the stomach. There is, however, a store of bile laid up in the gall-bladder; and as the acid chyme passes into the duodenum, and flows over the common aperture of the gall and pancreatic ducts, a quantity of bile from this reservoir in the gall-bladder is ejected into the intestine. The bile and pancreatic juice together here mix with the chyme and convert it into what is called *chyle*.

24. Chyle differs from chyme in two respects. In the first place, the alkali of the bile neutralizes the acid of the chyme; in the second place, both the bile and the pancreatic juice appear to exercise an influence over the fatty matters contained in the chyme, which facilitates the subdivision of these fats into very minute separate particles. The chyme, in fact, which results from the digestion of fatty food, is a mere mixture of watery fluid with oily matters, which are ready to separate from it

and unite with one another. In the chyle, on the other hand, the fatty matters are suspended in the fluid, just as oil may be evenly diffused through water by gradually rubbing it up with white of egg into what is termed an *emulsion*; or as the fat (that is, the butter) of milk is naturally held suspended in the watery basis of milk.

The chyle, with these suspended particles, looks white and milky, for the same reason that milk has the same aspect—the multitude of minute suspended fatty particles reflecting a great amount of light.

The conversion of starch into sugar, which seems to be suspended wholly, or partially, so long as the food remains in the stomach, on account of the acidity of the chyme, is resumed as soon as the latter is neutralized, the pancreatic and intestinal juices operating powerfully in this direction.

Recent observations moreover have shown that pancreatic juice has a powerful effect on proteid matters, converting them into peptones differing little, if at all, from the peptones resulting from gastric digestion. It would appear too that fats are not only minutely divided or emulsionized by the bile and pancreatic juice, *i.e.* acted upon mechanically, but also to a small extent converted by a chemical change into soaps, and thus rendered more soluble.

Hence it appears that, while in the mouth amyloids only, and in the stomach proteids only, are digested, in the intestine all three kinds of food-stuffs, proteids, fats and amyloids are either completely dissolved or minutely subdivided, and so prepared for their passage into the vessels.

As the chyle is thrust along the small intestines by the grasping action of the peristaltic contractions, the dissolved matter which it contains is absorbed, in the ordinary way, by osmosis into the vessels of the villi. The minute particles of fatty matter, on the other hand, which, not being dissolved, are incapable of osmosis, pass bodily through the soft substance of the epithelium into that of the villi, and so into the beginning of the lacteal.

The exact manner in which this is effected is at present a matter of dispute. The contents of the intestine are undoubtedly subject to pressure from the peristaltic contractions of the muscular walls; and this may help to squeeze the fat into the villi, just as mercury may be squeezed through the pores of a piece of wash leather. The process, however, is probably not one of mere pressure only.

As the network of capillaries lies outside the lacteal radicle in each villus, it would appear probable that the blood-vessels must carry off the greater part of the more soluble matters of the chyle. It is possible, however, that some of these pass by simple diffusion into the lacteals as well as into the blood-vessels. We are not, in fact, in possession of exact knowledge as to which constituents of the chyle pass into the lacteals, and which into the blood-vessels (or which into both), except on one point; and that is, that the minutely divided fat passes not into the blood-vessels, but into the lacteals, fills them, and only enters the blood after a roundabout passage through the mesenteric lymphatics and the thoracic duct. (Lesson II. §§ 5, 6.)

25. The digested matters, as they are driven along the small intestines, gradually become deprived of their peptones, fats, and soluble amyloids, and are forced through the ileo-cæcal valve into the cæcum and large intestine. Here they acquire an acid reaction and the characteristic fæcal odour and colour, which become more and more marked as they approach the rectum. It has been supposed that a sort of second digestion occurs in the upper part of the large intestine.

LESSON VII.

MOTION AND LOCOMOTION.

1. IN the preceding Lessons the manner in which the incomings of the human body are converted into its outgoings has been explained. It has been seen that new matter, in the form of vital and mineral foods, is constantly appropriated by the body, to make up for the loss of old matter, in the shape, chiefly, of carbonic acid, urea, and water, which is as constantly going on.

The vital foods are derived directly, or indirectly, from the vegetable world: and the products of waste either are such compounds as abound in the mineral world, or immediately decompose into them. Consequently, the human body is the centre of a stream of matter which sets incessantly from the vegetable and mineral worlds into the mineral world again. It may be compared to an eddy in a river, which may retain its shape for an indefinite length of time, though no one particle of the water of the stream remains in it for more than a brief period.

But there is this peculiarity about the human eddy, that a large portion of the particles of matter which flow into it have a much more complex composition than the particles which flow out of it. To speak in what is not altogether a metaphor, the atoms which enter the body are, for the most part, piled up in large heaps, and tumble down into small heaps before they leave it. The force which they set free in thus tumbling down, is the source of the active powers of the organism.

2. These active powers are chiefly manifested in the form of motion—movement, that is, either of part of the body, or of the body as a whole, which last is termed *locomotion*.

The organs which produce total or partial movements of the human body are of three kinds: *cells exhibiting amœboid movements*, *cilia* and *muscles*.

The *amœboid movements* of the white corpuscles of the blood have been already described, and it is probable that similar movements are performed by many other simple cells of the body in various regions.

The amount of movement which each cell is thus capable of giving rise to may appear perfectly insignificant; nevertheless, there are reasons for thinking that these amœboid movements are of great importance to the economy, and may under certain circumstances be followed by very notable consequences.

3. *Cilia* are filaments of extremely small size, attached by their bases to, and indeed growing out from, the free surfaces of epithelial cells (see Lesson XII.); there being in most instances very many (thirty for instance), but, in some cases, only a few cilia on each cell. In some of the lower animals, cells may be found possessing only a single cilium. They are in incessant waving motion, so long as life persists in them. Their most common form of movement is that each cilium is suddenly bent upon itself, becomes sickle-shaped instead of straight, and then more slowly straightens again, both movements, however, being extremely rapid and repeated about ten times every second. These two movements are of course antagonistic; the bending drives the water or fluid in which the cilium is placed in one direction, while the straightening drives it back again. Inasmuch, however, as the bending is much more rapid than the straightening, the force expended on the water in the former movement is greater than in the latter. The total effect of the double movement therefore is to drive the fluid in the direction towards which the cilium is bent; that is, of course, if the cell on which the cilia are placed is fixed. If the cell be floating free, the effect is to drive or row the cell backwards; for

their movements may continue even for some time after the epithelial cell, with which they are connected, is detached from the body. And not only do the movements of the cilia thus go on independently of the rest of the body, but they cannot be controlled by the action of the nervous system. Each cilium seems to be composed of *contractile* substance, and the cause of its movement would appear to be the alternate contraction and relaxation of its opposite sides along its whole length or at its base only; but why these alternations take place is unknown.

Although no other part of the body has any control over the cilia, and though, so far as we know, they have no direct communication with one another, yet their action is directed towards a common end—the cilia, which cover extensive surfaces, all working in such a manner as to sweep whatever lies upon that surface in one and the same direction. Thus, the cilia which are developed upon the epithelial cells, which line the greater part of the nasal cavities and the trachea, with its ramifications, tend to drive the mucus in which they work, outwards.

In addition to the air-passages, cilia are found, in the human body, in the ventricles of the brain, and in one or two other localities; but the part which they play in man is insignificant in comparison with their function in the lower animals, among many of which they become the chief organs of locomotion.

4. *Muscles* (Lesson I. § 13) are accumulations of fibres, each fibre having a definite structure which is different in the *striated* and *unstriated* kinds (see Lesson XIII.). These fibres are bound up by fibrous (or connective) tissue with blood-vessels, &c. into small bundles; and these bundles are again similarly bound up together in various ways so as to form muscles of various shapes and sizes. Every fibre has the power, under certain conditions, of shortening in length, while it increases its other dimensions, so that the absolute volume of the fibre remains unchanged. This power is called *muscular contractility*; and whenever, in virtue of this power, a muscular fibre *contracts*, it tends to bring its two ends, with whatever may be fastened to them, together.

The condition which ordinarily determines the contraction of a muscular fibre is a change of state in a nerve fibre, which is in close anatomical connection with the muscular fibre. The nerve fibre is thence called a ——— fibre, because, by its influence on a muscle, it becomes the indirect means of producing motion (Lesson XI. § 6.).

Muscle is a highly elastic substance. It contains a arge amount of water (about as much as the blood), ınd during life has a clear and semi-transparent aspect.

When subjected to pressure in the perfectly fresh state, ınd after due precautions have been taken to remove all he contained blood, *striated* muscle (Lesson XII. § 15) ʼields a fluid which undergoes spontaneous coagulation at ›rdinary temperatures. At a longer or shorter time after leath this coagulation takes place within the muscles hemselves. They become more or less opaque, and, osing their previous elasticity, set into hard rigid masses, vhich retain the form which they possess when the coaguation commences. Hence the limbs become fixed in the ›osition ın which death found them, and the body passes nto the condition of what is termed the "death-stiffening," or *rigor mortis*.

After the lapse of a certain time the coagulated matter ıquefies, and the muscles pass into a loose and flaccid ondition; which marks the commencement of putrefaction.

It has been observed that the sooner *rigor mortis* sets ı, the sooner it is over; and the later it commences, the ›nger it lasts. The greater the amount of muscular xertion and consequent exhaustion before death, the ooner *rigor mortis* sets in.

Rigor mortis evidently presents some analogies with the oagulation of the blood, and the substance which thus oagulates within the fibre (*myosin* or muscle-clot as it is ›metimes called) is in many respects not unlike fibrin. t forms at least the greater part of the substance which ıay be extracted from muscle by dilute acids, and is alled *syntonin* (see Lesson VI. § 4). Besides myosin, ıuscle contains other varieties of proteid material about ʼhich we at present know little; a variable quantity of ıt; certain inorganic saline matters, phosphates and otash being, as is the case in the red blood-corpuscles, ı excess; and a large number of substances existing in nall quantities, and often classed together as "extractives." Some of these extractives contain nitrogen; the most important of this class is *kreatin*, a crystalline body which is supposed to be the chief form in which nitrogenous waste matter leaves the muscle on its way to become urea.

The other class of extractives contains bodies free from nitrogen. Perhaps the most important of these is *lactic acid*, which seems always to be formed when a muscle contracts or when it enters into rigor mortis. For it is a curious fact that a muscle when at rest has a neutral or alkaline reaction as shown by testing it with litmus, but becomes acid when it has been contracting for some time or become rigid by death.

Most muscles are of a deep, red colour; this is due in part to the blood remaining in their vessels; but only in part, for each fibre (into which no capillary enters) has a reddish colour of its own, like a blood-corpuscle but fainter. And this colour is probably due to the fibre possessing a small quantity of that same hæmoglobin in which the blood-corpuscles are so rich.

Muscles may be conveniently divided into two groups, according to the manner in which the ends of their fibres are fastened; into muscles not attached to solid levers, and muscles attached to solid levers.

5. *Muscles not attached to solid levers.*—Under this head come the muscles which are appropriately called *hollow* muscles, inasmuch as they enclose a cavity or surround a space; and their contraction lessens the capacity of that cavity, or the extent of that space.

The muscular fibres of the heart, of the blood-vessels, of the lymphatic vessels, of the alimentary canal, of the urinary bladder, of the ducts of the glands, of the iris of the eye, are so arranged as to form hollow muscles.

In the heart the muscular fibres are of the striated kind, and their disposition is exceedingly complex. The cavities which they enclose are those of the auricles and ventricles; and, as we have seen, the fibres, when they contract, do so suddenly and together.

The iris of the eye is like a curtain, in the middle of which is a circular hole. The muscular fibres are of the smooth or unstriated kind (see Lesson XII.), and they are disposed in two sets: one set radiating from the edges of the hole to the circumference of the curtain; and the other set arranged in circles, concentrically with the aperture. The muscular fibres of each set contract suddenly and together, the radiating fibres necessarily enlarging the hole, the circular fibres diminishing it.

In the alimentary canal the muscular fibres are also of the unstriated kind, and they are disposed in two layers; one set of fibres being arranged parallel with the length of the intestines, while the others are disposed circularly, or at right angles to the former.

As has been stated above (Lesson VI. § 22), the contraction of these muscular fibres is successive; that is to say, all the muscular fibres, in a given length of the intestines, do not contract at once, but those at one end contract first, and the others follow them until the whole series have contracted. As the order of contraction is, naturally, always the same, from the upper towards the lower end, the effect of this peristaltic contraction is, as we have seen, to force any matter contained in the alimentary canal, from its upper towards its lower extremity. The muscles of the walls of the ducts of the glands have a substantially similar arrangement. In these cases the contraction of each fibre is less sudden and lasts longer than in the case of the heart.

6. *Muscles attached to definite levers.*—The great majority of the muscles in the body are attached to distinct levers, formed by the bones, the minute structure of which is explained in Lesson XII. § 11. In such bones as are ordinarily employed as levers, the osseous tissue is arranged in the form of a *shaft* (Fig. 47, *b*), formed of a very dense and compact osseous matter, but often containing a great central cavity (*b*) which is filled with a very delicate vascular and fibrous tissue loaded with fat called *marrow*. Towards the two ends of the bone, the compact matter of the shaft thins out, and is replaced by a much thicker but looser sponge-work of bony plates and fibres, which is termed the *cancellous* tissue of the bone. The surface even of this part, however, is still formed by a thin sheet of denser bone.

At least one end of each of these bony levers is fashioned into a smooth, articular surface, covered with cartilage, which enables the relatively fixed end of the bone to play upon the corresponding surface of some other bone with which it is said to be *articulated* (see § 11), or, contrariwise, allows that other bone to move upon it.

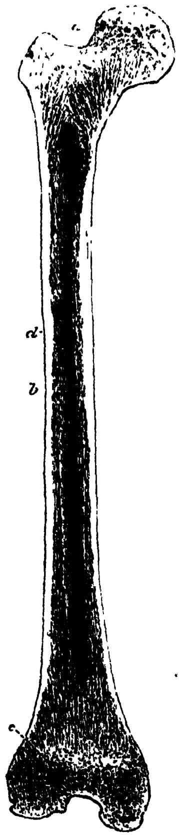

FIG. 47.—LONGITUDINAL SECTION OF THE SHAFT OF A HUMAN FEMUR OR THIGH-BONE.

a, the head, which articulates with the haunch-bone; *b*, the medullary cavity, and *d*, the dense bony substance of the shaft; *c*, the part which enters into the knee-joint, articulating with the shin-bone, or tibia.

It is one or other of these extremities which plays the part of fulcrum when the bone is in use as a lever.

Thus, in the accompanying figure (Fig. 48) of the bones of the upper extremity, with the attachments of the *biceps* muscle to the shoulder-blade and to one of the two bones of the fore-arm called the *radius*, P indicates the point of action of the power (the contracting muscle) upon the radius.

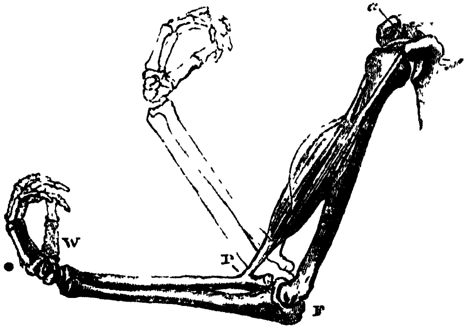

FIG. 48.—THE BONES OF THE UPPER EXTREMITY WITH THE BICEPS MUSCLE.

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

But to understand the action of the bones, as levers, properly, it is necessary to possess a knowledge of the different kinds of levers, and be able to refer the various combinations of the bones to their appropriate lever-classes.

A lever is a rigid bar, one part of which is absolutely or relatively fixed, while the rest is free to move. Some one point of the moveable part of the lever is set in motion by a force, in order to communicate more or less of that motion to another point of the moveable part, which presents a resistance to motion in the shape of a weight or other obstacle.

Three kinds of levers are enumerated by mechanicians, the definition of each kind depending upon the relative positions of the point of support, or *fulcrum;* of the point which bears the *resistance*, *weight*, or other obstacle to be overcome by the force; and of the point to which the force, or *power* employed to overcome the obstacle, is applied.

If the fulcrum be placed between the power and the weight, so that, when the power sets the lever in motion, the weight and the power describe arcs, the concavities of which are turned towards one another, the lever is said to be of the *first order*. (Fig. 49, I.)

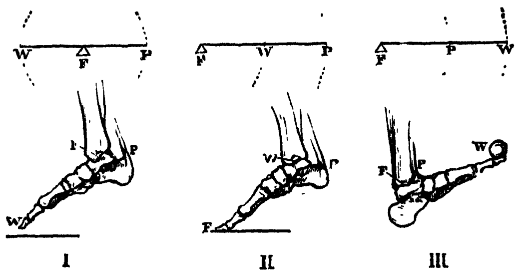

FIG. 49.

The upper three figures represent the three kinds of levers; the lower, the foot, when it takes the character of each kind.—W, weight or resistance; F, fulcrum; P, power.

If the fulcrum be at one end, and the weight be between it and the power, so that weight and power describe concentric arcs, the weight moving through the less space when the lever moves, the lever is said to be of the *second order*. (Fig. 49, II.)

And if, the fulcrum being still at one end, the power be between the weight and it, so that, as in the former case, the power and weight describe concentric arcs, but the power moves through the less space, the lever is of the *third order*. (Fig. 49, III.)

7. In the human body, the following parts present examples of levers of the first order.

(*a*) The skull in its movements upon the atlas, as *fulcrum.*

(*b*) The pelvis in its movements upon the heads of the thigh-bones, as *fulcrum.*

(*c*) The foot, when it is raised, and the toe tapped on the ground, the ankle-joint being *fulcrum.* (Fig. 49, I.)

The positions of the weight and of power are not given in either of these cases, because they are reversed according to circumstances. Thus, when the face is being depressed, the power is applied in front, and the weight to the back part, of the skull; but when the face is being raised, the power is behind and the weight in front. The like is true of the pelvis, according as the body is bent forward, or backward, upon the legs. Finally, when the toes, in the action of tapping, strike the ground, the power is at the heel, and the resistance in the front of the foot. But, when the toes are raised to repeat the act, the power is in front, and the weight, or resistance, is at the heel, being, in fact, the inertia and elasticity of the muscles and other parts of the back of the leg.

But, in all these cases, the lever remains one of the first class, because the fulcrum, or fixed point on which the lever turns, remains between the power and the weight, or resistance.

8. The following are three examples of levers of the second order:—

(*a*) The thigh-bone of the leg which is bent up towards the body and not used, in the action of hopping.

For, in this case, the fulcrum is at the hip-joint. The power (which may be assumed to be furnished by the thick muscle[1] of the front of the thigh) acts upon the knee-cap; and the position of the weight is represented by that of the centre of gravity of the thigh and leg, which will lie somewhere between the end of the knee and the hip.

(*b*) A rib when depressed by the *rectus* muscle[2] of the abdomen, in expiration.

Here the fulcrum lies where the rib is articulated with

[1] This muscle, called *rectus*, is attached above to the haunch-bone and below to the knee-cap (Fig. 2, 2, p. 12). The latter bone is connected by a strong ligament with the *tibia*.

[2] This muscle lies in the front abdominal wall on each side of the middle line. It is attached to the sternum above and to the front of the pelvis below (Fig. 2, 3).

the spine; the power is at the sternum—virtually the opposite end of the rib; and the resistance to be overcome lies between the two.

(*c*) The raising of the body upon the toes, in standing on tiptoe, and in the first stage of making a step forwards. (Fig. 49, II.)

Here the fulcrum is the ground on which the toes rest; the power is applied by the muscles of the calf to the heel (Fig. 2, I.); the resistance is so much of the weight of the body as is borne by the ankle-joint of the foot, which of course lies between the heel and the toes.

9. Three examples of levers of the third order are—

(*a*) The spine, head, and pelvis, considered as a rigid bar, which has to be kept erect upon the hip-joints. (Fig. 2.)

Here the fulcrum lies in the hip-joints; the weight is at the centre of gravity of the head and trunk, high above the fulcrum; the power is supplied by the extensor, or flexor, muscles of the thigh, and acts upon points comparatively close to the fulcrum. (Figs. 2, 2, and II.)

(*b*) Flexion of the forearm upon the arm by the *biceps* muscle, when a weight is held in the hand.

In this case, the weight being in the hand and the fulcrum at the elbow-joint, the power is applied at the point of attachment of the tendon of the biceps, close to the latter. (Fig. 48.)

(*c*) Extension of the leg on the thigh at the knee-joint.

Here the fulcrum is the knee-joint; the weight is at the centre of gravity of the leg and foot, somewhere between the knee and the foot; the power is applied by the muscles in front of the thigh (Fig. 2, 2) through the ligament of the knee-cap, or *patella*, to the tibia, close to the knee-joint.

10. In studying the mechanism of the body, it is very important to recollect that one and the same part of the body may represent each of the three kinds of levers, according to circumstances. Thus it has been seen that the foot may, under some circumstances, represent a lever of the first, in others, of the second order. But it may become a lever of the third order, as when one dances a weight resting upon the toes, up and down, by moving only the foot. In this case, the fulcrum is at the ankle-

joint, the weight is at the toes, and the power is furnished by the extensor muscles at the front of the leg (Fig. 2, 1), which are inserted between the fulcrum and the weight. (Fig. 49, III.)

11. It is very important that the levers of the body should not slip, or work unevenly, when their movements are extensive, and to this end they are connected together in such a manner as to form strong and definitely arranged *joints* or *articulations*.

Joints may be classified into imperfect and perfect.

(*a*) *Imperfect joints* are those in which the conjoined levers (bones or cartilages) present no smooth surfaces, capable of rotatory motion, to one another, but are connected by continuous cartilages, or ligaments, and have only so much mobility as is permitted by the flexibility of the joining substance.

Examples of such joints as these are to be met with in the vertebral column—the flat surfaces of the bodies of the vertebræ, being connected together by thick plates of very elastic fibro-cartilage, which confer upon the whole column considerable play and springiness, and yet prevent any great amount of motion between the several vertebræ. In the pelvis (see Plate, Fig. VI.), the pubic bones are united to each other in front, and the iliac bones to the sacrum behind, by fibrous or cartilaginous tissue, which allows of only a slight play, and so gives the pelvis a little more elasticity than it would have if it were all one bone.

(*b*) In all perfect joints, the opposed bony surfaces which move upon one another are covered with cartilage, and between them is placed a sort of sac, which lines these cartilages, and, to a certain extent, forms the side walls of the joint; and which, secreting a small quantity of viscid, lubricating fluid—the *synovia*—is called a *synovial membrane*.

12. The opposed surfaces of these *articular* cartilages, as they are called, may be spheroidal, cylindrical, or pulley-shaped; and the convexities of the one answer, more or less completely, to the concavities of the other.

Sometimes, the two articular cartilages do not come directly into contact, but are separated by independent plates of cartilage, which are termed *inter-articular*. The opposite faces of these inter-articular cartilages are fitted to receive the faces of the proper articular cartilages.

While these co-adapted surfaces and synovial membranes provide for the free mobility of the bones entering into a joint, the nature and extent of their motion is

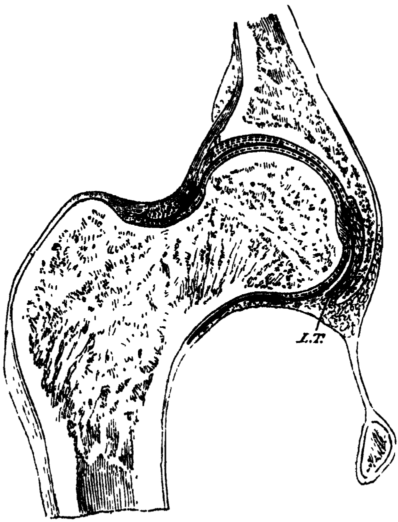

FIG. 50.—A SECTION OF THE HIP JOINT TAKEN THROUGH THE ACETABULUM OR ARTICULAR CUP OF THE PELVIS AND THE MIDDLE OF THE HEAD AND NECK OF THE THIGH-BONE.

L.T. Ligamentum teres, or round ligament. The spaces marked with an interrupted line (- - - -) represent the articular cartilages. The cavity of the synovial membrane is indicated by the dark line between these, and as is shown, extends along the neck of the femur beyond the limits of the cartilage. The peculiar shape of the pelvis causes the section to have the remarkable outline shown in the cut. This will be intelligible if compared with Fig. VI. in the Plate.

defined, partly by the forms of the articular surfaces, and partly by the disposition of the *ligaments*, or firm, fibrous cords which pass from one bone to the other.

13. As respects the nature of the articular surfaces, joints may be what are called *ball and socket joints*, when

the spheroidal surface furnished by one bone plays in a cup furnished by another. In this case the motion of the former bone may take place in any direction, but the extent of the motion depends upon the shape of the cup—being very great when the cup is shallow, and small in proportion as it is deep. The shoulder is an example of a ball and socket joint with a shallow cup; the hip of such a joint with a deep cup (Fig. 50).

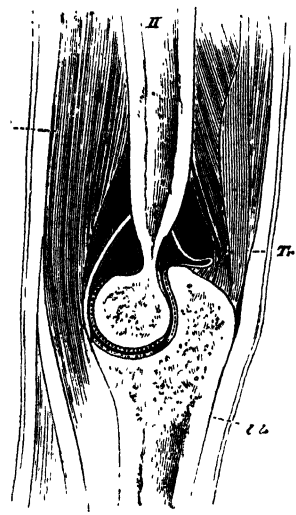

FIG. 51.—LONGITUDINAL AND VERTICAL SECTION THROUGH THE ELBOW-JOINT.

H. humerus; *Ul.* ulna; *Tr.* the *triceps* muscle which extends the arm; *Bi.* the *biceps* muscle which flexes it.

14. *Hinge-joints* are single or double. In the former case, the nearly cylindrical head of one bone fits into a corresponding socket of the other. In this form of hinge-joint the only motion possible is in the direction of a plane perpendicular to the axis of the cylinder, just as a door can

only be made to move round an axis passing through its hinges. The elbow is the best example of this joint in the human body, but the movement here is limited, because the *olecranon*, or part of the ulna which rises up behind the humerus, prevents the arm being carried back behind the straight line; the arm can thus be bent to, or straightened, but not bent back (Fig. 51). The knee and ankle present less perfect specimens of a single hinge-joint.

A double hinge-joint is one in which the articular surface of each bone is concave in one direction, and convex in another, at right angles to the former. A man seated in a saddle is "articulated" with the saddle by such a joint. For the saddle is concave from before backwards, and convex from side to side, while the man presents to it the concavity of his legs astride, from side to side, and the convexity of his seat, from before backwards.

The metacarpal bone of the thumb is articulated with the bone of the wrist, called *trapezium*, by a double hinge-joint.

15. A *pivot-joint* is one in which one bone furnishes an axis, or pivot, on which another turns; or itself turns on its own axis, resting on another bone. A remarkable example of the former arrangement is afforded by the *atlas* and *axis*, or two uppermost vertebræ of the neck (Fig. 52). The axis possesses a vertical peg, the so-called *odontoid* process (*b*), and at the base of the peg are two, obliquely placed, articular surfaces (*a*.) The atlas is a ring-like bone, with a massive thickening on each side. The inner side of the front of the ring plays round the neck of the odontoid peg, and the under surfaces of the lateral masses glide over the articular faces on each side of the base of the peg. A strong ligament passes between the inner sides of the two lateral masses of the atlas, and keeps the hinder side of the neck of the odontoid peg in its place (Fig. 52, A). By this arrangement, the atlas is enabled to rotate through a considerable angle either way upon the axis, without any danger of falling forwards or backwards—accidents which would immediately destroy life by crushing the spinal marrow.

The lateral masses of the atlas have, on their upper faces, concavities (Fig. 52, A, *a*) into which the two convex, occipital condyles of the skull fit, and in which they play upward and downward. Thus the nodding of the head is effected by the movement of the skull upon the atlas; while, in turning the head from side to side, the skull does not move upon the atlas, but the atlas slides round the odontoid peg of the axis vertebra.

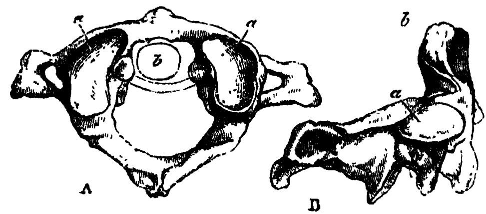

FIG. 52.

A The Atlas viewed from above: *a a*, upper articular surfaces of its lateral masses for the condyles of the skull, *b*, the peg of the axis vertebra B. Side view of the axis vertebra: *a*, articular surface for the lateral mass of the atlas, *b*, peg or odontoid process.

The second kind of pivot-joint is seen in the forearm. If the elbow and forearm, as far as the wrist, are made to rest upon a table, and the elbow is kept firmly fixed, the hand can nevertheless be freely rotated so that either the palm, or the back, is turned directly upwards. When the palm is turned upwards, the attitude is called *supination* (Fig. 53, A); when the back, *pronation* (Fig. 53, B).

The forearm is composed of two bones; one, the *ulna*, which articulates with the *humerus* at the elbow by the hinge-joint already described, in such a manner that it can move only in flexion and extension (see § 17), and has no power of rotation. Hence, when the elbow and wrist are rested on a table, this bone remains unmoved.

But the other bone of the forearm, the *radius*, has its small upper end shaped like a very shallow cup with thick edges. The hollow of the cup articulates with a spheroidal surface furnished by the humerus; the lip of the cup, with a concave depression on the side of the ulna.

The large lower end of the radius bears the hand, and has, on the side next the ulna, a concave surface, which articulates with the convex side of the small lower end of that bone.

Thus the upper end of the radius turns on the double surface, furnished to it by the pivot-like ball of the humerus, and the partial cup of the ulna : while the lower end of the radius can rotate round the surface furnished to it by the lower end of the ulna.

In *supination*, the radius lies parallel with the ulna, with its lower end to the outer side of the ulna (Fig. 53, A). In

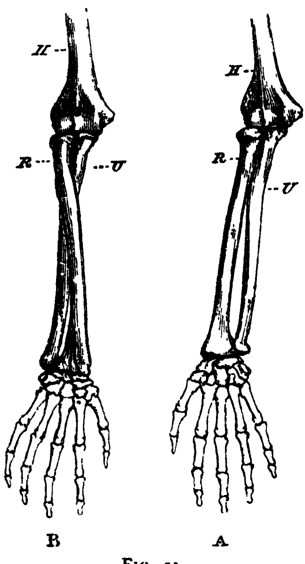

FIG. 53.

The bones of the right forearm in supination (A) and pronation (B). *H.* humerus; *R.* radius; *U.* ulna.

pronation, it is made to turn on its own axis above, and round the ulna below, until its lower half crosses the ulna, and its lower end lies on the inner side of the ulna (Fig. 53, B).

16. The ligaments which keep the mobile surfaces of bones together are, in the case of ball and socket joints,

strong fibrous *capsules* which surround the joint on all sides. In hinge-joints, on the other hand, the ligamentous tissue is chiefly accumulated, in the form of *lateral ligaments*, at the sides of the joints. In some cases ligaments are placed within the joints, as in the knee, where the bundles of fibres which cross obliquely between the femur and the tibia are called *crucial* ligaments; or, as in the hip, where the *round ligament* passes from the bottom of the socket or acetabulum of the pelvis to the ball furnished by the head of the femur (Fig. 50).

Again, two ligaments pass from the apex of the odontoid peg to either side of the margins of the occipital foramen, *i.e.* the large hole in the base of the skull, through which the spinal cord passes to join the brain; these, from their function in helping to stop excessive rotation of the skull, are called *check ligaments* (Fig. 54, *a*).

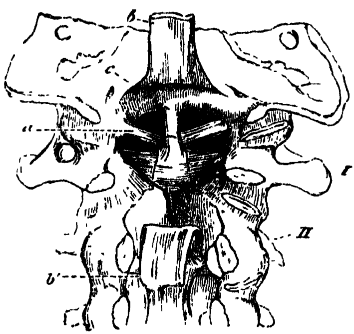

FIG. 54.

The vertebral column in the upper part of the neck laid open, to show *a*, the check ligaments of the axis; *b*, the broad ligament which extends from the front margin of the occipital foramen along the hinder faces of the bodies of the vertebræ; it is cut through, and the cut ends turned back to show, *c*, the special ligament which connects the point of the "odontoid" peg with the front margin of the occipital foramen; *I*. the atlas, *II*. the axis.

In one joint of the body, the hip, the socket or *acetabulum* (Fig. 50) fits so closely to the head of the femur, and the capsular ligament so completely closes its cavity on all sides, that the pressure of the air must be reckoned among the causes which prevent dislocation. This has deen proved experimentally by boring a hole through the floor of the acetabulum, so as to admit air into its cavity, when the thigh-bone at once falls as far as the round and capsular ligaments will permit it to do, showing that it was previously pushed close up by the pressure of the external air.

17. The different kinds of movement which the levers thus connected are capable of performing, are called *flexion* and *extension; abduction* and *adduction; rotation* and *circumduction.*

A limb is *flexed,* when it is bent; *extended,* when it is straightened out. It is *abducted,* when it is drawn away from the middle line; *adducted,* when it is brought to the middle line. It is *rotated,* when it is made to turn on its own axis; *circumducted,* when it is made to describe a conical surface by rotation round an imaginary axis.

No part of the body is capable of perfect rotation like a wheel, for the simple reason that such motion would necessarily tear all the vessels, nerves, muscles, &c. which unite it with other parts.

18. Any two bones united by a joint may be moved one upon another in, at fewest, two different directions. In the case of a pure hinge-joint, these directions must be opposite and in the same plane; but, in all other joints, the movements may be in several directions and in various planes.

In the case of a pure hinge-joint, the two practicable movements—viz. flexion and extension—may be effected by means of two muscles, one for either movement, and running from one bone to the other, but on opposite sides of the joint. When either of these muscles contracts, it will pull its attached ends together, and bend or straighten, as the case may be, the joint towards the side on which it is placed. Thus the biceps muscle is attached, at one end, to the shoulder blade, while, at the other end, its tendon passes in front of the elbow-joint to the radius (Figs. 48 and 51): when this muscle contracts, therefore, it bends, or flexes, the forearm on the arm. At the back of the joint there is the triceps (*Tr* Fig. 51); when this contracts, it straightens, or extends, the forearm on the arm.

In the other extreme form of articulation—the ball and socket joint—movement in any number of planes may be effected, by attaching muscles in corresponding number and direction, on the one hand, to the bone which affords the socket, and on the other to that which furnishes the head. Circumduction will be effected by the combined and successive contraction of these muscles.

19. It usually happens that the bone to which one end of a muscle is attached is absolutely or relatively stationary, while that to which the other is fixed is moveable. In this case, the attachment to the stationary bone is termed the *origin*, that to the moveable bone the *insertion*, of the muscle.

The fibres of muscles are sometimes fixed directly into the parts which serve as their origins and insertions: but, more commonly, strong cords or bands of fibrous tissue, called *tendons*, are interposed between the muscle proper and its place of origin or insertion. When the tendons play over hard surfaces, it is usual for them to be separated from these surfaces by sacs containing fluid, which are called *bursæ;* or even to be invested by synovial sheaths, *i.e.* quite covered for some distance by a synovial bag forming a double sheath very much in the same way that the bag of the pleura covers the lung and the chest wall.

Usually, the direction of the axis of a muscle is that of a straight line joining its origin and its insertion. But in some muscles, as the *superior oblique muscle* of the eye, the tendon passes over a pulley formed by ligament, and completely changes its direction before reaching its insertion. (See Lesson IX.)

Again, there are muscles which are fleshy at each end, and have a tendon in the middle. Such muscles are called *digastric*, or two-bellied. In the curious muscle which pulls down the lower jaw, and specially receives this name of *digastric*, the middle tendon runs through a pulley connected with the hyoid bone; and the muscle, which passes downwards and forwards from the skull to this pulley, after traversing it, runs upwards and forwards, to the lower jaw (Fig. 55).

20. We may now pass from the consideration of the mechanism of mere motion to that of locomotion.

When a man who is standing erect on both feet proceeds to *walk*, beginning with the right leg, the body is inclined so as to throw the centre of gravity forward; and, the right foot being raised, the right leg is advanced for the length of a step, and the foot is put down again. In the meanwhile, the left heel is raised, but the toes of the left foot have not left the ground when the right foot has reached it, so that there is no moment at which both

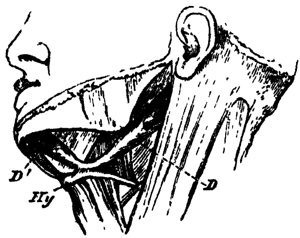

FIG 55.—THE COURSE OF THE DIGASTRIC MUSCLE.

D, its posterior belly; D', its anterior belly; between the two is the tendon passing through its pulley connected with *Hy*. the hyoid bone.

feet are off the ground. For an instant, the legs form two sides of an equilateral triangle, and the centre of the body is consequently lower than it was when the legs were parallel and close together.

The left foot, however, has not been merely dragged away from its first position, but the muscles of the calf, having come into play, act upon the foot as a lever of the second order, and thrust the body, the weight of which rests largely on the left astragalus, upwards, forwards, and to the right side. The momentum thus communicated to the body causes it, with the whole right leg, to describe an arc over the right astragalus, on which that leg rests below. The centre of the body consequently rises to its former height as the right leg becomes vertical, and descends again as the right leg, in its turn, inclines forward.

When the left foot has left the ground, the body is supported on the right leg, and is well in advance of the left foot; so that, without any further muscular exertion, the left foot swings forward like a pendulum, and is carried by its own momentum beyond the right foot, to the position in which it completes the second step.

When the intervals of the steps are so timed that each swinging leg comes forward into position for a new step without any exertion on the part of the walker, walking is effected with the greatest possible economy of force. And, as the swinging leg is a true pendulum,—the time of vibration of which depends, other things being alike, upon its length (short pendulums vibrating more quickly than long ones),—it follows that, on the average, the natural step of short-legged people is quicker than that of long-legged ones.

In *running*, there is a period when both legs are off the ground. The legs are advanced by muscular contraction, and the lever action of each foot is swift and violent. Indeed, the action of each leg resembles, in violent running, that which, when both legs act together, constistute a *jump*, the sudden extension of the legs adding to the impetus, which, in slow walking, is given only by the feet.

21. Perhaps the most singular motor apparatus in the body is the *larynx*, by the agency of which *voice* is produced.

The essential conditions of the production of the human voice are :—

a. The existence of the so-called *vocal chords*.

b. The parallelism of the edges of these chords, without which they will not vibrate in such a manner as to give out sound.

c. A certain degree of tightness of the vocal chords, without which they will not vibrate quickly enough to produce sound.

d. The passage of a current of air between the parallel edges of the vocal chords of sufficient power to set the chords vibrating.

22. The larynx is a short tubular box opening above into the bottom of the pharynx and below into the top of the trachea. Its framework is supplied by certain cartilages more or less moveable on each other, and these are connected together by joints, membranes and muscles. Across the middle of the larynx is a transverse partition,

formed by two folds of the lining mucous membrane, stretching from either side, but not quite meeting in the middle line. They thus leave, in the middle line, a chink or slit, running from the front to the back, called the *glottis*. The two edges of this slit are not round and flabby, but sharp and, so to speak, clean cut; they are also strengthened by a quantity of elastic tissue, the fibres of which are disposed lengthways in them. These sharp

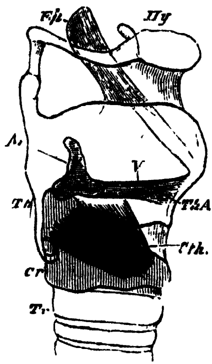

FIG. 56.

Diagram of the larynx, the thyroid cartilage (*Th.*) being supposed to be transparent, and allowing the right arytenoid cartilage (*Ar.*), vocal chords (*V.*) and thyro-arytenoid muscle (*ThA.*), the upper part of the cricoid cartilage (*Cr*), and the attachment of the epiglottis (*Ep*), to be seen. *C.th.* the right crico-thyroid muscle; *Tr* the trachea; *Hy.* the hyoid bone.

free edges of the *glottis* are the so-called *vocal chords* or *vocal ligaments*.

23. The *thyroid* cartilage (Fig. 56, *Th.*) is a broad plate of gristle bent upon itself into a V shape, and so disposed that the point of the V is turned forwards, and constitutes what is commonly called "Adam's apple." Above, the thyroid cartilage is attached by ligament and membrane to the *hyoid* bone (Fig. 56, *Hy.*). Below and behind, its broad sides are produced into little elongations or horns, which are articulated by ligaments with the outside of a

great ring of cartilage, the *cricoid* (Fig. 56, *Cr.*), which forms, as it were, the top of the windpipe.

The *cricoid* ring is much higher behind than in front, and a gap, filled up by membrane only, is left between its

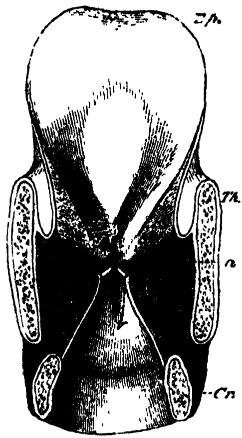

FIG. 57 —A VERTICAL AND TRANSVERSE SECTION THROUGH THE LARYNX, THE HINDER HALF OF WHICH IS REMOVED.

Ep. Epiglottis; *Th.* thyroid cartilage; *a*, cavities called the *ventricles of larynx* above the vocal ligaments (*V*), × the right thyro-arytenoid muscle cut across; *Cr.* the cricoid cartilage.

upper edge and the lower edge of the front part of the thyroid, when the latter is horizontal. Consequently, the thyroid cartilage, turning upon the articulations of its horns with the hinder part of the cricoid, as upon hinges, can be moved up and down through the space occupied by this membrane. When it moves downwards, the distance between the front part of the thyroid cartilage and the back of the cricoid is necessarily increased; and when it moves back again to the horizontal position, diminished. There is, on each side, a large muscle, the *crico-thyroid*, which passes from the outer side of the cricoid cartilage obliquely upwards and backwards to the thyroid, and pulls the latter down (Fig. 56, *C.th*).

24. Perched side by side, upon the upper edge of the back part of the cricoid cartilage are two small irregularly-shaped but, roughly speaking, pyramidal cartilages, the *arytenoid* cartilages (Fig. 58, *Ary.*). Each of these is articulated by its base with the cricoid cartilage by means of a shallow joint which permits of very varied movements,

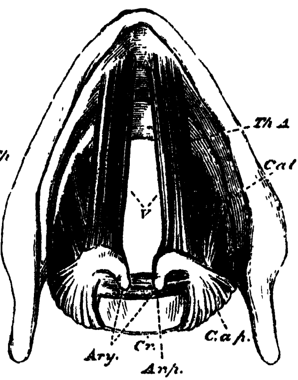

FIG. 58.—THE PARTS SURROUNDING THE GLOTTIS PARTIALLY DISSECTED AND VIEWED FROM ABOVE

Th. The thyroid cartilage; *Cr.* the cricoid cartilage; *V.* the edges of the vocal ligaments bounding the glottis; *Ary.* the arytenoid cartilages; *Th.A.* thyro-arytenoid; *C.a.l.* lateral crico-arytenoid; *C.a p.* posterior crico-arytenoid; *Ar p.* posterior arytenoid muscles.

and especially allows the front portions of the two arytenoid cartilages to approach, or to recede from, each other.

It is to the fore part of one of these arytenoid cartilages that the hinder end of each of the two vocal ligaments is fastened; and they stretch from these points horizontally across the cavity of the larynx, to be attached, close together, in the re-entering angle of the thyroid cartilage rather lower than half-way between its top and bottom.

Now when the arytenoid cartilages diverge, as they do when the larynx is in a state of rest, it is evident that the aperture of the glottis will be V-shaped, the point of the V being forwards, and the base behind.

For, in front, or in the angle of the thyroid, the two vocal ligaments are fastened permanently close together, whereas, behind, their extremities will be separated as far as the arytenoids, to which they are attached, are separated

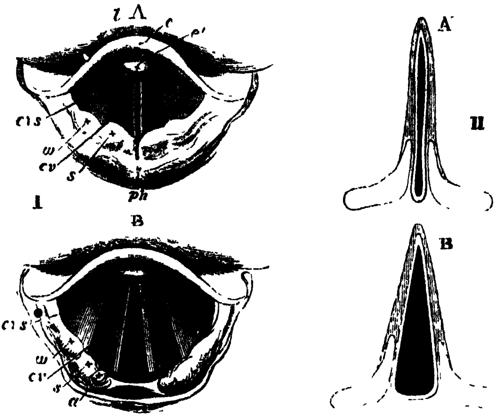

FIG. 59.

I View of the human larynx from above as actually seen by the aid of the instrument called the laryngoscope: A, in the condition when voice is being produced; B, at rest, when no voice is produced.
e Epiglottis (foreshortened).
c v. The vocal chords.
c.v s. The so-called false vocal chords, folds of mucous membrane lying above the real vocal chords.
a Elevation caused by the arytenoid cartilages.
s.w. Elevations caused by small cartilages connected with the arytenoids.
t Root of the tongue.
II. Diagram of the same.

from each other. Under these circumstances a current of air passing through the glottis produces no sound, the parallelism of the vocal chords being wanting; whence it is that, ordinarily, expiration and inspiration take place quietly. Passing from one arytenoid cartilage to the other, at their posterior surfaces are certain muscles called the *posterior arytenoid* (Fig. 58, *Ar.p.*). There are also two sets of muscles connecting each arytenoid with the cricoid, and called from their positions respectively the *posterior* and *lateral crico-arytenoid* (Fig. 58, *C.a.p.*, *Ca.l.*). By the more or less separate or combined action of these muscles, the arytenoid cartilages and, consequently, the hinder ends of the vocal chords attached to them, may be made to approach or recede from each other, and thus the vocal chords rendered parallel or the reverse.

We have seen that the crico-thyroid muscle pulls the thyroid cartilage down, and thus increases the distance between the front of the thyroid and the back of the cricoid, on which the arytenoids are seated. This movement, the arytenoids being fixed, must tend to pull out the vocal chords lengthways, or in other words to tighten them.

Running from the re-entering angle in the front part of the thyroid, backward, to the arytenoids, alongside the vocal chords (and indeed imbedded in the transverse folds, of which the chords are the free edges) are two strong muscles, one on each side (Fig. 58, *Th.A.*), called *thyro-arytenoid.* The effect of the contraction of these muscles is to pull up the thyroid cartilage after it has been depressed by the crico-thyroid muscles, and consequently to slacken the vocal chords.

Thus the parallelism (*b*) of the vocal chords is determined chiefly by the relative distance from each other of the arytenoid cartilages; the tension (*c*) of the vocal cords is determined chiefly by the upward or downward movement of the thyroid cartilage; and both these conditions are dependent on the action of certain muscles.

The current of air (*d*) whose passage sets the chords vibrating is supplied by the movements of expiration, which, when the chords are sufficiently parallel and tense, produce that musical note which constitutes the voice, but otherwise give rise to no audible sound at all.

25. Other things being alike, the musical note will be low or high, according as the vocal chords are relaxed or tightened; and this again depends upon the relative predominance of the contraction of the crico-thyroid and thyro-arytenoid muscles. For when the thyro-arytenoid muscles are fully contracted, the thyroid cartilage will be pulled up as far as it can go, and the vocal chords will be rendered relatively lax; while, when the crico-thyroid

muscles are fully contracted, the thyroid cartilage will be depressed as much as possible, and the vocal chords will be made more tense.

The *range* of any voice depends upon the difference of tension which can be given to the vocal chords, in these two positions of the thyroid cartilage. *Accuracy* of singing depends upon the precision with which the singer can voluntarily adjust the contractions of the thyro-arytenoid and crico thyroid muscles—so as to give his

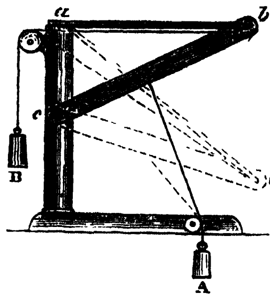

FIG. 60.

Diagram of a model illustrating the action of the levers and muscles of the larynx. The stand and vertical pillar represent the cricoid and arytenoid cartilages, while the rod (*b c*), moving on a pivot at *c*, takes the place of the thyroid cartilage; *a b* is an elastic band representing the vocal ligament. Parallel with this runs a cord fastened at one end to the rod *b c*, and, at the other, passing over a pulley to the weight B. This represents the thyro-arytenoid muscle. A cord attached to the middle of *b c*, and passing over a second pulley to the weight A, represents the crico-thyroid muscle. It is obvious that when the bar (*b c*) is pulled down to the position *c d*, the elastic band (*a b*) is put on the stretch.

vocal chords the exact tension at which their vibration will yield the notes required.

The *quality* of a voice—treble, bass, tenor, &c.—on the other hand, depends upon the make of the particular larynx, the primitive length of its vocal chords, their elasticity, the amount of resonance of the surrounding parts, and so on.

Thus, men have deeper notes than boys and women, because their larynxes are larger and their vocal chords longer—whence, though equally elastic, they vibrate less swiftly.

26. *Speech* is voice modulated by the throat, tongue, and lips. Thus, voice may exist without speech; and it is commonly said that speech may exist without voice, as in whispering. This is only true, however, if the title of voice be restricted to the sound produced by the vibration of the vocal chords; for, in whispering, there is a sort of voice produced by the vibration of the muscular walls of the lips which thus replace the vocal chords. A whisper is, in fact, a very low whistle.

The *modulation* of the voice into speech is effected by changing the form of the cavity of the mouth and nose, by the action of the muscles which move the walls of those parts.

Thus, if the pure *vowel* sounds—

E (as in *he*),	*A* (as in *hay*),	*A'* (as in *ah*),
O (as in *or*),	*O'* (as in *oh*),	*OO* (as in *cool*),

are pronounced successively, it will be found that they may be all formed out of the sound produced by a continuous expiration, the mouth being kept open, but the form of its aperture, and the extent to which the lips are thrust out or drawn in so as to lengthen or shorten the distance of the orifice from the larynx, being changed for each vowel. It will be narrowest, with the lips most drawn back, in *E*, widest in *A'*, and roundest, with the lips most protruded, in *OO*.

Certain *consonants* also may be pronounced without interrupting the current of expired air, by modification of the form of the throat and mouth.

Thus the aspirate, H, is the result of a little extra expiratory force—a sort of incipient cough. *S* and *Z*, *Sh* and *J* (as in *jugular* = *G* soft, as in *gentry*), *Th*, *L*, *R*, *F*, *V*, may likewise all be produced by continuous currents of air forced through the mouth, the shape of the cavity of which is peculiarly modified by the tongue and lips.

27. All the vocal sounds hitherto noted so far resemble one another, that their production does not involve the stoppage of the current of air which traverses either of the modulating passages.

But the sounds of *M* and *N* can only be formed by blocking the current of air which passes through the mouth, while free passage is left through the nose. For *M*, the mouth is shut by the lips; for *N*, by the application of the tongue to the palate.

28. The other consonantal sounds of the English language are produced by shutting the passage through both nose and mouth; and, as it were, forcing the expiratory vocal current through the obstacle furnished by the latter, the character of which obstacle gives each consonant its peculiarity. Thus, in producing the consonants *B* and *P*, the mouth is shut by the lips, which are then forced open in this *explosive* manner. In *T* and *D*, the mouth passage is suddenly barred by the application of the point of the tongue to the teeth, or to the front part of the palate; while in *K* and *G* (hard, as in *go*) the middle and back of the tongue are similarly forced against the back part of the palate.

29. An artificial larynx may be constructed by properly adjusting elastic bands, which take the place of the vocal chords; and, when a current of air is forced through these, due regulation of the tension of the bands will give rise to all the notes of the human voice. As each vowel and consonantal sound is produced by the modification of the length and form of the cavities, which lie over the natural larynx, so, by placing over the artificial larynx chambers to which any requisite shape can be given, the various letters may be sounded. It is by attending to these facts, and principles that various speaking machines have been constructed.

30. Although the tongue is credited with the responsibility of speech, as the "unruly member," and undoubtedly takes a very important share in its production, it is not absolutely indispensable. Hence, the apparently fabulous stories of people who have been enabled to speak, after their tongues had been cut out by the cruelty of a tyrant, or persecutor, may be quite true.

Some years ago I had the opportunity of examining a person, whom I will call Mr. R., whose tongue had been removed as completely as a skilful surgeon could perform the operation. When the mouth was widely opened, the truncated face of the stump of the tongue, apparently covered with new mucous membrane, was to be seen, occupying a position as far back as the level of the anterior pillars of the fauces. The dorsum of the tongue was visible with difficulty ; but I believe I could discern some of the circumvallate papillæ upon it. None of these were visible upon the amputated part of the tongue, which had been preserved in spirit ; and which, so far as I could judge, was about 2½ inches long.

When his mouth was open, Mr. R. could advance his tongue no further than the position in which I saw it ; but he informed me that, when his mouth was shut, the stump of the tongue could be brought much more forward.

Mr. R.'s conversation was perfectly intelligible ; and such words as *think*, *the*, *cow*, *kill*, were well and clearly pronounced. But tin became *fin ;* tack, *fack* or *pack ;* toll, *pool ;* dog, *thog ;* dine, *vine ;* dew, *thew ;* cat, *catf ;* mad, *madf ;* goose, *gooth ;* big, pig, *bich*, *pich*, with a guttural *ch*.

In fact, only the pronunciation of those letters the formation of which requires the use of the tongue was affected ; and, of these, only the two which involve the employment of its tip were absolutely beyond Mr. R.'s power. He converted all *t's*, and *d's*, into *f's*, *p's*, *v's*, or *th's*. *Th* was fairly given in all cases ; *s* and *sh*, *l* and *r*, with more or less of a lisp. Initial *g's* and *k's* were good ; but final *g's* were all more or less guttural. In the former case, the imperfect stoppage of the current of air by the root of the tongue was of no moment, as the sound ran on into that of the following vowel ; while, when the letter was terminal, the defect at once became apparent.

LESSON VIII.

SENSATIONS AND SENSORY ORGANS.

1. THE agent by which all the motor organs (except the cilia) described in the preceding Lesson are set at work, is muscular fibre. But, in the living body, muscular fibre is made to contract only by a change which takes place in the *motor* or *efferent nerve*, which is distributed to it. This change again is effected only by the activity of the *central nervous organ*, with which the motor nerve is connected. The central organ is thrown into activity immediately, or ultimately, only by the influence of changes which take place in the molecular condition of nerves, called *sensory* or *afferent*, which are connected, on the one hand, with the central organ, and, on the other hand, with some other part of the body. Finally, the alteration of the afferent nerve is itself produced only by changes in the condition of the part of the body with which it is connected; which changes usually result from external impressions.

2. Thus the great majority (if not the whole) of the movements of the body and of its parts, are the effect of an influence (technically termed a *stimulus* or *irritation*) applied directly, or indirectly, to the ends of *afferent nerves*, and giving rise to a molecular change, which is propagated along their substance to the *central nervous organ* with which they are connected. The molecular activity of the afferent nerve communicates itself to the central organ, and is then transmitted along the *motor nerves*, which pass from the central organ to the muscles affected. And, when the disturbance in the molecular

condition of the efferent nerves reaches their extremities, it is communicated to the muscular fibres, and causes their particles to take up a new position, so that each fibre shortens and becomes thicker.

3. Such a series of molecular changes as that just described is called a *reflex action*—the disturbance caused by the irritation being as it were *reflected* back, along the motor nerves, to the muscles.

A reflex action, strictly so called, takes place without our knowing anything about it, and hundreds of such actions are going on continually in our bodies without our being aware of them. But it very frequently happens that we learn that something is going on, when a stimulus affects our afferent nerves, by having what we call a *feeling* or *sensation*. We class sensations along with *emotions*, and *volitions*, and *thoughts*, under the common head of *states of consciousness*. But what consciousness is, we know not; and how it is that anything so remarkable as a state of consciousness comes about as the result of irritating nervous tissue, is just as unaccountable as any other ultimate fact of nature.

4. Sensations are of very various degrees of definiteness. Some arise within ourselves, we know not how or where, and remain vague and undefinable. Such are the sensations of *uncomfortableness*, or *faintness*, of *fatigue*, or of *restlessness*. We cannot assign any particular place to these sensations, which are very probably the result of affections of the afferent nerves in general brought about by the state of the blood, or that of the tissues in which they are distributed. And however real these sensations may be, and however largely they enter into the sum of our pleasures and pains, they tell us absolutely nothing of the external world. They are not only *diffuse*, but they are also *subjective* sensations.

5. What is termed the *muscular sense* is less vaguely localized than the preceding, though its place is still incapable of being very accurately defined. This muscular sensation is the feeling of resistance which arises when any kind of obstacle is opposed to the movement of the body, or of any part of it; and it is something quite different from the feeling of contact or even of pressure.

Lay one hand flat on its back upon a table, and rest a disc of cardboard a couple of inches in diameter upon the ends of the outstretched fingers; the only result will be a sensation of *contact*—the pressure of so light a body being inappreciable. But put a two-pound weight upon the cardboard, and the sensation of *contact* will be accompanied, or even obscured, by the very different feeling of *pressure*. Up to this moment the fingers and arm have rested upon the table; but now let the hand be raised from the table, and another new feeling will make its appearance—that of *resistance to effort*. This feeling comes into existence with the exertion of the muscles which raise the arm, and is the consciousness of that exertion given to us by the muscular sense.

Anyone who raises or carries a weight, knows well enough that he has this sensation; but he may be greatly puzzled to say where he has it. Nevertheless, the sense itself is very delicate, and enables us to form tolerably accurate judgments of the relative intensity of resistances. Persons who deal in articles sold by weight, are constantly enabled to form very precise estimates of the weight of such articles by balancing them in their hands; and in this case, they depend in a great measure upon the muscular sense.

6. In a third group of sensations, each feeling, as it arises, is assigned to a definite part of the body, and is produced by a stimulus applied to that part of the body; but the bodies, or forces, which are competent to act as stimuli, are very various in character. Such are the sensations of *touch*, which is restricted to the integument covering the surface, and to some portions of the membranes lining the internal cavities of the body; and of *taste* and *smell*, which are similarly confined to certain regions of the mucous membrane of the mouth and nasal cavities.

Any portion of the body to which a sensation is thus restricted is called a sensory organ.

And lastly, in a fourth group of sensations, each feeling requires for its production the application of a single kind of stimulus to a very specially modified part of the integument. The latter serves as an intermediator between the physical agent of the sensation and the sensory nerve, which is to convey to the brain the impulse necessary to awake in it that state of consciousness which we call the sensation. Such are the sensations of *sight* and *hearing*. The physical agents which can alone awaken these sensations (under natural circumstances) are light and sound. The modified parts of the integument, which alone are competent to intermediate between these agents and the nerves of sight and hearing, are the *eye* and the *ear*.

7. In every sensory organ it is necessary to distinguish the terminal expansion of the afferent or sensory nerve, and the structures which intermediate between this expansion and the physical agent which gives rise to the sensation.

And in each group of special sensations there are certain phenomena which arise out of the structure of the organ, and others which result from the operation of the central apparatus of the nervous system upon the materials supplied to it by the sensory organ.

8. The sense of TOUCH (including that of heat and cold) is possessed, more or less acutely, by all parts of the free surface of the body, and by the walls of the mouth and nasal passages.

Whatever part possesses this sense consists of a membrane (integumentary or mucous) composed of a deep layer made up of fibrous tissue, containing a capillary network and the ultimate terminations of the sensory nerves; and of a superficial layer consisting of epithelial or epidermic cells, among which are no vessels.

Wherever the sense of touch is delicate, the deep layer is not a mere flat expansion, but is raised up into multitudes of small, close-set, conical elevations (see Fig. 32), which are called *papillæ*. In the skin, the coat of epithelial or epidermic cells does not follow the contour of these papillæ, but dips down between them and forms a tolerably even coat over them. Thus, the points of the papillæ are much nearer the surface than the general plane of the deep layer whence these papillæ proceed.

Loops of vessels enter the papillæ, and the fine ultimate terminations of the sensory nerve-fibres distributed to the skin terminate in them, but in what way has not been thoroughly made out.

In certain cases, the delicate fibrous sheath, or ***neurilemma***, of the nerve which enters the papilla, enlarges in the papilla into an oval swelling, which is called a *tactile corpuscle* (see Lesson XII.). These corpuscles are found in the papillæ of those localities which are endowed with a very delicate sense of touch, as in the tips of the fingers, the point of the tongue, &c.

9. It is obvious, from what has been said, that no direct contact takes place between a body which is touched and the sensory nerve,—a thicker or thinner layer of epithelium, or epidermis, being situated between the two. In fact, if this layer is removed, as when a surface of the skin has been blistered, contact with the raw surface gives rise to a sense of pain, not to one of touch properly so called. Thus, in touch, it is the epidermis, or epithelium, which is the intermediator between the nerve and the physical agent, the external pressure being transmitted through the horny cells to the subjacent ends of the nerves, and the kind of impulse thus transmitted must be modified by the thickness and character of the cellular layer, no less than by the forms and number of the papillæ.

10. Certain very curious phenomena appertaining to the sense of touch, are probably due to these varying anatomical arrangements. Not only is tactile sensibility to a single impression much duller in some parts than in others—a circumstance which might be readily accounted for by the different thickness of the epidermic layer—but the power of distinguishing double simultaneous impressions is very different. Thus, if the ends of a pair of compasses (which should be blunted with pointed pieces of cork) are separated by only one-tenth or one-twelfth of an inch, they will be distinctly felt as two, if applied to the tips of the fingers; whereas, if applied to the back of the hand in the same way, only one impression will be felt; and, on the arm, they may be separated for a quarter of an inch, and still only one impression will be perceived.

Accurate experiments have been made in different parts of the body, and it has been found that two points can be distinguished by the tongue, if only one-twenty-fourth of an inch apart; by the tips of the fingers if one-twelfth of an inch distant; while they may be one inch distant on the cheek, and even three inches on the back, and still give rise to only one sensation.

11. The feeling of warmth, or cold, is the result of an excitation of sensory nerves distributed to the skin, which are probably distinct from those which give rise to the sense of touch. And it would appear that the heat must be transmitted through the epidermic or epithelial layer, to give rise to this sensation; for, just as touching a naked nerve, or the trunk of a nerve, gives rise only to pain, so heating or cooling an exposed nerve, or the trunk of a nerve, gives rise not to a sensation of heat or cold, but simply to pain.

Again, the sensation of heat, or cold, is relative rather than absolute. Suppose three basins be prepared, one filled with ice-cold water, one with water as hot as can be borne, and the third with a mixture of the two. If the hand be put into the hot-water basin, and then transferred to the mixture, the latter will feel cold; but if the hand be kept awhile in the ice-cold water, and then transferred to the very same mixture, it will feel warm.

Like the sense of touch, the sense of warmth varies in delicacy in different parts of the body.

The cheeks are very sensitive, more so than the lips; the palms of the hands are more sensitive to heat than their backs. Hence a washerwoman holds her flat-iron to her cheek to test the temperature, and one who is cold spreads the palms of his hands to the fire.

12. The organ of the sense of TASTE is the mucous membrane which covers the tongue, especially its back part, and the hinder part of the palate. Like that of the skin, the deep, or vascular, layer of the mucous membrane of the tongue is raised up into papillæ, but these are large, separate, and have separate coats of epithelium. Towards the tip of the tongue they are for the most part elongated and pointed, and are called *filiform;* over the rest of the surface of the tongue, these are mixed with other larger papillæ, with broad ends and narrow bases, called *fungiform;* but towards its root there are a number of large papillæ, arranged in the figure of a V with its point backwards, each of which

is like a fungiform papilla surrounded by a wall. These are the circumvallate papillæ (Fig. 61, *C.p.*). The larger of these papilla have subordinate small ones upon their surfaces. They are very vascular, and they receive nervous filaments from two sources, the one the nerve

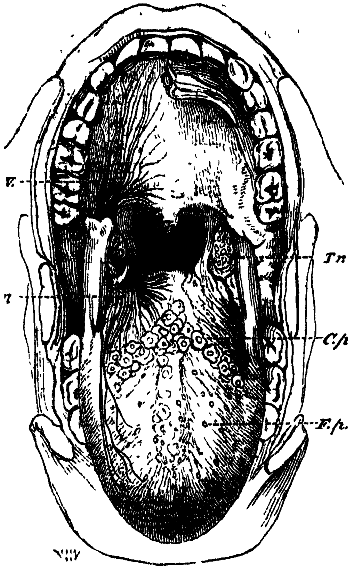

FIG. 61.—THE MOUTH WIDELY OPENED TO SHOW THE TONGUE AND PALATE.

Uv. the uvula; *Tn.* the tonsil between the anterior and posterior pillars of the fauces; *C.p.* circumvallate papillæ; *F.p.* fungiform papillæ. The minute filiform papillæ cover the interspaces between these. On the right side the tongue is partially dissected to show the course of the filaments of the glossopharyngeal nerve, *VIII.*

called *glossopharyngeal*, the other the *gustatory*, which is a branch of the *fifth* nerve. (See Lesson XI. § 18.) The latter chiefly supplies the front of the tongue, the former its back and the adjacent part of the palate: and there is reason to believe that it is the latter region which is more especially the seat of the sense of taste.

The great majority of the sensations we call taste, however, are in reality complex sensations, into which smell and even touch largely enter. When the sense of smell is interfered with, as when the nose is held tightly pinched, it is very difficult to distinguish the taste of various objects. An onion, for instance, the eyes being shut, may then easily be confounded with an apple.

13. The organ of the sense of SMELL is the delicate mucous membrane which lines a part of the nasal cavities, and is distinguished from the rest of the mucous membrane of these cavities—firstly, by possessing no cilia; secondly, by receiving its nervous supply from the olfactory, or first, pair of cerebral nerves, and not, like the rest of the mucous membrane, from the fifth pair.

Each nostril leads into a spacious nasal chamber, separated, in the middle line, from its fellow of the other side, by a partition, or *septum*, formed partly by cartilage and partly by bone, and continuous with that partition which separates the two nostrils one from the other. Below, each nasal chamber is separated from the cavity of the mouth by a floor, the bony palate (Figs. 62 and 63); and when this bony palate comes to an end, the partition is continued down to the root of the tongue by a fleshy curtain, the soft palate, which has been already described. The soft palate and the root of the tongue together, constitute, under ordinary circumstances, a moveable partition between the mouth and the pharynx, and it will be observed that the opening of the larynx, the *glottis*, lies behind the partition; so that when the root of the tongue is applied close to the soft palate no passage of air can take place between the mouth and the pharynx. But in the upper part of the pharynx above the partition are the two hinder openings of the nasal cavities (which are called the *posterior nares*) separated by the termination of the septum; and through these wide openings the air passes, with great readiness, from the nostrils along the lower part of each nasal chamber to the glottis, or in the opposite direction. It is by means of the passages thus freely open to the air that we breathe, as we ordinarily do, with the mouth shut.

Each nasal chamber rises, as a high vault, far above the

FIG. 62.—VERTICAL LONGITUDINAL SECTIONS OF THE NASAL CAVITY.

The up

nerve and its branches; *V*, branches of the fifth nerve; *Pa*. the palate, which separates the nasal cavity from that of the mouth; *S.T.* the superior turbinal bone; *M.T.* the middle turbinal; *I.T* the inferior turbinal. The letter *I* is placed in the cerebral cavity; and the partition on which the olfactory lobe rests, and through which the filaments of the olfactory nerves pass, is the cribriform plate.

level of the arch of the posterior nares—in fact, about as high as the depression of the root of the nose. The uppermost and front part of its roof, between the eyes, is formed by a delicate horizontal plate of bone, perforated like a sieve by a great many small holes, and thence called the *cribriform* plate (Fig. 63, *Cr.*). It is this plate (with the membranous structures which line its two faces) alone which, in this region, separates the cavity of the nose from that which contains the brain. The olfactory lobes which are directly connected with, and form indeed a part of, the brain, enlarge at their ends, and their broad extremities rest upon the upper side of the cribriform plate ; sending immense numbers of delicate filaments, the olfactory nerves, through it to the olfactory mucous membrane (Fig. 62).

On each wall of the septum this mucous membrane forms a flat expansion, but on the side walls of each nasal cavity it follows the elevations and depressions of the inner surfaces of what are called the upper and middle turbinal, or spongy bones. These bones are called spongy because the interior of each is occupied by air cavities separated from each other by very delicate partitions only, and communicating with the nasal cavities. Hence the bones, though massive-looking, are really exceedingly light and delicate, and fully deserve the appellation of spongy (Fig. 63).

There is a third light scroll-like bone distinct from these two, and attached to the maxillary bone, which is called the *inferior* turbinal, as it lies lower than the other two, and imperfectly separates the air passages from the proper olfactory chamber (Fig. 62). It is covered by the ordinary ciliated mucous membrane of the nasal passage, and receives no filaments from the olfactory nerve (Fig. 62).

14. From the arrangements which have been described, it is clear that, under ordinary circumstances, the gentle inspiratory and expiratory currents will flow along the comparatively wide, direct passages afforded by so much of the nasal chamber as lies below the middle turbinal ; and that they will hardly move the air enclosed in the narrow interspace between the septum and the upper and middle spongy bones, which is the proper olfactory chamber.

If the air currents are laden with particles of odorous matter, they can only reach the olfactory membrane by diffusing themselves into this narrow interspace; and, if there be but few of these particles, they will run the risk of not reaching the olfactory mucous membrane at all, unless the air in contact with it be exchanged for some of the odoriferous air. Hence it is that, when we wish to

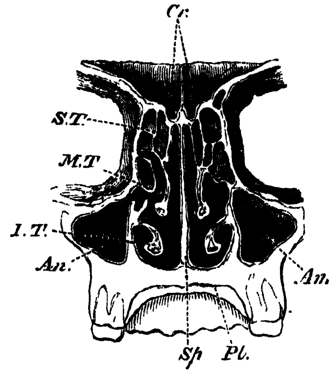

FIG 63.—A TRANSVERSE AND VERTICAL SECTION OF THE OSSEOUS WALLS OF THE NASAL CAVITY TAKEN NEARLY THROUGH THE LETTER *l* IN THE FOREGOING FIGURE.

Cr. the cribriform plate; *S.T.*, *M.T.* the chambered superior and middle turbinal bones on which and on the septum (*Sp.*) the filaments of the olfactory nerve are distributed; *I.T.* the inferior turbinal bone; *Pl.* the palate; *An.* the *Antrum* or chamber which occupies the greater part of the maxillary bone and opens into the nasal cavity.

perceive a faint odour more distinctly, we sniff, or snuff up the air. Each sniff is a sudden inspiration, the effect of which must reach the air in the olfactory chamber at the same time as, or even before, it affects that at the nostrils; and thus must tend to draw a little air out of that chamber from behind. At the same time, or immediately afterwards, the air sucked in at the nostrils entering with a sudden vertical rush, part of it must tend to flow directly into the olfactory chamber, and replace that thus drawn out.

The loss of smell which takes place in the course of a severe cold may, in part, be due to the swollen state of the mucous membrane which covers the inferior turbinal bones, which thus impedes the passage of odoriferous air to the olfactory chamber

15. The EAR, or organ of the sense of Hearing, is very much more complex than either of the sensory organs yet described. It will be useful to distinguish the *essential* parts of this complicated apparatus from certain other parts, which, though of great assistance to the sense, are not absolutely necessary, and therefore may be called *accessory*.

The essential parts, on either side of the head, consist, substantially, of two peculiarly formed membranous bags, called, respectively, the *membranous labyrinth* and the *scala media of the cochlea*. Both these bags are lodged in cavities which they do not completely fill, situated in the midst of a dense and solid mass of bone (from its hardness called *petrosal*), which forms a part of the temporal bone, and enters into the base of the skull.

Each bag is filled with a fluid, and is also supported in a fluid which fills the cavity in which it is lodged. In the interior of each bag, certain small, mobile, hard bodies are contained ; and the ultimate filaments of the auditory nerves are so distributed upon the walls of the bags that their terminations must be knocked by the vibrations of these small hard bodies, should anything set them in motion. It is also quite possible that the vibrations of the fluid contents of the sacs may themselves suffice to affect the filaments of the auditory nerve ; but, however this may be, any such effect must be greatly intensified by the co-operation of the solid particles.

In bathing in a tolerably smooth sea, on a rocky shore, the movement of the little waves as they run backwards and forwards is hardly felt by anyone lying down ; but in bathing on a sandy and gravelly beach, the pelting of the showers of little stones and sand, which are raised and let fall by each wavelet, makes a very definite impression on the nerves of the skin.

Now, the membrane on which the ends of the auditory nerves are spread out is virtually a sensitive beach, and waves, which by themselves would not be felt, are readily perceived when they raise and let fall hard particles.

Both these membranous bags are lined by an epithelium.

The auditory nerve after passing through the dense bone of the skull is distributed to certain regions of each bag, where its ultimate filaments come into peculiar connection with the epithelial lining. The epithelium itself too at these spots becomes specially modified. In certain parts of the membranous labyrinth, for instance, the epithelium connected with the terminations of the auditory nerve is produced into long, stiff, slender, hair-like pro-

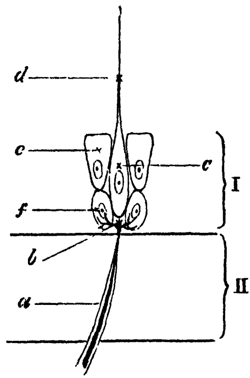

FIG. 64.—DIAGRAM TO ILLUSTRATE THE TERMINATION OF THE AUDITORY NERVE IN AN AMPULLA.

I. The epithelium of the ampulla. II. The membranous wall of the ampulla on which the epithelium rests.
a, a filament of the auditory nerve running through the wall of the ampulla and breaking up into a fine network (*b*) in the epithelium; *c*, epithelium cell with long stiff hair-like filament, *d* (this cell is supposed by some to be directly continuous with the nerve network); *e*, cells, not bearing filaments, placed by the side of, and supporting the filament-bearing cells; *f*, a deeper layer of smaller cells.

cesses (Fig. 64, *d*), which project into the fluid filling the bag, and which therefore are readily affected by any vibration of that fluid, and communicate the impulse to the ends of the nerve. In certain other parts of the same labyrinth these hairs are scanty or absent, but their place is supplied by minute angular particles of calcareous sand (called *otoconia* or *otolithes*), lying free in the fluid of the bag.

These, driven by the vibrations of that fluid, strike the epithelium and so affect the auditory nerve.

In the scala media of the cochlea, minute, rod-like bodies, called the *fibres of Corti*, and which are peculiarly modified cells of the epithelial lining of the scala, appear to serve the same object.

16. For simplicity's sake, the membranous labyrinth and the scala media have hitherto been spoken of as if they were simple bags ; but this is not the case, each bag having a very curious and somewhat complicated form. (Figs. 65 and 66.)

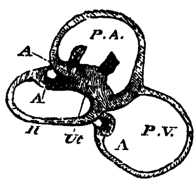

FIG. 65.—THE MEMBRANOUS LABYRINTH, TWICE THE NATURAL SIZE.

Ut. the *Utriculus*, or part of the vestibular sac, into which the semicircular canals open; *A*, *A*, *A*, the ampullæ ; *P.A.* anterior vertical semicircular canal, *P.V.* posterior vertical semicircular canal, *H* horizontal semicircular canal. The sacculus is not seen, as in the position in which the labyrinth is drawn the sacculus lies behind the utriculus. The white circles on the ampullæ of the posterior vertical and horizontal canals indicate the cut ends of the branches of the auditory nerve ending in those ampullæ ; the branches to the ampulla of the anterior vertical canal are seen in the space embraced by the canal, as is also the branch to the utriculus.

This form is also followed to a certain extent by the bony casing of the cavity in which each is lodged. Thus the membranous labyrinth is surrounded by a *bony labyrinth*, and the scala media is only a part of an intricate structure called the *cochlea*. The bony labyrinth and cochlea with all the parts inside each constitute together what is called the *internal ear*.

The *membranous labyrinth* (Fig. 65) has the figure of an oval *vestibular sac*, consisting of two parts, the one called *utriculus*, the other *sacculus hemisphericus*. The hoop-like *semicircular canals* open into the utriculus. They are three in number, and, two being vertical, are called the nterior (*P.A.*) and *posterior* (*P.V.*) *vertical semicircular canals;* while the third, lying outside, and horizontally, is termed the *external horizontal semicircular canal* (*H*). One end of each of these canals is dilated into what is called an *ampulla* (*A*).

It is upon the walls of these ampullæ and those of the vestibular sac that the branches of the auditory nerve are distributed.

In each ampulla the nervous filaments may be traced to a transverse ridge caused by a thickening of the connective tissue which forms the walls of the canal (as well as of all other parts of the membranous labyrinth), and also by a thickening of the epithelium. Some of the epithelium cells are here prolonged into the fine hair-like processes described above. It is probable that these cells are specially connected with the terminations of the nerve filaments.

In the vestibule are similar but less marked ridges, or patches; here, however, the hair-like prolongations of the epithelium cells are absent or scanty, but, instead, otolithes are found in the fluid.

The fluid which fills the cavities of the semicircular canals and utriculus is termed *endolymph*. That which separates these delicate structures from the bony chambers in which they are contained is the *perilymph*. Each of these fluids is little more than water.

17. In the *scala media*[1] of the cochlea the primitive bag is drawn out into a long tube, which is coiled two and a half times on itself into a conical spiral, and lies in a much wider chamber of corresponding form, excavated in the petrous bone in such a way as to leave a central column of bony matter called the *modiolus*. The scala media has a triangular transverse section (Fig. 66), being bounded above and below by the membranous walls which converge internally and diverge externally. At their convergence, the walls are fastened to the edge of a thin plate of bone, the *lamina spiralis* (*L.S.* Fig. 66), which winds round the modiolus. At their divergence they are

[1] I employ this term as the equivalent of *canalis cochlearis*. The true nature and connections of these parts have only recently been properly worked out, and the account now given will be found to be somewhat different from that in the first edition of this work. See particularly the explanation of Fig. 67.

fixed to the wall of the containing bony chamber, which thus becomes divided into two passages, communicating at the summit of the spire, but elsewhere separate. These two passages are called respectively the *scala tympani* and *scala vestibuli*, and are filled with perilymph.

The scala media, which thus lies between the other two scalæ, opens below, or at the broad end of the cochlea, by a narrow duct into the sacculus hemisphericus, but at its opposite end terminates blindly. (Fig. 70.)

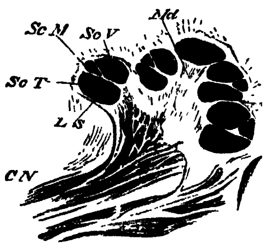

FIG. 66.—A SECTION THROUGH THE AXIS OF THE COCHLEA, MAGNIFIED THREE DIAMETERS.

Sc.M. scala media ; *Sc.V.* scala vestibuli ; *Sc.T.* scala tympani ; *L.S.* lamina spiralis ; *Md.* bony axis, or modiolus, round which the scalæ are wound , *C.N.* cochlear nerve.

That branch of the auditory nerve which goes to supply the cochlea, enters the broad base of the central column or modiolus, and there divides into branches, which, spreading out in a spiral fashion in channels excavated in the bony tissue, are distributed to the lamina spiralis throughout its whole length. They do not end here ; but in any section of the lamina spiralis (Fig. 66, *L.S.*) they may be found running outwards from the central column across the lamina towards the angle of the scala media, in which indeed they become finally lost.

The upper wall of the scala media, that which separates it from the scala vestibuli, is called the *membrane of Reissner*. The opposite or lower wall, which separates it from the scala tympani, is the *basilar membrane*. The latter is very elastic, and on it rest the *fibres of Corti* (*C C'*, Fig. 67), each of which is composed of two filaments

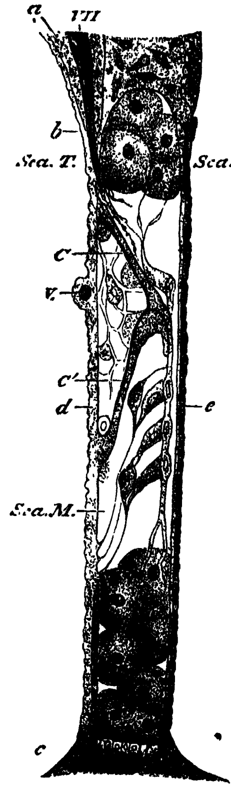

FIG 67.—A SECTION THROUGH THAT WALL OF THE "SCALA MEDIA" OF THE COCHLEA WHICH LIES NEXT TO THE SCALA TYMPANI.

a, That end of the lamina spiralis which passes into the inner wall, pillar, or modiolus of the bony cochlea; *c*, the outer wall of the bony cochlea; *Sca. T.* the cavity of the scala tympani; *Sca. M.* the cavity of the scala media; *d*, the elastic basilar membrane which separates the scala media from the scala tympani; *V.* a vessel which lies in this, cut through; *e*, the so-called memjoined at an angle. An immense number of these filaments are set side by side, with great regularity, throughout the whole length of the scala media, so that this organ presents almost the appearance of a key-board, if viewed from either the scala vestibuli or the scala tympani. These fibres of Corti lie among a number of epithelium cells forming the lining of the scala media at this part, and those cells which are close to the fibres of Corti have a peculiarly modified form. The ends of the nerves have not yet been distinctly traced, but they probably come into close relation either with these fibres or with the modified epithelium cells lying close to them, which are capable of being agitated by the slightest impulse.

18. These essential parts of the organ of hearing are, we have seen, lodged in chambers of the petrous part of the temporal bone. Thus the membranous labyrinth is contained in a *bony labyrinth* of corresponding form, of which that part which lodges the sac is termed the *vestibule*, and those portions which contain the semicircular canals, the *bony semicircular canals*. And the scala media is contained in a spirally-coiled chamber, the cochlea, which it divides into two passages. Of these, one, the *scala vestibuli*, is so called because at the broad end or base of the cochlea it opens directly by a wide aperture into the vestibule; by this opening the perilymph which fills the vestibule and bony semicircular canals and surrounds the membranous labyrinth, is put in free communication with the perilymph which fills the scala vestibuli of the cochlea, and, by means of the communication which exists between the two scalæ at the summit of the spire, with that of the scala tympani also.

In the fresh state, this collection of chambers in the petrous bone is perfectly closed; but in the dry skull there are two wide openings, termed *fenestræ*, or windows, on its outer wall; *i.e.* on the side nearest the outside of the skull. Of these fenestræ, one, termed *ovalis* (the

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brane of Corti; *C C′*, the fibres of Corti; *VII.* the filaments of the auditory nerve. It is doubtful whether the membrane of Corti really has the extent and connections given to it in this figure, which must not be taken for more than a general representation of the disposition of the parts. The membrane of Reissner, which separates the scala media from the scala vestibuli, is not represented.

oval window), is situated in the wall of the vestibular cavity; the other, *rotunda* (the round window), behind and below this, is the open end of the *scala tympani* at the base of the spire of the cochlea. In the fresh state, each of these windows or fenestræ is closed by a fibrous membrane, continuous with the periosteum of the bone.

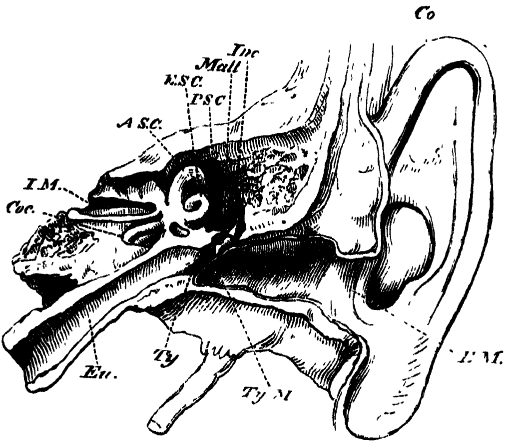

FIG. 68.—TRANSVERSE SECTION THROUGH THE SIDE WALLS OF THE SKULL TO SHOW THE PARTS OF EAR.

Co Concha or external ear; *E M.* external auditory meatus; *Ty M.* tympanic membrane; *Inc.Mall.* incus and malleus; *A S C*, *P S.C.*, *E.S C.* anterior, posterior, and external semicircular canals, *Coc* cochlea; *Eu.* Eustachian tube; *I.M* internal auditory meatus, through which the auditory nerve passes to the organ of hearing.

The *fenestra rotunda* is closed only by membrane; but istened to the centre of the membrane of the *fenestra valis*, so as to leave only a narrow margin, is an oval late of bone, part of one of the little bones to be escribed shortly.

19. The outer wall of the internal ear is still far away om the exterior of the skull. Between it and the visible pening of the ear, in fact, are placed in a straight line,

first, the drum of the ear, or *tympanum;* secondly, the long external passage, or *meatus* (Fig. 68).

The drum of the ear and the external meatus, which together constitute the middle ear, would form one cavity, were it not that a delicate membrane, the tympanic membrane (*Ty.M.* Fig. 68), is tightly stretched in an oblique direction across the passage, so as to divide the comparatively small cavity of the drum from the meatus.

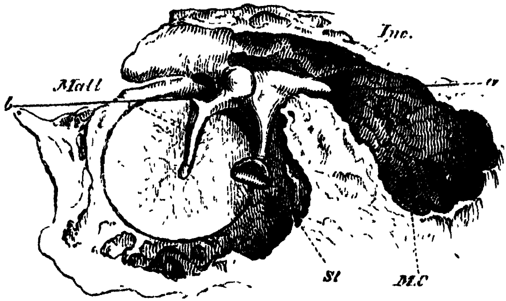

FIG. 69.—THE MEMBRANE OF THE DRUM OF THE EAR SEEN FROM THE INNER SIDE, WITH THE SMALL BONES OF THE EAR; AND THE WALLS OF THE TYMPANUM, WITH THE AIR-CELLS IN THE MASTOID PART OF THE TEMPORAL BONE.

M.C. mastoid cells; *Mall.* malleus; *Inc.* incus; *St* stapes; *a b*, lines drawn through the horizontal axis on which the malleus and incus turn.

The membrane of the tympanum thus prevents any communication by means of the meatus, between the drum and the external air, but such a communication is provided, though in a roundabout way, by the Eustachian tube (*Eu.* Fig. 68), which leads directly from the fore part of the drum inwards to the roof of the pharynx, where it opens.

20. Three small bones, the auditory ossicles, lie in the cavity of the tympanum. One of these is the *stapes*, a small bone shaped like a stirrup. It is the foot-plate of this bone which, as already mentioned, is firmly fastened to the membrane of the *fenestra ovalis*, while its hoop projects outwards into the tympanic cavity (Fig. 69).

Another of these bones is the *malleus* (*Mall.* Figs. 68, 69, 70), or hammer-bone, a long process of which is similarly fastened to the inner side of the tympanic membrane (Fig. 70), and a very much smaller process, the slender process, is fastened, as is also the body of the malleus, to the bony wall of the tympanum by ligaments. The

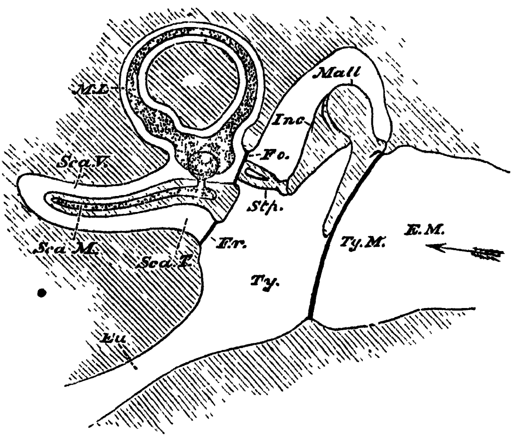

FIG. 70.—A DIAGRAM ILLUSTRATIVE OF THE RELATIVE POSITIONS OF THE VARIOUS PARTS OF THE EAR.

E.M. external auditory meatus; *Ty.M.* tympanic membrane; *Ty.* tympanum; *Mall.* malleus: *Inc.* incus; *Stp.* stapes; *F.o.* fenestra ovalis, *F.r.* fenestra rotunda; *Eu.* Eustachian tube; *M.L.* membranous labyrinth, only one semicircular canal with its ampulla being represented; *Sca.V.*, *Sca.T.*, *Sca.M.*, the scalæ of the cochlea, which is supposed to be unrolled.

rounded surface of the head of the malleus fits into a corresponding pit in the end of a third bone, the *incus* or anvil bone, which has two processes—one, horizontal, which rests upon a support afforded to it by the walls of the tympanum; while the other, vertical, descends almost parallel with the long process of the malleus, and articulates with the stapes, or rather unites with a little bone, the *os orbiculare*, which articulates with the stapes (Figs. 69 and 70).

The three bones thus form a chain between the fenestra ovalis and the tympanic membrane ; and the whole series turns upon a horizontal axis, the two ends of which, formed by the horizontal process of the incus and the slender process of the malleus, rest in the walls of the tympanum. The general direction of this axis is represented by the line *a b* in Fig. 69, or by a line perpendicular to the plane of the paper, passing through the head of the malleus in Fig. 70. It follows, therefore, that whatever causes the membrane of the drum to vibrate backwards and forwards, must force the handle of the malleus to travel in the same way. This must cause a corresponding motion of the long process of the incus, the end of which must drag the stapes backwards and forwards. And, as this is fastened to the membrane of the fenestra ovalis, which is in contact with the perilymph, it must set this fluid vibrating throughout its whole extent, the thrustings in of the membrane of the fenestra ovalis being compensated by corresponding thrustings out of the membrane of the fenestra rotunda, and *vice versâ*.

The vibrations of the perilymph thus produced will affect the endolymph, and this the otolithes, hairs, or fibres; by which, finally, the auditory nerves will be excited.

21. The membrane of the fenestra ovalis and the tympanic membrane will necessarily vibrate the more freely the looser they are, and the reverse. But there are two muscles—one, called the *stapedius*, which passes from the floor of the tympanum to the orbicular bone, and the other, the *tensor tympani*, from the front wall of the drum to the malleus. Each of the muscles when it contracts tightens the membranes in question, and restricts their vibrations or, in other words, tends to check the effect of any cause which sets these membranes vibrating.

22. The outer extremity of the external meatus is surrounded by the *concha* or external ear (*Co.* Fig. 68), a broad, peculiarly-shaped, and for the most part cartilaginous plate, the general plane of which is at right angles with that of the axis of the auditory opening. The concha can be moved by most animals and by some human beings

in various directions by means of muscles, which pass to it from the side of the head.

23. The manner in which the complex apparatus now described intermediates between the physical agent, which is the condition of the sensation of sound, and the nervous expansion, the affection of which alone can excite that sensation, must next be considered.

All bodies which produce sound are in a state of vibration, and they communicate the vibrations of their own substance to the air with which they are in contact, and thus throw that air into waves, just as a stick waved backwards and forwards in water throws the water into waves.

The aërial waves, produced by the vibrations of sonorous bodies, in part enter the external auditory passage, and in part strike upon the concha of the external ear and the outer surface of the head. It may be that some of the latter impulses are transmitted through the solid structure of the skull to the organ of hearing; but before they reach it they must, under ordinary circumstances, have become so scanty and weak, that they may be left out of consideration.

The aërial waves which enter the meatus all impinge upon the membrane of the drum and set it vibrating, stretched membranes taking up vibrations from the air with great readiness.

24. The vibrations thus set up in the membrane of the tympanum are communicated, in part, to the air contained in the drum of the ear, and, in part, to the malleus, and thence to the other auditory ossicles.

The vibrations communicated to the air of the drum impinge upon the inner wall of the tympanum, on the greater part of which, from its density, they can produce very little effect. Where this wall is formed by the membrane of the *fenestra rotunda*, however, the communication of motion must necessarily be greater.

The vibrations which are communicated to the malleus and the chain of ossicles may be of two kinds: vibrations of the particles of the bones, and vibrations of the bones as a whole. If a beam of wood, freely suspended, be very gently scratched with a pin, its particles will be thrown into a state of vibration, as will be evidenced by the sound given out, but the beam itself will not be moved. Again, if a strong wind blow against the beam, it will swing visibly, without any vibrations of its particles among themselves. On the other hand, if the beam be sharply struck with a hammer, it will not only give out a sound, showing that its particles are vibrating, but it will also swing from the impulse given to its whole mass.

Under the last-mentioned circumstances, a blind man standing near the beam would be conscious of nothing but the sound, the product of molecular vibration, or invisible oscillation of the particles of the beam; while a deaf man in the same position, would be aware of nothing but the visible oscillation of the beam as a whole.

25. Thus, to return to the chain of auditory ossicles, while it seems hardly to be doubted that, when the membrane of the drum vibrates, they may be set vibrating both as a whole and in their particles, it depends upon subsidiary arrangements whether the large vibrations, or the minute ones, shall make themselves obvious to the auditory nerve, which is in the position of our deaf, or blind, man.

The evidence at present is in favour of the conclusion, that it is the vibrations of the bones, as a whole, which are the chief agents in transmitting the impulses of the aërial waves.

For, in the first place, the disposition of the bones and the mode of their articulation are very much against the transmission of molecular vibrations through their substance, while, on the other hand, they are extremely favourable to their vibration *en masse*. The long processes of the malleus and incus swing, like a pendulum, upon the axis furnished by the short processes of these bones; while the mode of connection of the incus with the stapes, and of the latter with the edges of the fenestra ovalis, allows that bone free play, inwards and outwards. In the second place the total length of the chain of ossicles is very small compared with the length of the waves of audible sounds, and physical considerations teach us that in a like small rod, similarly capable of swinging *en masse*, the minute molecular vibrations would be inappreciable. Thirdly, it is affirmed, as the result of experiments, that the bone called *columella*, which, in birds, takes the place of the chain of ossicles in man, does actually vibrate as a whole, and at the same rate as the membrane of the drum, when aërial vibrations strike upon the latter.

26. Thus, there is reason to believe that when the tympanic membrane is set vibrating, it causes the process of the malleus, which is fixed to it, to swing at the same rate; the head of the malleus consequently turns through a small arc on its pivot, the slender process. But the turning of the head of the malleus involves that of the head of the incus upon its pivot, the short process. In consequence the long process of the incus swings through an arc which has been estimated as being equal to about two-thirds of that described by the handle of the malleus. The extent of the push is thereby somewhat diminished, but the force of the push is proportionately increased; in so confined a space this change is advantageous. The long process, however, is so fixed to the stapes that it cannot vibrate without, to a corresponding extent and at the same rate, pulling this out of, and pushing it into, the fenestra ovalis. But every pull and push imparts a corresponding set of shakes to the perilymph, which fills the bony labyrinth and cochlea, external to the membranous labyrinth and scala media. These shakes are communicated to the endolymph and fluid of the scala media, and, by the help of the otolithes and the fibres of Corti, are finally converted into impulses, which act as irritants of the ends of the vestibular and cochlear divisions of the auditory nerve.

27. The difference between the functions of the membranous labyrinth (to which the vestibular nerve is distributed) and those of the cochlea are not quite certainly made out, but the following views have been suggested:—

The membranous labyrinth may be regarded as an apparatus whereby sounds are appreciated and distinguished according to their intensity or quantity; but which does not afford any means of discriminating their qualities. The vestibular nerve tells us that sounds are weak or loud, but gives us no impression of tone, or melody, or harmony.

The cochlea, on the other hand, it is supposed, enables the mind to discriminate the quality rather than the quantity or intensity of sound. It is suggested that the excitement of any single filament of the cochlear nerve gives rise, in the mind, to a distinct musical impression; and that every fraction of a tone which a well-trained ear is capable of distinguishing is represented by its separate nerve-fibre. Under this view the scala media resembles a key-board, in function, as well as in appearance, the fibres of Corti being the keys, and the ends of the nerves representing the strings which the keys strike. If it were possible to irritate each of these nerve-fibres experimentally, we should be able to produce any musical tone, at will, in the sensorium of the person experimented upon, just as any note on a piano is produced by striking the appropriate key.

28. A tuning-fork may be set vibrating, if its own particular note, or one harmonic with it, be sounded in its neighbourhood. In other words, it will vibrate under the influence of a particular set of vibrations, and no others. If the vibrating ends of the tuning-fork were so arranged as to impinge upon a nerve, their repeated minute blows would at once excite this nerve.

Suppose that of a set of tuning-forks, tuned to every note and distinguishing fractions of a note in the scale, one were thus connected with the end of every fibre of the cochlear nerve; then any vibration communicated to the perilymph would affect the tuning-fork which could vibrate with it, while the rest would be absolutely, or relatively, indifferent to that vibration. In other words, the vibration would give rise to the sensation of one particular tone, and no other, and every musical interval would be represented by a distinct impression on the sensorium.

29. It is suggested that the fibres of Corti are competent to perform the function of such tuning-forks; that each of them is set vibrating to its full strength by a particular kind of wave sent through the perilymph, and by no other; and that each affects a particular fibre of the cochlear nerve only. But it must be remembered that the view here given is a suggestion only which, however probable, has not yet been proved. Indeed recent inquiries have rather diminished than increased its probability.

The fibres of the cochlear nerve may be excited by internal causes, such as the varying pressure of the blood and the like: and in some persons such internal influences do give rise to veritable musical spectra, sometimes of a very intense character. But, for the appreciation of music produced external to us, we depend upon the intermediation of the scala media and its Cortian fibres.

30. It has already been explained that the *stapedius* and *tensor tympani* muscles are competent to tighten the membrane of the fenestra ovalis and that of the tympanum, and it is probable that they come into action when the sonorous impulses are too violent, and would produce too extensive vibrations of these membranes. They therefore tend to moderate the effect of intense sound, in much the same way that, as we shall find, the contraction of the circular fibres of the iris tends to moderate the effect of intense light in the eye.

The function of the Eustachian tube is, probably, to keep the air in the tympanum, or on the inner side of the tympanic membrane, of about the same tension as that on the outer side, which could not always be the case if the tympanum were a closed cavity.

LESSON IX.

THE ORGAN OF SIGHT.

1. IN studying the organ of the sense of sight, the eye, it is needful to become acquainted, firstly, with the structure and properties of the sensory expansion in which the optic nerve, or nerve of sight, terminates; secondly, with the physical agent of the sensation; thirdly, with the intermediate apparatus by which the physical agent is assisted in acting upon the nervous expansion.

The ball, or globe, of the eye is a globular body, moving freely in a chamber, the *orbit*, which is furnished to it by the skull. The optic nerve, the root of which is in the brain, leaves the skull by a hole at the back of the orbit, and enters the back of the globe of the eye, not in the middle, but on the inner, or nasal, side of the centre. Having pierced the wall of the globe, it spreads out into a very delicate membrane, varying in thickness from $\frac{1}{80}$th of an inch to less than half that amount, which lines the hinder two-thirds of the globe, and is termed the *retina*. This retina is the only organ connected with sensory nervous fibres which can be affected, by any agent, in such a manner as to give rise to the sensation of light.

2. If the globe of the eye be cut in two, transversely, so as to divide it into an anterior and a posterior half, the retina will be seen lining the whole of the concave wall of the posterior half as a membrane of great delicacy, and, for the most part, of even texture and smooth surface. But, exactly opposite the middle of the posterior wall, it presents a slight circular depression of a yellowish hue,

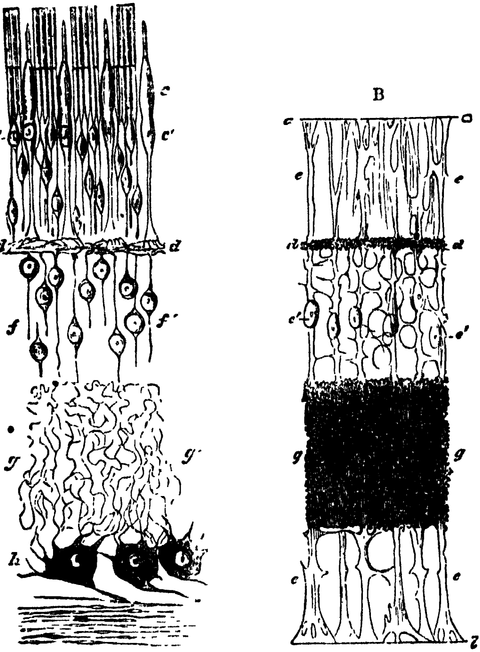

Fig. 71.

Diagrammatic views of the nervous (A) and the connective (B) elements of the retina, supposed to be separated from one another. A, the nervous structures—*b*, the rods; *c*, the cones; *b' c'*, the granules of the outer layer, with which these are connected; *d d'*, interwoven very delicate nervous fibres, from which fine nervous filaments, bearing the inner granules, *ff'*, proceed towards the front surface; *g g'*, the continuation of these fine nerves, which become convoluted and interwoven with the processes of the ganglionic corpuscles, *h h'*; *i i*, the expansion of the fibres of the optic nerve. B, the connective tissue—*a a*, external or posterior limiting membrane; *e e*, radial fibres passing to the internal or anterior limiting membrane; *e' e'*, nuclei; *d d*, the intergranular layer; *g g*, the molecular layer; *l*, the anterior limiting membrane.

(Magnified about 250 diameters.)

the *macula lutea*, or yellow spot (Fig. 72, *m.l.*; Fig. 75, 8″),—not easily seen, however, unless the eye be perfectly fresh,—and, at some distance from this, towards the inner, or nasal, side of the ball, is a radiating appearance, produced by the entrance of the optic nerve and the spreading out of its fibres into the retina.

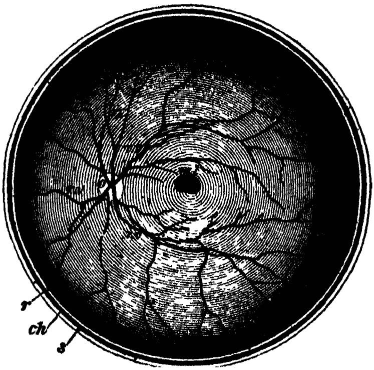

FIG. 72.—THE EYE-BALL DIVIDED TRANSVERSELY IN THE MIDDLE LINE, AND VIEWED FROM THE FRONT.

s, sclerotic ; *ch*, choroid, seen in section only.
r, the cut edge of the retina ; *v.v.* vessels of the retina, springing from *o*, the optic nerve or blind spot ; *m.l*, the yellow spot, the darker spot in its middle being the fovea centralis.

3. A very thin vertical slice of the retina, in any region except the yellow spot and the entrance of the optic nerve, may be resolved into the structures represented separately in Fig. 71. The one of these (A) occupies the whole thickness of the section, and comprises its essential, or nervous, elements. The outer (or posterior) fourth, or rather less, of the thickness of these consists of a vast multitude of minute, either rod-like, or conical bodies, ranged side by side, perpendicularly to the plane of the retina. This is the *layer of rods and cones* (*b c*). From the front ends or bases of the rods and cones very delicate fibres pass, and in each is developed a granule-like body (*b′ c′*), which forms a part of what has been termed the

outer layer of granules. It is probable that these fibres next pass into and indeed form the close meshwork of very delicate nervous fibres which is seen at *d d'* (Fig. 71, A). From the anterior surface of this meshwork other fibres proceed, containing a second set of granules, which forms the *inner granular layer* (*f f'*) In front of this layer is a stratum of convoluted fine nervous fibres (*g g'*)—and anterior to this again numerous ganglionic corpuscles (*h h'*). Processes of these ganglionic corpuscles extend, on the one hand, into the layer of convoluted nerve-fibres; and on the other are probably continuous with the stratum of fibres of the optic nerve (*i*).

These delicate nervous structures are supported by a sort of framework of connective tissue of a peculiar kind (B), which extends from an *inner or anterior limiting membrane* (*l*), which bounds the retina and is in contact with the vitreous humour, to an *outer* or *posterior limiting membrane*, which lies at the anterior ends, or bases, of the rods and cones near the level of *b' c'* in A. Thus the framework is thinner than the nervous substance of the retina, and the rods and cones lie altogether outside of it, and wholly unsupported by any connective tissue. They are, however, as we shall see, imbedded in the layer of pigment on which the retina rests (§ 16).

The fibres of the optic nerve spread out between the limiting membrane (*l*) and the ganglionic corpuscles (*h'*), and the vessels which enter along with the optic nerve ramify between the limiting membrane and the inner granules (*f f'*). Thus, not only the nervous fibres, but the vessels, are placed altogether in front of the rods and cones.

At the entrance of the optic nerve itself, the nervous fibres predominate, and the rods and cones are absent. In the yellow spot, on the contrary, the cones are abundant and close set, becoming at the same time longer and more slender, while rods are scanty, and are found only towards its margin. The layer of fibres of the optic nerve disappears, and all the other layers, except that of the cones, become extremely thin in the centre of the *macula lutea* (Fig. 73).

4. The most notable property of the retina is its power

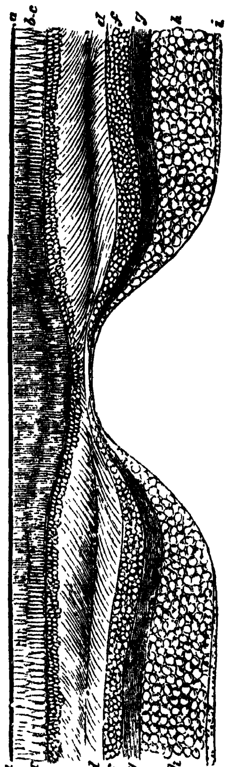

FIG. 73.—A DIAGRAMMATIC SECTION OF THE MACULA LUTEA, OR YELLOW SPOT.

a a, the pigment of the choroid ; *b*, *c*, rods and cones ; *d d*, outer granular layer ; *f f*, inner granular layer ; *g g*, molecular layer ; *h h*, layer of ganglionic cells ; *i i*, fibres of the optic nerve.

(Magnified about 60 diameters.)

of converting the vibrations of ether, which constitute the physical basis of light, into a stimulus to the fibres of the optic nerve—which fibres, when excited, have the power of awakening the sensation of light in, or by means of, the brain. The sensation of light, it must be understood, is the work of the brain, not of the retina; for, if an eye be destroyed, pinching, galvanizing, or otherwise irritating the optic nerve, will still excite the sensation of light, because it throws the fibres of the optic nerve into activity; and their activity, however produced, brings about in the brain certain changes which give rise to the sensation of light.

Light, falling directly on the optic nerve, does not excite it; the fibres of the optic nerve, in themselves, are as blind as any other part of the body. But just as the delicate filaments of the ampullæ, or the otoconia of the vestibular sac, or the Cortian fibres of the cochlea, are contrivances for converting the delicate vibrations of the perilymph and endolymph into impulses which can excite the auditory nerves, so the structures in the retina appear to be adapted to convert the infinitely more delicate pulses of the luminiferous ether into stimuli of the fibres of the optic nerve.

5. The sensibility of the different parts of the retina to light varies very greatly. The point of entrance of the optic nerve is absolutely blind, as may be proved by a very simple experiment. Close the left eye, and look steadily with the right at the cross on the page, held at ten or twelve inches' distance.

The black dot will be seen quite plainly, as well as the cross. Now, move the book slowly towards the eye, which must be kept steadily fixed upon the cross; at a certain point the dot will disappear, but, as the book is brought still closer, it will come into view again. It results from optical principles that, in the first position of the book, the figure of the dot falls between that of the cross (which throughout lies upon the yellow spot) and the entrance of the optic nerve: while, in the second position, it falls on the entrance of the optic nerve itself; and, in the third, inside that point. So long as the image of the spot rests upon the entrance of the optic nerve, it is not perceived, and hence this region of the retina is called the *blind spot.*

6. The impression made by light upon the retina not only remains during the whole period of the direct action of the light, but has a certain duration of its own, however short the time during which the light itself lasts. A flash of lightning is, practically, instantaneous, but the

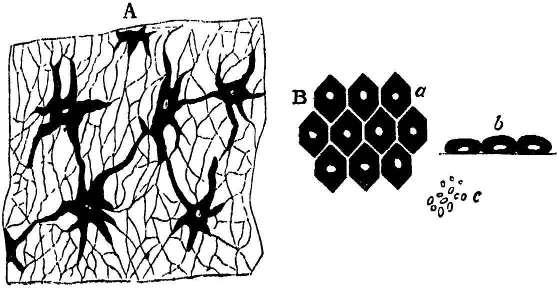

FIG. 74.—PIGMENT CELLS FROM THE CHOROID COAT.

A Branched pigment cells from the deep layer.
B. Pigment epithelium. *a*, seen in face; *b*, seen in profile; *c*, pigment granules.

sensation of light produced by that flash endures for an appreciable period. It is found, in fact, that a luminous impression lasts for about one-eighth of a second; whence it follows, that if any two luminous impressions are separated by a less interval, they are not distinguished from one another.

For this reason a "Catherine-wheel," or a lighted stick turned round very rapidly by the hand, appears as a circle of fire; and the spokes of a coach wheel at speed are not separately visible, but only appear as a sort of opacity, or film, within the tire of the wheel.

7. The excitability of the retina is readily exhausted. Thus, looking at a bright light rapidly renders the part of the retina on which the light falls, insensible; and on looking from the bright light towards a moderately-lighted surface, a dark spot, arising from a temporary blindness

of the retina in this part, appears in the field of view. If the bright light be of one colour, the part of the retina on which it falls becomes insensible to rays of that colour, but not to the other rays of the spectrum. This is the explanation of the appearance of what are called *complementary colours.* For example, if a bright red wafer be stuck upon a sheet of white paper, and steadily looked at for some time with one eye, when the eye is turned aside to the white paper a greenish spot will appear, of about the size and shape of the wafer. The red image has, in fact, fatigued the part of the retina on which it fell for red light, but has left it sensitive to the remaining coloured rays of which white light is composed. But we know that if from the variously coloured rays which make up the spectrum of white light we take away all the red rays, the remaining rays together make up a sort of green. So that, when white light falls upon this part, the red rays in the white light having no effect, the result of the operation of the others is a greenish hue. If the wafer be *green*, the *complementary image*, as it is called, is *red.*

8. In some persons, the retina appears to be affected in one and the same way by rays of light of various colours, or even of all colours. Such *colour-blind* persons are unable to distinguish between the leaves of a cherry-tree and its fruit by the colour of the two, and see no difference between blue and yellow cloth.

This peculiarity is simply unfortunate for most people, but it may be dangerous if unknowingly possessed by railway guards or sailors. It probably arises either from a defect in the retina, which renders that organ unable to respond to different kinds of luminous vibrations, and consequently insensible to red rays or yellow rays, &c., as the case may be, or it may proceed from some unusual absorptive power of the humours of the eye which prevents particular rays from reaching the retina; or the fault may lie in the brain itself.

9. The sensation of light may be excited by other causes than the impact of the vibrations of the luminiferous ether upon the retina. Thus, an electric shock sent through the eye, gives rise to the appearance of a flash of light: and pressure on any part of the retina produces a luminous image, which lasts as long as the

pressure, and is called a *phosphene.* If the point of the finger be pressed upon the outer side of the ball of the eye, the eyes being shut, a luminous image—which, in my own case, is dark in the centre, with a bright ring at the circumference (or, as Newton described it, like the "eye" in a peacock's tail)—is seen; and this image lasts as long as the pressure is continued. Most persons, again, have experienced the remarkable display of subjective fireworks which follows a heavy blow upon the eyes, produced by a fall from a horse, or by other methods well known to English youth.

It is doubtful, however, whether these effects of pressure, or shock, really arise from the excitation of the retina proper, or whether they are not rather the result of the violence done to the fibres of the optic nerve apart from the retina.

10. The last paragraph raises a distinction between the "fibres of the optic nerve" and the "retina" which may not have been anticipated, but which is of much importance.

We have seen that the fibres of the optic nerve ramify in the inner or anterior fourth of the thickness of the retina, while the layer of rods and cones forms its outer or posterior fourth. The light, therefore, must fall first upon the fibres of the optic nerve, and, only after traversing them, can it reach the rods and cones. Consequently, if the fibrillæ of the optic nerve themselves are capable of being affected by light, the rods and cones can only be some sort of supplementary optical apparatus. But, in fact, it is the rods and cones which are affected by light, while the fibres of the optic nerve are themselves insensible to it. The evidence on which this statement rests is—

a. The blind spot is full of nervous fibres, but has no cones or rods.

b. The yellow spot, where the most acute vision is situated, is full of close-set cones, but has no nerve fibres.

c. If you go into a dark room with a single small bright candle, and, looking towards a dark wall, move the light up and down, close to the outer side of one eye, so as to allow the light to fall very obliquely into the eye, one of what are called *Purkinje's figures* is seen. This is a vision of a series of diverging, branched, red lines on a dark field, and in the interspace of two of these lines is a sort of cup-shaped disk. The red lines are the retinal blood-vessels, and the disk is the yellow spot. As the candle is moved up and down, the red lines shift their position, as shadows do when the light which throws them changes its place.

Now, as the light falls on the inner face of the retina, and the images of the vessels to which it gives rise shift their position as it moves, whatever perceives these images must needs lie on the other, or outer, side of the vessels. But the fibres of the optic nerve lie among the vessels, and the only retinal structures which lie outside them are the granular layers and the rods and cones.

d. Just as, in the skin, there is a limit of distance within which two points give only one impression, so there is a minimum distance by which two points of light falling on the retina must be separated in order to appear as two. And this distance corresponds pretty well with the diameter of the cones.

11. The impact of the ethereal vibrations upon the sensory expansion, or *essential* part of the visual apparatus alone, is sufficient to give rise to all those *feelings*, which we term sensations of *light* and of *colour*, and to that feeling of *outness* which accompanies all visual sensation. But, if the retina had a simple transparent covering, the vibrations radiating from any number of distinct points in the external world would affect all parts of it equally, and therefore the feeling aroused would be that of a generally diffused luminosity. There would be no separate feeling of light for each separate radiating point, and hence no correspondence between the visual sensations and the radiating points which aroused them.

It is obvious that, in order to produce this correspondence, or, in other words, to have distinct vision, the essential condition is, that distinct luminous points in the external world shall be represented by distinct feelings of light. And since, in order to produce these distinct feelings, vibrations must impinge on separate rods or cones, it follows that, for the production of distinct vision, some apparatus must be interposed between the retina and the external world, by the action of which, distinct luminous points in the latter shall be represented by corresponding points of light on the retina.

In the eye of man and of the higher animals, this *accessory* apparatus of vision is represented by structures which, taken together, act as a biconvex lens, composed of substances which have a much greater refractive power than the air by which the eye is surrounded; and which throw upon the retina luminous points, which correspond in number, and, in one sense, in position, with those luminous points in the external world from which ethereal vibrations proceed towards the eye. The luminous points thus thrown upon the retina form a picture of the external world—a picture being nothing but lights and shadows, or colours, arranged in such a way as to correspond with the disposition of the luminous or coloured parts of the object represented.

12. That a biconvex lens is competent to produce a picture of the external world on a properly arranged screen is a fact of which everyone can assure himself by simple experiments. An ordinary spectacle glass is a transparent body denser than the air, and convex on both sides. If this *lens* be held at a certain distance from a screen or wall in a dark room, and a lighted candle be placed on the opposite side of it, it will be easy to adjust the distances of candle, lens, and wall, so that an image of the flame of the candle, upside down, shall be thrown upon the wall.

The spot on which the image is formed is called a *focus*. If the candle be now brought nearer to the lens, the image on the wall will enlarge, and grow blurred and dim, but may be restored to brightness and definition by moving the lens further from the wall. But if, when the new adjustment has taken place, the candle be moved away from the lens, the image will again become confused, and, to restore its clearness, the lens will have to be brought nearer the wall.

Thus a convex lens forms a distinct picture of luminous objects, but only at the focus on the side of the lens opposite to the object; and that focus is nearer when the object is distant, and further off when it is near.

13. Suppose, however, that, leaving the candle unmoved, a lens with more convex surfaces is substituted for the first, the image will be blurred, and the lens will have to be moved nearer the wall to give it definition. If, on the other hand, a lens with less convex surfaces is sub-

stituted for the first, it must be moved further from the wall to attain the same end.

In other words, other things being alike, the more convex the lens the nearer its focus; the less convex, the further off its focus.

If the lens were elastic, pulling it at the circumference would render it flatter, and thereby lengthen its focus; while, when let go again, it would become more convex, and of shorter focus.

Any material more refractive than the medium in which it is placed, if it have a convex surface, causes the rays of light which pass through the less refractive medium to that surface to converge towards a focus. If a watch-glass be fitted into one side of a box, and the box be then filled with water, a candle may be placed at such a distance outside the watch-glass that an image of its flame shall fall on the opposite wall of the box. If, under these circumstances, a doubly convex lens of glass were introduced into the water in the path of the rays, it would act (though less powerfully than if it were in air) in bringing the rays more quickly to a focus, because glass refracts light more strongly than water does.

A *camera obscura* is a box, into one side of which a lens is fitted, so as to be able to slide backwards and forwards, and thus throw on the screen at the back of the box distinct images of bodies at various distances off. Hence the arrangement just described might be termed a *water camera.*

14. The intermediate organs, by means of which the physical agent of vision, light, is enabled to act upon the expansion of the optic nerve, comprise three kinds of apparatus: (*a*) a "water camera," the eyeball; (*b*) muscles for moving the eyeball; (*c*) organs for protecting the eyeball, viz. the eyelids, with their lashes, glands, and muscles; the conjunctiva; and the lachrymal gland and its ducts.

The *eyeball* is composed, in the first place, of a tough, firm, spheroidal case consisting of fibrous or connective tissue, the greater part of which is white and opaque, and is called the *sclerotic* (Fig. 75, 2). In front, however, this fibrous capsule of the eye, though it does not change its essential character, becomes transparent, and receives the name of the *cornea* (Fig. 75, 1). The corneal portion of the case of the eyeball is more convex than the sclerotic portion, so that the whole form of the ball is such as would be produced by cutting off a segment from the

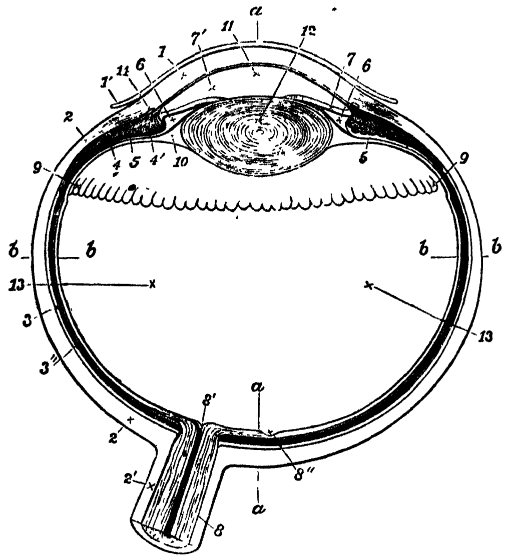

FIG. 75.—HORIZONTAL SECTION OF THE EYEBALL.

1, cornea; 1', conjunctiva; 2, sclerotic; 2', sheath of optic nerve; 3, choroid; 3'', rods and cones of the retina; 4, ciliary muscle; 4', circular portion of ciliary muscle; 5, ciliary process; 6, posterior chamber between 7, the iris and the suspensory ligament; 7', anterior chamber; 8, artery of retina in the centre of the optic nerve; 8', centre of blind spot; 8'', macula lutea, 9, ora serrata (this is of course not seen in a section such as this, but is introduced to show its position); 10, space behind the suspensory ligament (canal of Petit); 12, crystalline lens; 13, vitreous humour; 14 marks the position of the ciliary ligament; *a*, optic axis (in the actual eye of which this is an exact copy, the yellow spot happened, curiously enough, not to be in the optic axis); *b*, line of equator of the eyeball.

front of a spheroid of the diameter of the sclerotic, and replacing this by a segment cut from a smaller, and consequently more convex, spheroid.

15. The corneo-sclerotic case of the eye is kept in shape by what are termed the *humours*—watery or semi-fluid substances, one of which, the *aqueous* humour (Fig. 75, 7′), which is hardly more than water holding a few organic and saline substances in solution, distends the corneal chamber of the eye, while the other, the *vitreous* (Fig. 75, 13), which is rather a delicate jelly than a regular fluid, keeps the sclerotic chamber full.

The two humours are separated by the very beautiful, transparent, doubly-convex *crystalline lens* (Fig. 75, 12), denser, and capable of refracting light more strongly than either of the humours. The crystalline lens is composed of fibres having a somewhat complex arrangement, and is highly elastic. It is more convex behind than in front, and it is kept in place by a delicate, but at the same time strong and elastic, membranous frame or *suspensory ligament*, which extends from the edges of the lens to what are termed the *ciliary processes* of the choroid coat (Figs. 75, 5, and 76, *c*). In the ordinary condition of the eye this ligament is kept tense, *i.e.* is stretched pretty tight, and the front part of the lens is consequently flattened.

16. This *choroid coat* (Fig. 75, 3) is a highly vascular membrane, in close contact with the sclerotic externally, and lined, internally, by a layer of small polygonal bodies containing much pigmentary matter, called *pigment cells* (Fig. 74). These pigment cells are separated from the vitreous humour by the retina only. The rods and cones of the latter are in immediate contact with them. The choroid lines every part of the sclerotic, except just where the optic nerve enters it at a point below, and to the inner side of the centre of the back of the eye; but when it reaches the front part of the sclerotic, its inner surface becomes raised up into a number of longitudinal ridges, with intervening depressions, like the crimped frills of a lady's dress, terminating within and in front by rounded ends, but passing, externally, into the iris. These ridges, which when viewed from behind seem to radiate on all sides from the lens (Figs. 76, *c*, and 75, 5), are the above-mentioned ciliary processes.

17. The *iris* itself (Figs. 75, 7, and 76, *a*, *b*) is, as has been already said, a curtain with a round hole in the

middle, provided with circular and radiating unstriped muscular fibres, and capable of having its central aperture enlarged or diminished by the action of these fibres, the contraction of which, unlike that of other unstriped muscular fibres, is extremely rapid. The edges of the iris are firmly connected with the capsule of the eye, at the junction of the cornea and sclerotic, by the connective tissue which enters into the composition of the so-called *ciliary ligament.* Unstriped muscular fibres, having the same attachment in front, spread backwards on to the outer surface of the choroid, constituting the *ciliary muscle* (Fig. 75, 4). If these fibres contract, it is obvious that they will pull the choroid forwards; and as the frame, or suspensory ligament of the lens, is connected with the

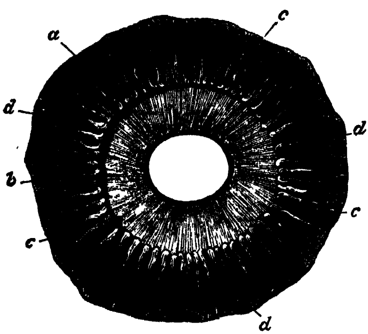

FIG. 76.—VIEW OF FRONT HALF OF THE EYEBALL SEEN FROM BEHIND.

a, circular fibres; *b*, radiating fibres of the iris; *c*, ciliary processes; *d*, choroid. The crystalline lens has been removed.

ciliary processes (which simply form the anterior termination of the choroid), this pulling forward of the choroid comes to the same thing as a relaxation of the tension of that suspensory ligament, which, as I have just said, like the lens itself, is highly elastic.

The iris does not hang down perpendicularly into the space between the front face of the crystalline lens and the posterior surface of the cornea, which is filled by the aqueous humour, but applies itself very closely to the anterior face of the lens, so that hardly any interval is left between the two (Figs. 75 and 77).

The retina, as we have seen, lines the interior of the eye, being placed between the choroid and vitreous humour, its rods and cones being imbedded in the former, and its anterior limiting membrane touching the latter.

About a third of the distance back from the front of the eye the retina seems to end in a wavy border called the *ora serrata* (Fig. 75, 9), and in reality the nervous elements of the retina do end here, having become considerably reduced before this line is reached. Some of the connective tissue elements however pass on as a delicate kind of membrane at the back of the ciliary processes towards the crystalline lens.

18. The eyeball, the most important constituents of which have now been described, is, in principle, a camera of the kind described above—a water camera. That is to say, the sclerotic answers to the box, the cornea to the watch-glass, the aqueous and vitreous humours to the water filling the box, the crystalline to the glass lens, the introduction of which was imagined. The back of the box corresponds with the retina.

But further, in an ordinary camera obscura, it is found desirable to have what is termed a *diaphragm* (that is, an opaque plate with a hole in its centre) in the path of the rays, for the purpose of moderating the light and cutting off the marginal rays which, owing to certain optical properties of spheroidal surfaces, give rise to defects in the image formed at the focus.

In the eye, the place of this diaphragm is taken by the iris, which has the peculiar advantage of being self-regulating: dilating its aperture, and admitting more light when the light is weak; but contracting its aperture and admitting less light when the illumination is strong.

19. In the water camera, constructed according to the description given above, there is the defect that no provision exists for adjusting the focus to the varying distances of objects. If the box were so made that its back, on which the image is supposed to be thrown, received distinct images of very distant objects, all near ones would be

indistinct. And if, on the other hand, it were fitted to receive the image of near objects, at a given distance, those of either nearer, or more distant, bodies would be blurred and indistinct. In the ordinary camera this difficulty is overcome by sliding the lenses in and out, a process which is not compatible with the construction of our water camera. But there is clearly one way among many, in which this adjustment might be effected—namely, by changing the glass lens; putting in a less convex one when more distant objects had to be pictured, and a more convex one when the images of nearer objects were to be thrown upon the back of the box.

But it would come to the same thing, and be much more convenient, if, without changing the lens, one and the same lens could be made to alter its convexity. This is what actually is done in the adjustment of the eye to distances.

20. The simplest way of experimenting on the *adjustment of the eye* is to stick two stout needles upright into a straight piece of wood, not exactly, but nearly in the same straight line, so that, on applying the eye to one end of the piece of wood, one needle (*a*) shall be seen about six inches off, and the other (*b*) just on one side of it at twelve inches' distance.

If the observer look at the needle *b*, he will find that he sees it very distinctly, and without the least sense of effort; but the image of *a* is blurred and more or less double. Now let him try to make this blurred image of the needle *a* distinct. He will find he can do so readily enough, but that the act is accompanied by a sense of effort somewhere in the eye. And in proportion as *a* becomes distinct, *b* will become blurred. Nor will any effort enable him to see *a* and *b* distinctly at the same time.

21. Multitudes of explanations have been given of this remarkable power of adjustment, but it is only within the last few years that the problem has been solved, by the accurate determination of the nature of the changes in the eye which accompany the act. When the flame of a taper is held near, and a little on one side of, a person's eye, anyone looking into the eye from a proper point of view, will see three images of the flame, two upright and

one inverted. One upright figure is reflected from the front of the cornea, which acts as a convex mirror. The second proceeds from the front of the crystalline lens, which has the same effect ; while the inverted image proceeds from the posterior face of the lens, which, being convex backwards, is, of course, concave forwards, and acts as a concave mirror.

Suppose the eye to be steadily fixed on a distant object, and then adjusted to a near one in the same line of vision, the position of the eyeball remaining unchanged. Then the upright image reflected from the surface of the cornea, and the inverted image from the back of the lens, will remain unchanged, though it is demonstrable that their size or apparent position must change if either the cornea, or the back of the lens, alter either their form or

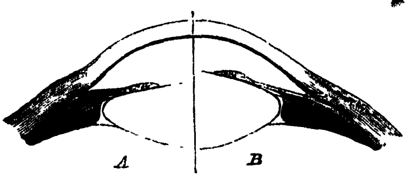

FIG. 77

Illustrates the change in the form of the lens when adjusted—*A* to distant, *B* to near objects.

their position. But the second upright image, that reflected by the front face of the lens, does change both its size and its position ; it comes forward and grows smaller, proving that the front face of the lens has become more convex. The change of form of the lens is, in fact, that represented in Fig. 77.

These may be regarded as the *facts of adjustment* with which all explanations of that process must accord. They at once exclude the hypotheses (1) that adjustment is the result of the compression of the ball of the eye by its muscles, which would cause a change in the form of the cornea ; (2) that adjustment results from a shifting of the lens bodily, for its hinder face does not move ; (3) that it results from the pressure of the iris upon the front face of the lens, for under these circumstances the hinder face of the lens would not remain stationary. This last hypothesis is further negatived by the fact that adjustment takes place equally well when the iris is absent.

One other explanation remains, which is, in all probability, the true one, though not altogether devoid of difficulties. The lens, which is very elastic, is kept habitually in a state of tension by the elasticity of its suspensory ligament, and consequently has a flatter form than it would take if left to itself. If the ciliary muscle contracts, it must, as has been seen, relax that ligament, and thereby diminish its elastic tension upon the lens. The lens, consequently, will become more convex, returning to its former shape when the ciliary muscle ceases to contract, and allows the choroid to return to its ordinary place.

If this be the true explanation of adjustment, the sense of effort we feel must arise from the contraction of the ciliary muscle.

22. Adjustment can take place only within a certain range, which admits of great individual variations. As a rule, no object which is brought within less than about ten inches of the eye can be seen distinctly without effort.

But many persons are born with the surface of the cornea more convex than usual, or with the refractive power of the eye increased in some other way; while, very generally, as age draws on, the cornea flattens. In the former case, objects at ordinary distances are seen indistinctly, because these images fall not on the retina, but in front of it; while, in the latter, the same indistinctness is the result of the rays of light striking upon the retina before they have been brought to a focus. The defect of the former, or short-sighted people, is amended by wearing concave glasses, which cause the rays to diverge; of the latter, or long-sighted people, by wearing convex glasses, which make the rays converge.

In the water camera the image brought to a focus on the screen at the back is *inverted;* the image of a tree for instance is seen with the roots upwards and the leaves and branches hanging downwards. The right of the image also corresponds with the left of the object and *vice versâ.* Exactly the same thing takes place in the eye with the image focussed on the retina. It too is inverted. (See Lesson X. § 11.)

23. The *muscles* which move the eyeball are altogether six in number—four straight muscles, or *recti*, and two oblique muscles, the *obliqui* (Fig. 78). The straight muscles are attached to the back of the orbit, round the edges of the hole through which the optic nerve passes, and run straight forward to their insertions into the sclerotic—one, the *superior rectus*, in the middle line above; one,

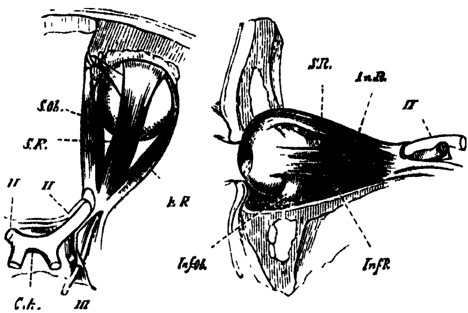

FIG 78.

A, the muscles of the right eyeball viewed from above, and B of the left eyeball viewed from the outer side; *S.R.* the superior rectus; *Inf. R.* the inferior rectus; *E.R.*, *In R.* the external rectus; *S.Ob.* the superior oblique; *Inf Ob.* the inferior oblique; *Ch.* the chiasma of the optic nerves (*II.*); *III.* the third nerve which supplies all the muscles except the superior oblique and the external rectus.

the *inferior*, opposite it below; and one half-way on each side, the *external* and *internal recti.* The eyeball is completely imbedded in fat behind and laterally; and these muscles turn it as on a cushion; the superior rectus inclining the axis of the eye upwards, the inferior downwards, the external outwards, the internal inwards.

The two oblique muscles are both attached on the outer side of the ball, and rather behind its centre; and they both pull in a direction from the point of attachment towards the inner side of the orbit—the lower, because it arises here; the upper, because, though it arises along with the recti from the back of the orbit, yet, after passing forwards and becoming tendinous at the upper and inner corner of the orbit, it traverses a pulley-like loop of ligament, and then turns downwards and outwards to its insertion. The action of the oblique muscles is somewhat complicated, but their general tendency is to roll the eyeball on its axis, and pull it a little forward and inward.

24. The *eyelids* are folds of skin containing thin plates of cartilage, and fringed at their edges with hairs, the *eye-lashes*, and with a series of small glands called *Meibomian.*

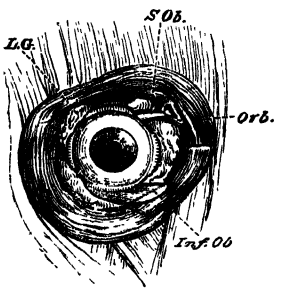

FIG. 79.

The front view of the right eye dissected to show, *Orb.*, the orbicular muscle of the eyelids; the pulley and insertion of the superior oblique, *S.Ob.*, and the inferior oblique, *Inf.Ob.*; *L.G.* the lachrymal gland.

Circularly disposed fibres of striped muscle lie beneath the integuments of the eyelids, and constitute the *orbicularis* muscle which shuts them. The upper eyelid is raised by a special muscle, the *levator* of the upper lid, which arises at the back of the orbit and runs forwards to end in the lid.

The lower lid has no special depressor.

25. At the edge of the eyelids the integument becomes continuous with a delicate, vascular, and highly nervous mucous membrane, the *conjunctiva*, which lines the interior of the lids and the front of the eyeball, its epithelial layer being even continued over the cornea.

The numerous small ducts of a gland which is lodged in the orbit, on the outer side of the ball (Fig. 79, *L.G.*), the *lachrymal gland*, constantly pour its watery secretion into the interspace between the conjunctiva lining the upper eyelid and that covering the ball. On the inner side of the eye is a reddish fold, the *caruncula lachrymalis*, a sort of rudiment of that third eyelid which is to be found in many animals. Above and below, close to the caruncula, the edge of each eyelid presents a minute aperture (the *punctum lachrymale*), the opening of a

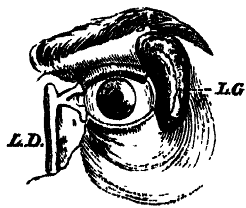

FIG. 80.

A front view of the left eye, with the eyelids partially dissected to show lachrymal gland, *L.G.*, and lachrymal duct, *L.D.*

small canal. The canals from above and below converge and open into the *lachrymal sac;* the upper blind end of a duct (*L.D.*, Fig. 80) which passes down from the orbit to the nose, opening below the inferior turbinal bone (Fig. 40, *h*). It is through this system of canals that the conjunctival mucous membrane is continuous with that of the nose; and it is by them that the secretion of the lachrymal canal is ordinarily carried away as fast as it forms.

But, under certain circumstances, as when the conjunctiva is irritated by pungent vapours, or when painful emotions arise in the mind, the secretion of the lachrymal gland exceeds the drainage power of the lachrymal duct, and the fluid, accumulating between the lids, at length overflows in the form of tears.

LESSON X.

THE COALESCENCE OF SENSATIONS WITH ONE ANOTHER AND WITH OTHER STATES OF CONSCIOUSNESS.

1. IN explaining the functions of the sensory organs, I have hitherto confined myself to describing the means by which the physical agent of a sensation is enabled to irritate a given sensory nerve; and to giving some account of the simple sensations which are thus evolved. *Simple sensations* of this kind are such as might be produced by the irritation of a single nerve-fibre, or of several nerve-fibres by the same agent. Such are the sensations of contact, of warmth, of sweetness, of an odour, of a musical note, of whiteness, or redness.

But very few of our sensations are thus simple. Most of even those which we are in the habit of regarding as simple, are really compounds of different sensations, or of sensations with ideas, or with judgments. For example, in the preceding cases, it is very difficult to separate the sensation of contact from the judgment that something is touching us; of sweetness, from the idea of something in the mouth; of sound or light, from the judgment that something outside us is shining, or sounding.

2. The sensations of smell are those which are least complicated by accessories of this sort. Thus, particles of musk diffuse themselves with great rapidity through the nasal passages, and give rise to the sensation of a powerful odour. But beyond a broad notion that the odour is in the nose, this sensation is unaccompanied by any ideas of locality and direction. Still less does it give rise to any conception of form, or size, or force,

or of succession, or contemporaneity. If a man had no other sense than that of smell, and musk were the only odorous body, he could have no sense of *outness*—no power of distinguishing between the external world and himself.

3. Contrast this with what may seem to be the equally simple sensation obtained by drawing the finger along the table, the eyes being shut. This act gives one the sensation of a flat, hard surface outside oneself, which appears to be just as simple as the odour of musk, but is really a complex state of feeling compounded of—

(*a*) Pure sensations of contact.

(*b*) Pure muscular sensations of two kinds,—the one arising from the resistance of the table, the other from the actions of those muscles which draw the finger along.

(*c*) Ideas of the order in which these pure sensations succeed one another.

(*d*) Comparisons of these sensations and their order, with the recollection of like sensations similarly arranged, which have been obtained on previous occasions.

(*e*) Recollections of the impressions of extension, flatness, &c. made on the organ of vision when these previous tactile and muscular sensations were obtained.

Thus, in this case, the only pure sensations are those of contact and muscular action. The greater part of what we call the sensation is a complex mass of present and recollected ideas and judgments.

4. Should any doubt remain that we do thus mix up our sensations with our judgments into one indistinguishable whole, shut the eyes as before, and, instead of touching the table with the finger, take a round lead pencil between the fingers, and draw that along the table. The "sensation" of a flat hard surface will be just as clear as before; and yet all that we touch is the round surface of the pencil, and the only pure sensations we owe to the table are those afforded by the muscular sense. In fact, in this case, our "sensation" of a flat hard surface is entirely a judgment based upon what the muscular sense tells us is going on in certain muscles.

A still more striking case of the tenacity with which we adhere to complex judgments, which we conceive to be pure sensations, and are unable to analyse otherwise than by a process of abstract reasoning, is afforded by our sense of roundness.

Anyone taking a marble between two fingers will say that he feels it to be a single round body; and he will probably be as much at a loss to answer the question how he knows that it is round, as he would be if he were asked how he knows that a scent is a scent.

Nevertheless, this notion of the roundness of the marble is really a very complex judgment, and that it is so may be shown by a simple experiment. If the index and middle fingers be crossed, and the marble placed between them, so as to be in contact with both, it is utterly impossible to avoid the belief that there are two marbles instead of one. Even looking at the marble, and seeing that there is only one, does not weaken the apparent proof derived from touch that there are two.[1]

The fact is, that our notions of singleness and roundness are, really, highly complex judgments based upon a few simple sensations; and when the ordinary conditions of those judgments are reversed, the judgment is also reversed.

With the index and the middle fingers in their ordinary position, it is of course impossible that the outer sides of each should touch opposite surfaces of one spheroidal body. If, in the natural and usual position of the fingers, their outer surfaces simultaneously give us the impression of a spheroid (which itself is a complex judgment), it is in the nature of things that there must be two spheroids. But, when the fingers are crossed over the marble, the outer side of each finger is really in contact with a spheroid; and the mind, taking no cognizance of the crossing, judges in accordance with its universal experience, that two spheroids, and not one, give rise to the sensations which are perceived.

5. Phenomena of this kind are not uncommonly called *delusions of the senses;* but there is no such thing as a fictitious, or delusive, sensation. A sensation must

[1] A ludicrous form of this experiment is to apply the crossed fingers to the end of the nose, when it at once appears double; and, in spite of the absurdity of the conviction, the mind cannot expel it, so long as the sensations last.

exist to be a sensation, and, if it exists, it is real and not delusive. But the judgments we form respecting the causes and conditions of the sensations of which we are aware, are very often erroneous and delusive enough; and such judgments may be brought about in the domain of every sense, either by artificial combinations of sensations, or by the influence of unusual conditions of the body itself. The latter give rise to what are called *subjective sensations.*

Mankind would be subject to fewer delusions than they are, if they constantly bore in mind their liability to false judgments due to unusual combinations, either artificial or natural, of true sensations. Men say, "I felt," "I heard," "I saw" such and such a thing, when, in ninety-nine cases out of a hundred, what they really mean is, that they judge that certain sensations of touch, hearing, or sight, of which they were conscious, were caused by such and such things.

6. Among *subjective sensations* within the domain of touch, are the feelings of creeping and prickling of the skin, which are not uncommon in certain states of the circulation. The subjective evil smells and bad tastes which accompany some diseases are very probably due to similar disturbances in the circulation of the sensory organs of smell and taste.

Many persons are liable to what may be called *auditory spectra*—music of various degrees of complexity sounding in their ears, without any external cause, while they are wide awake. I know not if other persons are similarly troubled, but in reading books written by persons with whom I am acquainted, I am sometimes tormented by hearing the words pronounced in the exact way in which these persons would utter them, any trick or peculiarity of voice, or gesture, being, also, very accurately reproduced. And I suppose that everyone must have been startled, at times, by the extreme distinctness with which his thoughts have embodied themselves in apparent voices.

The most wonderful exemplifications of subjective sensation, however, are afforded by the organ of sight.

Anyone who has witnessed the sufferings of a man labouring under *delirium tremens* (a disease produced by excessive drinking), from the marvellous distinctness of his visions, which sometimes take the forms of devils, sometimes of creeping animals, but almost always of something fearful or loathsome, will not doubt the intensity of subjective sensations in the domain of vision.

7. But that illusive visions of great distinctness should appear, it is not necessary for the nervous system to be thus obviously deranged. People in the full possession of their faculties, and of high intelligence, may be subject to such appearances, for which no distinct cause can be assigned. An excellent illustration of this is the famous case of Mrs. A. given by Sir David Brewster, in his "Natural Magic." (See Appendix.)

It should be mentioned that Mrs. A. was naturally a person of very vivid imagination, and that, at the time the most notable of these illusions appeared, her health was weak from bronchitis and enfeebled digestion.

It is obvious that nothing but the singular courage and clear intellect of Mrs. A. prevented her from becoming a mine of ghost stories of the most excellently authenticated kind. And the particular value of her history lies in its showing, that the clearest testimony of the most unimpeachable witness may be quite inconclusive as to the objective reality of something which the witness has seen.

Mrs. A. undoubtedly saw what she said she saw. The evidence of her eyes as to the existence of the apparitions, and of her ears to those of the voices, was, in itself, as perfectly trustworthy as their evidence would have been had the objects really existed. For there can be no doubt that exactly those parts of her retina which would have been affected by the image of a cat, and those parts of her auditory organ which would have been set vibrating by her husband's voice, or the portions of the sensorium with which those organs of sense are connected, were thrown into a corresponding state of activity by some internal cause.

What the senses testify is neither more nor less than the fact of their own affection. As to the cause of that affection they really say nothing, but leave the mind to form its own judgment on the matter. A hasty or superstitious person in Mrs. A.'s place would have formed a wrong judgment, and would have stood by it on the plea that "she must believe her senses."

8. The delusions of the judgment, produced not by abnormal conditions of the body, but by unusual or artificial combinations of sensations, or by suggestions of ideas, are exceedingly numerous, and, occasionally are not a little remarkable.

Some of those which arise out of the sensation of touch have already been noted. I do not know of any produced through smell or taste, but hearing is a fertile source of such errors.

What is called *ventriloquism* (speaking from the belly), and is not uncommonly ascribed to a mysterious power of producing voice somewhere else than in the larynx, depends entirely upon the accuracy with which the performer can simulate sounds of a particular character, and upon the skill with which he can suggest a belief in the existence of the causes of these sounds. Thus, if the ventriloquist desire to create the belief that a voice issues from the bowels of the earth, he imitates with great accuracy the tones of such a half-stifled voice, and suggests the existence of some one uttering it by directing his answers and gestures towards the ground. These gestures and tones are such as would be produced by a given cause; and no other cause being apparent, the mind of the bystander insensibly judges the suggested cause to exist.

9. The delusions of the judgment through the sense of sight—*optical delusions*, as they are called—are more numerous than any others, because such a great number of what we think to be simple visual sensations are really very complex aggregates of visual sensations, tactile sensations, judgments, and recollections of former sensations and judgments.

It will be instructive to analyse some of these judgments into their principles, and to explain the delusions by the application of these principles.

10. *When an external body is felt by the touch to be in a given place, the image of that body falls on a point of the retina which lies at one end of a straight line joining the body and the retina, and traversing a particular region of the centre of the eye. This straight line is called the* OPTIC AXIS.

Conversely, when any part of the surface of the retina *is excited, the luminous sensation is referred by the mind to some point outside the body, in the direction of the optic axis.*

It is for this reason that when a phosphene is created by pressure, say on the outer and lower side of the eyeball, the luminous image appears to lie above, and to the inner side of, the eye. Any external object which could produce the sense of light in the part of the retina pressed upon must, owing to the inversion of the retinal images (see Lesson IX. § 23), in fact occupy this position; and hence the mind refers the light seen to an object in that position.

11. The same kind of explanation is applicable to the apparent paradox that, while all the pictures of external objects are certainly inverted on the retina by the refracting media of the eye, we nevertheless see them upright. It is difficult to understand this, until one reflects that the retina has, in itself, no means of indicating to the mind which of its parts lies at the top, and which at the bottom; and that the mind learns to call an impression on the retina high or low, right or left, simply on account of the association of such an impression with certain coincident tactile impressions. In other words, when one part of the retina is affected, the object causing the affection is found to be near the right hand; when another, the left; when another, the hand has to be raised to reach the object; when yet another, it has to be depressed to reach it. And thus the several impressions on the retina are called right, left, upper, lower, quite irrespectively of their real positions, of which the mind has, and can have, no cognizance.

12. *When an external body is ascertained by touch to be simple, it forms but one image on the retina of a single eye; and when two or more images fall on the retina of a single eye, they ordinarily proceed from a corresponding number of bodies which are distinct to the touch.*

Conversely, the sensation of two or more images is judged by the mind to proceed from two or more objects.

If two pin-holes be made in a piece of cardboard at a distance less than the diameter of the pupil, and a small object like the head of a pin be held pretty close to the eye, and viewed through these holes, two images of the head of the pin will be seen. The reason of this is, that the rays of light from the head of the pin are split by the card into two minute pencils, which pass into the eye on either side of its centre, and cannot be united again and brought to one focus on account of the nearness of the pin to the eye. Hence they fall on different parts of the retina, and each pencil of rays, being very small, makes a tolerably distinct image of its own of the pin's head on the retina. Each of these images is now referred outward (§ 10) in the direction of the appropriate optic axis, and two pins are apparently seen instead of one. A like explanation applies to *multiplying glasses* and *doubly refracting* crystals, both of which, in their own ways, split the pencils of light proceeding from a single object into two or more separate bundles. These give rise to as many images, each of which is referred by the mind to a distinct external object.

13. *Certain visual phenomena ordinarily accompany those products of tactile sensation to which we give the name of size, distance, and form. Thus, other things being alike, the space of the retina covered by the image of a large object is larger than that covered by a small object; while that covered by a near object is larger than that covered by a distinct object; and, other conditions being alike, a near object is more brilliant than a distant one. Furthermore, the shadows of objects differ with the forms of their surfaces, as determined by touch.*

Conversely, if these visual sensations can be produced, they inevitably suggest a belief in the existence of objects competent to produce the corresponding tactile sensations.

What is called *perspective*, whether *solid* or *aerial*, in drawing, or painting, depends on the application of these principles. It is a kind of visual ventriloquism—the painter putting upon his canvas all the conditions requisite for the production of images on the retina, having the size, relative form, and intensity of colour of those which would actually be produced by the objects themselves in nature. And the success of his picture, as an imitation, depends upon the closeness of the resemblance between the images it produces on the retina, and those which would be produced by the objects represented.

14. To most persons the image of a pin, at five or six

inches from the eye, appears blurred and indistinct—the eye not being capable of adjustment to so short a focus. If a small hole be made in a piece of card, the circumferential rays which cause the blur are cut off, and the image becomes distinct. But at the same time it is magnified, or looks bigger, because the image of the pin, in spite of the loss of the circumferential rays, occupies a much larger extent of the retina when close than when distant. All convex glasses produce the same effect—while concave lenses diminish the apparent size of an object, because they diminish the size of its image on the retina.

15. The moon, or the sun, when near the horizon appear very much larger than they are when high in the sky. When in the latter position, in fact, we have nothing to compare them with, and the small extent of the retina which their images occupy suggests small absolute size. But as they set, we see them passing behind great trees and buildings which we know to be very large and very distant, and yet occupying a larger space on the retina than the latter do. Hence the vague suggestion of their larger size.

16. If a convex surface be lighted from one side, the side towards the light is bright—that turned from the light, dark, or in shadow; while a concavity is shaded on the side towards the light, bright on the opposite side.

If a new half-crown, or a medal with a well-raised head upon its face, be lighted sideways by a candle, we at once know the head to be raised (or a *cameo*) by the disposition of the light and shade; and if an *intaglio*, or medal on which the head is hollowed out, be lighted in the same way, its nature is as readily judged by the eye.

But now, if either of the objects thus lighted be viewed with a convex lens, which inverts its position, the light and dark sides will be reversed. With the reversal the judgment of the mind will change, so that the cameo will be regarded as an intaglio, and the intaglio as a cameo; for the light still comes from where it did, but the cameo appears to have the shadows of an intaglio, and *vice versâ*. So completely, however, is this interpretation of the facts as a matter of judgment, that if a pin be stuck beside the medal so as to throw a shadow, the pin and its shadow, being reversed by the lens, will suggest that the direction of the light is also reversed, and the medals will seem to be what they really are.

17. *Whenever an external object is watched rapidly changing its form, a continuous series of different pictures of the object is impressed upon the same spot of the retina.*

Conversely, if a continuous series of different pictures of one object is impressed upon one part of the retina, the mind judges that they are due to a single external object, undergoing changes of form.

This is the principle of the curious toy called the *thaumatrope*, or "zootrope," or "wheel of life," by the help of which, on looking through a hole, one sees images of jugglers throwing up and catching balls, or boys playing at leapfrog over one another's backs. This is managed by painting at intervals, on a disk of card, figures and jugglers in the attitudes of throwing, waiting to catch, and catching; or boys "giving a back," leaping, and coming into position after leaping. The disk is then made to rotate before an opening, so that each image shall be presented for an instant, and follow its predecessor before the impression of the latter has died away. The result is that the succession of different pictures irresistibly suggests one or more objects undergoing successive changes—the juggler seems to throw the balls, and the boys appear to jump over one another's backs.

18. *When an external object is ascertained by touch to be single, the centres of its retinal images in the two eyes fall upon the centres of the yellow spots of the two eyes, when both eyes are directed towards it; but if there be two external objects, the centres of both their images cannot fall, at the same time, upon the centres of the yellow spots.*

Conversely, when the centres of two images, formed simultaneously in the two eyes, fall upon the centres of the yellow spots, the mind judges the images to be caused by a single external object; but if not, by two.

This seems to be the only admissible explanation of the facts, that an object which appears single to the touch and when viewed with one eye, also appears single when it is viewed with both eyes, though two images of it are necessarily formed; and on the other hand, that when the centres of the two images of one object do not fall on the centres of the yellow spots, both images are seen separately, and we have double vision. In squinting, the axes of the two eyes do not converge equally towards the object viewed. In consequence of this, when the centre of the image formed by one eye falls on the centre of the yellow spot, the corresponding part of that formed by the other eye does not, and double vision is the result.

For simplicity's sake we have supposed the images to fall on the centre of the yellow spot. But though vision is distinct only in the yellow spot, it is not absolutely limited to it; and it is quite possible for an object to be seen as a single object with two eyes, though its images fall on the two retinas outside the yellow spots. All that is necessary is that the two spots of the retinas on which the images fall should be similarly disposed towards the centres of their respective yellow spots. Any two points of the two retinas thus similarly disposed towards their respective yellow spots (or more exactly to the points in which the optic axes end), are spoken of as *corresponding points;* and any two images covering two corresponding areas are conceived of as coming from a single object. It is obvious that the inner (or nasal) side of one retina *corresponds* to the outer (or cheek) side of the other.

19. *In single vision with two eyes, the axes of the two eyes, of the movements of which the muscular sense gives an indication, cut one another at a greater angle when the object approaches, at a less angle when it goes further off.*

Conversely, if without changing the position of an object, the axes of the two eyes which view it can be made to converge or diverge, the object will seem to approach or go further off.

In the instrument called the *pseudoscope*, mirrors or prisms are disposed in such a manner that the angle at which rays of light from an object enter the two eyes, can be altered without any change in the object itself; and consequently the axes of these eyes are made to converge or diverge. In the former case the object seems to approach; in the latter, to recede.

20. *When a body of moderate size, ascertained by touch to be solid, is viewed with both eyes, the images of it, formed by the two eyes, are necessarily different (one showing more of its right side, the other of its left side).*

Nevertheless, they coalesce into a common image, which gives the impression of solidity.

Conversely, if the two images of the right and left aspects of a solid body be made to fall upon the retinas of the two eyes in such a way as to coalesce into a common image, they are judged by the mind to proceed from the single solid body which alone, under ordinary circumstances, is competent to produce them.

The *stereoscope* is constructed upon this principle. Whatever its form, it is so contrived as to throw the images of two pictures of a solid body, such as would be obtained by the right and left eye of a spectator, on to such parts of the retinas of the person who uses the stereoscope as would receive these images, if they really proceeded from one solid body. The mind immediately judges them to arise from a single external solid body, and sees such a solid body in place of the two pictures.

The operation of the mind upon the sensations presented to it by the two eyes is exactly comparable to that which takes place when, on holding a marble between the finger and thumb, we at once declare it to be a single sphere (§ 4). That which is absolutely presented to the mind by the sense of touch in this case is by no means the sensation of one spheroidal body, but two distinct sensations of two convex surfaces. That these two distinct convexities belong to one sphere, is an act of judgment, or process of unconscious reasoning, based upon many particulars of past and present experience, of which we have, at the moment, no distinct consciousness.

LESSON XI.

THE NERVOUS SYSTEM AND INNERVATION.

1. THE sensory organs are, as we have seen, the channels through which particular physical agents are enabled to excite the sensory nerves with which these organs are connected; and the activity of these nerves is evidenced by that of the central organ of the nervous system, which activity becomes manifest as a state of consciousness—the sensation.

We have also seen that the muscles are instruments by which a motor nerve, excited by the central organ with which it is connected, is able to produce motion.

The sensory nerves, the motor nerves, and the central organ, constitute the greater part of the *nervous system*, which, with its function of *innervation*, we must now study somewhat more closely, and as a whole.

2. The nervous apparatus consists of two sets of nerves and nerve-centres, which are intimately connected together and yet may be conveniently studied apart. These are the *cerebro-spinal* system and the *sympathetic* system. The former consists of the *cerebro-spinal axis* (composed of the *brain* and *spinal cord*) and the *cerebral* and *spinal nerves*, which are connected with this axis. The latter comprises the chain of *sympathetic ganglia*, the nerves which they give off, and the nervous cords by which they are connected with one another and with the cerebro-spinal nerves.

Nerves are made up entirely of nerve-fibres, the structure of which is somewhat different in the cerebro-spinal and in the sympathetic systems. (See Lesson XII., § 16.)

Nerve-centres, on the other hand, are composed of *nerve-cells* or *ganglionic corpuscles*, mingled with nerve-fibres (Lesson XII., § 16). Such cells, or corpuscles, are found in various parts of the brain and spinal cord, in the sympathetic ganglia, and also in the ganglia belonging to spinal nerves as well as in certain sensory organs, such as the retina and the internal ear.

3. The *cerebro-spinal axis* lies in the cavity of the skull and spinal column, the bony walls of which cavity are lined by a very tough fibrous membrane, serving as the periosteum of the component bones of this region, and called the *dura mater*. The brain and spinal cord themselves are closely invested by a very vascular fibrous tissue, called *pia mater*. The numerous blood-vessels supplying these organs run for some distance in the pia mater, and where they pass into the substance of the brain or cord, the fibrous tissue of the pia mater accompanies them to a greater or less depth.

The outer surface of the *pia mater*, and the inner surface of the *dura mater*, pass into a delicate fibrous tissue, lined by an epithelium, which is called the *arachnoid* membrane. Thus one layer of arachnoid coats the brain and spinal cord, and another lines the dura mater. As these layers become continuous with one another at various points, the arachnoid forms a sort of shut sac, like the *pericardium;* and, in common with other serous membranes, it secretes a fluid, the *arachnoid fluid*, into its interior. The interspace between the internal and external layers of the arachnoid of the brain is, for the most part, very small; that between the corresponding layers of the arachnoid of the spinal cord is larger.

4. The *spinal cord* (Fig. 81) is a column of greyish-white soft substance, extending from the top of the spinal canal, where it is continuous with the brain, to about the second lumbar vertebra, where it tapers off into a filament. A deep fissure, the *anterior fissure* (Fig. 82, 1), divides it in the middle line in front, nearly down to its centre: and a similar cleft, the *posterior fissure* (Fig. 82, 2), also extends nearly to its centre in the middle line behind. The pia mater extends into each of these fissures, and supports the vessels which supply the cord with blood. In consequence of the presence of these fissures, only a narrow

the interior. And this *grey matter*, as it is called, is so disposed that, in a transverse section, it looks something like a crescent, with one end bigger than the other, and with the concave side turned outwards. The two ends of the crescents are called its *horns* or *cornua* (Fig. 82, *e e*), the one directed forwards being the *anterior cornu;* the one turned backwards the *posterior cornu* (Fig. 82, *a a*). The convex sides of the cornua of the grey matter approach one another, and are joined by the bridge which contains the central canal.

There is a fundamental difference in structure between the grey and the white matter. The white matter consists entirely of nerve-fibres supported in a delicate framework of connective tissue, and accompanied by blood-vessels. Most of these fibres run lengthways in the cord, and consequently, in a transverse section, the white matter is really composed of a multitude of the cut ends of these fibres.

The grey matter, on the other hand, contains in addition, a number of nerve-cells or ganglionic corpuscles, some of them of considerable size. These cells are wholly absent in the white matter.

Many of the nerve-fibres of which the anterior roots are composed may be traced into the anterior cornu, while those of the posterior roots enter the posterior cornu.

6. The physiological properties of the organs now described are very remarkable.

If the *trunk* of a spinal nerve be irritated in any way, as by pinching, cutting, galvanizing, or applying a hot body, two things happen: in the first place, all the muscles to which filaments of this nerve are distributed, contract; in the second, acute pain is felt, and the pain is referred to that part of the skin to which fibres of the nerve are distributed. In other words, the effect of irritating the trunk of a nerve is the same as that of irritating its component fibres at their terminations.

The effects just described will follow upon irritation of any part of the *branches* of the nerve: except that when a branch is irritated, the only muscles directly affected, and the only region of the skin to which pain is referred, will be those to which that branch sends nerve-fibres. And these effects will follow upon irritation of any part of a nerve from its smallest branches up to the point of its trunk, at which the anterior and posterior bundles of root fibres unite.

7. If the anterior bundle of root fibres be irritated in the same way, only half the previous effects are brought about. That is to say, all the muscles to which the nerve is distributed contract, but no pain is felt.

So again if the posterior, ganglionated bundle be irritated, only half the effects of irritating the whole trunk is produced. But it is the other half; that is to say, none of the muscles to which the nerve is distributed contract, but intense pain is referred to the whole area of skin to which the fibres of the nerve are distributed.

8. It is clear enough, from these experiments, that all the power of causing muscular contraction which a spinal nerve possesses, is lodged in the fibres which compose its anterior roots; and all the power of giving rise to sensation, in those of its posterior roots. Hence the anterior roots are commonly called *motor*, and the posterior *sensory*.

The same truth may be illustrated in other ways. Thus, if, in a living animal, the anterior roots of a spinal nerve be cut, the animal loses all control over the muscles to which that nerve is distributed, though the sensibility of the region of the skin supplied by the nerve is perfect. If the posterior roots be cut, sensation is lost, and voluntary movement remains. But if both roots be cut, neither voluntary movement nor sensibility is any longer possessed by the part supplied by the nerve. The muscles are said to be paralysed, and the skin may be cut, or burnt, without any sensation being excited.

If, when both roots are cut, that end of the motor root which remains connected with the trunk of the nerve be irritated, the muscles contract; while, if the other end be so treated, no apparent effect results. On the other hand, if the end of the sensory root connected with the trunk of the nerve be irritated, no apparent effect is produced, while, if the end connected with the cord be thus served, violent pain immediately follows.

When no apparent effect follows upon the irritation of any nerve, it is not probable that the molecules of the nerve remain unchanged. On the contrary, it would appear that the same change occurs in all cases; but a motor nerve is connected with nothing that can make that change apparent save a muscle: and a sensory nerve with nothing that can show an effect but the central nervous system.

9. It will be observed that in all the experiments mentioned there is evidence that, when a nerve is irritated, a something, probably a change in the arrangement of its molecules, is propagated along the nerve-fibres. If a motor or a sensory nerve be irritated at any point, contraction in the muscle, or sensation in the central organ, immediately follows. But if the nerve be cut, or even tightly tied at any point between the part irritated and the muscle or central organ, the effect at once ceases, just as cutting a telegraph wire stops the transmission of the electric current or impulse. When a limb, as we say, "goes to sleep," it is because the nerves supplying it have been subjected to pressure sufficient to destroy the nervous [1] continuity of the fibres. We lose voluntary control over, and sensation in, the limb, and these powers are only gradually restored as that nervous continuity returns.

Having arrived at this notion of an impulse travelling along a nerve, we readily pass to the conception of a sensory nerve as a nerve which, when active, brings an impulse to the central organ, or is *afferent;* and of a motor nerve, as a nerve which carries away an impulse from the organ, or is *efferent.* It is very convenient to use these terms to denote the two great classes of nerves; for, as we shall find (§ 12), there are afferent nerves which are not sensory in the sense of giving rise to a change of consciousness, or sensation, while there are efferent nerves which are not motor, in the sense of inducing muscular contraction. Such, for example, are the nerves by which the electrical fishes give rise to discharges of electricity from peculiar organs to which those nerves are distributed. The pneumogastric when it stops the beat of the heart cannot be called a motor, and yet is then acting as an efferent nerve.

[1] Their "nervous continuity"—because their physical continuity is not interrupted as a whole, but only that of the substance which acts as a conductor of the nervous influence; or, it may be that only the conducting power of a part of that substance is interfered with. Imagine a telegraph cable, made of delicate caoutchouc tubes, filled with mercury—a squeeze would interrupt the "electrical continuity" of the cable, without destroying its physical continuity. This analogy may not be exact, but it helps to make the nervous phenomena intelligible.

It will, of course, be understood, as pointed out above, that the use of these words does not imply that when a nerve is irritated in the middle of its length, the impulses set up by that irritation travel only away from the central organ if the nerve be efferent, and towards if it be afferent. On the contrary, we have evidence that in both cases the impulses travel both ways. All that is meant is this, that the afferent nerve from the disposition of its two ends, in the skin, &c. and in the central organ, is of use only when impulses are travelling along it towards the central organ, and similarly the efferent nerve is of use only when impulses are travelling along it, away from the central organ.

10. There is no difference in structure, in chemical or in physical character, between afferent and efferent nerves. The impulse which travels along them requires a certain time for its propagation, and is vastly slower than many other forces—even slower than sound.

11. Up to this point our experiments have been confined to the nerves. We may now test the properties of the spinal cord in a similar way. If the cord be cut across (say in the middle of the back), the legs and all the parts supplied by nerves which come off below the section, will be insensible, and no effort of the will can make them move; while all the parts above the section will retain their ordinary powers.

When a man hurts his back by an accident, the cord is not unfrequently so damaged as to be virtually cut in two, and then paralysis and insensibility of the lower part of the body ensue.

If, when the cord is cut across in an animal, the cut end of the portion below the division, or away from the brain, be irritated, violent movements of all the muscles supplied by nerves given off from the lower part of the cord take place, but there is no sensation. On the other hand, if that part of the cord, which is still connected with the brain, or better, if any afferent nerve connected with that part of the cord be irritated, great pain ensues, as is shown by the movements of the animal, but in these movements the muscles supplied by nerves coming from the spinal cord below the cut take no part; they remain perfectly quiet.

12. Thus, it may be said that, in relation to the brain

the cord is a great mixed motor and sensory nerve. But it is also much more. For if the trunk of a spinal nerve be cut through, so as to sever its connection with the cord, an irritation of the skin to which the sensory fibres of that nerve are distributed, produces neither motor nor sensory effect.

But if the cord be cut through anywhere so as to sever its connection with the brain, irritation applied to the skin of the parts supplied with sensory nerves from the part of the cord below the section, though it gives rise to no sensation, may produce violent motion of the parts supplied with motor nerves from the same part of the cord.

Thus, in the case supposed above, of a man whose legs are paralysed and insensible from spinal injury, tickling the soles of the feet will cause the legs to kick out convulsively. And as a broad fact, it may be said that, so long as both roots of the spinal nerves remain connected with the cord, irritation of any afferent nerve is competent to give rise to excitement of some, or the whole, of the efferent nerves so connected.

If the cord be cut across a second time at any distance below the first section, the efferent nerves below the second cut will no longer be affected by irritation of the afferent nerves above it—but only of those below the second section. Or, in other words, in order that an afferent impulse may be converted into an efferent one by the spinal cord, the afferent nerve must be in uninterrupted material communication with the efferent nerve, by means of the substance of the spinal cord.

This peculiar power of the cord, by which it is competent to convert afferent into efferent impulses, is that which distinguishes it physiologically, as a central organ, from a nerve, and is called *reflex action*. It is a power possessed by the grey matter, and not by the white substance of the cord.

13. The number of the efferent nerves which may be excited by the reflex action of the cord, is not regulated alone by the number of the afferent nerves which are stimulated by the irritation which gives rise to the reflex action. Nor does a simple excitation of the afferent nerve by any means necessarily imply a corresponding simplicity in the arrangement and succession of the reflected motor impulses.

Tickling the sole of the foot is a very simple excitation of the afferent fibres of its nerves ; but in order to produce the muscular actions by which the legs are drawn up, a great multitude of efferent fibres must act in regulated combination. In fact, in a multitude of cases, a reflex action is to be regarded rather as an order given by an afferent nerve to the cord, and executed by it, than as a mere rebound of the afferent impulse into the first efferent channels open to it.

The various characters of these reflex actions may be very conveniently studied in the frog. If a frog be decapitated, or, better still, if the spinal cord be divided close to the head and the brain be destroyed by passing a blunt wire into the cavity of the skull, the animal is thus deprived (by an operation which, being almost instantaneous, can give rise to very little pain) of all consciousness and volition, and yet the spinal cord is left intact. At first the animal is quite flaccid and apparently dead, no movement of any part of the body (except the beating of the heart) being visible. This condition, however, being the result merely of the so-called shock of the operation, very soon passes off, and then the following facts may be observed.

So long as the animal is untouched, so long as no stimulus is brought to bear upon it, no movement of any kind takes place—volition is wholly absent.

If, however, one of the toes be gently pinched, the leg is immediately drawn up close to the body.

If the skin between the thighs around the anus be pinched, the legs are suddenly drawn up and thrust out again violently.

If the flank be very gently stroked, there is simply a twitching movement of the muscles underneath ; if it be more roughly touched, or pinched, these twitching movements become more general along the whole side of the creature, and extend to the other side, to the hind legs, and even to the front legs.

If the digits of the front limbs be touched, these will be drawn close under the body as in the act of clasping.

If a drop of vinegar or any acid be placed on the top of one thigh, rapid and active movements will take place in the leg. The foot will be seen distinctly trying to rub off the drop of acid from the thigh. And what is still more striking, if the leg be held tight and so prevented from moving, the other leg will begin to rub off the acid. Sometimes if the drop be too large or too strong both legs begin at once, and then frequently the movements spread from the legs all over the body, and the whole animal is thrown into convulsions.

Now all these various movements, even the feeblest and simplest, require a certain combination of muscles, and some of them, such as the act of rubbing off the acids, are in the highest degree complex. In all of them, too, a certain purpose or end is evident, which is generally either to remove the body or part of the body from the stimulus, from the cause of irritation, or to thrust away the offending object from the body: in the more complex movements such a purpose is strikingly apparent.

It seems, in fact, that in the frog's spinal cord there are sets of nervous machinery destined to be used for a variety of movements, and that a stimulus passing along a sensory nerve to the cord sets one or the other of these pieces of machinery at work.

14. Thus the spinal cord is, in part, merely a transmitter of impulses to and from the brain; but, in part, it is an independent nervous centre, capable of originating combined movements upon the reception of the impulse of an afferent nerve.

Regarding it merely as a conductor, the question arises, do all parts of it conduct all kinds of impulses indifferently? Or are certain kinds of impulses communicated only through particular parts of the cord?

The following experiments furnish a partial reply to these questions:—

If the anterior half of the white matter of the dorsal part of the cord be cut through, the will is no longer capable of exerting any influence on the muscles which are supplied with nerves from the lower segment of the cord. A similar section, carried through the posterior half of the white matter in this region, has no effect on the transmission of voluntary impulses. It is obvious, therefore, that in the dorsal part of the cord, nervous impulses *from* the brain are sent through the anterior part of the white matter.

The posterior half of the white matter may be cut through at one point, and the anterior half at a point a little higher up, so that all the white fibres shall be divided transversely by the one cut or the other, without any interference with the material continuity of the cord, or damage to the grey matter.

When this has been done, irritation of those sensory nerves which are connected with parts below the section excites the sensation of pain as strongly as ever. Hence it follows, that the afferent impulses, which excite pain when they reach the brain, pass through, and are conveyed by, the grey matter. And it has been found, by experiment, that, so long as even a small portion of the grey matter remains entire, these afferent impulses are efficiently transmitted. Singularly enough, however, irritation of the grey matter itself is said not to cause pain.[1]

If one-half of the cord, say the right, be cut through, transversely, down to its very middle, so as to interrupt all continuity of both white and grey matter between its upper and lower parts, irritation of the skin of the right side of the body, below the line of section, will give rise to as much pain as before, but all voluntary power will be lost in those muscles of that side, which are supplied by nerves coming off from the lower portion of the cord. Hence it follows, that the channels by which the afferent impulses are conveyed must cross over from the side of the cord which they enter to the opposite side; while the efferent impulses, sent down from the brain, must travel along that side of the cord by which they pass out.

If this be true, it is clear that a longitudinal section, taken through the exact middle of the cord, will greatly impair, if not destroy, the sensibility of both sides of the body below the section, but will leave the muscles under the control of the will. And it is found experimentally that such is very largely the case.

15. Such are the functions of the spinal cord, taken as a whole. The *spinal* nerves are, as we have said, chiefly distributed to the muscles and to the skin. The nerves of the blood-vessels, for instance, the so-called *ɔ-motor* nerves (Lesson II. § 23), belong not to the spinal,

[1] This is why, in the experiment described at end of § 11., it is better for testing the presence of sensations to irritate afferent nerves connected with the cord rather than the cut end of the cord itself.

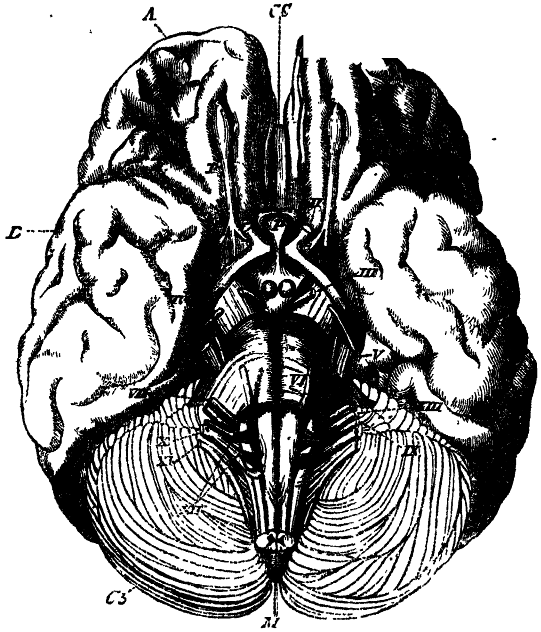

FIG. 83.—THE BASE OF THE BRAIN.

A. frontal lobe; *B*. temporal lobe of the cerebral hemisphere; *Cb*. cerebellum; *I*. the olfactory nerve; *II*. the optic nerve; *III*. *IV*. *VI*. the nerves of the muscles of the eye; *V*. the trigeminal nerve; *VII*. the portio dura; *VIII*. the auditory nerve; *IX*. the glossopharyngeal; *X*. the pneumogastric; *XI*. the spinal accessory; *XII*. the hypoglossal, or motor nerve of the tongue. The number *VI*. is placed upon the *pons Varolii*. The *crura cerebri* are the broad bundles of fibres which lie between the third and the fourth nerves on each side. The medulla oblongata (*M*) is seen to be really a continuation of the spinal cord; on the lower end are seen the two crescents of grey matter; the section, in fact, has been carried through the spinal cord, a little below the proper medulla oblongata. From the sides of the medulla oblongata are seen coming off the *X*., *XI*., and *XII*. nerves; and just where the medulla is covered, so to speak, by the transversely disposed *pons Varolii*, are seen coming off the *VII*. nerve, and more towards the middle line the *VI*. Out of the substance of the *pons* springs the *V*. nerve. In front of that is seen the well-defined anterior but to the *sympathetic* system. Along the spinal column, however, the spinal nerves give off branches which run in and join the sympathetic system. And it appears that many at least of the fibres which run along in the sympathetic nerves going to blood-vessels, do really spring from the spinal cord, finding their way into the sympathetic system through these communicating or commissural branches.

Experiments moreover go to show that the nervous influence which keeps up the tone of the blood-vessels, that is, which keeps them in the usual condition of moderate contraction, proceeds from the spinal cord.

The cord is, therefore, spoken of as containing *centres* for the vaso-motor nerves or, more shortly, *vaso-motor centres*.

For example, the muscular walls of the blood-vessels supplying the ear and the skin of the head generally, are made to contract, as has been already mentioned, by nervous fibres derived immediately from the sympathetic. These fibres, however, do not arise from the sympathetic ganglia, but simply pass through them on their way from the spinal cord, to the upper dorsal region of which they can all be traced. At least, this is the conclusion drawn from the facts, that irritation of this region of the cord produces the same effect as irritation of the vaso-motor nerves themselves, and that destruction of this part of the cord paralyses them.

Recent researches, however, have shown that the nervous influence does not originate here, but proceeds from higher up, from the medulla oblongata in fact, and simply passes down through this part of the spinal cord on its way to join the sympathetic ganglia.

16. The brain (Fig. 83) is a complex organ, consisting of several parts, the hindermost of which, termed *medulla*

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border of the *pons*; and coming forward in front of that line, between the *IV.* and *III.* nerves, on either side, are seen the crura cerebri. The two round bodies in the angle between the diverging crura are the so-called *corpora albicantia*, and in front of them is *P*, the pituitary body. This rests on the chiasma, or junction, of the optic nerves; the continuation of each nerve is seen sweeping round the crura cerebri on either side. Immediately in front, between the separated frontal lobes of the cerebral hemispheres, is seen the corpus callosum, *CC*. The fissure of Sylvius, about on a level with *I.* on the left and *II.* on the right side, marks the division between frontal and temporal lobes.

oblongata, passes insensibly into, and in its lower part has the same structure as, the spinal cord.

Above, however, it widens out, and the central canal, spreading with it, becomes a broad cavity, which (leaving certain anatomical minutiæ aside) may be said to be widely open above. This cavity is termed the *fourth ventricle*. Overhanging the fourth ventricle is a great laminated mass, the *cerebellum* (*Cb.* Figs. 83, 84, 85). On each side, this organ sends down several layers of transverse fibres, which sweep across the brain and meet in the middle line of its base, forming a kind of bridge (called *pons Varolii*, Fig. 83) in front of the medulla oblongata. The longitudinal nerve-fibres of the medulla oblongata pass forwards, among, and between these layers of transverse fibres, and become visible, in front of the pons, as two broad diverging bundles, called *crura cerebri* (Fig. 83). Above the crura cerebri lies a mass of nervous matter raised up into four hemispherical elevations, called *corpora quadrigemina* (C.Q. Fig. 85). Between these and the crura cerebri is a narrow passage, which leads from the fourth ventricle into what is termed the *third ventricle* of the brain. The third ventricle is a narrow cavity lodged between two great masses of nervous matter, called *optic thalami*, into which the crura cerebri pass. The roof of the third ventricle is merely membranous; and a peculiar body of unknown function, the *pineal body*, is connected with it. The floor of the third ventricle is produced into a sort of funnel, which ends in another anomalous organ, the *pituitary body* (*Pt.* Fig. 85; *P.* Fig. 83).

The third ventricle is closed, in front, by a thin layer of nervous matter; but, beyond this, on each side, there is an aperture in the boundary wall of the third ventricle which leads into a large cavity. The latter occupies the centre of the *cerebral hemisphere*, and is called the *lateral ventricle*. Each hemisphere is enlarged backwards, downwards, and forwards into as many *lobes*; and the lateral ventricle presents corresponding prolongations, or *cornua*.

The floor of the lateral ventricle is formed by a mass of nervous matter, called the *corpus striatum*, into which the fibres that have traversed the optic thalamus enter (Fig. 85, *C.S.*).

The hemispheres are so large that they overlap all the other parts of the brain, and, in the upper view, hide them.

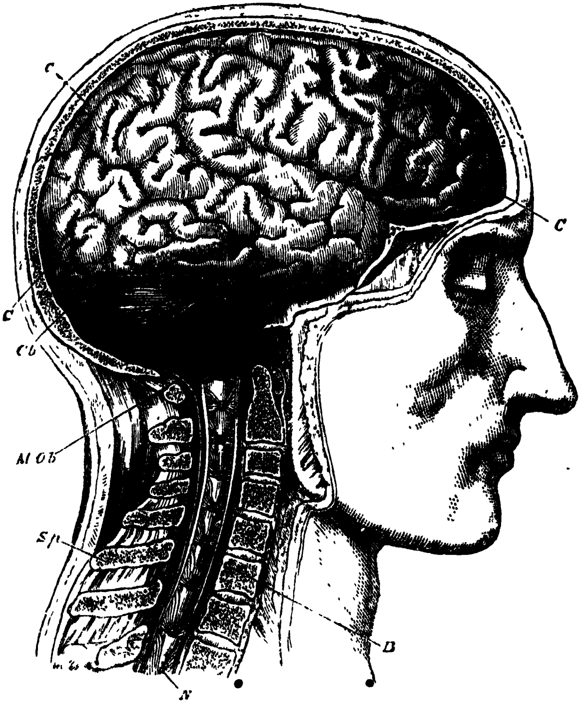

FIG. 84.

A side view of the brain and upper part of the spinal cord in place—the parts which cover the cerebro-spinal centres being removed. *C. C.* the convoluted surface of the right cerebral hemisphere; *Cb.* the cerebellum; *M. Ob.* the medulla oblongata; *B.* the bodies of the cervical vertebræ; *Sp.* their spines; *N.* the spinal cord with the spinal nerves.

Their applied faces are separated by a median fissure for the greater part of their extent; but, inferiorly, are joined by a thick mass of transverse fibres, the *corpus callosum* (Fig. 83, *CC*).

The outer surfaces of the hemispheres are marked out into *convolutions*, or *gyri*, by numerous deep *fissures* (or *sulci*), into which the pia mater enters. One large and deep fissure which separates the anterior from the middle division of the hemisphere is called the *fissure of Sylvius* (Fig. 83).

17. In the *medulla oblongata* the arrangement of the white and grey matter is substantially similar to that which obtains in the spinal cord; that is to say, the white matter is external and the grey internal. But in the *cerebellum* and *cerebral hemispheres*, the grey matter is external and the white internal; while, in the optic *thalami* and *corpora striata*, grey matter and white matter are variously intermixed.

18. Nerves are given off from the brain in pairs, which succeed one another from before backwards, to the number of twelve (Fig. 85).

The *first pair*, counting from before backwards, are the *olfactory nerves*, and the *second* are the *optic* nerves. The functions of these have already been described.

The *third pair* are called *motores oculi* (movers of the eye), because they are distributed to all the muscles of the eye except two.

The nerves of the *fourth pair* and of the *sixth pair* supply, each, one of the muscles of the eye, on each side; the fourth going to the superior oblique muscle, and the sixth to the external rectus. Thus the muscles of the eye, small and close together as they are, receive their nervous stimulus by three distinct nerves.

Each nerve of the *fifth pair* is very large. It has two roots, a motor and a sensory, and further resembles a spinal nerve in having a ganglion on its sensory root. It is the nerve which supplies the skin of the face and the muscles of the jaws, and, having three chief divisions, is often called *trigeminal*. One branch containing sensory fibres, supplies the front of the tongue and is often spoken of as the *gustatory*.

The *seventh pair* furnish with motor nerves the muscles of the face, and some other muscles, and are called *facial*.

The *eighth pair* are the *auditory* nerves. As the seventh and eighth pairs of nerves leave the cavity of the skull together, they are often, and especially by English writers on anatomy, reckoned as one, divided into *portio dura*, or hard part (the facial); and *portio mollis*, or soft part (the auditory) of the " seventh " pair.

The *ninth pair* in order, the *glossopharyngeal*, are mixed nerves; each being, partly, a nerve of taste, and supplying the back of the tongue, and, partly, a motor nerve for the pharyngeal muscles.

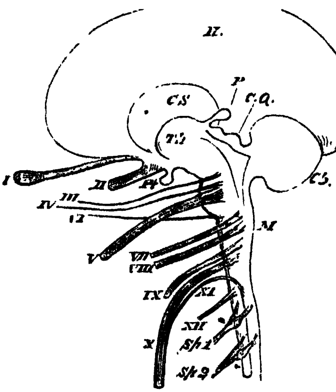

FIG. 85.—A DIAGRAM ILLUSTRATING THE ARRANGEMENT OF THE PARTS OF THE BRAIN AND THE ORIGIN OF THE NERVES.

H the cerebral hemispheres; *C.S.* corpus striatum; *Th.* optic thalamus; *P.* pineal body; *Pt.* pituitary body; *C.Q* corpora quadrigemina; *Cb.* cerebellum; *M.* medulla oblongata; *I.—XII.* the pairs of cerebral nerves; *Sp* 1, *Sp.* 2, the first and second pairs of spinal nerves.

The *tenth pair* is formed by the two *pneumogastric* nerves, often called the *par vagum*. These very important nerves, and the next pair, are the only cerebral nerves which are distributed to regions of the body remote from the head. The pneumogastric supplies the larynx, the lungs, the liver, and the stomach, and branches of it are connected with the heart.

The *eleventh pair* again, called *spinal accessory*, differ widely from all the rest, in arising from the sides of the spinal marrow, between the anterior and posterior roots of the dorsal nerves. They run up, gathering fibres as they go, to the medulla oblongata, and then leave the skull by the same aperture as the pneumogastric and glossopharyngeal. They are purely motor nerves, supplying certain muscles of the neck, while the pneumogastric is mainly sensory, or at least afferent. As, on each side, the glosso-pharyngeal, pneumogastric, and spinal accessory nerves leave the skull together, they are frequently reckoned as one pair, which is then counted as the *eighth*.

The last two nerves, by this method of counting, become the *ninth* pair, but they are really the *twelfth*. They are the motor nerves which supply the muscles of the tongue.

19. Of these nerves, the two foremost pair do not properly deserve that name, but are really processes of the brain. The olfactory pair are prolongations of the cerebral hemispheres ; the optic pair, of the walls of the third ventricle ; and it is worthy of remark, that it is only these two pair of what may be called *false nerves* which arise from any part of the brain but the medulla oblongata—all the other *true nerves* being indirectly, or directly, traceable to that part of the brain, while the olfactory and optic nerves are not so traceable.

20. As might be expected from this circumstance alone, the medulla oblongata is an extremely important part of the cerebro-spinal axis, injury to it giving rise to immediate evil consequences of the most serious kind.

Simple puncture of one side of the floor of the fourth ventricle produces for a while an increase of the quantity of sugar in the blood, beyond that which can be destroyed in the organism. The sugar passes off by the kidneys, and thus this slight injury to the medulla produces a temporary disorder closely resembling the disease called *diabetes*.

More extensive injury arrests the respiratory processes, the medulla oblongata being the nervous centre which gives rise to the contractions of the respiratory muscles and keeps the respiratory pump at work.

The motor nerves engaged in ordinary respiration are certain spinal nerves, viz. the intercostal nerves supplying the intercostal muscles and the *phrenic* nerve supplying the diaphragm. These motor nerves are undoubtedly brought into action by impulses proceeding at intervals from the medulla oblongata. But how these rhythmic impulses originate in the medulla oblongata is not very clear. There are reasons for thinking that the presence of venous blood in the lungs acts as a stimulus to the endings of the pneumogastric nerves, and sets going impulses which, travelling up along those nerves to the medulla oblongata, there produce respiratory movements by reflex action. But this is not all, for respiration, though profoundly modified, is not arrested by division or destruction of the pneumogastric nerves. Probably the medulla oblongata contains a nervous mechanism which acts as an independent centre in a manner somewhat similar to the ganglia of the heart; and so goes on of itself, though extremely sensitive to, and thus continually influenced by, the condition of the blood not only in the lungs but all over the body.

If the injuries to the medulla oblongata be of such a kind as to irritate the roots of the pneumogastric nerve violently, death supervenes by the stoppage of the heart's action in the manner already described (See Lesson II.)

21. The afferent impulses, which are transmitted through the cord to the brain and awake sensation there, cross, as we have seen, from one-half of the cord to the other, immediately after they enter it by the posterior roots of the spinal nerves; while the efferent, or volitional, impulses from the brain remain, throughout the cord, in that half of it from which they will eventually pass by the anterior roots. But at the lower and front part of the medulla oblongata, these also cross over; and the white fibres which convey them are seen passing obliquely from left to right and from right to left in what is called the *decussation of the anterior pyramids* (Fig. 83). Hence, any injury, at a point higher up than the decussation, to the nerve-fibres which convey motor impulses from the brain, paralyses the muscles of the body and limbs of the opposite side.

Division, therefore, of one of the *crura cerebri*, say the right, gives rise to paralysis of the left side of the body and limbs, and the animal operated upon falls over to the left side, because the limbs of that side are no longer able to support the weight.

But, as the motor nerves given off from the brain itself and arising from the medulla above the decussation of the pyramids do not cross over in this way, it follows, that disease or injury at a given point, on one side of the medulla oblongata, involving at once the course of the volitional motor channels to the spinal marrow, and the origins of the cranial motor nerves, will affect the same side of the head as that of the injury, but the opposite side of the body.

If the origin of the left facial nerve, for example, be injured, and the volitional motor fibres going to the cord destroyed, in the upper part of the medulla oblongata, the muscles of the face of the left side will be paralysed, and the features will be drawn over to the opposite side, the muscles of the right side having nothing to counteract their action. But it is the right arm, and the right leg and side of the body, which will be powerless.

22. The functions of most of the parts of the brain which lie in front of the medulla oblongata are, at present, very ill understood; but it is certain that extensive injury, or removal, of the cerebral hemispheres puts an end to intelligence and voluntary movement, and leaves the animal in the condition of a machine, working by the reflex action of the remainder of the cerebro-spinal axis.

We have seen that in the frog the movements of the body which the spinal cord alone, in the absence of the whole of the brain including the medulla oblongata, is capable of executing, are of themselves strikingly complex and varied. But none of these movements are voluntary or spontaneous; they never occur unless the animal be stimulated. Removal of the cerebral hemispheres is alone sufficient to deprive the frog of all spontaneous or voluntary movements; but the presence of the medulla oblongata and other parts of the brain (such as the corpora quadrigemina, or what corresponds to them in the frog, and the cerebellum) renders the animal master of movements of a far higher nature than when the spinal cord only is left. In the latter case the animal does not breathe when left to itself, lies flat on the table with its fore limbs beneath it in an unnatural position; when irritated kicks out its legs, and may be thrown into actual convulsions, but never jumps from place to place; when thrown into a basin of water falls to the bottom like a lump of lead, and when placed on its back will remain so, without making any effort to turn over. In the former case the animal sits on the table, resting on its front limbs, in the position natural to a frog; breathes quite naturally; when pricked behind jumps away, often getting over quite a considerable distance; when thrown into water begins at once to swim, and continues swimming until it finds some object on which it can rest; and when placed on its back immediately turns over and resumes its natural position. Not only so, but the following very striking experiment may be performed with it. Placed on a small board it remains perfectly motionless so long as the board is horizontal; if, however, the board be gradually tilted up so as to raise the animal's head, directly the board becomes inclined at such an angle as to throw the frog's centre of gravity too much backwards, the creature begins slowly to creep up the board, and, if the board continues to be inclined, will at last reach the edge, upon which when the board becomes vertical he will seat himself with apparent great content. Nevertheless, though his movements when they do occur are extremely well combined and apparently identical with those of a frog possessing the whole of his brain, he never moves spontaneously, and never stirs unless irritated.

There can be no doubt that the cerebral hemispheres are the seat of powers, essential to the production of those phenomena which we term intelligence and will; but there is no satisfactory proof, at present, that the manifestation of any particular kind of mental faculty is especially allotted to, or connected with, the activity of any particular region of the cerebral hemispheres.

23. Even while the cerebral hemispheres are entire, and in full possession of their powers, the brain gives rise to actions which are as completely reflex as those of the spinal cord.

When the eyelids wink at a flash of light, or a threatened blow, a reflex action takes place, in which the afferent nerves are the optic, the efferent the facial. When a bad smell causes a grimace, there is a reflex action through the same motor nerve, while the olfactory nerves constitute the afferent channels. In these cases, therefore, reflex action must be effected through the brain, all the nerves involved being cerebral.

When the whole body starts at a loud noise, the afferent auditory nerve gives rise to an impulse which passes to the medulla oblongata, and thence affects the great majority of the motor nerves of the body.

24. It may be said that these are mere mechanical actions, and have nothing to do with the operations which we associate with intelligence. But let us consider what takes place in such an act as reading aloud. In this case, the whole attention of the mind is, or ought to be, bent upon the subject-matter of the book; while a multitude of most delicate muscular actions are going on, of which the reader is not in the slightest degree aware. Thus the book is held in the hand, at the right distance from the eyes; the eyes are moved from side to side, over the lines and up and down the pages. Further, the most delicately adjusted and rapid movements of the muscles of the lips, tongue, and throat, of the laryngeal and respiratory muscles, are involved in the production of speech. Perhaps the reader is standing up and accompanying the lecture with appropriate gestures. And yet every one of these muscular acts may be performed with utter unconsciousness, on his part, of anything but the sense of the words in the book. In other words, they are reflex acts.

25. The reflex actions proper to the spinal cord itself are *natural*, and are involved in the structure of the cord and the properties of its constituents. By the help of the brain we may acquire an infinity of *artificial* reflex actions, that is to say, an action may require all our attention and all our volition for its first, or second, or third performance, but by frequent repetition it becomes, in a manner, part of our organization, and is performed without volition, or even consciousness.

As everyone knows, it takes a soldier a long time to learn his drill—for instance, to put himself into the attitude of "attention" at the instant the word of command is heard. But, after a time, the sound of the word gives rise to the act, whether the soldier be thinking of it, or not. There is a story, which is credible enough, though it may not be true, of a practical joker, who, seeing a discharged veteran carrying home his dinner, suddenly called out "Attention!" whereupon the man instantly brought his hands down, and lost his mutton and potatoes in the gutter. The drill had been thorough, and its effects had become embodied in the man's nervous structure.

The possibility of all education (of which military drill is only one particular form) is based upon the existence of this power which the nervous system possesses, of organizing conscious actions into more or less unconscious, or reflex, operations. It may be laid down as a rule, that if any two mental states be called up together, or in succession, with due frequency and vividness, the subsequent production of the one of them will suffice to call up the other, and that whether we desire it or not.

The object of intellectual education is to create such indissoluble associations of our ideas of things, in the order and relation in which they occur in nature; that of a moral education is to unite as fixedly, the ideas of evil deeds with those of pain and degradation, and of good actions with those of pleasure and nobleness.

26. The *sympathetic system* consists chiefly of a double chain of ganglia, lying at the sides and in front of the spinal column, and connected with one another, and with the spinal nerves, by commissural cords. From these ganglia, nerves are given off which for the most part follow the distribution of the vessels, but which, in the thorax and abdomen, form great networks, or *plexuses*, upon the heart and about the stomach. It is probable that a great proportion of the fibres of the sympathetic system is derived from the spinal cord; but others also, in all probability, originate in the ganglia of the sympathetic itself. The sympathetic nerves influence the muscles of the vessels generally, and those of the heart, of the intestines, and of some other viscera: and it is probable that their ganglia are centres of reflex action to afferent nerves from these organs. But many of the motor nerves of the vessels are, as we have seen, under the influence of particular parts of the spinal cord, though they pass through sympathetic ganglia.

LESSON XII.

HISTOLOGY; OR, THE MINUTE STRUCTURE OF THE TISSUES.

1. THE various organs and parts of the body, the working of which has now been described, are not merely separable by the eye and the knife of the anatomist into membranes, nerves, muscles, bones, cartilages, and so forth; but each of them is, by the help of the microscope, susceptible of a finer analysis, into certain minute constituents which, for the present, may be considered the ultimate structural elements of the body.

2. There is a time when the human body, or rather its rudiment, is of one structure throughout, consisting of a more or less transparent *matrix*, very similar in nature to the substance of which the white blood-corpuscles are composed, and often called *protoplasm*, through which are scattered minute rounded particles of a different optical aspect. These particles are called *nuclei;* and as the matrix, or matter in which these nuclei are imbedded, readily breaks up into spheroidal masses, one for each nucleus, and these investing masses easily take on the form of vesicles or *cells*, this primitive structure is called *cellular*, and each cell is said to be *nucleated.*

The material of the body when in this stage of growth is often spoken of as *indifferent tissue.* A very fair idea of its nature may be formed by supposing a multitude of white blood-corpuscles to be collected together into a soft but yet semi-solid mass.

In the present use of the term any distinct mass of protoplasm or living material may be called a *cell.* In the vast majority of cases, however, the cell contains a *nucleus*, distinguished as has just been said from the *cell-substance* in which it lies. Very frequently, but by no means always, the outer layer of the cell-substance is hardened into a distinct casing or envelope, the *cell-wall*, the cell then becoming an undeniable vesicle, and the cell-substance being often spoken of as the *cell contents*. The cell-substance may remain as soft semi-solid protoplasm, or may be hardened in various ways, or may be wholly or partially liquefied; in the latter case a cell-wall is naturally always present.

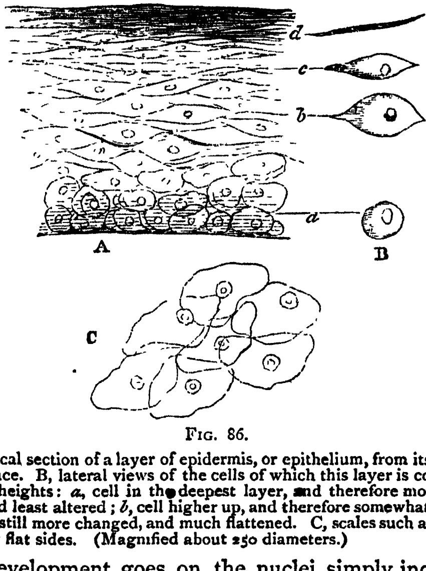

FIG. 86.

A, vertical section of a layer of epidermis, or epithelium, from its free to its deep surface. B, lateral views of the cells of which this layer is composed at different heights: *a*, cell in the deepest layer, and therefore most recently formed and least altered; *b*, cell higher up, and therefore somewhat changed; *c*, *d*, cells still more changed, and much flattened. C, scales such as *d* viewed from their flat sides. (Magnified about 250 diameters.)

As development goes on, the nuclei simply increase in number by division and subdivision, without undergoing any marked change;[1] but the substance in which they are

[1] Each nucleus divides into two, and each half soon grows up into the size of the parent nucleus. While this is going on the matrix round the nuclei also divides, each new nucleus having a quantity of matrix allotted to it, so as to form a new cell exactly like the old one, from which it sprang.

imbedded, becomes very variously modified, both chemically and structurally, and gives rise to those peculiarities by which completely formed tissues are distinguished from one another.

3. In the adult body the simplest forms of tissue, *i.e.* those in which the matrix has been least changed, are perhaps the various kinds of *epithelium* (including the *epidermis*).

These are distinctly *cellular* in nature, that is, the portion of the matrix belonging to each nucleus can, with a little pains, be recognized as distinct from the portions belonging to the other nuclei. In fact they differ from white blood corpuscles chiefly in two points: firstly, the matrix of each cell becomes more or less chemically changed so as to lose its soft protoplasmic nature (and at the same time its power of executing amœboid movements); and, secondly, takes on a rigid definite form, which may or may not be globular. These epithelial tissues are constantly growing in their deepest parts, and are, as constantly, being shed at their surfaces.

The deep part consists of a layer of such globular, nucleated cells as have been mentioned, the number of which is constantly increasing by the spontaneous division of the nuclei and cells. The increase in number thus effected causes a thrusting of the excess of cell population towards the surface; on their way to which they become flattened, and their walls acquire a horny texture. Arrived at the surface, they are mere dead horny scales, and are thrown off (Fig. 86).

Epithelium of the kind just described is called *squamous*. It is found in the mouth, and its scales may always be obtained in abundance by scraping the inside of the lip.

Epidermis consists of exactly similar cells, except that the conversion of the topmost cells into horny scales is still more complete. The nucleus, too, is eventually lost. The deep layers of epidermis, consisting of softer cells not yet flattened or made horny, often form quite a distinct part, and these are often spoken of as the *rete mucosum*. (See Fig. 32, *b*; Fig. 88, C, *d*.)

In other parts of the alimentary tract, as in the intestines, the full-grown epithelial cells are placed side by side with one another, and perpendicular to the surface of the membrane. Such epithelium is called *cylindrical* (Fig. 46, *b*, *b'*), or *columnar*.

In some places, such as in the gastric glands, in some parts of the kidney, in the ureters and elsewhere, the epithelial cells remain *globular* or *spheroidal*.

Squamous epithelium generally consists of many layers of cells, one over the other; in other forms of epithelium there are few, in some cases apparently only one layer.

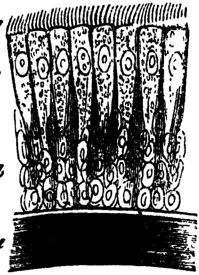

FIG. 87.—CILIATED EPITHELIUM.

a, the submucous vascular tissue; *b*, the deep layer of young epithelium cells; *c*, the cylindrical full-grown cells, with (*d*) the cilia. (Magnified about 350 diameters.)

Ciliated epithelium is usually of the cylindrical kind, and differs from other epithelium only in the circumstance that one or more incessantly vibrating filaments are developed from the free surface of each cell. (See Lesson VII. § 3.)

4. In certain regions of the integument, the epidermis becomes metamorphosed into *nails* and *hairs*.

Underneath each nail the deep or *dermic* layer of the integument is peculiarly modified to form the *bed of the nail*. It is very vascular, and raised up into numerous parallel ridges, like elongated papillæ (Fig. 88, B, C). The surfaces of all these are covered with growing epidermic cells, which, as they flatten and become converted into horn, coalesce into a solid continuous plate, the nail. At the hinder part of the bed of the nail, the integument forms a deep fold, from the bottom of which, in like manner, new epidermic cells are added to the base of the nail, which is thus constrained to move forward.

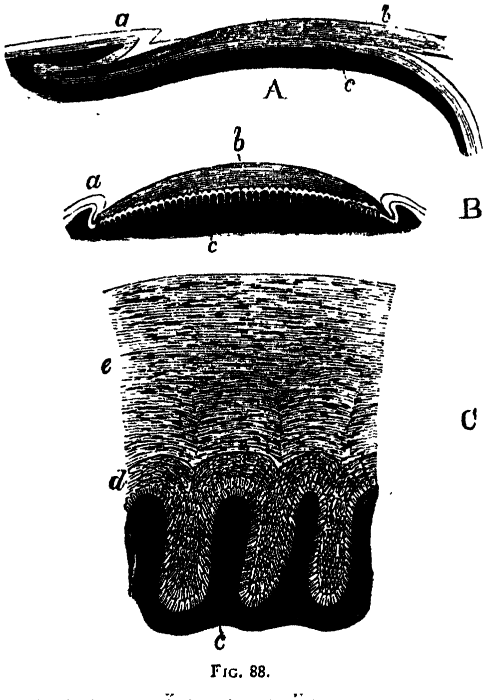

FIG. 88.

A, a longitudinal and vertical section of a nail: *a*, the fold at the base of the nail; *b*, the nail; *c*, the bed of the nail. The figure B is a transverse section of the same—*a*, a small lateral fold of the integument; *b*, nail; *c*, bed of the nail, with its ridges. The figure C is a highly-magnified view of a part of the foregoing—*c*, the ridges; *d*, the deep layers of epidermis; *e*, the horny scales coalesced into nail substance. (Figs. A and B magnified about 4 diameters; Fig. C magnified about 200 diameters.)

The nail, thus constantly receiving additions from below and from behind, slides forwards over its bed, and projects beyond the end of the finger, where it is worn away, or cut off.

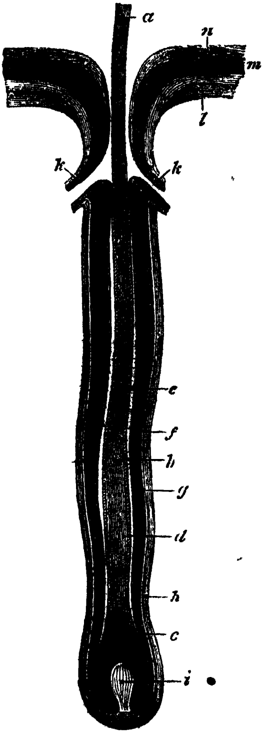

FIG. 89.—A HAIR IN ITS HAIR-SAC.

a, shaft of hair above the skin; *b*, cortical substance of the shaft, the medulla not being visible; *c*, newest portion of hair growing on the papilla (*i*); *d*, cuticle of hair; *e*, cavity of hair-sac; *f*, epidermis (and root-sheaths) of the hair-sac corresponding to that of the integument (*m*); *g*, division between dermis and epidermis; *h*, dermis of hair-sac corresponding to dermis of integument (*l*); *k*, mouths of sebaceous glands; *n*, horny epidermis of integument.

5. A *hair*, like a nail, is composed of coalesced horny cells; but instead of being only partially sunk in a fold of the integument, it is at first wholly enclosed in a kind of bag, the *hair-sac*, from the bottom of which a papilla (Fig. 89, *i*), which answers to a single ridge of the nail, arises. The hair is developed by the conversion into horn, and coalescence into a *shaft*, of the superficial epidermic cells coating the papilla. These coalesced and cornified cells being continually replaced by new growths from below, which undergo the same metamorphosis, the shaft of the hair is thrust out until it attains the full length natural to it. Its base then ceases to grow, and the old papilla and sac die away, but not before a new sac and papilla have been formed by budding from the sides of the old one. These

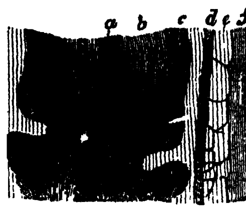

FIG. 90.

Part of the shaft of a hair enclosed within its root-sheaths and treated with caustic soda, which has caused the shaft to become distorted—*a*, medulla; *b*, cortical substance; *c*, cuticle of the shaft; from *d* to *f*, the root-sheaths, in section. (Magnified about 200 diameters.)

give rise to a new hair. The shaft of a hair of the head consists of a central pith, or *medullary* matter, of a loose and open texture, which sometimes contains air; of a *cortical* substance surrounding this, made up of coalesced elongated horny cells; and of an outer *cuticle*, composed of flat horny plates, arranged transversely round the shaft, so as to overlap one another by their outer edges, like closely-packed tiles. The superficial epidermic cells of the hair-sac also coalesce by their edges, and become converted into *root-sheaths*, which embrace the root of the hair, and usually come away with it, when it is plucked out.

Two sebaceous glands commonly open into the hair-sac near its opening, and supply the hair with a kind of natural pomatum; and delicate unstriped muscular fibres are so connected with the hair-sac as to cause it to pass from its ordinary oblique position into one perpendicular to the skin, when they contract (Fig. 31, B).

They are made to contract by the influence of cold and terror, which thus give rise to "horripilation" or "goose-skin," and the "standing of the hair on end."

6. The *crystalline lens* is composed of fibres, which are the modified cells of the epidermis of that inverted portion of the integument, from which the whole anterior chamber of the eye and the lens are primitively formed.

7. *Cartilage.*—While *epithelium* and *epidermis* are found only on the free surfaces of the organs, gristle, or cartilage, is a deep-seated structure (see Lesson VII.). Like them it is essentially cellular in nature, but differs from them widely in appearance on account of the development of a large quantity of the so-called *intercellular* substance. That is to say, the several cells do not lie closely packed together and touching each other, but are separated from each other by a quantity of material of a different nature from themselves. Just as in indifferent tissue each nucleus is imbedded in a matrix of protoplasm, so in cartilage, each cell, i.e. *each nucleus with its allotted quantity of protoplasm*, is imbedded in a matrix of *intercellular substance.*

Inasmuch as during the growth of cartilage the cells remain soft and protoplasmic, while the intercellular substance is converted into a solid semi-transparent hard matter, it comes to pass that the soft nucleated cells appear to lie in cavities in the harder intercellular substance or matrix.

In epithelium it is only the deepest lying cells which undergo division, and so carry on the growth of the tissue. In cartilage, cell-division is much more general; a cell lying in its cavity divides first into two, then into four, and so on, the intercellular substance meanwhile growing in between the young cells and thrusting them apart. It is by means of the repeated divisions of the cells in this way, and subsequent development of intercellular matrix in between the young cells, that cartilage grows. Con-

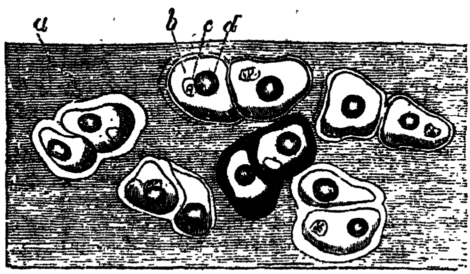

FIG. 91.

A section of cartilage, showing the matrix (*a*), with the groups of cells (*b*) containing nuclei (*c*) and fat globules (*d*). (Magnified about 350 diameters.)

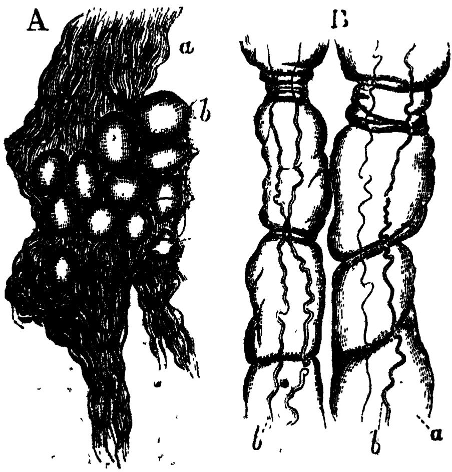

FIG. 92.—CONNECTIVE TISSUE.

A, unchanged: *a*, connective tissue; *b*, fat cells. B, acted upon by acetic acid, and showing (*a*) the swollen and transparent gelatine-yielding matter, and (*b*) the elastic fibres. (Magnified about 300 diameters.)

sequently, the cells are frequently seen arranged in groups with more or less matrix between, according to their age.

The cells remain during life soft and protoplasmic, but often contain a number of large oil globules. It is to the hard matrix which yields, on boiling, the substance *chondrine*, that the physical features of cartilage, its solidity and elasticity, are due. Cartilage contains no vessels, or only such as extend a little way into it from adjacent parts.

8. *Connective tissue* (also called *fibrous*, or *areolar*, or sometimes *cellular* tissue), the most extensively diffused

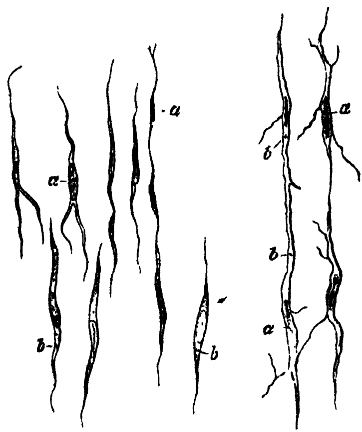

FIG. 93.

Connective tissue corpuscles (*a*, nucleus, *b*, cell substances), of various shapes, those to the right hand branching, and the branches joining.

of all in the body, at first sight seems to differ wholly from the preceding tissues. Viewed under the microscope, it is seen to consist of bands or cords, or sheets of whitish substance, having a wavy, fibrous appearance, and capable of being split up mechanically into innumerable fine filaments or *fibrillæ*. The addition of acetic acid causes it to swell up and become transparent, entirely losing its fibrous aspect; and, further, reveals the presence of two elements which acetic acid does not affect, viz. nuclei and certain sharply defined fibres of different degrees of fineness, which are called elastic fibres. If the acid be now very carefully neutralized by a weak alkali, the connective tissue assumes its former partial opacity and fibrillated aspect. The nuclei thus brought to light by acetic acid are worthy of attention because careful examination shows that they belong to certain cells which exist in all connective tissue in greater or less number, though never in abundance. These cells, generally called *connective tissue corpuscles*, consist of a nucleus and protoplasmic cell-substance, and in fact are not unlike cartilage cells except that they are very often very irregular in form, and as a general rule very

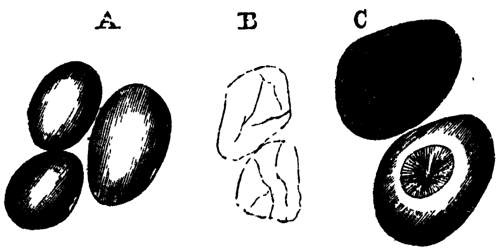

FIG. 94.—FAT CELLS.

A, having their natural aspect. B, collapsed, the fat being exhausted. C, with fatty crystals. The nuclei are not seen in this case. (Magnified about 350 diameters.)

small. Indeed we may very justly compare connective tissue with cartilage, much as they seem to differ in general appearance. The connective tissue corpuscles correspond to the cartilage-cells; both are imbedded in a matrix which, in the case of cartilage, remains structureless, but becomes solid and dense, while it, in the case of connective tissue, is altered or metamorphosed, as it is said, into a substance composed of excessively fine filaments, mingled with which are elastic fibres.

The fine fibrillated substance is not very elastic, and when boiled swells up and yields *gelatine*. The elastic fibres do not yield gelatine, and, as their name indicates, are highly elastic. The proportion of elastic fibre to the gelatine-yielding constituents of connective tissue varies in different parts of the body. Sometimes it is so great that elasticity is the most marked character of the resulting tissue.

Ligaments and *tendons* are simply cords, or bands, while *fasciæ* are sheets, of very dense connective tissue. In some parts of the body, the connective tissue is more or less mixed with, or passes into, cartilage, and such tissues are called *fibro-cartilages* (see Lesson VII.), or, in other words, the matrix of the cartilage becomes more or less fibrillated, thus indicating the analogies of the two tissues.

The name *cellular* applied to this tissue is apt to lead to confusion. When first used it referred to the cavities left in the meshes of the network of fibres ; it has nothing whatever to do with *cells* technically so called.

9. *Fat cells* are scattered through the connective tissue, in which they sometimes accumulate in great quantities.

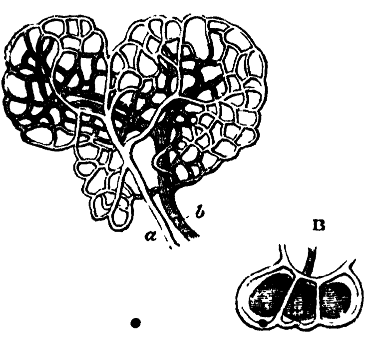

FIG. 95.—CAPILLARIES OF FAT.

A, network round a group of fat cells. *a*, the artery ; *b*, the vein. B, the loops of capillaries round three individual fat cells.

They are spheroidal sacs, composed of a delicate membrane, on one side of which is a nucleus, and distended by fatty matter, from which the more solid fats sometimes crystallize out after death. Ether will dissolve out the fat, and leave the sacs empty and collapsed (B, Fig. 94).

They are, in fact, cells with a distinct cell wall, the cell contents, or cell substance, of which have been wholly, or all but wholly, converted into fat.

Considerable aggregations of fat cells are constantly present in some parts of the body, as in the orbit, and about the kidneys and heart; but elsewhere their presence, in any quantity, depends very much on the state of nutrition. Indeed, they may be regarded simply as a reserve, formed from the nutriment which has been taken into the body in excess of its average consumption.

10. *Pigment cells* are either epidermic, or epithelial, cells, in which coloured granules are deposited; or they are connective tissue corpuscles of the deeper parts of the body, in which a like deposit occurs. Thus the colour of the choroid arises partly from the presence of a layer of epithelial cells (see Fig. 74), placed close to the retina, containing pigment granules, and partly from a large number of irregularly-shaped, connective tissue corpuscles crammed with pigment, which belong to the deeper connective tissue layer of the choroid. The pigment cells of the frog's web are, for the most part, connective tissue corpuscles, containing colouring matter.

11. *Bone* is essentially composed of an animal basis impregnated with salts of carbonate and phosphate of lime, through the substance of which are scattered minute cavities—the *lacunæ*, which send out multitudinous ramifications, called *canaliculi*. The canaliculi of different lacunæ unite together, and thus establish a communication between the different lacunæ. If the earthy matter be extracted by dilute acids, a nucleus may be found in each lacuna; and if young, fresh bone be carefully examined, a certain amount of cell substance will be found filling up the lacuna round the nucleus; and, not unfrequently, the intermediate substance appears minutely fibrillated. In fact bone, if we lay on one side the earthy matters, presents very close analogies in its fundamental structure with both cartilage and connective tissue. The corpuscles lodged in the lacunæ correspond to the corpuscles of connective tissue and to the cells of cartilage, while the matrix in which the earthy matter is deposited corresponds to the matrix of cartilage, and to the fibrillated material of connective tissue. (These three tissues

indeed are often classed together as "the connective tissue group.") In a dry bone the lacunæ are usually filled with air. When a thin section of such a bone is, as usual, covered with water and a thin glass, and placed under the microscope, the air in the lacunæ refracts the light which passes through them in such a manner as to prevent its reaching the eye, and they appear black. Hence the lacunæ were, at one time, supposed to be solid bodies, containing the lime salts of the bone, and were called *bone corpuscles* (Fig. 96, C).

All bones, except the smallest, are traversed by small canals, converted by side branches into a network, and containing vessels supported by more or less connective tissue and fatty matter. These are called *Haversian canals* (Fig. 96, A, B). They always open, in the long run, upon the surface of the bone, and there the vessels which they contain become connected with those of a sheet of tough connective tissue, which invests the bone, and is called *periosteum.*

In many long bones, such as the thigh bone, the centre of the bone is hollowed out into a considerable cavity, containing great quantities of fat, supported by a delicate connective tissue, rich in blood-vessels, and called the *marrow*, or *medulla.* The inner ends of the Haversian canals communicate with this cavity, and their vessels are continuous with those of the marrow.

When a section of a bone containing Haversian canals is made, it is found that the lacunæ are dispersed in concentric zones around each Haversian canal, so that the substance of the bone appears laminated; and, where a medullary cavity exists, more or fewer of these concentric lamellæ of osseous substance surround it.

This structure arises from the mode of growth of bones. In the place of every bone there exists, at first, either cartilage, or connective tissue hardly altered from its primitive condition of indifferent tissue. When *ossification* commences, the vessels from the adjacent parts extend into the ossifying tissue, and the calcareous salts are thrown down around them. These calcareous salts invade all the ossifying tissue, except the immediate neighbourhood of its nuclei, around each of which a space, the *lacuna*, is left. The lacunæ and canaliculi are thus, substantially,

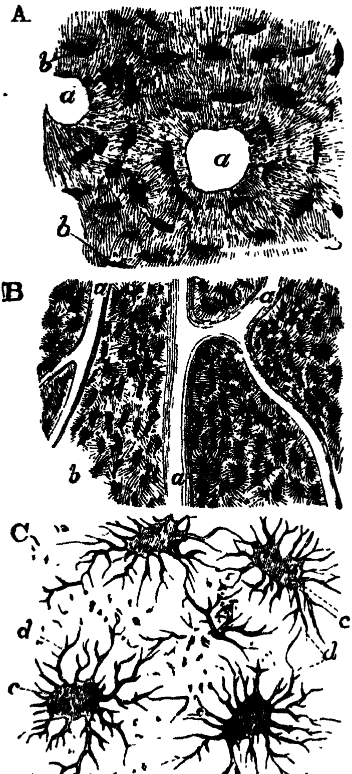

FIG. 96.

A. A transverse section of bone in the neighbourhood of two Haversi canals, *a a*; *b*, lacunæ. (Magnified about 250 diameters.)
B. A longitudinal section of bone with Haversian canals, *a a*, and lacun *b*. (Magnified about 100 diameters.)
C. Lacunæ, *c*, and canaliculi, *d*. (Magnified about 600 diameters.)

gaps left in the ossific matter around each nucleus, whence it is that nuclei are found in the lacunæ of fully-formed bone.[1]

Bone, once formed, does not remain during life, but is constantly disappearing and being replaced in all its parts. Nevertheless, the growth of a bone, as a general rule, takes place only by addition to its free ends and surfaces. Thus the bones of the skull grow in thickness, on their surfaces, and in breadth at their edges, where they unite by *sutures;* and when the sutures are once closed, they cease to increase in breadth.

The bones of the limbs, which are preceded by complete small cartilaginous models, grow in two ways. The cartilage of which they consist grows and enlarges at its extremities until the bones have attained their full size, and remains to the end of life as *articular cartilage.* But in the middle, or shaft, of the bone, the cartilage does not grow with the increase in the dimensions of the bone, but the small primary bone which results from the ossification of the cartilaginous model becomes coated by successive layers of bone, produced by the ossification of that part of the periosteum which lies nearest to it, and which really consists of indifferent tissue, that is of nuclei imbedded in a matrix. The shaft of the bone thus formed is gradually hollowed out in its interior to form the medullary cavity, so that, at last, the primitive cartilage totally disappears.

When ossification sets in, the salts of lime are not diffused uniformly through the whole mass of the pre-existing cartilage, or connective tissue, but begin to be deposited at particular points called *centres of ossification*, and spread from them through the bone. Thus, a long bone has usually, at fewest, three centres of ossification—one for the middle or shaft, and one for each end ; and it is only in adult life that the three bony masses thus formed unite into one bone.

12. *Teeth* partake more of the nature of bones than of any other organ, and are, in fact, partially composed of true bony matter, here called *cement;* but their chief constituents are two other tissues, called *dentine* and *enamel.*

Each tooth presents a crown, which is exposed to wear,

[1] For the sake of simplicity I purposely omit all mention of the complex secondary processes in the ossification of cartilage.

and one or more fangs, which are buried in a socket furnished by the jawbone and the dense mucous membrane of the mouth, which constitutes the *gum*. The line of junction between the crown and the fang is the *neck* of the tooth. In the interior of the tooth is a cavity, which communicates with the exterior by canals, which traverse the fangs and open at their points. This cavity is the *pulp cavity*. It is occupied by a highly vascular and nervous tissue, the *dental pulp*, which is continuous below, through the openings of the fangs, with the mucous membrane of the gum.

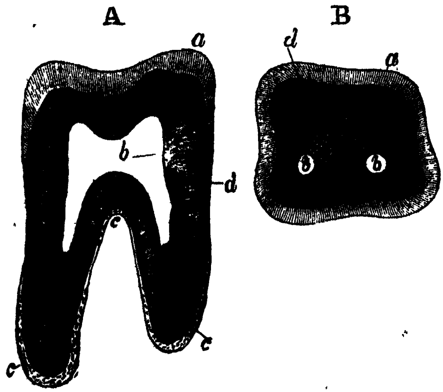

FIG. 97.

A, vertical, B, horizontal section of a tooth.—*a*, enamel of the crown; *b*, pulp cavity; *c*, cement of the fangs; *d*, dentine. (Magnified about three diameters.)

The chief constituent of a tooth is *dentine*—a dense calcified substance containing less animal matter than bone, and further differing from it in possessing no lacunæ, or proper canaliculi. Instead of these it presents innumerable, minute, parallel, wavy tubules, which give off lateral branches. The wider ends of these tubules open into the pulp cavity, while the narrower ultimate terminations ramify at the surface of the dentine, and may even extend into the enamel or cement (Fig. 98, C).

The *enamel* consists of very small six-sided fibres, set closely, side by side, nearly at right angles to the surface of the dentine, and covering the crown of the tooth as far

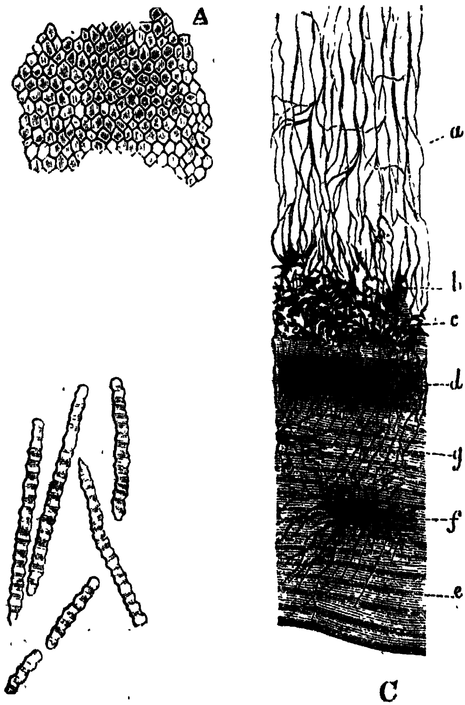

FIG. 98.

A. Enamel fibres viewed in transverse section.
B. Enamel fibres separated and viewed laterally.
C. A section of a tooth at the junction of the dentine
tubules continued from them f, g.
(Magnified about 400 diameters.)

as the neck, towards which the enamel thins off and joins the cement (Fig. 98, A, B).

Enamel is the hardest tissue of the body, and contains not more than 2 per cent. of animal matter.

The *cement* coats the fangs, and has the structure of true bone; but as it exists only in a thin layer, it is devoid of Haversian canals (Fig. 98, C).

13. The development of the teeth commences long before birth. A groove appears in the gum of each side of each jaw; and, at the bottom of this groove of the gum, five vascular and nervous *papillæ* arise, making twenty in all. The walls of the groove grow together, between and over each of the papillæ, and thus these become enclosed in what are called the *dental sacs*.

Each papilla gradually assumes the form of the future tooth. Next, a deposit of calcific matter takes place at the summit of the papillæ, and extends thence downwards, towards its base. In the crown the deposit takes on the form of enamel and dentine; in the root, of dentine and cement. As it increases it encroaches upon the substance of the papilla, which remains as the tooth pulp. The fully formed teeth press upon the upper walls of the sacs in which they are enclosed, and, causing a more or less complete absorption of these walls, force their way through. The teeth are then, as it is called, *cut*.

The cutting of this first set of teeth, called *deciduous*, or *milk teeth*, commences at about six months, and ends with the second year. They are altogether twenty in number—eight being cutting teeth, or *incisors;* four, eye teeth, or *canines;* and eight, grinders, or *molars*.

Each dental sac of the milk teeth, as it is formed, gives off a little prolongation, which becomes lodged in the jaw, enlarges, and develops a papilla from which a new tooth is formed. As the latter increases in size, it presses upon the root of the milk tooth which preceded it, and thereby causes the absorption of the root and the final falling out, or shedding, of the milk tooth, whose place it takes. Thus every milk tooth is replaced by a tooth of what is termed the *permanent dentition*. The permanent *incisors* and *canines* are larger than the milk teeth of the same name, but otherwise differ little from them. The permanent *molars*, which replace the milk molars, are small, and their crowns have only two points, whence they are called *bicuspid*. They never have more than two fangs.

14. We have thus accounted for twenty of the teeth of the adult. But there are thirty-two teeth in the complete adult dentition, twelve grinders being added to the twenty teeth which correspond with, and replace, those of the milk set. When the fifth, or hindermost, dental sac of the milk teeth is formed, the part of the groove which lies behind it also becomes covered over, extends into the back part of the jaw, and becomes divided into three dental sacs. In these, papillæ are formed and give rise to the great permanent back grinders, or *molars*, which have four, or five, points upon their square crowns, and, in the upper jaw, commonly possess three fangs.

The first of these teeth, the anterior molar of each side, is the earliest cut of all the permanent set, and appears at six years of age. The last, or hindermost, molar is the last of all to be cut, usually not appearing till twenty-one or twenty-two years of age. Hence it goes by the name of the "wisdom tooth."

15. *Muscle* is of two kinds, *striated* or *striped*, and *smooth*, *plain*, or *unstriated*. *Striated muscle*, of which all the ordinary muscles of the trunk and limbs consist, is composed of a number of long parallel cylindrical fibres, called *elementary* or *ultimate muscular fibres*, which are bound together by connective tissue into small bundles. These small bundles again are united into larger bundles, and these into one aggregate, by connective tissue, which supports the vessels and nerves of the muscle, and usually forms at one or both ends of the muscle a tendon (see Lesson VII.), and sometimes gives rise to a dense sheath or *fascia* on its exterior.

Into the *ultimate muscular fibre* neither vessels, nor connective tissue, enter. Each fibre is, however, enveloped in a sheath formed by a tough, elastic, transparent structureless membrane, the *sarcolemma* (Fig. 99, D, *b*).

The sarcolemma is not contractile, but its elasticity allows it to adjust itself, pretty accurately, to the changes of form of the contractile substance which it contains.

This contractile substance, when uninjured, presents a very strongly-marked transverse striation, its substance appearing to be composed of extremely minute disks of a partially opaque substance, imbedded at regular intervals in a more transparent matter. A more faint striation, separating these disks into longitudinal series, is also observable. When the sarcolemma is torn, the contractile substance of dead muscle may, under some circumstances, be either divided into disks (Fig. 99, C), but it may be

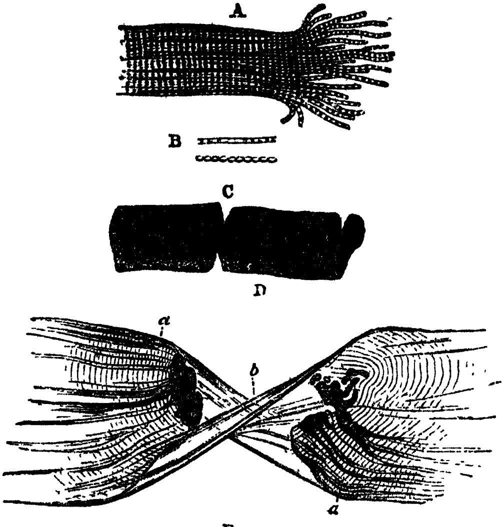

FIG. 99.

A, a muscular fibre, devoid of sarcolemma, and breaking up at one end into its *fibrillæ*; B, separate fibrillæ; C, a muscular fibre breaking up into disks; D, a muscular fibre, the contractile substance of which (*a*) is torn, while the sarcolemma (*b*) has not given way. (Magnified about 350 diameters.)

more readily broken up into minute *fibrillæ* (Fig. 99, A, B), each of which, viewed by transmitted light, presents dark and light parts, which alternate at intervals corresponding with the distances of the transverse striæ in the entire fibre. Nuclei are observed here and there in the contractile substance within the sarcolemma.

In the heart, the muscular fibres are striated, and have the same essential structure as that just described, but they possess no sarcolemma.

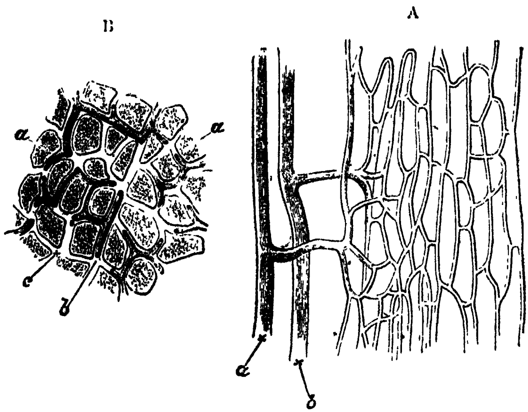

FIG. 100.—CAPILLARIES OF STRIATED MUSCLE.

A. Seen longitudinally. The width of the meshes corresponds to that of an ultimate fibre. *a*, small artery; *b*, small vein.
B. Transverse section of striated muscle. *a*, the cut ends of the ultimate fibres; *b*, capillaries filled with injection material; *c*, parts where the capillaries are absent or not filled.

Smooth muscle consists of elongated band-like fibres, devoid of striation, each of which bears a rod-like nucleus. These fibres do not break up into fibrillæ, and have no sarcolemma (Fig. 101).

16. *Nervous tissue* contains two elements, *nerve-fibres* and *ganglionic corpuscles*. Ordinary nerve-fibres, such as constitute the essential constituents of all the cerebro-spinal nerves except the olfactory, are during life, or when perfectly fresh, subcylindrical filaments of a clear, somewhat oily, look. But shortly after death, a sort of coagulation sets up within the fibre, and it is then found to be composed of a very delicate, structureless, outer membrane (which is not to be confounded with the *neuri-*

lemma), forming a tube, through the centre of which runs the *axis cylinder*, which is probably composed of an aggregation of very fine filaments. Between the axis cylinder and the tube is a fluid, rich in fatty matters, from which a solid strongly refracting substance has been thrown down and lines the tube.

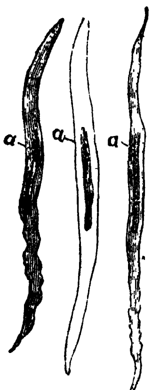

FIG. 101.

Smooth or non-striated muscular fibres from the middle coat of a small artery; the middle one having been treated with acetic acid, shows more distinctly the nucleus *a*. (Magnified about 350 diameters.)

Such is the structure of all the larger nerve fibres, which lie, side by side, in the trunks of the nerves, bound together by delicate connective tissue, and enclosed in a sheath of the same substance, called the *neurilemma*. In the trunks of the nerves, the fibres remain perfectly distinct from one another, and rarely, if ever, divide. But when the nerves enter the central organs, and when they approach their peripheral terminations, the nerve-fibres frequently divide into branches. In any case they become gradually finer and finer; until at length, axis-cylinder, sheath, and contents are no longer separable, and the nerve fibre is reduced to a delicate filament, the ultimate termination of which, in the sensory organs and in the muscles, is not yet thoroughly made out.

17. In Lesson VIII. mention is made of peculiar bodies called *tactile corpuscles*, which are oval masses of specially modified connective tissue in relation with the ends of the nerves in the papillæ of the skin. In Fig. 103 four such papillæ, which have been rendered transparent and stripped of their epidermis, are seen, and the largest contains a tactile corpuscle (*e*). This mode, in which nerves not connected with tactile corpuscles end in the skin, is not definitely known.

In muscles, the nerve-fibre seems to pierce the sarcolemma and to end inside the ultimate muscular fibre in a peculiar knob or plate.

In the brain and spinal cord, on the other hand, it is certain that, in many cases, the ends of the nerve-fibres are continued into the processes of the ganglionic corpuscles.

18. The *olfactory nerves* are composed of pale, flat fibres

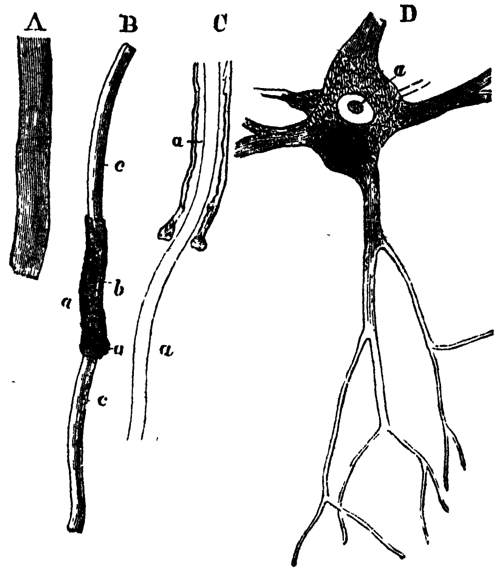

FIG. 102.

A, a nerve-fibre in its fresh and unaltered condition; B, a nerve-fibre in which the greater part of the sheath and coagulated contents (*a b*) have been stripped off from the axis cylinder (*c c*); C, a nerve-fibre, the upper part of which retains its sheath and coagulated contents, while the axis cylinder (*a a*) projects; D, a ganglionic corpuscle—*a*, its nucleus and nucleolus. (Magnified about 350 diameters.)

without any distinction into axis-cylinder and contents, but with nuclei set at intervals along their length.

Similar fibres are found in the sympathetic nerves, mingled with fibres of the same structure as those of the spinal nerves.

19. *Ganglionic corpuscles* are chiefly found in the cerebro-spinal axis; in the ganglia of the posterior nerve roots, and in those of the sympathetic; but they occur also elsewhere, notably in some of the sensory organs (see Lesson IX.).

They are spheroidal bodies, consisting of a soft semisolid cell substance in the midst of which is a large

FIG. 103.—PAPILLÆ OF THE SKIN OF THE FINGER.

a, a large papilla containing a tactile corpuscle (*e*) with its nerve (*d*); *b*, other papillæ, without corpuscles, but containing loops of vessels, *c*. (Magnified about 300 diameters.)

clear and transparent area usually termed the *nucleus*. Within the nucleus again is generally a smaller body commonly termed the *nucleolus* (Fig. 102, D_1 *a*). Each ganglionic corpuscle sends off one, two, or more prolongations, which may divide and subdivide; and which, in some cases, unite with the prolongations of other ganglionic corpuscles, while, in others, they are continued into nerve-fibres.

APPENDIX A.

A TABLE OF ANATOMICAL AND PHYSIOLOGICAL CONSTANTS.

THE weight of the body of a full-grown man may be taken at 154 lbs.

I. GENERAL STATISTICS.

Such a body would be made up of—

	lbs.
Muscles and their appurtenances	68
Skeleton	24
Skin	$10\frac{1}{2}$
Fat	28
Brain	3
Thoracic viscera	$2\frac{1}{2}$
Abdominal viscera	11
	147[1]

Or of—

	lbs.
Water	88
Solid matters	66

[1] The addition of 7 lbs. of blood, the quantity which will readily drain away from the body, will bring the total to 154 lbs. A considerable quantity of blood will, however, always remain in the capillaries and small blood-vessels, and must be reckoned with the various tissues. The total quantity of blood in the body is now calculated at about 1-13th of the body weight, *i.e.* about 12 lbs.

The solids would consist of the elements oxygen, hydrogen, carbon, nitrogen, phosphorus, sulphur, silicon, chlorine, fluorine, potassium, sodium, calcium (lithium), magnesium, iron (manganese copper, lead), and may be arranged under the heads of—

Proteids. Amyloids. Fats. Minerals.

Such a body would lose in 24 hours—of water, about 40,000 grains, or 6 lbs.; of other matters about 14,500 grains, or over 2 lbs.; among which of carbon 4,000 grains; of nitrogen 300 grains; of mineral matters 400 grains; and would part, per diem, with as much heat as would raise 8,700 lbs. of water 0° to 1° Fahr., which is equivalent to 3,000 foot-tons.[1] Such a body ought to do as much work as is equal to 450 foot-tons.

The losses would occur through various organs, thus—by

	WATER. grs	OTHER MATTER grs.	N. grs	C. grs.
Lungs	5,000	12,000	...	3,300
Kidneys . . .	23,000	1,000	250	140
Skin	10,000	700	10	100
Fæces	2,000	800	40	460
Total . . .	40,000	14,500	300	4,000

The *gains* and *losses* of the body would be as follows:—

		grs.
Creditor—	Solid dry food	8,000
	Oxygen	10,000
	Water	36,500
	Total	54,500

		grs.
Debtor—	Water	40,000
	Other Matters	14,500
	Total	54,500

[1] A foot-ton is the equivalent of the work required to lift one ton one foot high.

II. Digestion.

Such a body would require for daily food, carbon 4,000 grains, nitrogen 300 grains; which, with the other necessary elements, would be most conveniently disposed in—

	grs.
Proteids	2,000
Amyloids	4,400
Fats	1,200
Minerals	400
Water	36,500
Total	44,500

which, in turn, might be obtained, for instance, by means of—

	grs.
Lean beefsteaks	5,000
Bread	6,000
Milk	7,000
Potatoes	3,000
Butter, dripping, &c.	600
Water	22,900
Total	44,500

The fæces passed, per diem, would amount to about 2,800 grains, containing solid matter 800 grains.

III. Circulation.

In such a body the heart would beat 75 times a minute, and probably drive out, at each stroke from each ventricle, from 5 to 6 cubic inches, or about 1,500 grains of blood.

The blood would probably move in the great arteries at a rate of about 12 inches in a second, in the capillaries at 1 to $1\frac{1}{2}$ inches in a minute; and the time taken up in performing the entire circuit would probably be about 30 seconds.

The left ventricle would probably exert a pressure on the aorta equal to the pressure on the square inch of a column of blood about 9 feet in height; or of a column of mercury about 9½ inches in height; and would do in 24 hours an amount of work equivalent to about 90 foot-tons; the work of the whole heart being about 120 foot-tons.

IV. RESPIRATION.

Such a body would breathe 15 times a minute.

The lungs would contain of residual air about 100 cubic inches, of supplemental or reserve air about 100 cubic inches, of tidal air 20 to 30 cubic inches, and of complemental air 100 cubic inches.

The vital capacity of the chest—that is, the greatest quantity of air which could be inspired or expired—would be about 230 cubic inches.

There would pass through the lungs, per diem, about 350 cubic feet of air.

In passing through the lungs, the air would lose from 4 to 6 per cent. of its volume of oxygen, and gain 4 to 5 per cent. of carbonic acid.

During 24 hours there would be consumed about 10,000 grains oxygen; and produced about 12,000 grains carbonic acid, corresponding to 3,300 grains carbon. During the same time about 5,000 grains or 9 oz. of water would be exhaled by the lungs.

In 24 hours such a body would vitiate 1750 cubic feet of pure air to the extent of 1 per cent., or 17,500 cubic feet of pure air to the extent of 1 per 1,000. Taking the amount of carbonic acid in the atmosphere at 3 parts, and in expired air at 470 parts in 10,000, such a body would require a supply per diem of more than 23,000 cubic feet of ordinary air, in order that the surrounding atmosphere might not contain more than 1 per 1,000 of carbonic acid (when air is vitiated from animal sources with carbonic acid to more than 1 per 1,000, the concomitant impurities become appreciable to the nose). A man of the weight mentioned (11 stone) ought, therefore, to have at least 800 cubic feet of well-ventilated space.

V. CUTANEOUS EXCRETION.

Such a body would throw off by the *skin*—of water about 18 ounces, or 10,000 grains; of solid matters about 300 grains; of carbonic acid about 400 grains, in 24 hours.

VI. Renal Excretion.

Such a body would pass by the *kidneys*—of water about 50 ounces; of urea about 500 grains; of other solid matters about 500 grains, in 24 hours.

VII. Nervous Action.

In the frog a nervous impulse travels at the rate of about 80 feet in a second.

In a man a nervous (sensory) impulse has been variously calculated to travel at 100, 200, or 300 feet in a second.

VIII. Histology.

Red corpuscles of the blood are about $\frac{1}{3200}$th of an inch in breadth; white corpuscles $\frac{1}{2500}$th.

Striated muscular fibres are about $\frac{1}{400}$th of an inch in breadth; plain $\frac{1}{4000}$th.

Nerve-fibres vary between $\frac{1}{1500}$th and $\frac{1}{12000}$th of an inch in breadth.

Connective tissue fibrils are about $\frac{1}{4000}$th of an inch in breadth.

Epithelium scales (of the skin) are about $\frac{1}{500}$th of an inch in breadth.

Capillary blood-vessels are from $\frac{1}{3500}$th to $\frac{1}{2000}$th of an inch in breadth.

Cilia (from the wind-pipe) are about $\frac{1}{3000}$th of an inch in length.

The cones in the "yellow spot" of the retina are about $\frac{1}{10000}$th of an inch in breadth.

APPENDIX B.

THE CASE OF MRS. A——. (*See p.* 240.)

(1) THE first illusion to which Mrs. A. was subject, was one which affected only the ear. On the 21st of December, 1830, about half-past four in the afternoon, she was standing near the fire in the hall, and on the point of going up to dress, when she heard, as she supposed, her husband's voice calling her by name: "——, ——, come here! come to me!" She imagined that he was calling at the door to have it opened; but upon going there and opening the door, she was surprised to find no person there. Upon returning to the fire she again heard the same voice calling out very distinctly and loudly, "——, come, come here!" She then opened two other doors of the same room, and upon seeing no person, she returned to the fireplace. After a few moments she heard the same voice still calling, "Come to me, come! come away!" in a loud, plaintive, and somewhat impatient tone; she answered as loudly, "Where are you? I don't know where you are," still imagining that he was somewhere in search of her; but receiving no answer, she shortly went upstairs. On Mr. A.'s return to the house, about half an hour afterwards, she inquired why he had called her so often, and where he was, and she was of course greatly surprised to learn that he had not been near the house at the time. A similar illusion, which excited no particular notice at the time, occurred to Mrs. A. when residing at Florence, about ten years before, and when she was in perfect health. When she was undressing after a ball, she heard a voice call her repeatedly by name, and she was at that time unable to account for it.

(2) The next illusion which occurred to Mrs. A. was of a more alarming character. On the 30th of December, about four o'clock in the afternoon, Mrs. A. came downstairs into the drawing-room, which she had quitted only a few minutes before, and, on entering the room, she saw her husband, as she supposed, standing with his back to the fire. As he had gone out to take a walk about half an hour before, she was surprised to see him there, and asked him why he had returned so soon. The figure looked fixedly at her with a serious and thoughtful expression of countenance, but did not speak. Supposing that his mind was absorbed in thought, she sat down in an arm-chair near the fire, and within two feet, at most, of the figure, which she still saw standing before her. As its eyes, however, still continued to be fixed upon her, she said, after the lapse of a few minutes, "Why don't you speak?" The figure immediately moved off towards the window at the further end of the room, with its eyes still gazing on her, and it passed so very close to her in doing so, that she was struck with the circumstance of hearing no step or sound, nor feeling her clothes brushed against, nor even any agitation in the air.

Although she was now convinced that the figure was not her husband, yet she never for a moment supposed that it was anything supernatural, and was soon convinced that it was a spectral illusion. As soon as this conviction had established itself in her mind, she recollected the experiment which I had suggested of trying to double the object; but before she was able distinctly to do this, the figure had retreated to the window, where it disappeared. Mrs. A. immediately followed it, shook the curtains, and examined the window, the impression having been so distinct and forcible, that she was unwilling to believe that it was not a reality. Finding, however, that the figure had no natural means of escape, she was convinced that she had seen a spectral apparition like that recorded in Dr. Hibbert's work, and she consequently felt no alarm or agitation. The appearance was seen in bright daylight, and lasted four or five minutes. When the figure stood close to her, it concealed the real objects behind it, and the apparition was fully as vivid as the reality.

(3) On these two occasions Mrs. A. was alone, but when

the next phantom appeared, her husband was present. This took place on the 4th of January, 1830. About ten o'clock at night, when Mr. and Mrs. A. were sitting in the drawing-room, Mr. A. took up the poker to stir the fire, and when he was in the act of doing this, Mrs. A. exclaimed, "Why, there's the cat in the room!" "Where?" exclaimed Mr. A. "There, close to you," she replied. "Where?" he repeated. "Why, on the rug, to be sure, between yourself and the coal-scuttle." Mr. A., who still had the poker in his hand, pushed it in the direction mentioned. "Take care," cried Mrs. A., "take care! you are hitting her with the poker." Mr. A. again asked her to point out exactly where she saw the cat. She replied, "Why, sitting up there close to your feet on the rug; she is looking at me. It is Kitty—come here, Kitty!" There were two cats in the house, one of which went by this name, and they were rarely, if ever, in the drawing-room.

At this time Mrs. A. had no idea that the sight of the cat was an illusion. When she was asked to touch it, she got up for the purpose, and seemed as if she was pursuing something which moved away. She followed a few steps, and then said, "It has gone under the chair." Mr. A. assured her that it was an illusion, but she would not believe it. He then lifted up the chair, and Mrs. A. saw nothing more of it. The room was searched all over, and nothing found in it. There was a dog lying on the hearth, who would have betrayed great uneasiness if a cat had been in the room, but he lay perfectly quiet. In order to be quite certain, Mr. A. rang the bell, and sent for the cats, both of which were found in the housekeeper's room.

(4) About a month after this occurrence, Mrs. A., who had taken a somewhat fatiguing drive during the day, was preparing to go to bed about eleven o'clock at night, and, sitting before the dressing-glass, was occupied in arranging her hair. She was in a listless and drowsy state of mind, but fully awake. When her fingers were in active motion among the papillotes, she was suddenly startled by seeing in the mirror the figure of a near relative, who was then in Scotland, and in perfect health. The apparition appeared over her left shoulder, and its eyes met hers in the glass. It was enveloped in grave-clothes,

closely pinned, as is usual with corpses, round the head and under the chin; and, though the eyes were open, the features were solemn and rigid. The dress was evidently a shroud, as Mrs. A. remarked even the punctured pattern usually worked in a peculiar manner round the edges of that garment. Mrs. A. described herself as, at the time, sensible of a feeling like what we conceive of fascination, compelling her, for the time, to gaze upon this melancholy apparition, which was as distinct and vivid as any reflected reality could be, the light of the candle upon the dressing-table appearing to shine fully upon its face. After a few minutes she turned round to look for the reality of the form over her shoulder, but it was not visible, and it had also disappeared from the glass when she looked again in that direction.

* * * * * *

(7) On the 17th March, Mrs. A. was preparing for bed. She had dismissed her maid, and was sitting with her feet in hot water. Having an excellent memory, she had been thinking upon and repeating to herself a striking passage in the *Edinburgh Review*, when, on raising her eyes, she saw seated in a large easy-chair before her the figure of a deceased friend, the sister of Mr. A. The figure was dressed, as had been usual with her, with great neatness, but in a gown of a peculiar kind, such as Mrs. A. had never seen her wear, but exactly such as had been described to her by a common friend as having been worn by Mr. A.'s sister during her last visit to England. Mrs. A. paid particular attention to the dress, air, and appearance of the figure, which sat in an easy attitude in the chair, holding a handkerchief in one hand. Mrs. A. tried to speak to it, but experienced a difficulty in doing so, and in about three minutes the figure disappeared.

About a minute afterwards, Mr. A. came into the room, and found Mrs. A. slightly nervous, but fully aware of the delusive nature of the apparition. She described it as having all the vivid colouring and apparent reality of life; and for some hours preceding this and other visions, she experienced a peculiar sensation in her eyes, which seemed to be relieved when the vision had ceased.

(9) On the 11th October, when sitting in the drawing-room, on one side of the fire-place, she saw the figure of another deceased friend moving towards her from the window at the farther end of the room. It approached the fire-place, and sat down in the chair opposite. As there were several persons in the room at the time, she describes the idea uppermost in her mind to have been a fear lest they should be alarmed at her staring, in the way she was conscious of doing, at vacancy, and should fancy her intellect disordered. Under the influence of this fear, and recollecting a story of a similar effect in your[1] work on Demonology, which she had lately read, she summoned up the requisite resolution to enable her to cross the space before the fire-place, and seat herself in the same chair with the figure. The apparition remained perfectly distinct till she sat down, as it were, in its lap, when it vanished.

[1] Sir Walter Scott, to whom Sir David Brewster's Letters on Natural Magic were addressed.

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chronic, lasting weeks or months. When inflammation of the larynx is acute and severe, it is a dangerous disease. There are fever, pain, and tightness about the throat, husky croaking voice, cough of the clanging croupy character, thick tenacious expectoration, difficult breathing, long-drawn hissing inspiration, inability to swallow easily, sleeplessness, attacks of suffocative spasm, urgent fears of suffocation, and towards the end gasping for breath and convulsions. The throat may be seen red and swollen within, and on pressing the tongue downwards the upper part of the larynx or 'epiglottis' may be seen erect and inflamed (*vide* p. 548). The small aperture into the windpipe is, from the swelling of the parts, more or less closed, thus preventing the entrance of air. Laryngitis may be confounded with croup or diphtheria, the distinction being the absence of the false membrane and deposit described in those diseases (*vide* pp. 154, 177).

Treatment.—When the malady presents as simple *hoarseness,* or loss of voice, occurring, perhaps, chiefly in the morning, avoidance of cold, especially at night, flannel round the throat, or a mustard poultice, the feet in mustard-and-water at night, and an expectorant mixture (Recipe 57) may be sufficient. But when the disease is severe very active measures are required. Leeches should be applied to the *upper part of the chest*—one for each year of the patient's age to the number of thirty. The steam from hot water should be frequently inhaled, and hot moist sponges should be applied to the throat. Dover's powder should be given in 5-grain doses three times a day, and if necessary the bowels should be moved by Recipes 1 and 2. The patient is to be kept from talking, in a warm room free from draughts, the temperature of which should be maintained as equable as possible, and not be allowed to sink below 80° Fahrenheit. The air should be rendered moist by steam from a kettle of boiling water (*vide* p. 104).

The diet must consist of fluids, as strong soups and broths, and no stimulants should be allowed. The operation of opening the windpipe may be required.

[As soon as possible calomel and opium (Recipe 23) should be obtained and given instead of the Dover's powder mentioned above. The calomel should be continued until there is a metallic taste in the mouth, or slight soreness of the gums. If the patient is a strong, robust person, it will also be advisable to give the tartar emetic mixture (Recipe 59).]

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chronic, lasting weeks or months. When inflammation of the larynx is acute and severe, it is a dangerous disease. There are fever, pain, and tightness about the throat, husky croaking voice, cough of the clanging croupy character, thick tenacious expectoration, difficult breathing, long-drawn hissing inspiration, inability to swallow easily, sleeplessness, attacks of suffocative spasm, urgent fears of suffocation, and towards the end gasping for breath and convulsions. The throat may be seen red and swollen within, and on pressing the tongue downwards the upper part of the larynx or 'epiglottis' may be seen erect and inflamed (*vide* p. 548). The small aperture into the windpipe is, from the swelling of the parts, more or less closed, thus preventing the entrance of air. Laryngitis may be confounded with croup or diphtheria, the distinction being the absence of the false membrane and deposit described in those diseases (*vide* pp. 154, 177).

Treatment.—When the malady presents as simple *hoarseness*, or loss of voice, occurring, perhaps, chiefly in the morning, avoidance of cold, especially at night, flannel round the throat, or a mustard poultice, the feet in mustard-and-water at night, and an expectorant mixture (Recipe 57) may be sufficient. But when the disease is severe very active measures are required. Leeches should be applied to the *upper part of the chest*—one for each year of the patient's age to the number of thirty. The steam from hot water should be frequently inhaled, and hot moist sponges should be applied to the throat. Dover's powder should be given in 5-grain doses three times a day, and if necessary the bowels should be moved by Recipes 1 and 2. The patient is to be kept from talking, in a warm room free from draughts, the temperature of which should be maintained as equable as possible, and not be allowed to sink below 80° Fahrenheit. The air should be rendered moist by steam from a kettle of boiling water (*vide* p. 104), The diet must consist of fluids, as strong soups and broths, and no stimulants should be allowed. The operation of opening the windpipe may be required.

[As soon as possible calomel and opium (Recipe 23) should be obtained and given instead of the Dover's powder mentioned above. The calomel should be continued until there is a metallic taste in the mouth, or slight soreness of the gums. If the patient is a strong, robust person, it will also be advisable to give the tartar emetic mixture (Recipe 59).]

CHRONIC LARYNGITIS is often associated with scrofula, venereal, or cancer. The disease generally passes from bad to worse, and surgical operations may be required. But, in spite of all that can be done, the result is either sudden death from suffocative spasm, or lingering death from extension of the disease.

LEPROSY.—Leprosy appears in *three* forms. *First*, as circular spots, or blotches of irregular size and coppery hue, on any part of the body, which afterwards assume a whiter appearance, becoming dry, hard, horny, and glistening. *Secondly*, as loss of sensation in the fingers or toes, or of some part of the face or body. *Thirdly*, as a gradual growth of solid prominences or tubercles, varying in size from that of a pin's head to a walnut, causing the part to assume a curiously nodulated appearance. Ultimately the parts, however affected, ulcerate, the ulcers gradually eating away the flesh and bones, so that the fingers and toes are lost. It is hereditary, but may be communicated by contact of a sore or abrasion of the skin with leprous discharge. There is no cure for the disease, but its progress may be delayed by good diet, fresh air, and tonics.

The best tonic is arsenic (Recipe 75). Gurjon oil is also much recommended. The dose of oil is 2 drachms twice daily, with an equal quantity of lime-water. One part of oil with three of lime-water must also be rubbed into the body and limbs for two hours twice a day.

LIVER, DISEASES OF THE.—The liver is the largest organ in the body, and is situated in the right side, stretching across to the left.

The liver commences in a line immediately below the nipple, while its lower border comes down as low as the margin of the ribs. Its size varies a good deal in health, and in women who wear tight stays it may come down an inch or two lower. Its function is the secretion of bile, a fluid by which is effected the conversion of the food prepared by the stomach into material or 'chyle' required for the nourishment of the body. It also prepares materials which are destined to maintain animal heat by the slow combustion which a portion of the blood undergoes in the lungs. A third purpose of the liver is to remove effete or useless matter from the blood, *i.e.* to purify that fluid; and this effete matter is the main agent in the formation of the contents of the bowels into a suitable condition and consistence for their removal without injury. It thus acts as a natural aperient. Whenever the liver is disturbed or disordered, there cannot be health. Next to the stomach it is the part of the body most directly influenced by food or drinkables.

1. CONGESTION OF THE LIVER.—This term implies a distension of some part, or of the whole, of the organ. Or sometimes the gall-bladder and gall-ducts only are implicated. The causes are overcrowding; a sedentary life; too much sleep, especially in the daytime; excessive eating and drinking; rich and hotly seasoned food; stimulating liquors, especially those containing much sugar; the sudden cessation of accustomed discharges from piles; repeated cold stages of intermittent or remittent fever, during which the blood is driven forcibly into internal organs, which thereby become distended. But the principal cause of congestion, inflammation, and abscess of the liver in the East is climatic. The liver is excited by more secretory work falling on it than in temperate climates, some of the effete material which would in temperate regions pass away by the lungs being removed from the system by an increased flow of bile. From solar exposure, heat, and consequent perspiration, the skin is rendered irritable and weakened, and is therefore more susceptible to

changes of temperature, which, both seasonal and daily, are rapid and great. Hence, the surface of the body being easily chilled, the internal organs, especially the liver in its excited condition, suffer much in the same manner as in the cold stages of fever (*vide* pp. 253, 676).

The *symptoms* are coated tongue, bad taste in the morning, depression of spirits, defective appetite, headache, bowels acting irregularly, stools dark, or sometimes light in colour, occasionally bilious diarrhœa, but often constipation, nausea, a sense of weight and fulness in the right side, and pain or uneasiness in the tip of the right shoulder, or in the shoulder-blade. Similar symptoms are sometimes spoken of as *torpor of the liver*. When such symptoms exist in a minor degree the person is regarded as *bilious*. Biliousness may, however, be evidenced by dyspeptic headache (*vide* p. 291), or by bilious colic (*vide* p. 131), or by irritative bilious diarrhœa (p. 167).

Treatment.—Recipes 1 and 2 should be taken, with care and abstinence in diet. Mustard leaves should be applied over the liver, and moderate exercise short of fatigue should be taken. Horse exercise is advisable.

[If the above treatment is not successful, it will be desirable for the person to take several mercurial purges, as Recipe 8, followed by Recipe 6. In two or three days after the bowels have been frequently opened Recipe 7 will be useful. Iodine paint may also be applied daily over the liver, until the skin becomes tender (*vide Appendix*, No. 111). In chronic cases, Recipe 33 if there is tendency to jaundice, and Recipe 34 if there is no tendency to jaundice. The nitro-muriatic bath should also be used (Recipe 114). The use of Friedrichshall, or Hunyadi Janos, or Carlsbad mineral waters will also be beneficial. For *biliousness*, euonymin 1 grain; compound extract of colocynth 1 grain; extract of hyoscyamus half a grain, made into a pill: one or two to be taken at night.]

2. Liver, Inflammation of the.—The causes of inflammation of the liver are similar to those of congestion, especially chill. Congestion, if not checked, will often

terminate in inflammation. It is also sometimes connected with dysentery, appearing then to arise from absorption of dysenteric material, secreted in the intestines, by the veins passing between the latter parts and the liver.

The *symptoms* of inflammation of the liver are pain in the *right* side, increased by pressure under the ribs, by a long breath, by coughing, by lying on the *left* side. There is also pain in the shoulder, and often a dragging sensation at the pit of the stomach. The whites of the eyes may turn yellow, the urine is highly coloured, there is nausea or vomiting, there may be either costiveness or diarrhœa, and the stools may be dark or light in colour. The disease is generally marked by febrile symptoms, but in some cases there is little fever. Sometimes it may be distinctly made out that the liver is enlarged, but often this is not the case.

When the pain is very acute, with much fever, the covering of the liver will be chiefly involved in the inflammation. If the bladder is irritable, and the pain more towards the loins, the under part of the liver is most affected. When vomiting is a prominent symptom, with perhaps hiccup, and pain at the pit of the stomach, that part of the liver nearest the former organ is most implicated. When difficulty of breathing, inability to draw a long breath, and cough are prominent symptoms, that part of the liver supporting the right lung, and probably the lung itself, are implicated.

Treatment.—In the absence of medical advice, administer a purgative, as Recipe 1, followed by a saline draught (Recipe 2) four hours afterwards. If the bowels are costive, and *there is no dysenteric complication,* these medicines should be repeated every or every other day, so that a continued free action may be secured. *But if there is dysentery,* castor-oil should be given, and after the bowels have been once thoroughly cleansed, ipecacuanha and Dover's powder (Recipe 17) night and morning. Effervescing solutions of citrate of magnesia (*vide* p. 15) may be taken with benefit, as they allay thirst and sickness. Mustard poultices should be applied daily, or as often as can be borne, over the liver. Milk, broth, beef-tea, toast, and biscuits may be taken, but no stimulants should be given.

[For inflammation of the liver *without accompanying dysenteric symptoms, occurring in a moderately healthy and robust person*, it will be desirable, when the materials are available at the onset, to adopt the tartar emetic treatment, as soon as the bowels have been once thoroughly moved by the means indicated above. Two grains of tartar emetic are to be thoroughly mixed in a mortar with 2 drachms of nitrate of potash, and the mass divided into eight powders, one of which should be given in 2 ounces of water every hour until local pain and tenderness subside. If the tartar emetic produces distress by exciting nausea or vomiting, or too much purging, or great depression, the proportion should be reduced to 1 grain in the eight powders. *For less robust persons*, 20 grains of chloride of ammonium should be given three times daily in water. If, after the subsidence of the acute symptoms pain or tenderness continue, a blister should be applied, and podophyllin with nitric acid (Recipes 7 and 12) should be given, the latter being most useful if the skin is dry and the bowels constipated.]

3. Chronic Inflammation of the Liver.—This may be a sequel of the acute form, or it may arise from repeated attacks of congestion, or it may come on so gradually that it is often long unattended to. The first symptoms are sensation of weight in the right side, or feeling as if a lump were there, occasional pains of a shooting character, with loss of appetite, flatulence, and other dyspeptic symptoms. These symptoms are very similar to those of congestion, but instead of disappearing, as temporary congestion does, they become permanent. Then the liver *in one form of the malady* becomes enlarged, and may be felt below the ribs. From the pressure of the enlarged liver upwards, there is also cough, difficulty of taking a long breath, and pain in one or both shoulders.

But in another form known as *cirrhosis* (*vide* p. 163) brought on usually by spirituous liquors, the liver becomes *atrophied* or smaller than natural. In both forms the countenance becomes sallow, the skin dry, the patient desponding and debilitated. The stools, which may be loose or the reverse, are generally clay-coloured, while the urine is often high-coloured from bile. Sometimes the person becomes jaundiced. Discharge of blood from the bowels and bleeding from the nose are also liable to occur.

Treatment.—Saline aperients in the morning, as Recipe 2, and care in diet, with avoidance of stimulants, are the means of relief. But if the disease persists, as it probably will, change to a temperate climate must be taken.

[Nitro-muriatic acid (Recipe 34), taraxacum and acid (Recipe 33), podophyllin (Recipes 7 and 12), iodide of potassium (Recipe 21), all prove useful; sometimes one prescription, sometimes another, agreeing best, and they may be tried in the order named. The nitro-muriatic bath (Recipe 114) should also be used.]

4. Abscess of the Liver.—Abscess of the liver originates as below:

(1) *Suddenly, during an attack of congestion or acute inflammation.*—If during such conditions shivering occurs, followed by cold sweats, obstinately furred tongue, scanty and high-coloured urine, depositing much sediment, fever increased at night, and diarrhœa, there will be every reason to fear formation of abscess.

(2) *Gradually, or during chronic inflammation.*—The most frequent manner, however, in which abscess manifests itself is after the prominent symptoms of acute inflammation have been relieved. The patient does not recover health, remains weak and languid, and after a variable period experiences occasional chills, with feverishness towards evening. This soon assumes a hectic character, and is accompanied by a tongue furred in the centre, red

at tip and edges. Weight and uneasiness are experienced in the right side, and the palms of the hands are dry.

(3) *Insidiously, or without previous inflammation.*—But liver abscess sometimes occurs without any previous decided symptoms, or there may be simply loss of flesh, or a vague sense of uneasiness or obtuse dull pain, or feeling of weight in the side, with perhaps slight cough. These anomalous feelings are signs often scarcely appreciable; or, if observed, are considered too trivial to induce application for medical advice. Often it is not until shivering and cold sweats, with swelling of the liver, appear, that the serious nature of the disease is recognised.

(4) *During the progress of dysentery.*—If the languor, the emaciation, and evening fever are greater than can be accounted for by the violence of the dysentery, if the tongue becomes furred in the centre and red at the tip and edges, and if there is uneasiness and weight in the side, there will be little doubt that abscess has occurred. A fit of shivering in addition would render the matter certain.

When abscess forms it may appear as a swelling in the side or near the pit of the stomach, when it is said to 'point' externally; or it may burst into the stomach and be emptied by vomiting; or into the bowels, and the matter may pass away with the stools; or into the lungs, when the contents may be coughed up; or otherwise into the cavities of the chest and bowels, from which there is no escape.

If the abscess points externally, in the absence of medical aid, the skin must be allowed to become red, when it may be opened with a lancet and poultices applied. Then the abscess, if not large, may discharge its contents, contract, heal, and the patient recover. In other instances, little can be done except supporting the strength of the patient by good diet, and relieving pain by chloral.

5. Hepatalgia, or Neuralgia of the Liver.—The symptoms are slight uneasiness or sense of weight in the side—so slight as to be forgotten when the person is occupied. There is also uneasiness in the shoulder, which feels tired. These symptoms may be absent for days, returning from exposure to cold, or without any probable cause. Sometimes twitches are felt in the side, which the patient may state to be tender. But examination does not confirm this, or detect anything unnatural. The mind dwells on this uneasiness, and the individual dreads some serious disease appearing. There is also languor, want of resolution, and despondency. But the appetite and digestion are good, and the patient sleeps well. These symptoms may recur for years, and may at first be regarded with suspicion, as indicative of insidious abscess. When, however, months elapse during which the individual enjoys good health, and probably gains flesh, the neuralgic character of the affection becomes, even to the patient himself, undoubted.

Treatment.—A mustard poultice will relieve the pain temporarily, and tonics, as quinine (Recipe 66), will probably prove beneficial. But occupation of the mind and moderate exercise are the best remedies.

[In some instances it may be desirable to apply a blister over the liver, when the pain is more than ordinarily complained of. Solution of arsenic (Recipe 75), taken daily for some weeks, is the best tonic.]

LUMBAGO.—This term implies severe pain and tenderness of the muscles of the loins, aggravated by motion, often preventing the patient from walking, and frequently occurring suddenly. It is a variety of rheumatism. It generally arises from cold. It is distinguished from disease of the kidneys, in which pain occurs in the loins (*vide* p. 314) by being aggravated by motion, by the absence of frequent desire to make water, and from there being no *albumen* (*vide* p. 101) nor blood in the urine.

Treatment.—When, at the commencement of the attack, the bowels are costive and the urine scanty and high-coloured, becoming turbid on cooling, Recipes 1 and 2 may be taken, with 8 grains of nitrate of potash (*vide* p. 26), three times a day. But when the bowels are regular and the urine light-coloured and abundant, hot local applications are the best remedies. Mustard poultices may be applied, or the back may be well rubbed with hot 'grass oil.' Powdered sulphur wrapped up in a flannel belt, and worn habitually, is praised as a local remedy. Ironing the back with a hot flat iron, a piece of brown paper intervening, is often beneficial. When the pain is very distressing at night, Dover's powder or chloral may be used.

[A better medicine, when the urine is thick and high-coloured, is colchicum with alkalies (Recipe 30). If the patient is feverish, Recipe 52. As external applications, turpentine and salad oil in equal parts; a belladonna plaster; ammonia and oil in the proportion of one-third ammonia; iodine paint; chloroform and opium liniment (Recipes 89, 90), are all sometimes useful. Galvanism, or Faradisation, or wearing a Pulvermacher's galvanic chain may also be tried. In severe cases a surgeon would probably use acupuncture needles, or inject morphia.]

LUNGS, INFLAMMATION OF THE.—This disease, technically known as *Pneumonia*, is ordinarily the result of cold. The disease usually commences as a severe cold, with chills and flushes of heat. Or it may begin as an attack of bronchitis (*vide* p. 102). There is a short dry cough, afterwards attended with a thin, frothy, very tenacious expectoration, which at a later period becomes *rusty*-coloured, or streaked with blood. This coloured expectoration is, in adults, the great distinguishing characteristic between *bronchitis* or inflammation of the tubes leading to the lungs, and the still more dangerous *pneumonia*, or inflammation of the substance of the lungs. There is no acute pain attending this disease, unless it is also, as often happens, combined with some degree of *pleurisy* or inflammation of the covering of the lungs, when there will be a 'stitch,' or stabbing pain in the side, or under the nipple, more or less acute as the covering of the lungs is affected in a lesser or greater degree (*vide Pleurisy*, p. 352). But whether there is this acute pain, denoting the pleura to be affected or not, there is always a deep-seated, dull aching in the chest, and the respiration is frequent and short, rising from fourteen or sixteen (the number of respirations in the recumbent posture during health) to forty or upwards; while the temperature of the body rises to 104° or 105° Fahr. (*vide* p. 33). In favourable cases the disease may decline on the fifth or sixth day, or it may be protracted to a fortnight. As a rule, if the mean of the bodily temperature, taken several times daily, is not above 104° Fahr.; if the pulse does not rise above 120 beats in the minute; and if the respiration does not rise above 35 in the same period, the patient, if otherwise healthy, will begin to get well in eight or ten days. In unfavourable cases, on the fourth or fifth day the breathing becomes more frequent and difficult, the pulse quicker, the skin hotter, and delirium, followed by stupor, ensues.

There are certain physical signs to be discovered by listening to the breathing. The parts generally affected are the lower halves of the lungs, and by listening below the shoulder-blades at the commencement of the disease, a peculiar creaking noise will be heard, very similar to that produced by strongly rubbing the hair near the ears between the finger and thumb. This is caused by the passage of air through the sticky glutinous fluid secreted in the lungs. In the more advanced stages of the malady, the lungs, where chiefly affected, may become hardened, and therefore when the chest or lower part of the back beneath the blade-bones is tapped with the fingers, a more or less dull sound results instead of the resonant sound of health.

Inflammation of the lungs, instead of presenting all the characteristic symptoms noted, sometimes comes on very insidiously. This is especially the case with natives of India, with children, and with old people. Also during the progress of fevers. Natives of India thus suffering frequently die from affection of the lungs, without having shown any prominent symptoms.

Treatment.—The patient should remain in bed, and the atmosphere of the room should be maintained equable, free from draughts, and moist from the steam of boiling water (*vide* p. 104). The great thing is to avoid variations of temperature and chills. The patient should not be allowed to talk much, and movement, which often causes great distress by accelerating the breathing, should as much as possible be avoided. A large hot linseed-meal poultice, or spongio-piline moist with hot water, should be applied to the chest. After the linseed poultice, which may be repeated daily, cotton-wool should be applied. As medicine, ipecacuanha wine and paregoric (Recipe 57) should be given every three hours. The diet should be light and nutritious, as milk, light pudding, eggs, beef-tea, broth, and jelly. For previously strong and healthy persons stimulants will seldom be required, provided the case progresses favourably; but if signs of exhaustion occur, brandy should be given freely. A rapid pulse, amounting to 120 beats in the minute, respirations above 35 in the minute, or delirium, are indications that stimulants are necessary. In weakly or elderly people it will sometimes be desirable to treat the case altogether with stimulants from the first, adding 15 minims of aromatic spirits of ammonia to each dose of paregoric mixture. Similarly, when inflammation of the lungs occurs in very old people, a stimulating plan should be adopted.

[If the patient is strong, robust, and young, it will be more advisable to give tartar emetic mixture (Recipe 59). The tartar emetic mixture diminishes the force of the circulation, and also acts on the skin, promoting perspiration, and thus lessens the difficulty of breathing.]

INFLAMMATION OF THE LUNGS, OR PNEUMONIA, OCCURRING IN CHILDREN, demands special notice. *Pneumonia* in children occasionally comes on very insidiously, and may be overlooked. This is most likely to be the case when the lungs become affected during the progress of various diseases, as measles, teething, atrophy, fevers, and bowel complaints. When inflammation of the lungs in children arises from cold, as it often does, and is not a consequence of, or connected with, and masked by, some other malady, the symptoms are better marked. When the disease is commencing, there is feverishness, headache, sometimes vomiting, and talking in the sleep, and a dull heavy expression, soon followed by hard dry cough, parched lips, flushed countenance, furred tongue, hot skin, high-coloured urine, and short, panting, oppressed breathing, the nostrils dilating with each inspiration. The breathing is also chiefly performed by the muscles over the bowels, which may be observed moving more than occurs in a state of health. The mouth is instinctively kept open so that more air may enter, and this tends to make it hot and dry. Usually there is crying only during the spells of coughing, at other times a moan. The number of respirations may rise from 30 to 50 per minute; the pulse to 150, or even higher, and the temperature to 105° or more. This condition in children is very likely to be mistaken for simple bronchitis, and the more grave nature of the case may not be understood, especially as children rarely expectorate, and the distinctive sign, previously mentioned, of rusty-coloured discharge is generally absent. The following contrast of the symptoms of pneumonia and bronchitis is added :—

Bronchitis, or Inflammation of the Air-tubes leading to the Lungs	*Pneumonia, or Inflammation of the Lungs*
Skin warm and moist.	Skin hot and dry.
Mouth warm and moist.	Mouth hot and dry.
Breathing hurried, with wheezing.	Breathing short and panting, unaccompanied by wheezing, although a slight crackling sound may be heard.
Cough loud, noisy, and loose.	Cough hard, short, feeble, and dry.
Expectoration, if coughed out, white and glairy.	Expectoration, if coughed out, rusty and frothy.
Child cross and fretful.	Child dull and heavy.

The fever, headache, vomiting, and talking in the sleep, which occur in children, may be mistaken for affection of the stomach or head. But in chest maladies the vomiting does not continue so long as in stomach and head affections. The early cessation of vomiting, the quickened breathing and the cough, are usually sufficiently distinctive.

Treatment.—If confined, the bowels should be loosened by castor-oil or senna tea, after which Recipe 57 should be given in doses according to age. If necessary the gums should be lanced (*vide* p. 434). Hot poultices should be applied over the chest (*vide Bronchitis*, p. 108). All through the illness the patient should be encouraged to take broths, jelly, milk, or other digestible fluid food. If after two or three days the child is low and feeble, small quantities of wine-and-water may be allowed, for the disease is one rapidly producing exhaustion, which should be early guarded against. The atmosphere of the chamber should be maintained moist, and at an equable temperature, in India about 80° Fahr., if possible both day and night. But whatever the temperature may be, it should be *equable, and the colder atmosphere of the night should be guarded against*, a very slight fall of temperature aggravating the malady.

LUNGS, EMPHYSEMA OF THE.—This is the same disease which in horses is called 'broken wind.' The lungs are composed of a vast number of air cells. Emphysema signifies the dilatation of these air cells, and their eventual rupture into each other. Emphysema occurs in connection with, and may be the cause of, such maladies (as chronic bronchitis and asthma) as are attended by violent or prolonged cough. On the other hand, emphysema may be caused by such maladies. The straining consequent on whooping-cough may lay the foundation of future emphysema. It may originate from violent athletic exercises, which necessitate holding the breath long. It may also be induced by playing on wind instruments. But in the majority of cases there is hereditary predisposition, or probably some imperfection of lung structure, perhaps arising from a gouty condition, or from deposit of fat. When emphysema occurs the lung tissue loses elasticity, and acts slowly, the air not being properly expelled. The consequence is difficulty of breathing, especially on exertion, and cough with expectoration of a thin character. There is no acute pain, but a feeling of oppression in the chest, and there are often asthmatic attacks. As the disease grows worse the countenance may become dusky, especially the lips; and the nostrils dilate widely when the breath is drawn in, which is done shortly and quickly, followed by prolonged and wheezing expulsion of the breath. There is frequently some swelling of the feet and ankles of a dropsical nature, and in bad cases the voice becomes feeble, the body wastes, and more decided dropsy may ensue. Emphysema of the lungs may be complicated with chronic bronchitis, winter cough, asthma, and affections of the heart.

If the chest is examined there is found increase of resonance throughout, but most marked at the summits of the lungs and on their anterior borders (*vide* Plate, p. 20). There is also heard a short faint sound when the breath is drawn in, and a prolonged sound when it is expelled.

Treatment.—When the lung cells have broken into each other the condition is incurable. But much may be done to alleviate by careful diet as mentioned under Asthma (p. 63), especially avoiding articles which cause flatulence; by pure air; by residence in a climate neither too hot nor too cold (the Riviera for instance); by avoiding violent exercise; by warm clothing, especially for the feet; and by tonics, the best of which are iron and quinine (Recipe 70). If asthmatic attacks occur, they should be treated as mentioned at p. 61.

MEASLES.—A contagious eruptive fever which usually attacks early in life, and seldom occurs more than once to the same person. The period between exposure to infection and the commencement of the symptoms is from eight to fourteen days. The malady commences with chilliness, feverishness, and cold in the head. The eyes are red, sore, watery, and the throat may feel sore. The glands under the jaw may be enlarged; there are sneezing, running from the nose, cough, and probably pains in the limbs. The tongue is white, with red edges. At the end of the third day or beginning of the fourth day of the above symptoms, the rash appears first on the forehead, face, and neck, then on the trunk, and lastly on the arms and legs. The rash at first appears as small round, red, velvet-like spots, somewhat resembling flea-bites, but not feeling raised above the surface of the skin. These extend and merge into each other, assuming semicircular or crescentic outlines of a crimson or dark brick-red colour, and slightly raised above the surface of the skin. If pressure is made with the finger the eruption disappears, returning when pressure is removed. The fever and cough continue, but the latter becomes loose. Three or four days after its appearance the eruption begins to fade, first on the face, then on the limbs. In about two days it disappears, with scurfiness of the skin. Often there is intolerable itching, especially when the eruption is at its height and when it begins to decline. The fever does not diminish temporarily on the appearance of the rash, as is the case in small-pox, but continues until the fading of the rash commences, when it gradually subsides. If the temperature rises above 103° the case must be regarded as a severe one, when there is usually a peculiar characteristic odour. Great debility, the tongue becoming dry and brown, and the eruption purple, is indicative of danger.

In some severe cases of measles there is not only cough but also bronchitis, or even inflammation of the lungs, when symptoms present as described under such heads (pp. 102, 328). Sometimes towards the termination of the attack, *ophthalmia* (*vide* p. 227) may occur. In other cases the cough continues, and often there is delicacy of the chest, from which the patient is long in recovering.

The principal distinctions between the earlier stages of measles and of small-pox, scarlet fever, or roseola are as follows:—Measles is known by the catarrhal affection, or appearance of a cold, with which it is ushered in, and by the crescentic peculiarity of form and crimson colour of the rash, which first appears as red spots, not raised above the surface of the skin. In small-pox there are no catarrhal symptoms, and there are generally vomiting and pain across the loins before the rash comes out, which shows as raised red spots. Scarlet fever begins with a sore throat, and the vivid scarlet rash appears early. In roseola there is no prior cold, or watering of the eyes, and the rash appears suddenly, in patches of various sizes and shapes. For further distinctions *vide Scarlet Fever*, p. 377; *Small-pox*, p. 404; *Roseola*, p. 387; *German Measles*, p. 334.

Treatment.—The patient should be kept indoors—if a bad case, in bed—as this is the best method by which a more equable temperature may be maintained, draughts avoided, and tendency to bronchial or lung affection lessened. It is generally advisable to give a hot bath at the onset of the disease, then dry the surface of the body and put the child to bed directly. If the necessary precautions are used no chill need be feared, and the hot bath will probably tend to bring out the rash. While great care is taken that the patient should not be exposed to draught and chill, the room should be airy and well ventilated. The room should also be darkened, as the eyes are sensitive. Dryness or tingling of the skin may be relieved by bathing with tepid water, taking care that only one portion of the body is exposed at one time. Rubbing the hands and feet with salad oil will relieve the sensations of heat and tightness produced by the rash. At first no solid food will be cared for, but the patient is always thirsty, and may drink milk-and-water, toast-water, chicken broth, and lemonade or tamarind whey (*vide Addendum*). If the bowels are confined, castor-oil or senna, but after they have been thoroughly opened purgatives should be avoided, as the bowels are liable to become irritable. Citrate of magnesia (*vide* p. 15) may be given to diminish feverishness; if there is cough, Recipe 57. The inhalation of the steam from a mixture of 1 part of vinegar and 3 of water is also useful. If the breathing becomes hurried, a mustard poultice or the mustard leaf, or for young children a linseed-meal poultice, should be applied to the chest. As a general rule stimulants are not desirable, but in cases where there is much exhaustion a little port wine may be allowed. If cough continues after the rash is gone, it should be treated by giving Recipe 57. If the eruption suddenly disappears, and there is great depression and distress, a warm bath will generally revive the eruption and afford relief.

Measles is very contagious, and during the illness all offensive *excreta* or dirty linen should be immediately removed and disinfected. All the rules given regarding disinfecting (*vide Appendix*, No. 121) should be carried out. Measles is most contagious when the rash is out, but it may also be contracted by another child during the catarrhal stage before the rash appears; and it is not safe for other children to mix with affected patients until three weeks after the rash has disappeared, and then only if all clothing has been disinfected and washed. Isolation of a patient is the only way to prevent the disease spreading.

MEASLES, GERMAN or RÖTHELN.—Difference of opinion exists as to whether this is a mild form of measles or a distinct disease. It commences in the manner mentioned under measles, but the symptoms are less severe. The rash terminates sooner than that of measles, the itching is less, and scurfiness of the skin is almost limited to the face and chest. Fever and cough are present as in measles, but to a lesser degree. From the above it will be seen that German measles is a much less severe disease than ordinary measles. The *treatment* given for measles is equally applicable to German measles, so that practically it does not signify if the one is mistaken for the other.

MOLES and MOTHER'S MARKS are discolorations found in some part of the skin at birth. The *skin is not raised* or rough, but more or less discoloured, and often called 'port-wine mark.' Such marks are of no consequence, although if on the face disfiguring. Unfortunately they are irremediable. The term 'mother's mark' is often erroneously applied to a NÆVUS, which is a collection of small blood-vessels *raised above the surface of the skin.* This may be of various sizes, from that of a pin's head to the circumference of a crown piece, or larger. When the child cries the colour of these patches becomes deeper. Although not painful, they may grow to a large size, and be the source of periodical bleeding. Generally a surgical operation is required.

MOON, DISEASES SUPPOSED TO BE CAUSED BY THE.—The deleterious influence of the moon has been credited from the earliest times, for we have a passage in one of the Psalms, 'The sun shall not smite thee by day, *nor the moon by night.*' That the rays of the moon are injurious has received support from the fact of meat becoming tainted sooner on a moonlight night. This does not occur if the meat is well protected. When meat becomes tainted during a moonlight night it is from the operations of insects, which the moonlight lures from the retreats they pass the dark nights in.

The maladies most credited to the influence of the moon are as below:

Swollen face, toothache, deafness, earache, and *rheumatism.* But these are the natural results of exposure to damp from dew, or to cold winds, which must be the consequence of lying without any protection from the rays of the moon; for the absence of protection from the latter must also entail want of shield from the former. Moreover, similar results occur from exposure on dark nights, not only to human beings, but also to animals, when they are said to have a 'stroke of the land wind.'

Moon paralysis is a misnomer. After persons have slept in the open, either in the moonlight or otherwise, it has often occurred that they have found themselves unable to move the eyelids, or an arm, or a leg properly. But the loss of power thus occurring is not true paralysis. It is rheumatism, and it will be found the person is able to move the part affected, but refrains from doing so in consequence of the attendant pain. It is not consequent on the moon's rays, but arises from chill or cold. The malady should be treated as rheumatism, with hot baths, liniments, and colchicum (Recipe 52).

Paralysis of the bladder, or inability to make water, may result from night chill, and has been erroneously attributed to the moon. This is more likely to occur in men suffering from stricture or irritable bladder, especially if they have been drinking. A hot bath will probably afford relief; if not, the catheter is required, and the case must be treated as *retention of urine* (*vide* p. 421).

Dropsical effusions sometimes result from exposure to damp, chill, and cold land winds (*vide* p. 187), and are not attributable to the moon-rays.

Mental Excitement or *Insanity.*—Lunatics are more excitable and noisy in the brilliant moonlight of the tropics than at other periods. Not only does the light interfere with sleep, but a tropical moonlight night is more noisy than a dark night. Animals, birds, and insects are more restless and noisy. As mental excitement is thus caused to the confirmed lunatic, so those predisposed to insanity are kept awake and excited.

Moon-blindness arises from the rays of the moon. The *retina* or expansion of the nerve of the eye becomes paralysed from lengthened exposure to a brilliant moonlight, even although the eyes are covered by the lids; just as sometimes occurs to men working in front of a blazing furnace, or to arctic voyagers from the glare of snow. Sometimes there is total blindness both by day and night, or loss of vision may be only partial. The treatment is blisters behind the ears, purgative medicines, and confinement in a darkened room.

Paroxysmal Fevers.—It is a very general impression that these diseases are more prevalent and more likely to recur at the lunar changes. Statistics do not confirm such impressions. Nevertheless, persons subject to fever will often assert their malady returns at the new and full moons; or, if the fever does not recur, they feel uncomfortable, and suffer from various anomalous and ill-defined sensations, evidencing some deviation from health. That the moon *per se* exerts such influence may be questioned; but at the lunar phases there are atmospheric changes which may affect the sensitive constitutions of those disposed to disease. Thus the barometer suffers a depression of about the tenth of an inch at the new and full moon; while there may be other more subtle influences at work, with which we are unacquainted. In the description of intermittent fever it has been noted what apparently slight causes (errors of diet, cold, mental emotions, &c.) will induce a return of fever in those who have suffered from the complaint, and the atmospheric changes consequent on the lunar phases seem to be sufficiently powerful to induce a similar result. However this may be, the practical application of the present knowledge of the matter results in the desirability of those subject to fever taking precautionary measures, such as a dose of quinine, and avoidance of exposure, just previous to the changes of the moon.

MORTIFICATION, or GANGRENE.—This signifies the death of any part of the body. There are three varieties, *dry*, *moist*, and *senile*. *Dry gangrene* is marked by the part affected assuming a pale white appearance, here and there mottled brown. The part is cold, and there is loss of motion and sensation. Soon the skin is converted into a black mass.

Moist gangrene is characterised by swelling at first red, then becoming purple or black, on which blisters form. The part is cold, with much pain. *Senile gangrene* is often preceded by very cold feet, and commences as a blackish spot at the inner side of the great toe, or on the smaller toes, surrounded by an inflamed circle which extends up the limb. Mortification of various parts may occur from old age; from debility, poverty, starvation, excessive cold, disease of the arteries of the part; or from injury to the nerves or arteries. When any part mortifies it emits an offensive odour. Surgical advice is required. If this cannot be obtained, chloral should be given to relieve pain, and poultices made of powdered charcoal will be the best applications.

MUMPS.—An infectious disorder, consisting of inflammation of a gland called the 'parotid gland,' situated behind the jaw below the ear. It generally occurs in children, but sometimes in adults, and seldom attacks the same person twice. It commences with slight fever. After a few hours, or perhaps in a day or two, a swelling, often of almost stony hardness, is noticed before and under the ear, extending along the neck towards the chin. This lump is exceedingly painful, and continues swollen for four or five days, while the skin is often red. It then gradually disappears, leaving no trace. The swelling of mumps seldom gathers. It may affect one or both sides of the face. It is contagious, and sometimes runs through a whole family or school. In severe cases swallowing is difficult from the pressure of the swelling on the throat, and but little food can be taken. Occasionally during the course of the disease, but generally at its subsidence, a similar swelling may affect the breasts or the testicles.

Treatment.—If mumps is severe, causing difficulty of swallowing or of breathing, leeches to the part may be required; but usually hot fomentations will be sufficient. Flannel wrung out of hot poppy-head decoction (*vide Appendix*, No. 81) is the best application. During the intervals of fomentation the parts should be wrapped in flannel. The patient should be debarred for a few days from meat; and aperient medicines, as senna or castor-oil, should be given. Citrate of magnesia, in doses according to age, should be used as a cooling mixture, and rest and quiet should be enjoined. If the inflammation migrates to the breast or to the testicle, the treatment proper for inflammation of those parts should be employed (*vide* pp. 94, 438).

NAILS, DISEASES OF THE.—Sores near the toe-nails are often very troublesome, especially when accompanied by what is popularly termed 'ragnail,' or 'the growth of the nail into the flesh.' It does not, however, arise from any alteration in the nail, but from the soft parts being pushed up against the edge of the nail by tight or ill-fitting boots. If this continues, an ulcer is formed at the root of the nail.

Treatment.—The objects are to remove the irritation caused by the nail. In many cases, after soaking and softening the nail in hot water, it may be filed or scraped so thin, and so much of the corner may be cut away, that the soft parts are no longer irritated. Or, by filing the nail thin in the middle, the offending edge may be caused to rise into its situation. To aid this, the soft parts should also be carefully pressed away from the sharp edge of the nail, by introducing beneath the overhanging skin a small piece of lint, and pressing it well down towards the bottom of the sore. Persons disposed to this affection should wear their shoes loose, square at the tips, and keep their nails scraped rather thin, so that they may be more flexible. A V-shaped piece cut out from the middle of the nail, the apex going down as far as possible without pain, is a means of prevention.

[If the nail is very tough and thick, the lint mentioned above should be first soaked in a mixture of two drachms of *solution of potash* in one ounce of water. This will soften both the nail and the skin, which may be afterwards easily scraped, or even wiped away. If the means as above do not suffice, and the edge of the nail still presses into the parts, the corner must be cut away with a sharp pair of scissors, which is a very painful operation, and should be performed by a surgeon.]

An ulceration, technically termed '*Onychia*,' sometimes forms about the finger-nails of unhealthy children. It commences as a deep red swelling, in which matter forms, succeeded by an ulcerated condition. Poulticing and letting the matter out by means of a lancet are the remedies. Laxatives and tonics will also be required.

The nails are affected in certain diseases, viz., gout, psoriasis, ringworm, scrofula, and syphilis, as mentioned under such headings. Telegraph operators are liable to breakage and dropping off of the nail, caused by continual tapping cn the telegraph key, for which rest is the cure.

NERVOUSNESS.—There is an irritable state of the nervous system, most common in women, but occurring in men.

There are two systems of nerves. One called *cerebro-spinal*, passing from the nervous centres, viz. the brain and spinal cord, to all parts of the body. These nerves consist of two sets of fibres, one of which (sensory) convey impressions to the brain and spinal cord, the other set (motor) conveying mandates to the muscles. The other nervous system, called the *sympathetic* or unconscious system, consists of a number of ganglia or centres (being enlargements in the course of the nerves) placed at intervals throughout the body, and being connected with each other and with the other system of nerves by numerous filaments. Nerve force and the nervous system resemble electrical force and the telegraphic system. Electrical force originates in the battery, and nerve force in some nerve centre. Electricity must pass from the battery through the wire to the instrument before the click of the sounder is heard, and nerve force must pass from a nerve centre through the nerves to a muscle before that muscle can move, and it must pass from a nerve centre to the cells, of which internal organs are composed, before such organs can perform their functions.

The causes which may interfere with the vital process carried on by the nerves, and with the complicated mechanism of the nervous system, are multitudinous. The nervous system of some people is, probably from heredity, more prone to disturbance than that of others. In addition to heredity or constitutional tendency, the causes of nervous affections may be classed under two heads: (1) *mental* impressions, such as anxiety, excessive study, shocks of all kinds, &c.; (2) *defective nutrition* from any cause, but chiefly from dyspepsia, or worms. The nerves, like all parts of the body, require suitable nourishment. When food is not properly digested, the nerves, like other parts of the body, suffer in consequence. Thus a vicious circle is established. The indigestion affects the nerves, and the disordered nerves affect the indigestion.

Nervousness is characterised by numerous symptoms, such as causeless irritability, flushing from slight emotion, tremblings, sudden attacks of faintness or palpitation, frequent desire to make water, a variable and excitable temper, fits of low spirits, a tendency to weeping. When aggravated it constitutes *hypochondriasis* (*vide* p. 304) in men, and *hysteria* (*vide* p. 305) in women. It requires attention to the general health, and tonics.

NEURALGIA.—The term is applied to nervous pain which may occur in any part of the body. The principal local neuralgia are *brow-ague* or *brow-ache*, *hepatalgia pleurodynia*, *sciatica*, *tic-douloureux*, *toothache*, which are elsewhere described (*vide Index*). For neuralgia make a small muslin bag and fill it with salt, heat it hot, and place it against the aching spot; it will retain the heat for a long time, and will greatly relieve.

Many neuralgic affections are benefited by the injection of different agents beneath the skin. Hypodermic tabloids containing a certain amount of the agent required are prepared by Messrs. Burroughs & Wellcome. A person subject to neuralgia may, with the sanction of a medical man, learn to use the hypodermic syringe. A fold of the skin should be lifted, and the syringe needle should be introduced with a slight rotatory motion parallel with the surface. This is better than putting the skin on the stretch and then thrusting the needle through at right angles.

OXALURIA is the name given to a condition of urine when octohedral or 'dumb-bell' shaped crystals of oxalate of lime are passed in the urine. It is often associated with hypochondriasis, nervousness, insomnia, and atonic dyspepsia. Persons so affected are usually 'below par.' But others passing such crystals are apparently in good health, or sleepiness by day may be the only complaint. Exercise, good food, freedom from brain-work, and tonics (Recipe 75, or if in a malarious district, 76) are the requirements.

PAIN.—Pain is a symptom of disease (*vide* p. 37). There are two distinctive pains: *inflammatory* and *irritative.* Inflammatory pain is *increased* by pressure; irritative or spasmodic pain is *relieved* by pressure. Thus the pain of inflammation of the bowels is distinguished from that of colic, gravel, or gall-stones, being *increased* by pressure; while the pain of the latter maladies is *relieved* by pressure. Pain of the chest may arise from cold, consumption, inflammation, rheumatism, indigestion. Pain in the joints suggests rheumatism, gout, scrofulous or other inflammation, or hysteria. Pain in the stomach or bowels indicates wind, acidity, dyspepsia, colic; or, if long-continued and increased by pressure, inflammation. Pain in the back and limbs ushers in fevers and small-pox. Pains all over the body mark simple cold, influenza, or dengue fever. Pain in the face or other parts of the body, when periodic and without fever, is generally neuralgic. Whenever pain is dangerous there is generally fever.

PARALYSIS, or **PALSY**, signifies loss of power of motion of a limb or of one-half of the body. Sometimes sensation, or the power of feeling, is also lost, but this more rarely. The following are the principal varieties:—

1. *Paralysis from Disease or Injury of the Brain.*—Paralysis of one kind or other very often follows an attack of apoplexy, and sometimes occurs from disease of the brain, without any prior apoplectic fit (*vide* p. 53).

2. *Paralysis from Injury of the Spine.*—(*Vide* p. 557).

3. *Paralysis from Disease of the Spine.*—This form of paralysis, called *progressive locomotor ataxy, creeping paralysis,* or *tabes dorsalis,* depends on disease of the spinal cord. The symptoms are gradual, commencing with feelings of

fatigue in the loins and legs, tingling in the feet, and sometimes coldness of the bowels. Then pains occur in the thighs and legs of a boring paroxysmal character, sometimes described as like electric shocks, and often at first supposed to be rheumatic. There is frequently a history of preceding venereal affection. As the disease advances the muscles of the limbs waste, which has led to the affection being also termed *progressive muscular atrophy*. In some cases there is disordered vision, inability to retain urine at night, perhaps discharges from the privates, and a feeling of constriction about the waist. As the pains increase the patient finds he is losing control over his legs; that he staggers, particularly when commencing to walk; and that he cannot walk firmly without support. He lifts his feet unnecessarily high, throws them forwards and outwards, and brings the heels down with a stamp. He walks best when looking at his feet, and if he shuts his eyes or walks in the dark he probably falls. Sensation also becomes impaired, and the patient feels as if he were standing on wool or sand. At length walking is impossible, and the hands may be affected. Chronic inflammation of the bladder (p. 71) may result, but death usually occurs from chest affection. The duration of the disease may be some years. Treatment consists in nutritious diet and tonic medicines.

Paralysis of any of the above kinds is rarely cured, the most that can be done being attention to the general health and *massage* of the limbs, (*vide Appendix*, No. 116).

4. *Paralysis, Alcoholic.*—Paralysis from immoderate use of spirituous liquors chiefly affects females. The onset is gradual, with pain, followed by numbness in the feet and legs, weakness of the knees, loss of power, and uncertain gait. As the disease advances the legs waste, and the person becomes bedridden. The arms are rarely affected. The malady is generally ascribed to an accident

or chill, the habit of drinking being concealed. The brain and spinal cord are not implicated, the malady being in the local nerves. The treatment is strict abstinence from fermented drinks, good diet, massage, galvanism, tonics, and carriage exercise.

Alcoholic paralysis is often permanently benefited by Faradism or Voltaism. As a medicine, pills containing one-fiftieth of a grain of phosphorus, one-fourth of a grain of extract of nux vomica, and one grain of precipitated carbonate of iron. Dose—one, thrice daily.

5. *Paralysis, Lead.*—Painters and others who work with lead are subject to paralysis of the wrists, and the hand *drops*. A blue line on the edge of the gums close to the teeth generally accompanies wrist-paralysis from lead. This appearance and paralysis (also lead colic, *vide* p. 134) has resulted from lead in the colouring of room-paper. The treatment is removal from the cause and Recipe 49, with aperients if there is constipation. Afterwards Recipes 21 (*vide* p. 134, small type).

6. *Paralysis, Facial,* or paralysis of some of the muscles of the face, may be part of a general paralysis (*vide* p. 342), or it may arise from cold, unconnected with serious internal disorder. A person, after exposure to a draught, may not be able to move one side of the face, which appears blank and expressionless, and saliva may trickle from the mouth. It is often supposed the patient has had a 'stroke,' or that he has been affected by the moon (*vide* p. 335); but this is not the case. It is a species of rheumatism, and will gradually disappear under the influence of fomentation with hot poppy-head water (*vide Appendix*, No. 81) and Recipe 30.

7. *Paralysis, Infantile.*—Paralysis sometimes occurs to infants when teething, especially if being brought up by hand, or if suffering from improper feeding, or from debility, or from worms. It is usually met with when the double teeth are coming through. After some days of

feverishness, which, however, may not be noticed, the child goes to bed apparently as well as usual, but after probably a restless night the mother is alarmed to find one arm, or perhaps one arm and both legs, helpless. Generally the affection lasts only a few days or weeks, passing away as the child's feeding and nutrition improve.

Or the paralysis may happen as a *result of fevers*, or after *diphtheria*, only becoming evident when the child begins to walk. *Diphtheritic paralysis* generally commences in the muscles of the throat with some difficulty of swallowing, and children after diphtheria should be closely watched for such signs. These forms of paralysis are longer in getting well. The patient should be constantly in the fresh air, the limbs should be frequently shampooed, and iodide of iron (Recipe 74) should be used in doses according to the age of the child (*vide* p. 6).

8. *Paralysis, Hysterical*, has been referred to under *Hysteria* (*vide* p. 305). It generally affects a joint, as the knee or the legs, and may be accompanied by tenderness about the middle of the spine or between the shoulders. It is known from real paralysis by presenting in hysterical patients, generally young girls; and if tenderness of the back exists, by the skin being more sensitive and the tenderness more marked (*vide Hysteria*, p. 305) than is found in real disease of the spine. Although not much benefited by medicines, it generally gets well under the influence of hygienic measures.

PALSY, SCRIVENER'S, or **WRITER'S CRAMP**, and **TELEGRAPHIST'S CRAMP**, is a local spasm, or, in bad cases, a local palsy. In the spasmodic variety attempts to write call forth uncontrollable movements of the fingers or wrist, so that the pen starts up and down, and a mere scrawl results. In other instances the pen cannot be held, and the wrist is almost powerless. There is a tired feeling in the latter part, and particularly in the ball of the thumb and in the little finger. Occasionally the arm is painful to the elbow. The causes are too much writing, aided often by an irritable constitution. The only means of relief is perfect rest from the accustomed work, frequent shampooing in all directions, and strengthening the system by tonics, fresh air, and exercise. As prevention is better than cure, the first warnings of this malady, viz. a tired feeling in the thumb or little finger after writing, should be accepted as a hint that the parts are being used too much.

Among telegraph clerks the same kind of cramp occurs. *Pianists, bricklayers,* and *nailmakers* suffer from a very similar affection, caused by continual strain on the wrists, involved by their employments. The remarks under 'Writer's Cramp' regarding prevention and cure are applicable.

PARAPHYMOSIS.—A condition of the private parts often occurring in male children. It consists in the foreskin being drawn back from the end of the penis, where it remains and cannot be returned. The result is swelling and redness of the parts, attended with considerable pain and sometimes by difficulty in making water, or even complete inability to do so. The parts should be returned to their natural positions as soon as possible. They should be first bathed with ice-cold water. Then the 'glans,' or head of the penis, should be compressed with the fingers and thumb, so as to squeeze the blood out of it; at the same time it should be pressed backwards while the foreskin is drawn forwards. If this does not succeed after several trials, a slight cut will probably be necessary, for which the child should be taken to a surgeon.

PHYMOSIS signifies the opposite condition to the above, and consists in an unnaturally long foreskin, with a small opening, so that it cannot be drawn back to expose the head of the penis. This condition is often congenital;

but it may result from sores or ulcers. It causes much local irritation from retention of secretions between the head of the penis and the foreskin. It causes difficulty of micturition, the urine distending the foreskin like a bladder. From the straining efforts required in passing water, rupture or protrusion of the bowels may be produced. It may be the cause of nervous affections, as epilepsy and chorea. A surgeon should be consulted as soon as possible as to the propriety of operations; circumcision being required in bad congenital cases. When it occurs in connection with sores and ulcers, rest, fomentations, and Recipe 2.

PILES or **HÆMORRHOIDS.**—To understand piles it must be recollected that the blood is carried by the arteries *from* the heart to all parts of the body, and it returns by the veins *from* all parts to the heart (*vide* p. 500). The rectum or lower gut is a *terminal* point surrounded by a large amount of loose tissue in which a number of arteries and veins meet. It is also a *dependent* part, from which the blood must rise against the force of gravity. Hence it is a locality in which blood is liable to stagnate, especially if any obstruction occurs above, as so frequently offered by liver affection.

Piles may be either *external* or *internal*; or partly internal and partly external. *External piles* consist *at first* of an enlarged vein, which appears at the very verge of the orifice in the shape of a dark-coloured tender swelling, usually about the size of a hazel-nut. In a little time the watery part of the swelling is absorbed and the swelling disappears, leaving some thickening where the skin joins the gut. External piles are very tender and painful, causing much heat and pain about the fundament, especially when calls to stool occur; but they seldom bleed.

Internal piles are composed of an enlarged vein pushing the membrane of the gut before it, and to such an extent that they often assume a pear shape. Internal piles are very insidious in their growth, and sometimes it is bleeding which first attracts notice. A small and unsuspected internal pile may cause anomalous symptoms, such as mentioned under nervousness (*vide* p. 340), the cause of which is not recognised until blood is noticed in the stools. When piles increase in size they cause weight and burning in the gut, straining at stool, frequent desire to make water, sometimes inability to make water, pain in the loins and down the thighs, and whites (*vide* p. 462) in females. Internal piles may also ulcerate, giving rise to dysenteric symptoms (*vide* p. 194). Or they may protrude externally, when, if not returned, they may be constricted by the muscle round the orifice of the gut, when they first swell and afterwards mortify. Internal piles frequently bleed more or less, sometimes profusely. Bleeding from piles takes place as a rule *after* the action of the bowels, and the blood covers the motions; more rarely it precedes the stool; in exceptionally severe cases it occurs independently of the action of the bowels, on the person suddenly standing up, or without assignable cause. If the loss of blood is not excessive, it appears at first to have a salutary effect on stout and robust persons, not, as popularly supposed, by the discharge with the blood of some deleterious matters from the system, but by relieving other organs, especially the liver, of fulness and congestion. In time, however, the loss of blood being repeated, perhaps even daily, the debilitating effect far counterbalances any healthy tendency, rendering the person weak and anæmic, exciting many of the symptoms detailed under nervousness (p. 340) and anæmia (p. 46), and also rendering the person more liable to various diseases, especially ague and scurvy. On the other hand, the *sudden* cessation of bleeding from piles has been followed by apoplexy (*vide* p. 53) and liver congestion (*vide* p. 318).

Both external and internal piles may appear at the same time. At first they present during a short period, and then, becoming smaller, cease to give trouble probably for months. At length, if not properly treated, they become permanent, and if not always bleeding or inflamed, they are the source of continual discomfort. Both varieties are also liable to become inflamed and ulcerated. When piles become inflamed, there is much heat, pain and swelling, which last result may be seen in the case of external piles. There will also be an aggravation of all the symptoms previously enumerated.

The *causes* of piles are numerous. Constipation and the consequent straining at stool, sedentary pursuits, and too long sitting on soft seats have a tendency to excite them. Too much horse exercise or camel-riding, riding in a jolting vehicle, the immoderate use of strong purgatives, especially aloes, are all exciting causes. Warm, moist, and miasmatous climates, by inducing relaxation generally, and of the veins in particular, are also causes. Congestion of the liver is a fertile source of piles, also the frequent occurrence of bowel complaints. The connection between piles and chronic dysentery is noticed at p. 194. Piles are often associated with, or cause, *fissure* or *ulcer of the anus* (*vide* p. 272). Less frequently they are accompanied by *polypus* (*vide* p. 355).

Treatment.—The treatment of piles must be divided into that proper during the painful or inflammatory stage and that necessary when the parts are quiescent. When *external* piles are inflamed, fomentations or poultices should be applied, and the bowels should be maintained open by castor-oil or by sulphate of soda (Recipe 2), which produces watery stools. The patient should be kept at rest in bed, and, if feverish, citrate of magnesia (p. 15) should be administered. After the sore or inflammatory condition has passed away the parts should be bathed frequently with cold water or cold alum water, while tolerably active exercise must be taken, and the bowels prevented becoming costive by laxative medicines, or perhaps by brown bread. The utmost cleanliness is necessary, as dirt may cause the piles to ulcerate, from the irritation it excites.

In the treatment of inflamed *internal* piles, or those not protruding outside the verge, the bowels should be at once thoroughly moved by castor-oil, after which, as poultices or fomentations cannot be applied to the part, injections of warm water may be used. The patient should be kept quiet in bed, and, if feverish, should take citrate of magnesia draughts (*vide* p. 15). When piles are inflamed, whether internal or external, the diet should consist chiefly of broth, toast, eggs, or milk, and no stimulants should be allowed.

When internal piles protrude after stool, they should be sponged with cold water or with alum water (Recipe 100) before being returned. When they do not return, the person should lie down for a time, when perhaps the protruded substance will be drawn back by the action of the bowels. If not, they must be returned by gentle pressure, otherwise they may become constricted and inflamed by the pressure of the verge of the anus. Persons subject to internal piles should acquire the habit of visiting the closet at night instead of the morning, that the piles, if protruding, may be returned when the recumbent posture is about to be assumed, rather than previous to the active business of the day. *Excessive bleeding* may be stopped by injections of cold or iced alum water (Recipe 100).

A host of medicines have been lauded as beneficial in piles; but the cure of piles consists more in hygienic measures, and in attention to diet, than in medicines. The patient should restrict himself to a carefully regulated and temperate diet, with plenty of vegetable food and little meat, abstaining from highly seasoned dishes, pastry, and spirits. He should also take care that his bowels are

kept open, for which Recipe 2 may be used. After each motion the parts should be well bathed with cold water. Regular exercise is desirable. Change of climate to Europe will often relieve piles when other means fail. But frequently a surgical operation is required.

[Of local applications for *external* piles, the best is probably compound gall ointment (Recipe 25). Or a preparation from the American witch hazel, known as 'hazeline,' may be used, being a more cleanly application than ointment. The piles should be bathed with hazeline three or four times a day, and a piece of linen or absorbent cotton dipped in it should be kept applied during the intervals. The best applications for *internal* piles, when not inflamed, is injection of Recipe 100, cold, night and morning; or an ounce of hazeline with a similar quantity of water. When there is tendency to inactive or congested liver, Friedrichshall or Hunyadi Janos mineral waters.]

Plague, or Pestis.—As the disease prevails periodically on the shores of the Euphrates, and as communication with India is frequent and rapid, it is fortunate that plague has not yet been added to the list of ever-present Indian diseases; which, however, might occur at any time. In fact, an epidemic, which, if not true plague, was certainly very similar to plague, has several times prevailed in various parts of Western India. The first symptoms are lassitude, shivering, vomiting, often of black material, and a heavy, stupid expression of countenance, with redness of the eyes. Then there is high fever, and darting pains in the groins or armpits, where large boils quickly form. There is also often an eruption of mulberry-coloured spots or watery blisters on the body. Profuse perspirations are regarded as favourable; diarrhœa, bleeding from the nose or bowels, and delirium are unfavourable signs. The duration of bad cases is only two or three days, but less severe cases may be protracted two or three weeks. The disease may develop in a few hours after exposure to contagion. It may be communicated through the medium of the atmosphere, or by clothes or other articles which have been in contact with the sick. The conditions under which plague arises are a warm, moist, semi-tropical atmosphere; a low-lying alluvial soil, near the banks of rivers; crowded or badly ventilated dwellings; putrescent emanations from decaying animal or vegetable matters; insufficient or unwholesome food. When thus originating it may spread among other populations less influenced by the conditions named. The *treatment* consists in affording a pure atmosphere, in giving light but nourishing food, with stimulants, and in treating the boils as indicated under that heading.

PLEURISY.—Pleurisy is inflammation of the membrane covering the *outside* of the lungs and the *inside* of the chest, and separating one from the other. At the commencement of acute pleurisy there is generally shivering followed by fever, and by sense of weight, or 'stitches' in the chest. This in a few hours becomes acute *stabbing* pain, and is most felt in the side about the level of the nipple, shooting to the front of the chest, to the collar-bone, or to the armpit. There is short dry cough, the breathing is short and 'catching,' being frequently attended by an *expiratory* groan, and the pain is increased by coughing, by taking a long breath, or by lying on the affected side. The pulse is frequent and hard, feeling under the finger like a tense vibrating string. The tongue is furred white, the urine scanty and high-coloured, and the skin hot, rising in temperature to 100° or 102°.

Pleurisy may be caused by cold or by injuries, and often arises during the progress of fevers. If not checked, the result is the effusion of a watery fluid in the membrane placed between the lungs and the inside of the chest, forming dropsy of the chest. In favourable cases the acute pain and fever subside about the fourth or fifth day; but if there be any fluid effused, the cough and difficulty of breathing may persist indefinitely.

Pleurisy may be distinguished from *inflammation of the substance of the lungs* by, *first*, the character of the pain, which is *stabbing* or *lancinating* in pleurisy, but dull and aching in inflammation; *secondly*, by the cough, which is hard, dry, and short in pleurisy, and unattended with expectoration. In inflammation of the lungs the cough is more prolonged, and the expectoration is frothy and 'rusty,' or brown-coloured from admixture with blood. Mild cases of pleurisy may also be mistaken for the neuralgic pain in the side known as *pleurodynia* (*vide* p. 355), and *vice versâ*. *Pleurodynia* is distinguished by its generally affecting the left side of females, and by there being no attendant fever.

Treatment.—The patient should be kept in bed, warm and free from draughts. He should move and talk as little as possible, as motion accelerates the breathing and increases the pain. The diet should consist of eggs, beef-tea, broth, jelly, and fish. As a rule leeches are desirable and they may be applied over the painful part, one for each year of the patient's age, up to thirty in number. If they cannot be obtained, hot bruised poppy-head poultices should be applied over the painful part. As medicine, 3 or 4 grains of Dover's powder every four hours. Restlessness at night may be relieved by chloral. During convalescence care against cold and chill is urgently necessary, and if there is any remaining cough, Recipe 57.

[In young robust persons, if there is much feverishness, tartar emetic mixture (Recipe 59). When pain is relieved or ceases, this medicine must be discontinued. If the mixture produces sickness, the quantity given as a dose should be lessened. If the pain is *very severe*, and the patient a strong robust person, bleeding from the arm may be required, after which the pain is much relieved, and a long breath may be taken with more ease. But bleeding cannot be attempted except under medical advice. The pain may also be combated by the injection of morphia, a procedure requiring the supervision of a medical man.]

Pleurisy, Chronic.—Chronic pleurisy is generally a consequence of the acute form, but occasionally it commences as a sub-acute disease. In either case feverishness at night, a permanently quickened pulse, emaciation, difficulty of breathing increased on exertion, and inability to lie on the healthy side are the principal symptoms. These symptoms may be more or less severe according as the pleurisy is of greater or smaller extent. Such a condition is apt to alternate with symptoms of the more acute form, such as more severe pain, and fever of a *hectic* nature (*vide* p. 269). Chronic pleurisy may exist for months or years, the person so affected sometimes feeling little of the ailment, at others suffering from repeated sub-acute attacks. But in such patients the breathing is generally difficult, particularly on exertion, and there is tendency to night fever and night sweats. The *treatment* consists in supporting the patient's strength and in promoting the absorption of any effused fluid. The *first* indication should be fulfilled by liberal diet and by tonics, as Recipe 66; the second by the frequent application of some counter-irritant, which, in the absence of the remedy mentioned in the small type below, may be mustard poultices to the painful part. The chief means by which increase of the disease may be guarded against is care to avoid cold, for any slight cold is very liable to attack the chest as the weakest part, and to result in an accession of the more acute form of the malady. Intermittent fever or ague must also be guarded against by the use of quinine, for when fever occurs it is very liable to induce an increase of the pleuritic affection.

[The best local application is iodine paint, which should be applied to the side by means of a feather or brush every day, or less frequently after the first two or three days, so as to maintain an irritation of, but not to blister the skin (*vide Appendix*, No. 111). Iodide of potassium (Recipe 21) should also be administered internally. These measures, particularly the iodine paint, should be had recourse to immediately on every fresh attack.]

The ultimate results of either acute or chronic pleurisy may be accumulation of *water* in the cavity of the *pleura*, or membrane between the lungs and walls of the chest, which condition is called *Hydrothorax*, or accumulation of pus in the same position, called *Empyema*. These conditions may be suspected when, after pleurisy, night fever and pain remain, when the person grows emaciated, and when one side of the chest appears more prominent than the other. Such conditions require careful treatment by an experienced surgeon, and are often fatal.

PLEURODYNIA means nervous pain generally occurring in the left side, and especially to debilitated females suffering from chlorosis (*vide* p. 50), or flatulent dyspepsia (p. 204), amenorrhœa (p. 468), whites (p. 462), neuralgia (p. 341), or nervousness (p. 340). For distinction from pleurisy *vide* p. 352. Pain in either side may also be due to rheumatism of the muscles, when the pain is more diffused and movement is painful. A severe pain on either side may also be the precursor of shingles (*vide* p. 396). In either case a mustard leaf or poultice is a good local application. But medicines should be given with the view of remedying the condition with which the pain appears to be associated.

POLYPUS.—A polypus is a pear-shaped tumour, growing from a pedicle or stem. The most usual positions are the ear, the nose, the lower gut, the female privates, and less frequently the throat. Polypi may be soft, gelatinous, and light in colour, or comparatively hard, fleshy, and red. *Polypus of the ear* is noticed at p. 215. *Polypus of the nose* causes a feeling of stuffing in one or both nostrils, sneezing, and discharge, and snoring during sleep when the mouth is kept wide open. Taste and smell are impaired, and the speech becomes thick and nasal, all the symptoms being aggravated by damp weather. When one nostril only is affected, on stopping it by pressure with the finger, the person breathes well through the other. As the polypus grows it may present as a more or less reddened tumour at the entrance of the nostril; or it may hang through the posterior nostrils into the throat, causing constant hawking and spitting. Sometimes the patient feels the tumour flapping to and fro with the breathing, or it may be heard moving. It may cause bleeding from the nose (*vide* p. 510). *Polypus of the rectum*, or lower gut, causes the sensation of the presence of a foreign body in the part, or a feeling of weight and irritation which may be mistaken for piles. There is also frequently acute pain on going to stool very similar to that caused by *fissure* (*vide* p. 272). As the polypus grows it may present at the orifice, and, sometimes partially passing during stool, gets nipped, giving rise to much suffering. Polypus of the rectum is sometimes associated with piles, but the latter are much more common, and bleed much more than a polypus. When polypus of this part occurs, as it sometimes does, to children, it is generally of the red variety, and, presenting at the orifice like a red strawberry, may be mistaken for *protrusion of the bowel* (*vide* p. 84). But polypus is not common, and usually bleeds in children, while protrusion of the bowel is common, and does not usually bleed. *Polypus of the female private parts* gives rise to feelings of local weight and irritation, and the sensation of a foreign body. But polypus is comparatively rare, and such symptoms are mostly due to *displacements of the womb*, for which malady polypus may be mistaken (*vide* p. 478). As it grows it may present at the orifice, and may still be mistaken for a womb affection, so that persistent symptoms of the kind demand professional advice. The only cure for any kind of polypus is remova. by surgical operation.

PREGNANCY, DISEASES OF.—The most usual complaints during this period are as below.

1. INDIGESTION DURING PREGNANCY is generally marked by constipation, by heartburn, and by flatulence. The urine is also altered, often forming a filmy deposit on the surface when allowed to stand. The countenance occasionally becomes sallow, and there are sometimes eruptions on the face. The treatment consists in maintaining the bowels moderately loose by castor-oil, by senna, or by Recipes 1 and 2; in the use of remedies mentioned under *Flatulence* (*vide* p. 273), and in attention to diet, which should be nourishing but easily digestible,

2. Fainting Feelings and Palpitation are more common about the period of quickening, or between the end of the twelfth and the sixteenth week of pregnancy. Fainting feelings, or palpitations, often accompany the first movements of the child, and will be the more persistent and severe if indigestion prevails, or if the person exposes herself to the ordinary causes of fainting, as hot rooms, fatigue, or excitement. Often the least thing affects the patient, and there is frequently a dread felt of something unpleasant happening. A stimulant, as sal volatile or wine, and the recumbent posture are the immediate treatment required. All tight articles of dress should be discarded. But unless care is taken to avoid excitement this nervous condition is liable to result in abortion, or premature labour.

3. Alterations in Disposition and Temper show in various ways. The pleasant-tempered woman may become irritable, and *vice versâ*. There is often capricious appetite and 'longing' for improper or unobtainable articles of diet. Longings, if practicable, may be generally complied with.

4. Morning Sickness.—This generally sets in about the sixth week, ceasing after the third month. But it may commence earlier, and it may continue to the termination of the pregnancy. Most women suffer more or less from nausea and vomiting, especially in the morning, but with some women it continues more or less during the entire day, and may be extraordinarily violent. A minor degree of nausea during child-bearing is popularly supposed to be a good sign, and if only present to a slight degree in the morning, treatment is not required. In other cases great attention must be paid to diet, one article after another being abstained from, in order to discover any offending material. For it sometimes happens that substances taken by women with perfect im-

punity at other times cannot be eaten during pregnancy. Rich, indigestible food, as pastry, made dishes, and salt meat, should be avoided. The bowels must be kept open by castor-oil. Quinine with an aperient if the bowels are confined, as Recipe 66, with the addition of six drachms of sulphate of soda, may be tried. A little tea and toast should be taken in the morning, before the erect posture is assumed. If *acidity* of the stomach is present, the medicines mentioned under such head should be employed. Some women find it a good plan to drink a glass of warm water, and so encourage the sickness for a few minutes, which then passes off, leaving them free for the day. *When vomiting or nausea is very distressing, continuing all day*, nourishment in the shape of good soup and brandy should be administered at intervals of half an hour, but not more than two or three spoonfuls at once. Champagne and soda-water sometimes afford relief. Sal volatile in a little water may be tried. Ipecacuanha wine given in one-drop doses, in a teaspoonful of water, every hour, has sometimes a very good effect. Sucking ice is also often useful, and a mustard poultice to the pit of the stomach should not be neglected. The wet compress may also be tried. This is made by placing several folds of wet linen over the stomach, covering with oiled silk, and then applying a bandage from eight to ten inches wide. This should be drawn moderately tight, and worn for two or three hours every morning. When vomiting is very uncontrollable, an injection of forty grains of chloral in six ounces of lukewarm water may be given.

[Other remedies are effervescing draughts of citrate of magnesia (*vide* p. 15) with two or three drops of chloroform; magnesia in peppermint water, as Recipe 61; also Recipes 6, 16, 22, 36, and 37, any of which sometimes suit one person but not another, nor even the same person at different times. The inhalation of the steam from hot water in which a little laudanum has been mixed in the proportion of 1 ounce of the latter

5. **Toothache or Salivation.**—The pain is sometimes confined to a decayed tooth; occasionally it attacks a sound one. The first, if far gone, may be extracted, although this is not always advisable, as the shock has been in nervous women followed by miscarriage; but a sound tooth should never be taken out. Local applications may be used, as mentioned under *Toothache*, p. 448. But more benefit will be derived from attention to the general health as regards the state of the bowels, of the digestion, and of manner of life in matters of regimen and early hours. Washing the mouth with a tea-spoonful of salt in a tumbler of water is beneficial.

Salivation, or the profuse secretion of saliva, is less common than toothache, but sometimes occurs either in connection with the latter ailment or alone. Astringent gargles may be used (Recipe 100), or a piece of alum may be sucked occasionally. Attention must be paid to the general health, and constipation must be avoided.

6. Swelling of the Legs.—Occurs during the latter months of pregnancy. This condition, and *varicose* or enlarged veins, with which it is often associated, are due to the pressure exercised by the distended womb on the blood-vessels passing from the body to the lower extremities. When the legs are swelled, they 'pit,' or show an indentation when pressed with the fingers. The swelling is much less in the mornings, sometimes totally disappearing after lying down, but soon returning on the erect posture being reassumed. No kind of medicine is of avail; as, until the pressure is removed by the birth of the child, the results must continue. But the condition may be lessened by frequently lying down, by keeping the legs up on a stool when sitting, and by applying bandages, or wearing an elastic stocking.

Note.—If swelling of the face or of other parts of the body takes place, especially if there is *albumen* in the urine (*vide* p. 101), medical advice should be obtained, as it may be the commencement of some serious disease. In the absence of medical assistance the person should be treated as for dropsy from exposure (*vide* p. 187).

7. Cramps of the Legs.—(*Vide* p. 409.)

8. Varicose Veins.—(*Vide* p. 456.)

9. Irritation of the Breasts.—About two months after conception there is an uneasy sensation of fulness, with throbbing and tingling pain, or perhaps pain *below* the breast on the left side. The breasts increase in size, feel knotted, and there is a dark circle round the nipple. There is sometimes a milky or watery secretion from the nipple. These symptoms may cause annoyance, but they may be relieved by keeping the bowels open and by bathing the breasts with warm water.

During the latter month of pregnancy, and especially before the first confinement, the nipples should be bathed twice daily, with equal parts of brandy and water, or with alum water, or with infusion of green tea, and they should be pulled out and elongated with the fingers. Any flannel covering worn over the nipples should be dispensed with. It is also a good plan to expose the nipples to the air for two or three hours daily, which has a similar effect. These measures prevent 'cracking' during suckling, and render the nipple harder and longer, and therefore more easily accessible to the child's mouth. The pain *below* the breast, mentioned above, often depends on constipation, and may be relieved by aperients. When the breasts are tender, heavy, and enlarged, much benefit is experienced by supporting them by a pad of wadding attached to the stays, or by a handkerchief passing under the breast and tied over the opposite shoulder.

10. Piles.—Piles are very common during pregnancy; they are caused by the pressure of the distended womb, and medicines do not much benefit. After confinement

they generally disappear. Avoiding standing about, and lying down frequently, washing the parts with cold water and applying gall ointment (Recipe 95), or hazeline, is the proper treatment (*vide* p. 349).

11. Irritation of the Bladder and Private Parts. Depend on the pressure exerted by the distended womb. *Irritation of the bladder* manifests itself by 'scalding,' by frequent desire to make water, or by inability to retain the water, which frequently passes even against the will of the patient. Some relief may be obtained by drinking freely of barley-water, linseed tea, or lime-water and milk, by relieving constipated bowels, by aperients, and by maintaining the recumbent posture for several hours during the day, lying on either side instead of the back. But often nothing will relieve this condition, until the womb rises sufficiently high, so that the pressure from its bulk on the bladder is removed.

Occasionally not only irritation of the bladder, but even *retention of urine*, or *inability to make water*, is caused by women in the early months of pregnancy neglecting to pass water until the bladder becomes much distended, so that its muscle loses the power of contracting to expel the contents. Females travelling by rail, or in other positions where they are unable to obey the calls of nature, are exposed to this accident. When retention of urine occurs, the person should as soon as possible take a warm bath. If this does not produce the desired effect, she should go to bed, take 10 grains of Dover's powder, and be covered with blankets to produce perspiration, and so relieve the bladder until urine passes naturally, or a doctor can give relief by passing a catheter. Drinking meanwhile should be abstained from, and no medicines, as spirits of nitre or gin, calculated to increase the secretion of urine should be taken, for by such means the distension of the bladder would be increased, while its power of expulsion would be decreased. The bladder, when paralysed in this way, does not recover its tone immediately, and therefore may require to be again relieved by the warm bath or the instrument. When cases of this kind are neglected, and the bladder is distended to its greatest limit, the water may begin to flow off by drops *without the will or even knowledge of the patient.* Nurses are often deceived by this appearance, and fancy that the water having commenced to come will soon flow naturally. But the reverse is the fact, and when this occurs the case demands constant medical aid.

For *irritation of the private parts, vide* p. 365.

12. JAUNDICE.—Usually occurs about the fifth month, and probably passes away before the end of pregnancy, as the pressure causing it is removed by the alteration in the position of the womb. An occasional dose of castor-oil is desirable.

13. MISCARRIAGE.—Miscarriage occurs some time before the sixth month of pregnancy. If the child is born after that time it is called *premature delivery.* The most usual period of miscarriage is about the third month, and it is more likely to happen about the time corresponding with what would have been the natural monthly period had not pregnancy occurred. When it has once occurred it is very likely to happen again. The causes are various, often depending on debility, and often brought on by imprudence in horse exercise, dancing, or from excitement, from passion or fright. It also frequently results from blows, falls, or concussions, such as missing a step coming downstairs, bumps in a carriage, jolting in a palankeen, &c. In other instances it is due to local weakness or disease of the womb. Attacks of dysentery often lead to miscarriage. There is in some women an inherent weakness of constitution, which prevents pregnancy passing on to the full time. Attacks of

malarious fever add to this weakness, rendering miscarriage in such persons an ordinary sequence of conception.

Symptoms.—When threatened with a miscarriage the patient experiences a sense of uneasiness, languor, and weariness, with aching pain in the back, loins, and hips, and a slightly bloody discharge. After these symptoms have lasted a variable time, there are pains very like those of labour, often vomiting, and sometimes profuse bleeding, the blood passed being of a vivid red colour. This may continue for several days, the pain and bleeding recurring at intervals; or the miscarriage may commence suddenly, and the whole be over in a few hours. The *ovum* or *fœtus* is expelled in the shape of a reddish-white ball, the size of a pigeon's egg at three months, and larger in proportion afterwards. After the *ovum* or *fœtus* has passed away the pain and bleeding cease. The danger and after-injury are in proportion to the amount of pain and of attending bleeding.

Treatment.—If the bleeding is slight and the pain trifling, the abortion may sometimes be prevented by *perfect* quiet and rest on a hard bed in a cool room, aided by a dose of 30 drops of chlorodyne in 1 ounce of water, followed by alum mixture (Recipe 42). But if increased pain and bleeding occur, the miscarriage will certainly take place, when the danger to be guarded against is profuse loss of blood. The alum mixture should be continued, the patient should not be allowed to move from the bed, and cloths saturated with cold water should be applied to the external outlet. As before mentioned, the bleeding ceases directly the abortion passes, but it is sometimes necessary to remove the mass with the fingers. The after-treatment requires as much care as after confinement. The patient should rest in bed seven or eight days and then return gradually to her employments, while the diet should be simple, and the bowels be maintained moderately open. Getting about too soon after a miscarriage is not unfrequently the origin of some malady of the womb, from which the woman may long suffer.

[A better medicine than the alum mixture mentioned above is Recipe 43, which, if possible, should be procured and used.]

PRIVATE PARTS, FEMALE, DISCHARGE OF THE.—This may arise from *gonorrhœa* (*vide* p. 281) or from *whites* (*vide* p. 462). Discharge may also occur in children, as a result of the irritation caused by *worms*, especially by *thread-worms* (*vide* p. 487), or from *constipation* (*vide* p. 138); particularly when little balls of hard fæcal matter are allowed to collect in the lower gut. Discharges occurring to female children may arouse suspicion of unfair usage; but they are commonly due to the causes indicated. The treatment consists in finding out and in removing such causes; in cleanliness; and, as the malady mostly occurs to weakly children, in giving good nourishing diet, and, after removal of the causes, tonic medicine (Recipe 66).

PRIVATE PARTS, MALE, DISCHARGE FROM THE.—Generally occurs from *gonorrhœa* or *gleet* (*vide* p. 281). But a glairy, clear, ropy discharge may present when there has been neither gonorrhœa nor gleet, when it will probably be due to irritation of the parts, consequent on *Piles* (*vide* p. 347), or on *Worms* (*vide* p. 487), or on *Varicocele* (*vide* p. 454), or on *Constipation* (*vide* p. 137).

Another malady of the kind is known technically as *spermatorrhœa*, and consists of nocturnal discharges of a milky appearance. Occasional discharges of this description are of no consequence. In severe cases similar discharges may occur during the day. Often this depends on certain bad habits, and the result will cease when such practices are discontinued. Such discharges are often associated with dyspeptic symptoms, and the patient is frequently out of health, his system below par, and influenced by some disappointment or mental anxiety. The recurrence of the symptoms tends to exaggerate the depressed condition, the mind of the patient dwells needlessly upon it, and he erroneously supposes the malady to be of great importance. This, however, is not the fact. If there are piles, or varicocele, or constipation, these maladies must be treated, and not the effect they cause. If there are dyspeptic symptoms, treatment must be directed towards them (*vide* p. 197). If the spirits are depressed, change of employment, or relief from mental occupation, and change of locality are indicated. In the meantime the bowels should be kept open, and the closet should be visited in the evening, so that the lower bowel may be emptied before the person retires to rest. Late suppers should be avoided, and no spirits should be taken. The patient should sleep on a hard bed, and be lightly covered, and he should not lie on his back. To prevent this, some solid substance fastened with a handkerchief on the back, a little below the loins, is a good contrivance. As medicine, if there are no prominent dyspeptic symptoms requiring treatment, and if the bowels are sufficiently open, quinine and iron (Recipe 70), with double doses of bromide of potassium (Recipe 19) at night.

The following pill is very beneficial. Phosphorus *one-fiftieth* of a grain, extract of nux vomica one-fourth of a grain, precipitated carbonate of iron 1 grain. Dose—one, thrice daily.

PRIVATE PARTS, IRRITATION AND ITCHING OF THE. —Irritation of the private parts often takes the shape of intense itching or smarting, which prevents sleep, and so destroys the health. It may depend on thread-worms (*vide* p. 486), or lice (p. 613), or irritable bladder (p. 73), or whites (p. 462), or eczema (p. 396), or gout (p. 282), or diabetes (p. 164); or it may be sympathetic with cancer of the womb (p. 111), and it often occurs during pregnancy (p. 362). The itching may or may not be associated with an eruption of minute watery vesicles. The treatment must depend on the cause. As a local application for intense itching, bathing with cold or iced water is the best remedy. If the itching is accompanied by the eruption of vesicles mentioned above, alum water should be used. Sometimes much relief may be obtained by bathing with cold poppy-water (*vide Appendix*, No. 81).

A good lotion is made as follows: borax, a tea-spoonful; hot water, a pint; peppermint oil, 5 drops; to be used frequently with a sponge. Shake well before using.

PRIVATE PARTS, FEMALE, OCCLUSION OF THE.—This consists in the apparent formation of a skin at the orifice, uniting the two sides, which seem thus grown together. It depends on the collection of the natural discharge near the orifice, and although of some strength and thickness, it is not a new growth. The urine of children thus affected often squirts in a backward or forward direction, which may first attract attention. It chiefly occurs to children who are not kept properly clean. The remedy consists in breaking the obstruction down with a probe or a quill, in applying a little salad oil to the parts, and in perfect cleanliness.

PROSTATE GLAND, ENLARGEMENT OF THE.—The prostate gland surrounds the *urethra*, or urinary passage at the neck of the bladder, and is liable to several diseases. The most important disease of the gland is *slow enlargement*. This is most common after middle age, and is characterised by frequent calls to make water, especially during the night, increasing slowness and difficulty in making water, and straining. But straining does not much increase the flow of urine, which falls directly forward and is not ejected in a stream. There is a sense of weight in the fork so that the patient often imagines he has piles. The enlarged gland mechanically prevents the bladder being perfectly emptied, and the urine remaining decomposes and becomes ammoniacal, setting up chronic inflammation of the bladder (*vide* p. 71). Then the urine is loaded with sticky, tenacious mucus, or purulent matter, which adheres to the bottom of the utensil, and is frequently tinged with blood. There may also be fits of complete retention of urine (*vide* p. 420). Bleeding, sometimes copious and sudden, may also occur. The early symptoms of enlargement of the prostate are sometimes very like those arising from other causes, as *stone in the bladder* (p. 73) and *stricture* (p .419), so that physical examination is usually necessary to decide the point.

Treatment.—This disease is seldom cured, although much may be done to retard its progress. The patient must avoid irregular diet, fatigue, and exposure to cold. The bowels should be kept open, so that there may be no straining at stool. Enemas of warm water will prove beneficial for the relief of occasional fits of spasmodic pain.

The urine should be frequently tested with litmus paper (*vide* p. 288). If the urine is acid, Recipes 35 and 37 may be tried in succession. If the urine is ropy and thick as well as acid, Recipes 27, 28. If the urine is neutral, known by no change in the colour of the paper, Recipe 31. If it is alkaline, and especially if also thick and ropy, Recipes 33, 34; the former being advisable if the liver is not acting. The passage of a peculiarly shaped catheter may be also necessary, so that the malady is one requiring the daily attention of a surgeon.

RHEUMATISM, ACUTE.—Acute rheumatism, often termed *rheumatic fever*, is more common in young than in old persons; it commences usually after exposure to damp cold, with fever, a full quick pulse, hot skin, coated tongue, and scanty urine which deposits a dusky reddish sediment. The pain generally comes on in one of the larger joints, which is highly inflamed, red, and swollen, so that it cannot be moved, and the slightest touch is shrunk from.

The inflammation may attack several or all the joints, but more commonly two or three are affected one day, and then others are suddenly attacked, the first joint implicated growing, almost as suddenly, comparatively well. There are also frequent sour perspirations, which do not afford relief. These perspirations are often accompanied by an eruption of small vesicles known as *sudamina* (*vide* p. 399), which is caused by the heat and moisture, and is of no consequence. The duration of the disease may be a fortnight to three weeks, when complete recovery may occur, or stiffness and pain in the joints may remain. If the temperature of the body rises to 105° Fahr. it is an alarming symptom indicating *heart affection*, as described below.

A frequent accompaniment of acute rheumatism is *affection of the heart*, the disease extending inwards and attacking that organ. Sometimes the symptoms are very faintly pronounced, but there will be more or less sharp cutting pain in the left side, increased by taking a long breath, a feeling of distress or tightness of the chest, short hacking cough, and more or less difficulty of breathing. There may also be occasional palpitations and irregularity of the heart's action, manifested by the pulse being irregular, feeling *small* under the finger, and affording a peculiar jar or thrill to the touch. During an attack of rheumatic fever such symptoms should be daily watched for, as they denote a serious aggravation of the illness, from *inflammation of the membranes* covering or lining the heart. Of the latter membrane are formed the delicate valves guarding the portals of the four chambers of the heart. When these valves become inflated there is tendency to deposit of material from the blood upon them, or they may be contracted, or their action otherwise interfered with. Then there is an impediment to the easy passage of the blood, which even years afterwards may evidence itself by alteration in the sounds of the heart, and by the result—*dropsy*—from which death sooner or later occurs. Acute rheumatism, from its tendency to affect the heart, must always be regarded as serious.

Treatment.—In ordinary cases clothe the patient in flannel, keep him at rest during the whole period of the disease, and apply a hot alkaline lotion to the affected joints. The lotion should be composed of half a pound of common carbonate of soda dissolved in one quart of hot water, or, if obtainable, of poppy-head water (*Appendix*, No. 81), with which cloths should be well saturated, wrapped round the parts, and the whole covered with oiled silk, or other waterproof material. If the pain from movement is not too great, a hot bath at 98° Fahr. should be given daily, a couple of pounds of common carbonate of soda having been previously dissolved in the water. If the bowels are not moved naturally, they should be acted upon occasionally by Recipes 1 and 2, and citrate of magnesia draughts (*vide* p. 15) should be taken three times daily. Dover's powder in 10- or 15-grain doses may also be given at night when sleeplessness from pain is complained of. When the symptoms indicate extension to the heart, mustard leaves or poultices should be applied over the seat of pain, the patient should be forbidden to talk much, the Dover's powder should be continued at night, and Recipe 50 should be given very frequently, or every three hours. Low diet, no meat, and abstinence from stimulating liquors are necessary.

[If procurable, give the following: salicylate of soda, 3 drachms; distilled water, 12 ounces. Dose—two table-spoonfuls every three hours. Or if the case is very severe, with much pain and swelling of the joints, salicylic acid and morphia, Recipe 29. Either of these medicines often does much good; but if so the relief is experienced within two days, in which case it should be given less frequently. But salicylate of soda, or salicylic acid, in exceptional cases, or given in larger doses, may produce nausea, noises in the ears, deafness, delirium, or albumen in the urine (*vide* p. 101). When using these medicines the urine should be examined twice daily, and if any albumen presents, or if symptoms as above occur, the medicine should be stopped. If no relief is obtained the colchicum and alkaline mixture (Recipe 52) should be used. If the heart becomes affected a blister should be applied if obtainable, instead of mustard.]

RHEUMATISM, CHRONIC.—Is most frequent in elderly persons, especially in those classes exposed to vicissitudes of weather, and who are ill-fed. Chronic rheumatism may attack the joints, when it is termed *Rheumatoid Arthritis.* Or it may attack the muscles, when it is termed *Muscular Rheumatism.* There is pain in the larger joints, accompanied sometimes with swelling, but the smaller joints, as the knuckles of the fingers, do not always escape. It is to this form of the malady that the term *Rheumatic Gout* is often applied. In old cases of joint affection, cracking or grating sounds may be heard when the limbs are moved. With chronic rheumatism there is generally neither fever nor perspiration. Sometimes the pain is relieved by warmth, in other cases warmth increases it. The first thing to attend to is the removal of the causes by which the malady is kept up. Rooms with damp floors and walls, insufficient clothing, especially want of flannel, and absence of nourishing diet, are among the most prominent. As medical treatment, warm clothing, generous living, Dover's powder occasionally at night, and rubbing the parts with grass oil may be recommended.

Lumbago (*vide* p. 324) is a form of muscular rheumatism; *Sciatica* (*vide* p. 378) is frequently combined with muscular rheumatism. *Stiff Neck*, which is also muscular rheumatism, may often be much relieved by spreading a layer of cotton-wool over the part, and then ironing it with a hot flat iron.

[As internal remedies, Recipes 30 and 52 may be procured and tried in succession. As external application, Recipe 80.]

RICKETS.—This disease is an imperfect development of the bones, which, being deficient in earthy salts, become soft and yielding. It is a disease of early infancy, and sometimes exists at birth, although often not recognised till the child begins to walk. Rickets is most likely to occur from six months old till all the teeth (which are always backward) have appeared, but it may present up to seven years old. It usually occurs to scrofulous or to delicate children, particularly if they have suffered much from bad nutrition consequent on repeated or long-continued *disorder of the stomach* (*vide* p. 417); or if they have been fed too exclusively on farinaceous foods (*vide* Chapter V., *On the Feeding of Children*; or *Index*). Unhygienic conditions, as damp residences, want of ventilation, and unsuitable clothing, add much to the liability to the disease. The first symptoms are common to several diseases of children, viz. fretfulness, irritability, capricious appetite, disordered bowels, with lead-coloured stools, thick urine, and emaciation. Probably the first thing which attracts the attention of the mother or nurse, beyond the fact that the child is peevish, and that its food does not appear to do it good, will be sweating of the head at night. There is also slight fever, followed by swelling of the bowels, which often feel knotted; the condition, in fact, described as *atrophy* (*vide* p. 66) being established. Then there is profuse perspiration at night of the whole body, with a tendency to kick the clothing off. The joints, especially the knees, ankles, and wrists, now grow tender, and become swollen, thickened, and knotted in appearance; or as if surrounded by a ring of bone. To this the term 'double-jointed' has been applied. The legs may bend outwards or inwards, with the results, perhaps, of permanent 'bow leg' or 'knock-knee.' The child cannot stand, is unable to turn itself in bed, and dreads to be touched. There may also be a thinning of the bones ot the head, especially at the back; and the *fontanelles*, or spaces between the bones at the top, do not close, giving the head a large appearance. Sometimes the head is incessantly rolled from side to side, often making a bald place on the back of the head. Sometimes the spine or bones of the chest become affected, and there may be permanent deformity of the spine, or the condition known as 'chicken breast.' Before this occurs, if the fingers are passed carefully down the front of the chest, two rows of little bony knobs may be felt. A child with rickets always looks prematurely old and careworn, and there is an unnatural brilliancy of the eyes. The disease may last months, and may terminate from exhaustion, from diarrhœa, or from some affection of the chest supervening, or less frequently from convulsions. The first signs of recovery are the child being able to move better, decrease of emaciation, and natural stools.

Treatment.—Recipe 66 may be used. Also lime-water (Recipe 25) and milk in equal parts. Animal broths should also be given freely, but vegetable food more sparingly. A little port wine may be usually taken with advantage. Plenty of fresh air, ventilation of sleeping-rooms, freedom from damp, and warm clothing are imperative. Sea- or salt-water baths, or, if movement is painful, salt-water sponging, are beneficial. The child should sleep on a good even mattress, and should sit up as little as possible. He should also be kept from walking till the bones are able to bear the weight. If the spine is affected he should lie mostly on the back.

Cod-liver oil, and citrate of iron and quinine (Recipe 70) are required, or iodide of iron (Recipe 74) if the bowels are enlarged.

SALIVATION.—This term signifies an increased and unnatural flow of saliva. The salivation occurring to pregnant women is referred to at p. 359. But salivation may occur from inflammation of the gums and mouth, as the result of cold, of debility, of indigestion, of teething, and of taking mercury and some other substances. In such cases there are swelling of the cheeks, tongue, and gums, enlargement of the glands under the jaw, stiffness of the latter, shooting pains in the face, fœtor of the breath, and a profuse discharge of saliva. *When salivation has been caused by mercury*, the fœtor is more marked and peculiar, and there is a more or less distinct red line on the gums near the teeth. As the swelling becomes greater the tongue and cheeks are indented by the teeth, and ulcers form. The usual duration of mercurial salivation is from ten days to a fortnight; in some cases the inflammation may be more prolonged, and the resulting ulcers slower in healing. The treatment should consist in the use of astringent gargles, of which alum is one of the best (Recipe 100), or port wine and water in equal parts may be used, sometimes one, sometimes the other appearing to suit best. The patient's strength must be supported by fluid but nourishing and easily digestible diet. Afterwards, or *when salivation has occurred from debility from the first*, tonics, as quinine and iron (Recipe 73), will be advisable, while remaining ulcers should be daily touched with a concentrated solution of alum (3 drachms of powdered alum in 1 ounce of water), or with vinegar applied by means of a feather or camel-hair brush.

[Recipes 102 and 103 should be procured and used if the alum gargle is not satisfactory.]

SCARLET FEVER or SCARLATINA.—The latter word signifies the same as scarlet fever. It is not a diminutive, and is not properly employed to denote milder cases. Scarlet fever is not so common in India as in England, but becoming more so, consequent on successive importations from Europe. Scarlet fever is a contagious eruptive fever, generally occurring early in life. It seldom happens twice to the same person. The *cause* of scarlet fever is the conveyance in some way or another of the germs of the disease from the sick to the healthy. The active poison is believed to be an organism or *microbe* which has been found in the blood of the patient, in the scurf or peels of skin cast off, and in the breath. It has also been found that cows affected with small vesicles on a red and swollen teat, and with shedding of the hair in patches, develop a similar microbe, which, impregnating the milk, is believed to give rise to scarlet fever in those drinking it. The disease has also been supposed to be conveyed through the medium of books from circulating libraries, and it may be carried in any article of clothing. The germs may also adhere to the walls and furniture of rooms, giving rise to the malady in fresh occupants after a lengthened period, even of months. In the earlier stages especially the exhalations from the mouth and throat may convey the disease, if such exhalations are incautiously inhaled by a healthy individual; but in the latter stages the scurf or flakes of skin cast off are more likely to convey the malady if inhaled or swallowed by another person. The time at which the disease ordinarily appears after exposure to infection is from seven to ten days, although there are many instances when it showed itself much quicker, within twenty-four hours, and when it developed later, up to fourteen days. The time at which a patient ceases to be capable of conveying infection is not less than ten weeks after the appearance of sore-throat and rash. Complete freedom from scurf and scales is not, as often assumed, sufficient evidence of a patient being free from infectious material. After five weeks the danger is very much lessened; but complete safety cannot be assumed in less than ten weeks.

Symptoms.—The symptoms of an ordinary case of scarlet fever are as follows. For twenty-four hours there are chills or shivering, followed by fever, sore-throat, nausea, pains about the limbs and body, and often vomiting and diarrhœa, the urine being scanty and high-coloured. Sore-throat is the main characteristic of scarlet fever, as cough is of measles. The throat is vivid red, the redness being equally diffused over the tonsils and back of the throat, which distinguishes it from ordinary inflammation of the tonsils (*vide* p. 441), which usually affects one side. In young children convulsions, or premonitory symptoms of convulsions (p. 144), occasionally occur. The rise of temperature is very marked, often, as tested by the clinical thermometer (p. 34), rising to 105° on the first day, while the pulse may be 120 or much quicker in children (*vide* p. 31). On the second day the rash appears, spreading from the face and neck, over the breast, trunk, and limbs. But the rash is not (as in small-pox) attended with any diminution of the fever. First there are a multitude of minute red points. Then these run together, or others appear, until the whole surface of the skin is uniformly scarlet, without (as in measles) patches of intervening healthy-looking skin. The skin now begins to itch intolerably. The whites of the eyes may also become scarlet. The tongue presents characteristic red spots with white fur between, looking as if powdered with cayenne pepper. If not previous to, then accompanying the eruption, one or more glands in the neck may enlarge, causing increased difficulty of swallowing. The tonsils are now often coated with specks of white mucous deposit, which is different from the harder yellowish patches of exudation in diphtheria (*vide* p. 177). The rash generally lasts till the fifth or sixth day, when it begins to decline, disappearing on the eighth or ninth day with much scurfiness of the skin, which sometimes comes off the hands and feet in large flakes or scales. Occasionally this scaling commences earlier, or it may be delayed, and not be entirely completed for some weeks. When the attack is severe there is always much fever and often delirium at night, and in children there may be convulsions. The duration of an ordinary case is fourteen or fifteen days.

There is great variability in the symptoms of scarlet fever. During epidemics, cases occur, in which sore-throat is the *only* recognisable symptom, but the malady is nevertheless scarlet fever, and infectious. On the other hand, it is liable to assume aggravated forms. The tonsils or the glands of the neck, or both, may 'gather.' The throat affection may extend to the ears, causing violent pain, or inflammation in those organs. In another variety the face is dusky, the rash livid in colour, discharges occur from the female privates, and the fever is typhoid in character. The danger is then extreme, and the patient requires stimulants most urgently. In a third form of the disease the fever and sore-throat may appear without any rash. This variety is often fatal, and may be mistaken for diphtheria. The urine may become dusky and contain albumen (*vide* p. 101), symptoms which should be watched for, as they may be indicative (especially in children) of supervening convulsions, of head affection, of nephritis (*vide* p. 314), or of other future kidney malady.

Sequelæ.—After almost any variety of scarlet fever, the person often shows much debility for some time, and is liable to different kinds of dropsy. The whole body may become swollen (*Anasarca, vide* p. 187), the urine scanty and smoke-coloured, and the kidneys affected as in Bright's disease (*vide* p. 100); or there may be swelling of the abdomen only (*Ascites, vide* p. 188), or enlargement of one or more of the joints. Discharges from the nostrils, or from the ears, ophthalmic affections, permanently enlarged tonsils, and troublesome diarrhœa, are also frequent sequelæ.

Scarlet fever may be mistaken for measles. The prominent symptoms of each are therefore contrasted.

Measles	Scarlet Fever
Cold in the head.	None.
Hoarse cough.	None.
Eruption crimson-coloured.	Vividly scarlet.
Eruption raised in crescent-shaped patches.	Not raised, not crescent-shaped.
Affection of the chest or bronchitis accompanying.	Affections of the throat accompanying.
It is very common in India.	Seldom occurs in India.

Scarlet fever may be further distinguished from the eruption of measles, or from erythema, or erysipelas, by the production of a white line on the skin by scraping it with a pencil or the back of the finger-nail. This white line lasts a minute or so and then disappears—a condition not produced in the other forms of skin affection mentioned.

Treatment.—The diagnosis of scarlet fever from measles is important, as in the latter disease the patient should be at first kept warm, in order to guard against affections of the chest. In scarlet fever the patient should be at first kept moderately cool until after the eruption shows, when more clothing should be allowed. The patient should be placed in a well-ventilated room, and isolated to prevent the spread of the disease to others. During the preliminary fever, cooling draughts, as citrate of magnesia (*vide* p. 15), should be given, and the bowels should be opened by castor-oil or senna for a child, and by sulphate of soda (Recipe 2) for an adult. When the eruption has fairly come out the use of violet powder, or sponging gently with tepid water, is often both grateful and beneficial, or, if possible, a warm bath should be given every night. The diet should consist of good broths and gruels, and when convalescence is established a more generous diet.

with iron and quinine, should be allowed. When the throat is much inflamed or ulcerated, a poultice of linseed meal, or hot moist flannels, or sponges, may be applied externally, and a solution of alum of the strength of five drachms to the ounce of water should be brushed over the tonsils, or three or four grains of finely powdered alum may be blown into the throat from several quills joined together or from a long glass tube. The throat should also be well steamed internally several times daily, by permitting the steam of hot water to pass into the mouth. Sucking ice generally relieves the thirst, and sometimes the throat also. The ventilation of the sick-chamber, the prompt removal of *excreta*, the support of the patient with nourishing diet, especially in those cases where the throat is very inflamed, or when little or no eruption appears, and the avoidance of all causes of nervous or mental excitement, especially when there is albumen in the urine, are the principal measures of cure.

Scarlet fever is very infectious. The patient, therefore, should be isolated from the first. The sick-room should be cleared of all needless furniture or drapery, and all the rules given regarding 'disinfection' should be strictly carried out. (*Vide Appendix*, Nos. 121 to 130.)

If after scarlet fever any portion of the skin peels off in flakes, anointing with sweet oil or glycerine will relieve the soreness. Dropsical swellings, or other after-effects of scarlet fever, must be treated as mentioned under the heads of the different ailments.

If obtainable, disinfect the throat twice daily by painting it inside with boracic acid—2 drachms dissolved in 1 ounce of glycerine. Also, after the sponging or warm bath, when the eruption begins to subside, apply the following ointment to the whole body: carbolic acid 30 grains, thymol 10 grains, vaseline 1 drachm, simple ointment 1 ounce.

SCIATICA.—Sciatica is a painful affection of the large nerve passing down the back of the thigh. There is acute agonising pain extending from the buttock to the ham. It is known from rheumatism by the pain, being limited to the course of the sciatic nerve, and by being little if at all aggravated by motion, although increased by pressure. But sometimes the muscles near the nerve are also affected with rheumatism, when the distinction is not so clear, as the pain is felt in the whole of the back part of the limb instead of in a line nearly in the centre. It may originate from cold, or from sitting on a wet seat; or in more rare cases it is a consequence of constipation, being then produced by the direct pressure of fæcal matter in the bowels on the sciatic nerve, before it passes by the nates. The *treatment* consists in rest, wearing warm flannel drawers, hot fomentations, the use of the hot flat iron as recommended for stiff neck (*vide* p. 370), or mustard poultices or small blisters over the more painful parts. Purgatives, as Recipes 1 and 2, in full doses, should also be given. In cases connected with rheumatism the treatment appropriate to chronic rheumatism should be employed.

[Galvanism may also be tried; and the subcutaneous injection of morphia is often most beneficial.]

SCROFULA.—This is a depraved condition most frequently hereditary, and is indicated by two different but common types, both of which are very liable to tubercular affections (*vide* p. 88). The *dark* type is characterised by coarse black hair, a thick upper lip, wide nostrils, frequently ill-shaped features or hands, clubbed nails marked with lines, and ill-proportioned body and limbs. The scrofulous child thus indicated may be weak in intellect, and is particularly liable to *enlargement of the glands* of the neck, often ending in abscess; to *enlarged tonsils*; to *discharges about the ear*; to *ophthalmia* and *ulcers of the cornea*; to certain skin diseases, especially *eczema*; to *atrophy*; to *disease of the joints*; and less frequently to *rickets.* If the child grows up it is pale, ill-nourished, and still prone to eruptions, to swelling of the glands in the neck, to unhealthy ulcers, and to affections of the joints. The second or *light* type of scrofula often exhibits what many call beauty. There are a thin skin, clear complexion, rosy cheeks and lips, blue bright eyes, large pupils, long eyelashes, silken hair, oval face, delicately chiselled features, small bones, and the veins are distinctly visible through the skin. The intellect is often powerful, and sometimes precociously developed. Children thus characterised are more liable to *bronchitis*, to *atrophy*, to *water on the brain*, and, as they grow up, to *consumption*, than to the maladies mentioned above as most frequently associated with the *dark* type. Scrofula is in many instances dependent on some hereditary constitutional taint, but it may be excited by poor living and damp lodging, by unventilated apartments, combined it may be, with drunkenness and venereal taints. Matches between near relations are also supposed to engender scrofulous children. Good air, good food, cod-liver oil, and exercise may eradicate the taint.

SCURVY is popularly supposed to be a scab or scurf on the skin, which is erroneous, as it consists of an alteration in the blood and tissues of the whole body. Scurvy may be either *declared* or *latent*. *Latent* or *hidden* scurvy is much more prevalent in India than is supposed, arising from a difficulty experienced in many positions into which residents are thrown, of obtaining a sufficient amount of fresh vegetable diet possessing anti-scorbutic properties, and which no indigenous vegetable does possess in any useful degree. There is another cause why, among Europeans, the scorbutic taint frequently exists, either hidden or declared. Even those with a table well supplied with fresh vegetables often insensibly acquire a habit of eating less vegetable material as part of their daily food than they would do in

Europe. This partly arises from loss of appetite during the hot weather, and partly from soups and curries being mainly composed of animal constituents, resulting in a diminution of vegetable matter in food which is consumed. Another cause predisposing to scurvy in India is the darkened dwellings in which so many persons exist during half the year. The hot wind, and with that the light, are shut out by many Europeans, while most natives live in a hut, or even the better classes in a house, probably with only small external openings. As plants when deprived of light become white, so human beings become pale, weak, spiritless, unhealthy, and anæmic.

Latent Scurvy.—1. A minor degree of the degeneration constituting scurvy may exist for an indefinite period without any appreciable symptoms. 2. It may cause what at first appears to be simple anæmia. 3. It may manifest its presence by delaying convalescence from other diseases, by causing a slight bruise to become an ulcer, or by retarding the healing of sores, such sores often not presenting the usual spongy appearance and propensity to bleed of the confirmed scorbutic ulcer. 4. Maladies, as the Delhi and other boils and sores (*vide* p. 77), may be frequently traced to those conditions under which scurvy arises. 5. Scurvy sometimes develops itself by such premonitory symptoms as *malaise*, wandering rheumatic pains, a little puffiness under the eyes, ulcers of the mouth and soreness of the tongue, the gums being unaffected and no other symptoms of scurvy being present. In children the latent scorbutic condition is favourable to the development of aphthæ (*vide* p. 446). 6. Natives suffer considerably from chronic inflammation of the roots of the teeth, which is mostly scorbutic. 7. Debility and palpitations of the heart with dropsical swellings, especially of the abdomen, may exist in badly fed people, apparently partly as the result of starvation and partly as the result of scurvy. 8. A diarrhœa with chocolate-coloured stools may be the only manifestation of the scorbutic condition. 9. A chronic ophthalmia may be the result. 10. It may cause the development of gout. 11. It may appear as beri-beri (*vide* p. 384). 12. It may cause *purpura*; a condition in which the skin, especially of the legs, becomes studded with dark-coloured spots of various sizes, originating from the rupture of little blood-vessels in the skin.

DECLARED SCURVY.—The symptoms of scurvy *when the disease has passed the latent condition* are—soreness of the gums, weariness, dejection of spirits, dull pains in the limbs, palpitation, and shortness of breath. The tongue becomes pale and flabby, the complexion muddy, the lips bluish or livid, the eyes surrounded by a dark circle. The gums grow more affected, swollen, spongy, and bleeding on the slightest touch. The teeth are often loose, the breath foul, and as the disease advances blue spots, like bruises, appear on different parts of the body. Slight pressure or injury now produces a bruise, scratches become ulcers, and old wounds or scars open afresh. The joints become swollen and stiff, great emaciation takes place, 'puffy' dropsical swellings appear, diarrhœa or dysentery sets in, bleeding may occur from the gums, nose, or bowels, and the patient dies exhausted.

Treatment.—In all cases of scurvy, whether simply manifested by obscure premonitory symptoms, or when evident and confirmed, the use of fresh vegetables and of fresh meat is the great remedy. But the meat should be quite freshly killed, as certain chemical changes occur after a few hours, rendering it less anti-scorbutic. Plenty of salt should be eaten with the food. Milk should also be taken *ad libitum*, and if fresh milk cannot be obtained, preserved or condensed milk may be used. The *fresh* milk of the cocoa-nut is esteemed anti-scorbutic, and if available several pints may be drunk daily. Lemon-juice should also be taken to the extent of two or three ounces daily, or, if this is unobtainable, nitrate of potash (*vide* p. 26), in 10-grain doses, may be given twice a day. As adjuncts, fruits (especially oranges, lemons, limes, apples, grapes, and pummaloes), sugar and molasses, cocoa, pickles, vinegar, onions, all the *cruciferous* vegetables (as broccoli, kale, cabbage, turnips, mustard, cress, watercress, radishes, spoonwort or scurvy-grass), and potatoes will be the most beneficial. Wine (as sauterne, grave, claret), ale and beer, and a fresh infusion of malt, should also be given. If aperients are required, fresh infusion of tamarinds or sulphate of soda may be used. Ulceration of the gums requires astringent gargles of alum, or of port wine and water, or of decoction of pomegranate (*vide* p. 25). If diarrhœa persists, a milk diet is advisable, and syrup of bael (*vide* p. 22) should, if procurable, be taken as a medicine. When debility is very marked the recumbent posture should be maintained, or faintings, which have proved fatal, may occur.

If fresh meat cannot be procured, 'Liebig's extract of meat' is recommended, as it contains in a condensed form those substances (salts of potassa) which are required. If the aperients mentioned are not satisfactory in action, cream of tartar may be used in 1- to 3-drachm doses.

The *cure* of scurvy is more difficult than its *prevention*, and the latter should be constantly held in mind by those placed in such positions as to be exposed to scorbutic influences. The diet should contain a proportion of antiscorbutic material, and if fresh meat and vegetables cannot be obtained in sufficient quantities, vegetables which may be kept—as potatoes, onions, or preserved vegetables, or bottled lime-juice, or vinegar and milk—should be used daily. *Amchur* or *kuttai* (dried unripe mangoes) may be powdered and mixed with soup or vegetables, the dose being an ounce daily. Other preventive measures, whether on board ship or on land, consist in great attention to cleanliness, in ventilation, in a suitable degree of warmth, and especially in freedom from damp.

THE FORM OF SCURVY KNOWN AS BERI-BERI.—*Beri* is the Cinghalese for weakness, and the repetition of the word implies great weakness. The symptoms of beri-beri are great debility, stiffness of the legs and thighs, succeeded by numbness and swelling of those parts, with great difficulty in using the limbs. In the course of a few days, or even hours, the body becomes swollen, the breathing quick, and the pulse feeble, while the urine is very scanty, and the thirst great. Diarrhœa and insensibility terminate the illness. The causes are exposure to cold, damp, and night land winds, particularly when the person is debilitated by declared or latent scurvy. Beri-beri frequently occurs to natives living on the damp sea-coasts of Western India, or in persons long confined on board ship, or in others who, proceeding into the semi-desert districts of the west, cannot procure the more liberal diet and fresh vegetable material to which they have been accustomed. Europeans seldom suffer from the malady. Medicines to promote the flow of urine and to increase the action of the skin should be used. Half a drachm of sweet spirits of nitre may be given in a little water three times a day, and 8 or 10 grains of Dover's powder at night. A mustard poultice should be applied daily over the loins. Lime-juice and fresh vegetables should form a main feature of the diet. Wine and brandy will probably be required from the first, and should be freely given, to the extent of 6 or 8 ounces of wine, and half that quantity of brandy, daily.

[Other medicines which may be procured are—Recipe 11 if the bowels are confined, and the person has not been previously in a weak state of health; Recipe 15 to relieve constipation in a weakly person. Then Recipe 53 may be substituted, as preferable to the spirits of nitric ether alone.]

SCORBUTIC ULCER.—Trivial injuries in those affected with scurvy frequently cause ulcers, of foul, spongy, ill-conditioned appearance, and inclined to bleed. Eating into the flesh, they may produce great injury and disfigurement. They have often prevailed epidemically among troops and sailors who had become more or less scorbutic. These ulcers may attack any part of the body, and are attended with impaired appetite, foul tongue, spongy gums, and debility. Treatment consists in anti-scorbutic remedies internally, and the external application of various lotions or ointments, as Recipes 86 or 97.

[But a better application for a scorbutic ulcer is Recipe 96, or, if the sore is painful, Recipe 93, which should be procured for use.]

SEA-SICKNESS.—There are many remedies of doubtful efficacy; none decidedly curative. Cold brandy and water benefits some persons. Champagne suits others. Making a continuous expiratory effect as in whistling, when sinking sensations are felt, is sometimes beneficial. So is a tight belt or bandage round the body with a pad, so as to produce pressure on the stomach.

[Two drops of creosote on a lump of sugar will sometimes check the sickness. Five drops of chloroform on a lump of sugar, or in a glass of sherry, with half a tumbler of cold water, is often successful. Or chloroform globules, each containing about 5 minims of chloroform, may be procured from the chemist. Cocaine tablets containing one-twentieth of a grain of cocaine hydrochlorate are portable and efficacious, and may be tried. Applying ice-bags to the spine will check vomiting for a short voyage, as across the English Channel. A belt, which may be inflated so as to excite pressure over the stomach, has been invented.]

But the best means are, on commencing a sea voyage, to empty the stomach, and to remove acidity by an emetic, composed of a teaspoonful of soda and a table-spoonful of mustard, in a large tumblerful of warm water; or several good purgative doses should be taken. This will render the person much less liable to sea-sickness.

SHIVERING, or RIGORS.—Shivering, or cold feelings, not amounting to actual shivering, are very important symptoms of many diseases. Nearly all acute diseases, and especially fevers and inflammations, commence with chilliness or actual shivering. Shivering occurring *during the progress* of a malady is generally significant of the formation of matter in some part.

SKIN DISEASES.—Practically, diseases of the skin may be divided into the five following forms:—

1. RASHES; or alterations of the colour of the surface of the skin, generally of a reddish hue, and which do not proceed to the formation of watery matter.

2. VESICLES; which, commencing as little pimples, eventually contain a globule of watery fluid in the summit.

3. PUSTULES; which also, commencing as little pimples, eventually discharge matter.

4. SCALES, or SCALY ERUPTIONS; so called in consequence of flakes of diseased upper skin being cast off.

5. TUBERCLES; commencing as round bodies under the skin, which may eventually ulcerate.

1. RASHES.—The principal rashes are as follows:—

FRECKLES, or EPHELIS, are little coloured patches, caused chiefly in fair people by exposure to the sun. They are not painful, nor injurious. They may be got rid of by avoiding exposure to the sun, wind, and dust.

for Freckles.—A wash made by beating twenty sweet almonds into a paste in a mortar, adding a pint of warm water, and then straining the emulsion; or a wash composed of equal parts of lime water and milk may be employed. The face should be sponged with the wash, which should be allowed to dry on the skin. The latter should be cleansed with glycerine soap and water in half an hour, and prepared white fuller's-earth (called *cimolite*) may be applied. A mixture which has some repute for dispersing freckles is—2 ounces of lemon-juice, half a drachm of borax, and a drachm of white sugar, applied occasionally.

ERYTHEMA, OR THE BLUSH.—This consists of light red patches of various size and form, appearing in different parts of the body, and generally passing away in three days or a week. There is considerable itching or tingling. It frequently occurs previous to the monthly flow, on the legs of girls. It may follow drinking cold water when the body is heated. It may accompany teething, and in infants generally attacks the thighs and genitals. It is not dangerous, and is rarely attended with fever. The bowels should be acted upon by a gentle purgative, the patient should be careful in diet, and *white* fuller's-earth or violet powder may be applied.

ROSEOLA, ROSE RASH, TOOTH RASH, or RED GUM.—It is distinguished from measles by its occurring suddenly, without any prior cold, sneezing, or watering at the eyes, and by the eruption being in irregular patches of various sizes and forms, and not crescentic or half-moon shaped, as the eruption of measles presents. It is distinguished from scarlet fever by the absence of sore-throat. It is known from erythema by its more rosy tint. There are several kinds of roseola, only one of which need be particularly mentioned, viz. *roseola annulata*, which appears in rosy rings, inclosing a portion of healthy skin. Sometimes the eruption of roseola precedes the eruption of small-pox, and when this latter disease is in the neighbourhood, and rose rash occurs to a child, it must be regarded as a suspicious circumstance, as the possible forerunner of small-pox. If it presents in children, the gums, if swollen and painful, should be lanced; if the bowels are costive, they should be opened with a little castor oil or senna; and if there are symptoms of acidity of the stomach a few grains of citrate of magnesia may be given. When the malady occurs to adults there is generally one or other form of dyspepsia, for which appropriate treatment will be needed.

UTICARIA, or NETTLE RASH.—An eruption resembling in appearance, and in the accompanying stinging pain, the condition of the skin produced by nettles. But sometimes the rash commences as long white wheals, surrounded by a red band or margin, as if the part had been struck by a cane. The rash frequently appears suddenly; may last only a few minutes, or for a day or two, and may disappear as suddenly; or it may vanish in the daytime, returning at night. There is severe itching or tingling, which may be alleviated by applying sal volatile 1 part, water 2 parts. From the sudden manner in which it occurs, sometimes attended with vomiting and feverishness, it often excites alarm; but it is not dangerous, and often depends on improper diet. In some persons it follows eating shell-fish, strawberries, cucumbers, or mushrooms. A very similar rash has also followed taking copaiba, or quinine (*vide* pp. 18, 281). It often succeeds drinking cold water when the body is heated. If there is reason to suppose the stomach contains indigestible matter, as will probably be the case if the rash comes on after a full meal, particularly after a hearty supper or a late dinner, and especially if there is nausea and vomiting, an emetic should be given (Recipe 51). In other instances aperients, as Recipes 1 and 2.

LEUCODERMA, or WHITE SKIN.—This consists of white patches on any part of the body, giving when numerous a piebald appearance to the skin of the native. It depends on deficiency of colouring matter. When general it constitutes the condition known as *albinism*, the eyes being discoloured, and the body becoming a tawny red. There is no known cure. It is mentioned here because it is often mistaken for leprosy, to which it has no relation. It is not contagious, and a good servant need not be discharged because he develops white skin patches.

Leucoderma is not scientifically a rash, but it has as good a claim to be described under rashes as freckles, which dermatologists always place under rashes; freckles being an excess of pigment or colouring matter, leucoderma a deficiency.

2. VESICLES.—The principal vesicular affections are as follows:—

TINEA TONSURANS, OR RINGWORM.—A *contagious* skin disease, commonly attacking the heads of children, but frequently appearing on the face, body, or limbs, or in the roots of the nails, or in the beard. It is caused by the growth of a fungus (*Trycophyton tonsurans*) which belongs to the lowest species of vegetable organism.

Ringworm of the Head.—The earliest symptoms are a little redness or scurfiness on some part of the scalp, but these early symptoms most usually escape notice. Then in two or three days there are circles of minute pimples, which also may not be recognised until they, in the course of a few hours, turn into minute vesicles. These break and discharge their contents, producing a thin scab, which may be mistaken for scurf. Fresh circles of pimples and vesicles quickly form on the *outside* of the first crop, the disease spreading in more or less circular-shaped patches. As the malady goes on, from the discharge consequent on the eruption, and induced by scratching, larger and thicker scabs form. Neglected ringworm may thus involve nearly the whole of the scalp, these latter stages being very similar to *Scald Head*, p. 399. There is, however, a peculiar condition of the hairs in the part affected, which distinguishes ringworm from any other head affection. With a good magnifying glass the hairs over the affected spot appear as if rubbed off close to the scalp; the short portions remaining looking dry, lustreless, bent or twisted, split, and running in a line different from that of the healthy hairs, affording a fancied resemblance to a stubble-field. The hairs thus affected are dead; and when attempts are made to extract them they often break. When the root comes away, and is placed under the microscope, the distinctive fungus may be recognised in the shape of bright, round, cellular bodies, about $\frac{1}{7000}$ to $\frac{1}{5000}$ of an inch in diameter, collected in chains or groups. The most minute redness or scurfiness on the head of a child should always be regarded with suspicion, as the possible commencement of ringworm. When there is a scurfy spot although the place is *not* red; or when there is a red spot although the place is *not* scurfy, examination with a strong glass will often show either minute vesicles, or if at a later stage lighter-looking portions of hair-shafts, which have escaped observation by the naked eye. If redness or scurfiness present on the heads of children who have been exposed to infection, the safest plan is to conclude ringworm may be present, and to use appropriate remedies.

Treatment.—In a case of ringworm the child should wear a skull-cap, and the head should be washed twice daily with carbolic acid solution (Recipe 118), or with carbolic acid soap. If this does not remove the suspicious appearance in two or three days, the head for one inch round should be thoroughly shaved, not shaving the part affected. After which the great object is the removal of diseased hairs, which should be carefully extracted, one by one, with a pair of broad-nibbed forceps. Unless this is done very gently, but at the same time firmly, the hairs will break, and the roots remain. The hairs removed should be burnt. Then every particle of scaliness should be washed away with soap and water. Then strong vinegar, or strong alum water (alum 4 drachms, water 1 ounce), or ink may be applied to the part. Ink is a popular and useful remedy, the good effects resulting from the iron and tannin it contains. Whatever remedy is used should be rubbed on the scalp with the finger, so as to insinuate it into the holes from which the roots of the hairs have been plucked, and in which the fungus vegetates. The application may be repeated for five or six days, once daily; a search for and extraction of broken hairs, not previously observed, being first in-stituted. This may cut the malady short; if not, the remedies mentioned in the small type should be procured. As the fungus grows most luxuriantly on weakly children the diet should be liberal, constipated bowels should be relieved, and tonics (Recipe 67) will be required. The cure of ringworm is accomplished when the bad hairs have vanished, and when new, silky, downy hairs begin to spring up, and *not before*.

Ringworm is highly infectious, spreading both by direct contact and through the air. Other children must be kept as much as possible away from the patient, and separate combs, brushes, towels, soap, and washing utensils must be provided. Clothing and bedding used by the patient should be disinfected (*vide Appendix*, No. 122), and the soiled things should be washed separately. If ringworm occurs in a school, or large family, the first thing is to institute a regular and periodical search on all heads, and the next thing is to *isolate* those affected. If this is impossible the healthy should have their heads washed daily with carbolic acid solution (Recipe 119), and the hair should afterwards be anointed with some kind of greasy pomade. Plenty of brushing is also a precautionary measure of value; and extraordinary attention should be given to ventilation of both living and sleeping rooms.

If practicable 'Goa powder' should be obtained, which is the powdered pith of a tree (*araroba*) growing in the Brazils. A few grains of the powder should be mixed with vinegar or lime-juice to form a paste of the consistency of cream, which should be rubbed on with the fingers night and morning for eight or ten days. Under the action of the Goa powder the part affected becomes whitish, while the surrounding skin is stained brown. A preparation of Goa powder known as *chrysarobin* is made, a solution of which may be applied with a brush. Goa powder is often adulterated. It is a fine yellowish powder without smell or taste, and it is well to see the powder, and not trust to a prepared solution. Care should be taken that neither the powder nor the solution touch the eyes, as it may cause much irritation. Goa powder is reputed an infallible remedy for Indian parasitic ringworm, but it sometimes fails. Other remedies for ringworm which may be tried in obstinate cases are—*iodine paint* applied with a feather once daily, until the skin is blistered or very tender. A solution of carbolic acid (10 grains to the ounce of water), applied with a brush, often cures the disease. This application may be repeated once or twice according to the effect it produces, desisting as soon as the skin is tender or blistered. If these measures are not successful, an ointment composed of equal parts of simple and mercurial ointment should be well rubbed into the part for half an hour twice daily. Recipe 70 is a better tonic than Recipe 67 mentioned in the large type. But if the child is thin, feeble, and badly nourished, it should have cod-liver oil twice daily, in which 5 or 6 grains of carbonate of iron may be mixed, instead of Recipe 70.

RINGWORM OF THE BODY is known in the vernaculars as *dad, dadru, majees dad, denaii*, and among Europeans as 'dhobee's itch,' 'washerman's itch,' 'Malabar itch,' 'Burmese ringworm,' &c. It commences as a small itching scurfy spot, and, enlarging at the circumference, shows a line of minute vesicles. As this advances in semi-circular patches, the skin over which the disease has passed gets well. It frequently develops round the fork and waist, being determined to the latter part in natives, by the irritation of the clothing worn round the body. But it may appear on the face, or in the roots of the nails, or in the beard. Ringworm of the body causes much itching, especially at night, which keeps the person awake and tends to destroy the general health, while the scratching induced causes a scaly or cracked condition of the skin, when it has been mistaken for *eczema*. *Treatment* depends considerably on the extent of the disease. When, at first, the parts affected are small, the remedies mentioned for ringworm of the head may be used. But if early treatment has been neglected, and the disease is extensive, or the skin inflamed, the part should be sponged four or five times daily with a mixture of half an ounce of sal volatile in 6 ounces of water, until the remedies mentioned below can be procured.

Wash twice daily with carbolic acid soap. Then sponge with a solution of 2 drachms of bicarbonate of soda in 8 ounces of water. Afterwards rub the following ointment well in: sulphate of zinc 60 grains, lanolin 1 ounce. If this is not successful after six or eight days, use iodide of lead 1 drachm, lanolin 1 ounce. In proportion as the general health is improved, the more readily is the parasite destroyed by local measures.

SCABIES, OR ITCH.—Itch commences as small vesicles less than the size of a pin's head, generally between the fingers, afterwards spreading to other parts. It is caused by an animalcule, which burrows under the skin. This insect is called *Acarus scabiei*, and is round in shape, varying from one-seventh to one-quarter of a line in length and breadth. The female, being larger than the male, is sometimes visible to the naked eye as a greyish-white moving atom. Under the microscope it presents a tortoise-like shape, and is found to be studded with hairs and bristles, the head terminating with two pairs of mandibles. With these it burrows through the thinnest part of the upper layer of the skin, selecting such spots as the space between the fingers, or the inside of the wrist, where the structure is thinnest and softest. Once buried it does not come out again, but burrows within the skin, where other insects are produced, which in their turn burrow and reproduce their kind. These burrows may usually be seen in the shape of dotted or zigzag marks on the skin, looking like faint needle-scratches. The itching produced is intolerable, especially at night. After itch has continued some time, and been neglected, it discharges matter and may become open sores. A person with itch should be isolated. The parts affected should be first *well* washed with ordinary soap and water, which opens the burrows, and then *well* rubbed twice daily with compound sulphur ointment (Recipe 92). After three days the patient should take a hot bath and be well washed with carbolic soap. Then the sulphur ointment should be again employed. When the hands are affected, they should be well washed and rubbed with the ointment, and then inclosed in a bag of oiled silk all night, and the rubbing repeated in the morning, after a good washing with soap and water. Beyond opening the bowels if confined, no internal treatment is necessary. The clothing of persons with itch should be disinfected by baking in an oven at a temperature of 140° Fahr., or by the fumes from burning sulphur (*vide Appendix*, No. 129) ; or if this cannot be done the clothes should be boiled.

LICHEN TROPICUS, or PRICKLY HEAT.—This is probably the first complaint a new-comer to India suffers from, and, although unattended with danger, it is very annoying. The symptoms are itching, tingling, pricking, and sweating, while the skin is covered with a bright red eruption, eventually presenting little watery heads or vesicles, some of which afterwards contain a little white matter. The eruption is deepened in colour by exercise, or by hot drinks. The eruption should not be suddenly checked. As an external application, equal parts of sal volatile and water will be found to allay itching. Rubbing the skin with a rough towel tends to stop the itching, the heads of the little vesicles being broken, after which they do not itch. Light clothing, temperate diet, and an occasional aperient are necessary. Children suffering from prickly heat should be fed on bread, rice, sago, arrowroot, milk, and only a little meat broth. If thirsty and feverish, citrate of magnesia may be used as a drink (*vide* p. 15).

Twenty grains of sulphate of copper dissolved in an ounce of water, the solution to be sopped lightly on the parts, is much recommended. Or 2 drachms of bicarbonate of potash in half a pint of water.

PRURIGO, or ITCHING.—Intense itching, always worse at night, is the prominent symptom. It generally attacks the posterior parts or privates, but sometimes occurs in the flexures of the limbs, or on the shoulders and back.

At first the parts implicated are covered with pimples or vesicles, raised above the surface of, and redder than, the skin. But afterwards there is no evident deviation from the natural state, except redness or scabs produced by scratching. It is common among old people, it occurs in diabetes, and in other feeble conditions. It is also a frequent complaint of pregnant women.

A variety of the malady is *Prurigo formicans*, when there is not only an intolerable itching at one or more parts, but the patient also complains of a feeling like the creeping of ants or the stinging of insects (hence the specific name) over the whole body. These latter sensations are more generally complained of by natives than by Europeans, and are sometimes so distressing as to prevent sleep. The principal causes of this affection are debility, want of cleanliness, and friction or irritation of the skin.

Another variety is *Prurigo hyemalis*, or 'frost itch,' which may be general or local. It occurs to some people whenever the air is clear, dry, and frosty, and although more frequent in temperate climates, it may present, in those predisposed, during the cold season of Northern India.

Treatment.—When *local* itching occurs, stimulating drinks should be forbidden, and only easily digested food allowed. Internal remedies are seldom of much use, excepting chloral, which may be required to procure rest. Local applications recommended are numerous, but probably cold lotions (Recipe 97) or ice-cold water are the best. When troublesome local itching occurs, the absence of lice should be ascertained, for it sometimes arises from their presence, and can then only be cured by destroying the insects (*vide Lice*, p. 613). For *general* itching tonics, cleanliness, and unirritating clothing.

Herpes, or Tetter.—There are varieties of this eruption. It often occurs on the lips, accompanying a common cold, in the shape of five or six little vesicles on an inflamed base, which burst and form a scab. The foreskin is another part not uncommonly attacked. The number of vesicles, sometimes ten or a dozen, and the attendant itching, which is often very troublesome, serve to distinguish *herpes* of this part from more important affections (*vide* p. 457). Less frequently, *herpes* occurs on the forehead, when there is much stinging pain and numerous rings of vesicles, which when healing may leave a mark for life. The most serious variety is that called *Herpes Zoster*, or 'Shingles.' In this form of herpes a line of vesicles rises, reaching from the spine round the lower part of the chest to the breast-bone, usually on one side. There is a popular but erroneous idea that if it occurs on both sides it terminates fatally. The eruption is often preceded, and always accompanied, by severe shooting pain and feverishness. The vesicles burst about the fourth day, when scabbing takes place, the whole process lasting about one fortnight. Indigestion is the most usual cause of all varieties of herpes. The *first two forms* rarely require medical treatment. For the *two latter* the bowels should be kept open, the diet regulated, and an alum lotion (Recipe 97) applied. If the pain is great, a strip of lint, wet with poppy water (*vide Appendix*, No. 81), may be placed over the part. In all cases scratching should be refrained from.

ECZEMA, OR RUNNING SCALL.—There are various degrees of eczema. It occurs as an eruption of small raised vesicles crowded together on broad irregular patches of bright-red skin, accompanied by much itching, tingling, and smarting, and usually presenting in the flexures of the limbs, as the groins or armpits. The fluid in the vesicles soon becomes milky and turbid, and in four or five days the vesicles burst, when the fluid is discharged and dries into thin yellowish-green scabs. Fresh vesicles form on the surrounding skin, while the parts already affected remain sore. The duration of this malady may be from a week to months, or more, and in prolonged cases the scabs become detached, leaving a sore raw surface, or they crack, exuding a clear watery fluid, which has led to the term 'salt rheum.' When the discharge resembles matter it isoften called *impetigo*, or *pustular eczema*, also 'crusted tetter, and 'cowrass.' In children it may be connected with teething, and may appear behind the ears; in females it may be connected with irregular and painful monthly courses; and it sometimes appears near the nipples of suckling women. In many cases it appears to be caused by indigestion; it also may arise from heat, on a fair and tender skin, when it is called *eczema solare*, or 'heat spot.' When there is a predisposition to the malady, its appearance seems to be determined to different spots from the heat or irritation of clothing. It also arises from the handling of dry powders, or certain metals. From its affecting the hands of grocers, who handle sugar, it has been called 'Grocer's Itch.' It is sometimes induced on the hands of bakers by flour; and on the hands of bricklayers by lime: hence it has been called 'Baker's' and 'Bricklayer's Itch.' Eczema often recurs in different parts of the body at certain seasons, as the spring and fall. In such cases the cause is obscure; but it is often found there is some latent scrofulous taint in those affected. *Treatment* consists in the removal of indigestion, and in measures adopted against any irregularity in the monthly courses of the female. As a local application, olive or salad oil should be smeared on the parts, and if there are scabs or crusts a hot linseed-meal poultice should be applied at night. The scabs will come off with the poultice in the morning, and oil may be again applied. The parts may be occasionally sponged with hot water and glycerine soap, but only when cleanliness requires it. All irritating applications should be avoided, and if any application increases the itching and tingling, it does not agree. As scratching irritates the parts, it should be refrained from.

¶If the above-mentioned applications are not satisfactory, glycerine should be procured and used instead of the oil. If the malady still persists, lead ointment (Recipe 96) may be applied. If there is very much itching and smarting the following ointment: iodide of lead 12 grains, chloroform 40 drops, glycerine 1 drachm, lanolin 1 ounce. In some cases an ointment composed of 30 grains of sulphate of zinc, mixed in half an ounce of lanolin, is more beneficial: an ointment composed of white precipitate 1 drachm, lanolin 1 ounce, is successful in many instances; in others greasy applications do not suit, and the lotion (Recipe 97) may then be used. When eczema attacks children behind the ears an alkaline wash (Recipe 99) is often very useful, but in such cases attention to teething, if in progress, will be also necessary. When in adults the eczema persists after the acute stage has passed away, the malady becoming what is called 'chronic eczema,' the *liquor arsenitis potassæ* (Recipe 75) should be given three times a day, *after* meals, until the characteristic effects of arsenic are produced (*vide* note to Recipe 75), when the medicine should be stopped. Sulphur baths are also advisable, as those of Harrogate or Aix-les-Bains.]

PEMPHIGUS, OR POMPHOLIX, OR BLEBS.—These names have been given to a peculiar blister or *bleb*, which forms on different parts of the body, especially of children. The first change consists in the appearance on the back, belly, or limbs, of red circular spots, which itch and burn. In a few hours, at the middle of the spots, small transparent vesicles arise, which enlarge, and soon cover the whole of the red patch, excepting a narrow margin. The blebs are round or oval in shape, and may attain the size of a pea, or even of a hen's egg. The contents, at first transparent, gradually become turbid, and in two or three days the blebs burst; the place then becoming covered with a scab, under which the skin heals. Before the first blebs heal, new ones form, and the disease may continue in this manner for days or weeks. In infants, *pemphigus* usually appears to depend on *disordered stomach.* In adults it may be preceded by dyspepsia or debility from various causes; but sometimes the patient looks and feels well throughout the attack, until exhausted by the loss of sleep caused by the itching. The *treatment* consists in attention to the general health, and in the remedy of any digestive disorders. The diet should be liberal. Local treatment consists in puncturing the blebs with a fine needle, and in protecting the parts from injury from the clothing sticking to them, by simple dressing (Recipe 86). For some time afterwards a stain remains on the skin, but there is no permanent scar.

SUDAMINA, or MILIARIA.—An eruption of numerous minute watery vesicles, seldom attaining the size of a pin's head. *Miliaria* is the term generally given to this affection when the skin appears also reddened. It occurs during most diseases which are accompanied by much perspiration, as fevers, acute rheumatism, and inflammation of the lungs. From the eruption so frequently accompanying 'milk fever,' that malady is sometimes termed 'Miliary Fever' (*vide* p. 629). It is caused by the little ducts from which the perspiration oozes becoming clogged by the secretions of the skin, and it is usually seen on the bodies of patients who have been kept too warm, or whose skins have not been sufficiently cleansed. The eruption presents principally about the neck, chest, and armpits. It is of little consequence, but indicates that the patient requires a cooler regimen, and greater cleanliness of the skin. It is important that it should not be mistaken for the specific eruptions of certain fevers (*vide* pp. 242, 247).

3. PUSTULES.—The principal pustular affections are as follows:—

FAVUS, or SCALD-HEAD.—Scald-head is a contagious disease, caused by a parasite (the *Achorion Schönleinii*) which usually grows near the roots of the hair. Under the microscope the parasite differs considerably in appearance from the fungus of ringworm, being more jointed and smaller. The first symptoms are scarcely distinguishable from those of ringworm. It first causes slight itching and a red-coloured eruption, palpable also to the touch. As the eruption spreads it is not circular in shape like ringworm, but of irregular and undecided form. In about twelve hours each little red point of which the eruption is composed contains a small globule of yellowish watery fluid. This and the subsequent thicker secretion drying on the surface of the skin assume a honeycombed appearance, some part of the scab being depressed or 'cup-shaped,' and some elevated, or presenting the appearance of a series of concentric rings. The crust emits a mouse-like odour, and is often perforated by hairs, which do not break off so readily as in ringworm, and are consequently more easily extracted by the roots. As the disease advances the secretion becomes more thick and copious, until there may be a layer of yellowish-looking scab or crust over the whole head. When the malady has been neglected, sores and ulcers form on the scalp, underneath its scabby covering. The disease is sometimes called 'crusted ringworm,' or *porrigo favosa*. If the malady is recognised early, the *treatment* for 'ringworm' (*vide* p. 390) should be employed. If nothing has been done until scabs have formed, the head should be poulticed and bathed with hot water, until the whole of the scabby matter is removed, and the surface is quite clean. Then olive oil or glycerine should be applied, and the scalp should be covered with a close-fitting skull-cap. The remarks under ringworm, as regards diet, medicine, and preventive measures, are applicable. The parasite of scald-head may be conveyed by cats from one child to another, involving an obvious precaution.

[For scald-head it will be desirable to use carbolic acid ointment (Recipe 93). On this not being successful, an ointment composed of one drachm of tar and one ounce of simple cerate may be employed.]

Acne, or Copper Nose.—This consists of isolated pustules, forming on a hard red base in the small glands of the skin, sometimes very long in coming to a head, and most frequently seen on the nose, but sometimes on the cheeks, forehead, or chest. Acne pustules are sometimes called 'blackheads,' and the contents are erroneously supposed to be 'grubs'; being in reality compressed matter, the end of which has become blackened by exposure to the air. It is due to a stoppage in the glands of the skin by such matter accumulating there. It is generally connected with dyspepsia, with excess of eating or drinking, especially over-indulgence in alcoholic liquors, and in women with uterine disorders, or with the 'change of life.' The *treatment* consists in proper regulation of the diet and the mode of life generally, particularly as regards exercise, and in the relief of dyspeptic symptoms, or of symptoms referable to the womb.

SYCOSIS, or CHIN WHELK, commences with redness or smarting of the skin of the lips or chin, on which pimples appear, which slowly come to a head and discharge matter. Fresh crops occur for many weeks, until, in bad cases, the beard falls off in patches. Sycosis has been confounded with ringworm of the beard (*vide* p. 389), and has been erroneously attributed to a parasite. The causes are the same as those of *acne*. The hair should be cut close, poultices applied till the surface is clean, and afterwards olive oil. Aperient and alterative medicines, as Recipes 1, 2, 35, should also be given.

Steam the chin every night by holding it over hot water. Then rub for three minutes with terebene soap and flannel. Afterwards apply a lotion composed of precipitated sulphur half an ounce, glycerine 2 drachms, spirits of wine 1 ounce, rose water and lime water each 3 ounces. Allow this to dry on and remain all night. In the morning clean with terebene soap. If not successful after a few days, use carbolic acid ointment (Recipe 93) instead of the lotion.

4. SCALES, or SCALY ERUPTIONS.—The principal scaly eruption is *Psoriasis*, or *Dry Tetter*, of which there are three varieties, all non-contagious. The *first* form begins as small round shining, itching spots, soon becoming covered with thin white scales, which, falling off, leave the skin beneath slightly tender and reddened. The spots

increase in size, but retaining the circular shape until they attain several inches in circumference, when they become broken and assume the form of irregular scaly patches. This circular form is sometimes called *lepra,* and may be mistaken for ringworm; but lepra is scaly, while ringworm is not; it always appears on the body, while ringworm usually affects the head; and there are generally several or many patches of lepra, while ringworm is usually single. In the *second* form the disease commences as *irregular* scaly patches without the prior ring-like appearance. Both these varieties frequently attack the flexures of the limbs, and the inner surface of the thigh and armpits, the palms of the hands, and the nails, which become white speckled, irregular, and brittle. When the palms are affected by the non-circular form, it is often confounded with eczema of such parts, and has also been called 'Grocer's Itch' (*vide* p. 397). The *third* form is known as *pityriasis* (vernacular *senwha* or *chulee*). It differs from psoriasis in consisting of much smaller scales, which are sometimes almost microscopical in minuteness; and in being more diffused, occasionally even universal over the whole body. Boatmen who expose their naked backs to the sun are especially liable to pityriasis. As it does not cause much inconvenience, and as the scales glisten in the sun, giving rise to an appearance like tortoiseshell, pityriasis is often considered as a mark of beauty. The causes are not well understood. At some times it seems to depend on exposure or on digestive disorders, appearing and reappearing with such conditions. The *treatment* requires attention to the general health, as the avoidance of any article of diet known to induce dyspepsia, and the relief of constipation if present by laxative medicines, as Recipes 1 and 2.

[It will be desirable to take Recipe 35, and, after the acute stage has passed away, arsenical solution (Recipe 75). Itching may be relieved by a lotion, containing half an ounce of spirits of wine, half an ounce of tincture of opium, with 12 ounces of water. Equal parts of tar, spirits of wine, and soft soap, is a favourite formula. The patent 'Pearl Ointment' may be rubbed in with advantage. Sometimes mercurial ointment diluted with a similar quantity of simple ointment is beneficial. At other times sulphur ointment (Recipe 92). In chronic psoriasis, sulphur baths.]

5. TUBERCLES.—The principal tubercular forms of skin disease are tubercular *leprosy* (*vide* p. 317), *fibroma*, and *lupus*.

FIBROMA consists of the growth of numerous pendulous tumours in the skin. They are not painful, do not gather, remain during life, and are incurable.

LUPUS often commences with distinct tubercular elevations on the cheek by the side of the nose. Sometimes these are preceded by a red patch. In most cases pustules form which are succeeded by an ulcer. To this condition the term *Noli me tangere* has been applied. The ulcer is liable to spread. Lupus is most common in young scrofulous individuals. Surgeons destroy the ulcer with caustics, but until this can be done soothing applications are best.

SLEEPLESSNESS is technically known as *Insomnia*. There may be no desire to sleep, or a dread of going to sleep, or the slumber may be restless or disturbed, or a person may be sleepy during the daytime but unable to sleep at night. In the absence of any special disease, such as anæmia (*vide* p. 46) from any cause, or latent gout, sleeplessness may arise from dyspepsia, mental anxiety or excitement, late meals, taking tobacco or strong tea or coffee at night, want of exercise, close unventilated rooms, too soft or too hard beds, from cold feet, and in India from heat and mosquitoes. Every case must therefore be treated on its own merits. The dyspeptic should not go to bed with an undigested meal on the stomach, and should avoid tobacco, tea, and coffee at night. Regular hours of retiring should be adopted, so that the force of habit may be enlisted. Exercise is necessary, and should be taken to the verge of fatigue. The work of the day should be dismissed from the mind, and any excitement, such as reading works of fiction at night, should be avoided. Intervals of relaxation must be insisted upon, and in bad cases entire mental rest. When the tone of the system is lowered, a moderate supper of plainly cooked and nutritious food frequently predisposes to sleep. In other cases a glass of water taken before retiring often does good, but a 'night-cap' in the form of stimulants, is only of temporary benefit. In all instances the bedroom should be well ventilated, the bed should be in the middle of the room, and curtains should not be used. A hot bottle to cold feet is desirable. Bromide of potassium (Recipe 19) may be taken in double or even treble doses at bedtime—a medicine especially useful in cases of sleepiness by day and wakefulness at night. When the digestive organs are in good order and the bowels freely open, an occasional dose of chloral may be used; but the habit of taking chloral must not be indulged in (*vide* p. 11).

Bromidia (*vide* p. 62, small type) may be tried.

SMALL-POX.—A contagious eruptive fever, generally occurring but once in life. From the period of the formation of matter, until the skin has become quite free from scales, is the time during which the disease is most contagious, although a person may convey the affection up to ten weeks after the appearance of the first symptoms. Infection may also be conveyed by various articles, especially by clothing and bedding. The period from exposure to infection to the appearance of the disease is ordinarily twelve days. The early symptoms are shivering, alternating with burning heat, drowsiness, nausea, often vomiting, headache, pain in the back and loins, and occasionally sore throat. Then fever sets in, the pulse becoming quick, and the skin hot, the temperature (*vide* p. 33) perhaps rising to 104° or 105°. If now the finger is pressed on the forehead, a shotty feeling may be noticed before the eruption is visible. After two, or perhaps three days, an eruption of raised red spots appears on the face and forehead, and this is usually attended with some diminution of the fever, the temperature falling to 101° or 102°. The longer the eruption is in appearing, the less serious does the disease prove. On the third and fourth days the eruption spreads over the body; on the fifth day each pimple becomes a vesicle with watery head, round base, *central depression*, and inflamed margin. This *central depression* is characteristic, and distinguishes the malady from *modified* small-pox or chicken-pox. During the next three days matter forms in the vesicles, and they are more prominent. When matter has formed, the peculiar and unmistakable *smell* of small-pox is present. If the case is severe the face is much swollen, and the eyes are closed by the swelling. About the tenth day the pustules, first on the face, later on the hands and feet, begin to dry up, and about the fourteenth day they form scabs; these fall off from the twentieth to the twenty-third day, leaving the skin of a reddish-brown colour. Frequently scars or 'pits' are left by the healing of the pustules. As the eruption attains its height the fever generally for two or three days very much increases, the temperature again rising to 104° or 105°; this is called the *secondary fever* of small-pox, and usually occurs on or about the eleventh day, which is the period in bad cases of *the greatest danger from exhaustion.* The tongue is furred white throughout, and sometimes swollen. In adults the bowels are most frequently constipated during the whole time; in children there is frequently diarrhœa at the commencement. As mentioned at p. 387, the eruption called *roseola* sometimes precedes small-pox. For distinction from measles *vide* p. 332.

In very bad cases the pustules are so thick that they almost or quite join; the disease is then said to be *confluent*. In such instances the fever is much more severe, there is delirium, and the patient may die insensible. In severe cases the eruption appears in the nostrils, in the eyes, on the tongue, and in the mouth and throat, and there is profuse flow of saliva and great swelling of the hands and feet. Children, especially if teething, may be *attacked by convulsions, generally at the commencement of the eruption.*

Small-pox frequently leaves after-effects, such as a succession of boils, disease of the eyes, affections of the ears, formation of matter about the joints, or a weakened condition from which the patient is long in rallying.

Treatment.—The sick person should be as much as possible isolated, if practicable in a separate building. The room should be well ventilated, but not kept too cold, and *all* the rules given regarding 'Disinfection' (*vide Appendix*, Nos. 121 to 130) should be strictly carried out, both *during the disease and afterwards*; for small-pox germs retain vitality for a very long period, not only in clothing and bedding, but even in the paper and crevices of walls. Attendants should avoid inhaling the breath of patients. The bowels should be kept moderately open by aperient medicines, and cooling citrate of magnesia draughts (*vide* p. 15) should be given. The legs and arms may be sponged daily with warm water. The eyes should be carefully washed and bathed several times daily with warm milk and water, or, if affected, with warm alum lotion (Recipe 97), and after each bathing salad oil should be applied to the edges of the lids. The diet should consist of milk, tea, gruel, beef tea, or chicken broth. When the pulse is weak and the strength fails, symptoms most likely to present with the secondary fever about the eleventh day, stimulants, as wine and ammonia, may be required.

During the drying up period frequent changes of clothing, and if the patient is not very weak, a daily bath. During convalescence quinine is useful.

There have been many experiments tried with the view of preventing *pitting* or scars. The surface must be maintained as cleanly as possible, by *gently* sponging away the discharge. Then flour or starch may be abundantly dusted over the face and body, which will relieve itching. Olive oil and cold cream are also good applications. A better is carbolic acid 1 part, salad oil 10 parts, to be well mixed and applied over *one-half* the body daily. The carbolic acid tends to destroy the unpleasant fœtor, and also moderates the violence of the suppurative process. When the pustules have burst, the consequent itching and irritation may be relieved by sprinkling the parts with violet powder, or oxide of zinc, or a mixture of both. But in bad cases of small-pox, notwithstanding any application, there will always be some marking left. The patient should be prevented from scratching, and if a child, the hands should be muffled, as the irritation from scratching increases the after-marks.

VACCINATION. - Although the cure of small-pox is not practicable, its prevention is sufficiently easy by vaccination. Vaccine matter is small-pox matter deprived of its virulence by passing through the system of the cow. It produces no ill effect, and yet the person who has been vaccinated is as much protected against small-pox as if he had had that disease. If the latter affection is taken after cow-pox, which sometimes happens, it is always mild, scarcely ever leaving any injurious results on the constitution. Experience and statistics show that vaccination protects the individual, and greatly diminishes the amount of small-pox in the community. The vast majority of ailments which have been ignorantly attributed to vaccination have no possible connection with it. The most likely ailment to occur after vaccination is erysipelas, if in the neighbourhood. But erysipelas may occur after any trivial injury, and is entirely unconnected with the use of cow-pox matter.

Vaccination should be performed in infancy, and about the age of seventeen. Healthy children should be vaccinated within three months after birth, or prior to the commencement of teething; and when small-pox prevails, at a much earlier period. If, however, a child suffers from disordered bowels, or from eruptions of the skin, or is weakly, and there is no small-pox about, it may be desirable to postpone the operation till after most of the teeth have appeared. In India the cold season is the best time for vaccinating.

On the second day after vaccination a small red spot may be observed at each scratch of the lancet. On the fifth day there are circular pearly vesicles containing a limpid fluid. On the eighth day these are fully developed, the centre of each being *depressed*, with an inflamed red ring around, of the breadth of from one to three inches. There is probably slight fever, often some swelling of the arm, and sometimes enlargement of the glands in the armpits. On the eleventh day the pustules burst, leaving a scab. About the twentieth day the scab falls off, leaving permanent scars or 'pits.' If these symptoms (excepting the enlargement of the glands in the armpit) do not present, particularly if the red ring or *areola* is not well developed, the operation is not successful, and confers no protection.

During the progress of the vaccine pustule great care should be taken lest the child rubs or scratches the part. If this occurs there may be a troublesome sore, and much redness about the armpit. Under such circumstances it may be necessary to apply a bread poultice until the sore is clean and healthy, after which simple ointment (Recipe 80) is the best application. Shields have been devised for the protection of the part, but they are not recommended, as they may not be kept clean, and if lent may convey erysipelas.

Vaccination is usually performed on the arm, but there is no reason why the arm should be preferred, excepting that it is perhaps a more convenient place than any other part of the body; and the same side should be chosen as that on which the mother generally nurses, as there will afterwards be less liability to friction.

Modified Small-pox.—This is the term applied to small-pox occurring after vaccination or after small-pox. There is generally for three days more or less feverishness and headache. Then the eruption shows itself, and the protective value of previous vaccination, or of previous small-pox, becomes evident. In a case of unprotected small-pox, the progress of the eruption is attended by aggravation of the feverish symptoms; but in modified small-pox, when the eruption shows itself, the patient feels better. The eruption of modified small-pox consists of a few pimples, or a few vesicles (containing water only), or a few pustules. Often the vesicles dry up about the fifth or sixth day without becoming pustular, a condition which has given rise to the popular terms 'Horn-pock' and 'Wart-pock.' The small-pox pustules, on the contrary, pass through a definite course, and, instead of subsiding as pimples or vesicles, always suppurate. Lastly, modified small-pox does not emit that peculiar nauseous odour of small-pox, and there is no *secondary fever*, or increase of fever on the subsidence of the eruption. Chicken-pox (*vide* p. 117) is by many considered to be modified small-pox. Modified small-pox is contagious. The *treatment* of modified small-pox consists in free ventilation round the sick person, who should be isolated as much as possible. Aperient medicines, as Recipes 1, 2, and cooling medicines, as citrate of magnesia (*vide* p. 15), may be given.

SOMNAMBULISM.—A clear explanation of sleep-walking has not yet been given, but the condition is the power of movement remaining with apparent mental rest. Avoiding heavy meals at night, or mental excitement before going to bed, or thinking of the day's occupations, are the principal means of prevention. Freedom from worms should be assured.

SPASM, or **CRAMP.**—Spasm is the sudden, involuntary contraction of a muscle; which contraction may be *continuous*, or more or less *relaxing*, or altogether *ceasing*, during intervals. Spasm may be *general*—that is, numerous muscles may be affected—as occurs in *convulsions*; in *epilepsy*; in *tetanus*; in *hydrophobia*. Or spasms may be *local*—that is, confined to one muscle or set of muscles—of which spasmodic *asthma*, spasmodic *colic* (often called spasms or cramps of the stomach), spasmodic *stricture*, *hiccough*, *squinting*, *club-foot*, and *cramps in the legs* during cholera are examples. The treatment of spasms will therefore be found under the headings of the different maladies of which they form a part.

Spasm or cramp in the legs requires special mention. The attack is sudden, and most frequent in the night. The muscles of the calf are drawn into knots which may be felt; there is intense pain; and the parts frequently feel sore afterwards. Sometimes the thighs are attacked.

The malady is most prevalent in elderly people, but it also occurs to pregnant females. It is often caused by constipation, when a collection of fæcal matter in the lower gut presses on the nerve (*sciatic*) which afterwards divides into various smaller nerves to supply the legs.

When it occurs to pregnant females it is usually caused by the pressure of the enlarged womb on the nerve. For such cramps constipation must be avoided by the appropriate remedies (*vide* p. 135), and any dyspeptic symptom present should also be treated (*vide* p. 197). Locally the best plan is *brisk* rubbing with salad oil and brandy in equal parts, or, if available, with soap and opium liniment. But in cases where the cramps depend on pregnancy the rubbing should be *gentle*, as the enlarged veins generally also present during pregnancy might be ruptured by hard rubbing (*vide* p. 457). A bandage or garter tied tightly round the leg above the seat of pain will often relieve cramp, but the bandage should not be permitted to remain on for longer than four or five minutes, and should not be used if there are enlarged veins. The garter should be disused, and the stockings may be suspended by a tape buttoning to the corset.

SPINE, CURVATURE OF THE.—There are three principal varieties of spine-curvature, viz. to either side, forwards, and backwards, but the lateral curvature is most common. It occurs chiefly to young females, and the first sign is probably one shoulder being observed higher than the other. Preventive measures are—care against constrained positions, as during writing, for instance, so frequently fallen into by children. Also against the practice of raising children by placing the hands under their armpits, and letting the whole weight of the child's body drag on the shoulders. Children should be ordinarily raised by placing one arm under the buttocks; and they should never be hauled about by one arm. In all instances of threatening spine-curvature, exercise short of fatigue, avoidance of strained positions, much rest in the recumbent posture, attention to the general health, with liberal diet and tonic medicines, are the requirements.

SPITTING OF BLOOD.—Blood proceeding from the mouth may come from different sources. *It may be from the throat or tonsils*, in which case the quantity brought up is small, and the bleeding part, probably an ulcer of the tonsils, may be easily seen. This bleeding is of little consequence, and requires no particular treatment. *Or blood may come from the gums*, as during scurvy, when it should be treated by the remedies proper in that disease. *Or blood may proceed from the socket of a tooth* which has been extracted (*vide* p. 512), or it may come *from the back part of the nose* (*vide Bleeding from the Nose*, p. 510).

SPITTING OF BLOOD FROM THE LUNGS, or HÆMOPTYSIS, is a more serious form, and is often a symptom of consumption. Frothy bright-coloured blood is coughed up, and there may be pain and a sensation of 'bubbling' in the chest. *Perfect* quiet is necessary, and half a tea-spoonful of salt in a little water may be given every five minutes till nausea is induced. Or, if at hand, five grains of ipecacuhana in an ounce of water till the patient feels sick. Afterwards cold or iced acid drinks, of which the best is fresh lime or lemon water.

Recipes 43 and 44 should be procured if possible.

HÆMATEMESIS, *or vomiting of dark-coloured blood from the stomach*, must be distinguished from *hæmoptysis* or coughing up *bright frothy* blood from the lungs. *Hæmatemesis* is in some cases dependent on disease of the liver or spleen, and it occasionally occurs when the menstrual flow is scanty or suppressed. But in the great majority of instances it occurs in consequence of an ulcer of the stomach eating into a blood-vessel. In all such cases the blood is *vomited, not coughed up*, and its colour is almost *black*, like coffee-grounds—*not red*; and blood is often passed by stool. It is generally preceded or accompanied by burning boring pain in the stomach, and if the ulcer is large the loss of blood is sufficient to cause alarming faintness, which may be felt before any blood is vomited, and for which stimulants must *not* be given. The great point is to keep the stomach at rest, so as to allow the ulcer to heal, or, at least, the ruptured vessel to become plugged up. This will not take place if the stomach is excited to action by food, or if the circulation is excited by stimulants. Ice should be swallowed in little lumps, *cold* fluid food, as broth or milk, should be given in spoonfuls at intervals of a few minutes, alum mixture (Recipe 42) should be administered, and perfect quiet should be insisted upon. In very severe cases *all food* should be given as cold nutrient injections, thus affording the stomach perfect rest (*vide Appendix, Digested Enemas*). In cases of either *hæmoptysis* or *hæmatemesis* medical aid should be sought.

For vomiting of blood (*hæmatemesis*) obtain Recipe 46 if possible.

The distinctions between bleeding from the lungs and bleeding from the stomach are placed in comparison below:—

Hæmoptysis, or bleeding from the lungs	*Hæmatemesis, or bleeding from the stomach*
Usually difficulty of breathing, pain in chest.	Nausea, pain, and tenderness at the pit of the stomach.
Blood coughed up in mouthfuls.	Blood vomited profusely.
Blood frothy.	Blood not frothy.
Blood of a florid red colour.	Blood dark-coloured.
Blood mixed with saliva.	Blood mixed with food.
No blood passed by stool.	Blood often passed by stool.
Cough and bronchial symptoms.	None.

SPLEEN DISEASE.—The spleen is covered by the stomach in front and by the ribs behind (*vide* p. 29), and in health is not easily felt. Most diseases of the spleen are regarded as due to malaria, and are often the sequelæ of attacks of ague. The principal kinds of spleen disease are *acute* and *chronic congestion.*

Acute congestion of the spleen most frequently arises suddenly during ague. In the cold stage of ague the blood is driven from the surface, the spleen becomes extraordinarily full of blood, and its tissue is stretched and strained. There is pain and tenderness on pressure under the ribs on the *left* side, the pain sometimes extending to the *left* loin or to the *left* shoulder, and the person cannot lie comfortably on the *left* side. There may also be nausea and vomiting. There may be blood in the vomit, but more usually blood appears in the stools. Bleeding from the nose may occur. When the congestion is less there are feelings of fulness and distension in the side, without actual pain, which are also aggravated by pressure. In persons subject to attacks of ague, congestion of the spleen, sometimes occurs *instead* of the ague fit, but in such cases there will usually be some heat of skin and quickened pulse. More rarely acute congestion presents in persons who have not suffered from ague. Acute congestion generally terminates in a few days with perspirations, diarrhœa, and thick sediment in the urine. At first the congestion of the organ subsides, leaving no trace; but after repeated attacks the strained tissue does not resume its natural dimensions, as deposits from the blood take place in it. Then *permanent* enlargement results, when the spleen may be easily felt under the ribs, by placing the thumb in front towards the stomach, and the fingers behind towards the back, on the left side of the body.

Chronic congestion, or enlargement of the spleen, may be the result of attacks of acute congestion. But often chronic enlargement of the spleen comes on so gradually, and painlessly, that it is long unattended to, until at length the enlarged organ excites fulness, weight, and dull pain in the left side. When the organ is much affected the enlargement, popularly known as 'ague cake,' is sometimes so great that the spleen may be both seen and felt, filling up and rendering protuberant half the cavity of the bowels, thus forming the condition so often seen in native children, and known as 'pot-bellied.' With enlarged spleen it will usually be found, especially in children, that the temperature as tested by the clinical thermometer (*vide* p. 33) rises in the evening to above 100°. If this rise is persistent, there is evidence that the disease is gaining ground. Whether in children or adults, when the spleen is enlarged, it becomes tender and brittle, and is easily ruptured (*vide* p. 595).

The spleen is concerned in the elaboration of the blood, and when there is chronic disease of the organ it is always associated with a deficiency of red globules in the blood, and hence the person becomes pallid and sallow, there is a peculiar pale tremulous tongue, the whites of the eyes become pearly or lemon-coloured, there are frequent attacks of diarrhœa, and, in short, the condition known as *anæmia* becomes established (*vide* p. 46). Up to a certain point this state may terminate in recovery, but a stage of splenic blood-deterioration is at length reached, when medicines are useless. The spleen-enlargement increases, the person becomes more debilitated, dropsical swellings of the belly and legs occur, and diarrhœa or dysentery becoming permanent, the person sinks.

Treatment.—In cases when the spleen has become *suddenly* painful, hot fomentations are required. In all cases if there is no diarrhœa, the bowels should be acted upon by the sulphate of soda, quinine and iron (Recipe 3). If there is diarrhœa, the same recipe should be taken without the sulphate of soda. When intermittent fever or ague is present, treatment mentioned under that head must be adopted. When enlargement of the spleen occurs *gradually* without fever, or without pain and tenderness, tonics are required, and in the absence of other medicines Recipe 3 may be taken, with or without the soda salts, as the bowels may require. It should, however, be recollected that in all varieties of spleen disease a free action on the bowels is generally desirable. Children should be encouraged to take plenty of milk, with which a little lime water (Recipe 25) may be mixed; they should be clothed warmly, the bowels should be kept open if necessary by citrate of magnesia (*vide* p. 15), and small doses of sulphate of iron may be given (*vide* p. 24). Moderate pressure by a wide flannel bandage round the body is advisable.

[When obtainable, instead of the medicines mentioned above, *for acute cases*, 2 scruples of compound jalap powder with 5 grains of sulphate of iron every morning, and iron and quinine (Recipe 70) three times a day. In more chronic cases Friedrichshall or Hunyadi Janos water, and pills containing arseniate of iron one quarter of a grain, strychnine one-fortieth of a grain, quinine one grain, thrice daily. The part may be painted externally with iodine paint (*vide Appendix*, No. 111). Afterwards ointment of iodide of mercury (Recipe 94) may be rubbed in daily. For children Recipe 16, if the bowels are confined, and Recipe 70 in proportionate doses. The skin over the enlarged spleen may be gently rubbed with soap liniment.]

Spleen enlargement in Europeans eventually requires change to Europe. Removal to a cold climate will in most instances, if not too long deferred, result in recovery. When European children suffer from enlarged spleens their removal from India is imperatively demanded. If this is impossible, removal from the locality to the sea, if practicable; if not, to the hills.

STOMACH, DISORDERS OF THE.—The stomach may be disordered by a multitude of causes, the principal of which are improper food, alcoholic liquors, fevers, and (especially in children) other exhausting diseases. When disorder of the stomach arises from improper food or drink, there may be *headache* (*vide* p. 291); or there may be a *bilious colic attack* (*vide* p. 131). But the disorder may not terminate in such ailments. There may be increasing pain and tenderness at the pit of the stomach, with constant hiccough, nausea, and vomiting, even water being rejected. The vomit consists of fluid, often tinged with bile; the breath is sour, the tongue furred in the centre, with great thirst and much feverishness, and the mouth may be sore. It is to this condition that the term *gastric fever* has been applied. But a disordered stomach will recover itself in the course of two or three days. If the symptoms continue longer, there is reason to fear either *typhoid* or *remittent fever*, or, in children, *hydrocephalus*. All these diseases may commence with disordered stomach; and in some cases it is not, at first, possible to say whether such symptoms are referable to disordered stomach, or are the results of a commencing fever. If the stomach symptoms come on after indulgence or improper food, and if there is no *typhoid* fever in the neighbourhood, it may be safely concluded that the ailment is not *typhoid*. But it may be *remittent fever*, and this the more likely if there has been no prior cause for disordered stomach, or if the person has been exposed to the sun, or sleeping in damp malarious localities. If the attack is *remittent fever* the stomach symptoms will continue longer than two or three days, while fever will prevail as under 'Remittent' (*vide* p. 258).

Treatment.—If the disorder of the stomach assumes the form of headache, or of a bilious attack, the treatment mentioned at pp. 292, 131, should be pursued. If the disorder has arisen without evident cause, and the bowels are constipated, a laxative, as Recipe 2, should be given. Then *the main point is to allow the stomach perfect rest*; and only milk and lime water (Recipe 25), or, if preferred, milk and soda water, should be given in table-spoonfuls every half-hour. Sometimes weak beef-tea, or arrowroot, suits the irritable stomach best. If the stomach rejects a table-spoonful of fluid, the quantity should be reduced to a tea-spoonful. The patient should not drink quantities of water, which he will crave for, but suck pieces of ice. Chloral (Recipe 64) may be given at night. Fomentations should be applied over the pit of the stomach.

STOMACH DISORDER IN INFANTS AND CHILDREN.—Is much most common in infants being brought up by hand. It may be caused by uncleanliness of the feeding bottle, especially about the cork; by overfeeding, or by improper food. Very sour breath, vomiting after food, flinching when slight pressure is made on the pit of the stomach, flatulence, sometimes aphthous mouth and fever (*vide* p. 446), are characteristic. Children thus affected also usually suffer from diarrhœa, and the stools may be light of colour, and containing lumps of undigested milk. Disorder of the stomach most usually in children subsides in a few days; or it may terminate in *infantile diarrhœa*, or in *dysentery*, or in *remittent fever*, or in *thrush*, or in *convulsions*, or in *rickets*, or in *water on the brain*, or in *atrophy*, or, if the child has been exposed to the specific contagion, in *typhoid fever*.

Treatment is more dietetic than medicinal. The condition is often induced, and frequently kept up, purely by improper feeding. Giving milk or other food whenever the child cries is a fertile cause. Although much may be rejected by vomiting, enough remains to decompose in the stomach. The best treatment is abstinence, so that the stomach may have time to recover itself. Children with disordered stomach will not suffer from hunger, even if given water only, for a day or two. The milk should be given sparingly, and lime-water (Recipe 25) should be given several times daily; or, if the infant is being fed, lime-water should be mixed with the milk in one-third proportion. In severe cases it often happens that milk is injurious, because it so quickly decomposes in the sour stomach of the child. It is therefore often advisable to stop milk, or farinaceous foods if being used, and to give instead, at hourly intervals, tea-spoonfuls of raw meat soup, or of beef-extract; sometimes one, sometimes the other being best retained (*vide Addendum*).

[If obtainable, peptonise the milk with Fairchild's peptonising powders, when it may perhaps be retained. In severe cases, when there is no natural colour in the stools, it is advisable to give some medicine to act on the liver, when podophyllin and rectified spirit mixture, as recommended at p. 142 for some forms of constipation, may be tried. If the desired effect is not produced, for a child one year old, 1 grain of calomel, with one-sixth of a grain of ipecacuanha every three hours for six doses. When nothing can be retained on the stomach, and the child appears sinking from want of food, the limbs should be rubbed with cod-liver oil; small pieces of sponge, soaked in cod-liver oil, should be placed in the armpits, and injections of beef-tea may also be used.]

The diseases for which gastric disorder in children are most likely to be confounded are *hydrocephalus*, or *water on the brain*, and *enteric fever*. The chief characteristics are therefore placed in comparison:-

Gastric Disorder	*Hydrocephalus*	*Enteric Fever*
Common in young children.	Common in young children.	Not common in young children.
Vomiting continual and severe.	Vomiting continual and severe.	Vomiting occasionally present, but not severe and continued.
Disgust for food after vomiting.	Asks for food after vomiting.	Disgust for food.
Vomiting ceases after the stomach is empty.	Continues after the stomach is empty.	Continues.
Pain and tenderness at the pit of the stomach.	Pain in the head.	Pain and tenderness over the bowels at the sides.
Bowels loose; stools light, with undigested food.	Bowels usually constipated.	Diarrhœa, with yellow-coloured stools.

Gastric Disorder	*Hydrocephalus*	*Enteric Fever*
Bowels variable, often distended by flatus.	Bowels shrunken and contracted.	Bowels drum-like.
No delirium.	Delirium.	Delirium.
No eruption.	No eruption.	Eruption of mulberry-coloured spots about the twelfth day.
No rolling of the head.	Rolling of the head.	Not.
Origin from improper feeding.	Origin often constitutional.	Origin from a specific poison.

STRICTURE.—Stricture, or contraction of any of the natural passages of the body, may occur as the effects of disease or of injury.

Stricture of the Gullet.—This prevents the passage of food into the stomach, and is characterised principally by gradually increasing difficulty of swallowing, noticed probably during years, and occasionally aggravated by fits of spasm. There is also pain in the chest and between the shoulders, and if an instrument is passed into the gullet it meets with an obstruction. Hysterical females may also suffer from symptoms of stricture of the gullet, but in such cases the difficulty of swallowing often appears suddenly and vanishes as quickly. Hysterical females should be treated for hysteria. When symptoms as above occur to others, general and surgical treatment under professional superintendence is required.

Stricture of the Rectum.—The symptoms are pain, straining, and difficulty in passing the fæces, which are voided in small narrow flattened pieces. There are also cramps and pains in the thighs, frequent desire to make water, and dyspeptic symptoms. A medical man should be consulted as soon as possible.

Stricture of the Urethra.—The urethra, or channel by which the urine passes, is subject to both *permanent* and *spasmodic* stricture.

Permanent Stricture signifies a contraction of the canal of the urethra in one or more places owing *generally* to attacks of gonorrhœa, but caused *sometimes* by injury. The symptoms of stricture of the urethra are frequent desire to pass water, especially at night, a little urine dribbling out after micturition and wetting the clothes, increasing difficulty in making water, a small, forked or twisted stream of water, and that stream diminished in bulk. There is often itching at the end of the penis, and a gleety discharge. As symptoms much resembling those of stricture occur from stone in the bladder (*vide* p. 73), or enlarged prostate gland (*vide* p. 366), examination by passing an instrument (*vide* p. 493) is the only certain test.

Treatment.—Any stomach disorders, or acidity of the urine, must be removed by aperients and antacids, and temperance, rest, and early hours must be adopted. But mechanical treatment is of most importance, and consists in the periodical passing of an instrument, only to be performed by a surgeon. When the stricture has been dilated, the passage may be kept open by the patient, if instructed how to use a bougie of the proper kind.

Spasmodic Stricture usually occurs to persons who have some slight permanent stricture. The exciting causes of spasm of the part are indulgence in drink, especially of an acid nature, retaining the urine too long, exposure to wet, horse or bicycle exercise, irritation from piles, or some unnatural condition of urine. The symptoms are now those of *Retention of Urine*. The patient has a great desire to pass water, and on straining finds himself unable to do so; the bladder becomes distended, and appears as a globular tumour in the lower part of the belly. The suffering is great and the person grows feverish, and, if not relieved, the continued efforts at evacuation may terminate in rupture of the bladder or urethra, and in *extravasation*, or escape of the urine into the surrounding tissues. When this serious complication results, the patient during a violent effort of straining feels something give way; his painful sense of distension becomes immediately less, and he thinks himself getting well. He probably now makes a little water, as the stricture relaxes when the pressure behind is removed, and this further adds to his satisfaction. But in a very short time smarting pain occurs about the anus, in the fork, and in the privates; for the irritating urine has penetrated into all these parts, which rapidly become red, much swollen, and inflamed. Blackish spots and blisters, significant of *mortification*, soon appear, the tongue becomes black, the pulse feeble, and muttering delirium and hiccough precede a fatal termination.

When the escape of urine is not great, as occurs if the patient is relieved at the critical period, an abscess forms in the fork behind the scrotum. Or sometimes an abscess forms without any escape of urine, simply as the result of irritation. This, called *perinæal abscess*, is known by throbbing pain, tenderness, hardness, and a globular swelling, with hot skin and feverishness. Frequently a *perinæal* abscess results in *fistula* (*vide* p. 44), through which often urine finds its way from the bladder.

Treatment.—When stricture causes *retention of urine*, the first thing is to relieve the patient. If the symptoms are not very severe, and if the stoppage of water has succeeded a debauch or exposure to cold, a hot bath followed by fomentations to the fork and lower part of the bowels, and a full dose, as 12 or 15 grains, of Dover's powder, will generally afford relief. If the bowels have not been recently opened, an ounce of castor oil should be taken one hour after the Dover's powder. If these measures do not succeed in the course of three hours, a full dose, as 30 grains, of chloral may be given, and leeches to the number of thirty should be applied *behind* the scrotum. If urine does not pass, the catheter should be introduced (*vide* p. 493), which may be very difficult, and will require the aid of a surgeon. *The treatment of extravasation of urine*, and of abscess from this cause, urgently require skilled aid, in the absence of which it will be best to apply poultices made of finely powdered charcoal, and poppy water (Recipe 81).

[In addition to the remedies mentioned above for the relief of *retention of urine*, tincture of iron mixture (Recipe 71) should be procured, 1 ounce of which should be given every quarter-hour. It will also be advisable to give a morphia draught (Recipe 65).]

When *extravasation* of urine occurs, a free incision, three inches long and one deep, should be made in the middle line of the swollen scrotum, and any other parts of the scrotum or perinæum which are swollen and prominent should also be pricked. Then a poultice should be applied, and a catheter should be introduced into the bladder and retained there, to allow of the escape of urine. When abscess forms in the perinæum or fork, it should be opened without delay. The diet should consist of nourishing broths and soups, and, if *extravasation* occurs, wine or brandy should be freely administered.

ST. VITUS'S DANCE.—This disease, technically termed *chorea*, generally affects children, especially female children, and is most common from eight to fourteen years of age. Children badly fed, or living under bad hygienic conditions, are especially liable. Antecedent illness, as scarlet fever, measles, whooping-cough, or rheumatism, predisposes. Other causes are intestinal irritation from constipation, or from worms; it has been known to arise from the irritation caused by a decayed tooth or from teething; it is sometimes a consequence of debility or *anæmia*; it is frequently associated in young girls with irregularities of the menstrual flow. It has followed frights occurring to weakly children. Mental over-work is a predisposing cause. Immoral practices may induce it. It occasionally seems to be hereditary without special cause.

Chorea generally comes on very insidiously, and is often preceded by night terrors (*vide* p. 145), or by vague pains of a rheumatic nature, which may be regarded as 'growing pains.' Other premonitory symptoms are moping and melancholy combined with fidgetiness and restlessness, bad temper, and inability to sleep. Then there are slight contortions of the face, or slight convulsive movements of the legs. When fully formed there may be convulsive movements of all the limbs. In walking the leg is suddenly thrust to one side, or pulled backwards; or in conveying the hand to the mouth it is snatched towards the forehead or shoulder, or above the head. Occasionally there may be difficulty of speech, or paralysis of one limb, or fainting fits, or palpitation of the heart. The valves of the heart are also liable to become affected, especially in those who have previously had rheumatism. In exceptionally severe cases the convulsive movements are so violent and continued that the patient may die from exhaustion. The ordinary duration of chorea is two months, but it may last six.

Treatment.—The probable cause of the malady must be studied. If from worms, they should be expelled (*vide Worms*, p. 482). If from constipation, this condition must be relieved. If from decayed teeth, they must be removed. If from teething, the swollen gums must be lanced (*vide* p. 434). If from anæmia, that condition must be treated (*vide* p. 46). If from menstrual irregularity, this must be treated (*vide* pp. 468, 470). If from simple debility, tonics are necessary, of which the most successful is arsenic (Recipe 75) in doses according to age (*vide* p. 6). If from immoral practices, such habits must be abandoned. In very severe cases perfect rest and quiet should be ensured, the patient should be placed in bed in a darkened room, all causes of excitement should be avoided, the limbs should be shampooed several times daily, and for adults bromide of potassium (Recipe 19) should be given thrice daily, and chloral (Recipe 64) at night to procure sleep. For children, the same medicines, in the doses mentioned at pp. 9 and 11. As soon as possible in severe cases, and immediately in mild cases, change of air and surroundings is most desirable. The heart-affection sometimes accompanying chorea usually remains for some time afterwards, but gradually gets quite well.

SUNSTROKE, or INSOLATIA.—There are several forms, presenting considerable variety of symptoms, as below:—

1. *Heat Fainting*, or *Syncope*. 2. *Heat Apoplexy*, or *Coup de Soleil*. 3. *Sun Fever*.

Sunstroke of all kinds is due to nervous disturbance from prolonged high temperature,[1] either with or without direct exposure to the sun's rays. The liability to sunstroke is increased by fatigue, mental excitement, depression of spirits, living and especially sleeping in crowded apartments; by want of ventilation, by want of water, by constipation of the bowels, and by the abuse of alcoholic drinks.

Premonitory Symptoms of Sunstroke.—Frequently previous to an attack of sunstroke, the person affected becomes irritable, restless, and complains of headache. He feels dull and listless, and is unable to make much exertion without a great effort. The appetite fails, and a feeling of nausea, and constipation of the bowels are often present. An absence of perspiration may also be noticed, the skin may be unusually hot and dry, there may be slight sensations of giddiness, and there may be more frequent desire than usual to make water, although little fluid is passed. Confusion of ideas, confusion of vision, loquacity, fits of laughing and crying may occur. Such premonitory symptoms may prevail for hours or for days previous to the fully developed attack, or they may not occur; or, occurring,

[1] For the manner in which elevated temperature acts, *vide* Chapter VI., 'Heat.'

pass away. When anything of the kind is noticed in persons exposed to a high temperature, every means possible should be used to secure ventilation and movement of air, shade and coolness should be sought, cold water should be plentifully drunk, and the body should be well sponged with water, or a bath should be taken. A purgative (Recipes 1 and 2) will generally be desirable, and citrate of magnesia draughts (*vide* p. 15) should be given every two hours.

1. HEAT FAINTING, OR SYNCOPE.—Either after the foregoing premonitory symptoms, or without such symptoms, *heat fainting*, or *syncope*, commences with feelings of faintness, sickness, giddiness, shivering, cold extremities, frequent desire to make water, and sometimes drowsiness. The face is pale, the surface of the body is cold, and often bathed in perspiration. The breathing is of a sighing or gasping character, the action of the heart and pulse are weak, sometimes intermittent, the pupils of the eyes are contracted, and there may be more or less insensibility.

2. HEAT APOPLEXY, OR COUP DE SOLEIL.—Heat apoplexy may be preceded for a variable time by the *premonitory symptoms* as above detailed. Or, *secondly*, it may commence as *heat fainting*, or *syncope*, which condition, after a few minutes, or perhaps a few hours, passes into another state, characterised by *flushing of the face, heat of body and head, bloodshot eyes, strong quick pulse, stertorous snoring, or puffing breathing (marking the brain most affected), or noisy, irregular, and incomplete breathing (marking the lungs most affected). In a very short period insensibility ensues, and sometimes convulsions. Or, *thirdly*, *coup de soleil* may occur suddenly, without either premonitory symptoms or the fainty feelings of heat syncope. In such cases the person falls down as suddenly as if struck with apoplexy, and the symptoms are as above (*commencing at *flushing of the face*). Sometimes

there may be convulsions, but in the majority of these cases the patient does not move again. According as the malady appears to expend itself on the head or chest, the terms *Heat Apoplexy* and *Heat Asphyxia*, or *Heat Suffocation*, have been applied.

Treatment.—The form in which the disease attacks should be recognised. When the patient is faint, sick, giddy, shivering, and cold, lay him on his back in the shade, rub the limbs, loosen the clothing, and give wine or brandy and water. But the case must be treated with caution, on account of the tendency of the malady to run on to that condition marked by flushed face, heat of skin, bloodshot eyes, and quick, strong pulse. When such symptoms are observed stimulants should be withheld, cold water should be poured on the head, punkahs should be used to cool the surrounding atmosphere, and, if the patient can swallow, a quick purgative, as 1 ounce of sulphate of soda in three ounces of water, should be given. If available, 8 or 10 grains of quinine should be added to this draught; or it may be given afterwards. Recipe 105 should also be used cold as an injection; or, if not at hand, an injection of cold water. The extremities should be rubbed, mustard poultices or turpentine stupe should be applied to the nape of the neck, and, if insensibility and puffing breathing ensue, the injection should be repeated, and twenty leeches may be applied at the roots of the hair above the temples. The patient may also be wrapped in a wet sheet.

When the symptoms point to lung affection (known by the irregular, noisy, laboured, and incomplete breathing, but neither sighing nor stertorous or puffing), in addition to cold affusion, quick purging, and friction to the extremities, a large mustard poultice should be applied to the chest. If doubt is felt as to which is most affected (the head or the chest), or if, as often occurs, both are affected, mustard poultices or turpentine should be placed both on the back of the neck and on the chest (*vide Appendix*, Nos. 108, 109).

In all varieties of sunstroke the patient should be encouraged to drink plentifully of cold water, to supply the place of the evaporation of fluid constantly taking place from the skin.

If the patient has previously suffered from venereal, iodide of potassium (Recipe 21) should be given as soon as possible. Venereal sometimes produces a condition of the blood-vessels of the brain which may predispose to sunstroke and to its after-effects, and which condition the iodide tends to correct.

Although recovery is often rapid and complete, more commonly fever and oppressed breathing prevail more or less for some days. All forms of sunstroke are frequently followed by periodical headaches, by fever, by neuralgic affections, by dysentery, and sometimes by paralysis. They occasionally leave permanent injury of the brain, which may terminate in softening of that organ, or in insanity. Often, when recovery seems complete, the person is afterwards unable to bear any exposure to the sun, and is unfitted for active life in the tropics.

[As noted above, in the great majority of cases of sunstroke, quick purging is most desirable. Therefore, if obtainable, two drops of croton oil mixed in a little sugar should be given instead of the sulphate of soda. If the patient cannot swallow the croton oil and sugar, it should be placed, by means of a feather, on the back of the tongue. Subcutaneous injection of quinine is also advisable.]

3. Sun Fever.—May be very trivial or very severe. Probably most people who are exposed to the sun during the day experience some feverishness afterwards, and often take no notice of it. It may disappear in a few hours, or it may cause a restless night, and perhaps diarrhœa. Or it may continue with languor, weakness,

loss of appetite, &c., presenting precisely the same symptoms as described under *continued* or *ephemeral* fever at p. 239. It seldom lasts more than twenty-four hours, and then declines, or develops into a condition known as ARDENT SUN FEVER. This severe form of sun fever chiefly prevails in the months of April and May, and in seasons when the temperature is unusually elevated. The attack, or development from a minor degree, is generally sudden, commencing with premonitory chills. There is pungent heat of skin and great thirst, the tongue is parched, red, and dry, the pulse quick and strong. There is much headache, flushed face, throbbing of the temples, restlessness, nausea, and bilious vomiting. The duration of the disease is about sixty hours, after which, if amendment does not take place, insensibility precedes death.

Treatment.—For a minor degree of sun fever, or for irritability after exposure, a cold or tepid bath according to habit, rest and quiet under a punkah, and, if the bowels are confined, an aperient dose are desirable. For *ardent sun fever*, leeches to the head (one for each year of the patient's age up to thirty), shaving the head, and the application of cold to the head, a darkened room, rest, quiet, and repeated purgatives (Recipes 1, 2). In the latter stages, if great exhaustion occurs, ammonia, wine, brandy and water, and nourishing broths.

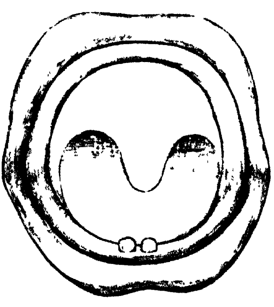
[Whenever the temperature rises suddenly to 103° or 104° Fahr. (*vide* p. 34) *cold* baths are very serviceable, but in the absence of a medical man are not advised.]

The means of prevention of sunstroke and sun fever are considered in Chapter VI., under 'Heat.'

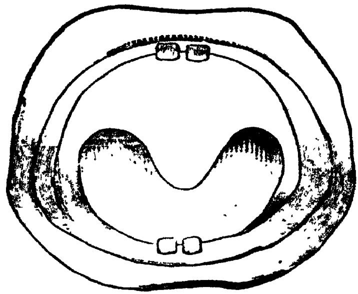
SWELLING OF THE LEGS.—Occurs from causes specified under dropsy (p. 186); and under diseases of pregnancy (p. 359); or at the change of life (p. 481); or in connection with amenorrhœa (*vide* p. 468) ; or from scurvy (p. 380) ; or from enlargement of the spleen (p. 414) ; or as a consequence of debility, or of heat. Swelling of the feet is common in India, especially towards night ; but, unless connected with obvious derangement of the health, does not need medical treatment.

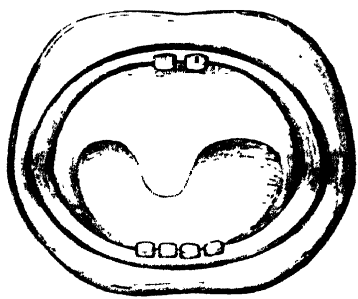
TEETHING, or DENTITION.—The intimate connections which exist between the nerves supplying the stomach (*pneumogastric*), the nerves supplying the teeth-pulp (*the fifth pair*, or *trifacial*), and the nerves supplying the general system (*the sympathetic*), are so extensive and numerous that functional interference with any part of one set is liable to act upon the others. Hence the frequent association of stomach or bowel complaints, of fever, of skin diseases, and of other derangements, with teething, especially when children are improperly fed.

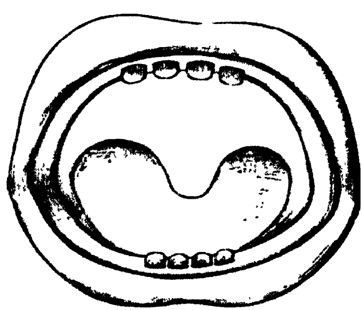
When the teeth appear naturally, and the child is in good health, they do so in the order shown by the following plates. The two lower central incisors, or front

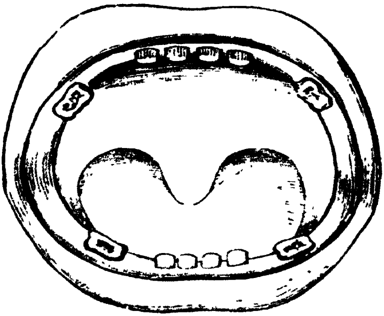


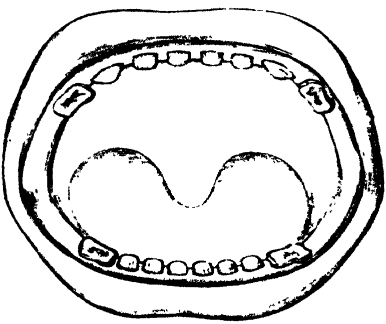
teeth, penetrate the gums between the sixth and seventh months (plate 1) ; the corresponding upper central incisors

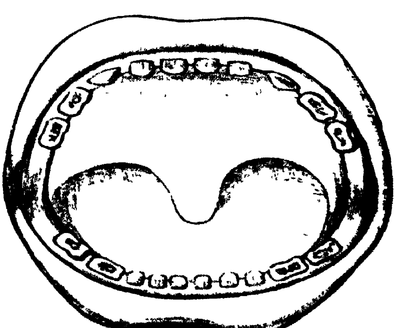












in from three weeks to a month afterwards (plate 2); the two lower lateral incisors about the eighth or ninth month (plate 3); the two upper[1] lateral incisors generally soon or a month afterwards (plate 4). The anterior molars or grinders of the under jaw make their appearance between the twelfth and fourteenth months, those of the upper jaw following shortly afterwards (plate 5). The canine or eye teeth are cut between the sixteenth and twentieth months (plate 6). Last of all, the second molars are cut between the twentieth and thirtieth or thirty-sixth months (plate 7).

Thus, the cutting of the twenty temporary or 'milk teeth,' as they are called, is completed, as a general rule, at the age of two and a half to three years.

FORMATION OF THE TEETH.—At birth the teeth consist of pulpy substance buried in the gums, and it is not till the *third or fourth month* that they assume shape and hardness. Infants at this period may suffer from symptoms of teething. The mouth may be hot; there may be restlessness, flushings of the face, heat of hands and surface generally, with loss of appetite, and perhaps vomiting and diarrhœa. But the gums do not show *localised* irritation, and the condition is often attributed to some other cause. The same occurs during the intervals between the appearance of the teeth, and is vulgarly called 'the breeding of the teeth' in the gums. It arises from the pressure made below the surface of the gums by the growing teeth, which have not yet risen sufficiently to render the skin of the gums tense and prominent. A little of a preparation of sixty grains of bicarbonate of soda, well mixed with one ounce of honey, should be rubbed on the gums two or three times daily, and cooling medicine, as citrate of magnesia (*vide* p. 15), should be given. Remedies for diarrhœa, or for constipation, or for flatulence (*vide*

[1] The upper lateral incisors often precede the lower ones.

pp. 172, 138, 273), as such conditions may prevail, should also be prescribed.

Cutting of the Teeth.—Most people will, doubtless, remember feeling pain when the wisdom teeth appeared, and infants, probably, often experience the same annoyance. This, however, is not always the case, for sometimes it is discovered that an infant has cut a tooth who had not yet shown any indication, excepting an increased flow of saliva, that dentition had commenced. But more frequently the mouth becomes hot, and the gums look tense, tumid, and shining, while the position of each tooth is marked some time before its appearance by an increased prominence of the gum. If teething is going on naturally, and there are no symptoms beyond a little feverishness, dribbling from the mouth, or occasional diarrhœa, interference is not necessary. Preventing the dribbling from the child's mouth saturating the clothing and producing cold is all that is required. The most common complaints during teething are restlessness, and feverishness at night. The child's temper is cross, the flesh becomes soft, and there is loss of colour, all improving on the day the tooth comes through. But the liability of infants to illness at such period should be borne in mind; and care should be taken not to make any alteration in the infant's food while it is actually cutting the teeth; but rather, if change of diet be necessary, to take the opportunity afforded by one of those pauses of dentition to which reference has been made. Should the child grow suddenly hot and feverish, or wake screaming at night, cooling medicine, as citrate of magnesia (*vide* p. 15), may be given every two hours, while the bowels, if confined, should be moved by castor oil. An india-rubber *ring*—the best shape, as it cannot be thrust into the eye—may always be given to the child to suck. The pressure against the gums of the elastic india-rubber substance is agreeable to the child, and, moreover, tends to increase the rapidity with which the gum above the rising tooth is absorbed. Giving sweet things to children to suck during teething must be condemned, as the 'barley sugar,' or other material sometimes used for this purpose, being swallowed, turns acid in the child's stomach and disorders the bowels. When a tooth is near the surface, there is a prominent, shining, and sometimes white appearance of the gum, and the child who before was pleased to have the gums rubbed, does not willingly permit them to be touched. If the child is feverish or otherwise suffering, the gum may be lanced. But the gum-lancet should seldom be used unless there is evident irritation or prominence of a gum, or when it appears the gum will certainly burst in a day or two. Under such circumstances lancing the gum will spare the infant much suffering. In a smaller number of cases it may be necessary to lance a red and swollen gum when the tooth is not so near—as when a child has convulsions, or is attacked with other serious ailment. But this is done to scarify and relieve the turgid gums, *not* to divide them down to the tooth.

LANCING THE GUMS OF CHILDREN.—This is very easily managed, and any intelligent person seeing it done once or twice may do it effectually. The operation may be performed with a gum-lancet (*vide* p. 491), the edge of which must be placed vertically on the top of the inflamed gum, and moved along, pressing firmly at the same time, till the edge of the instrument grates on the tooth. Care must be taken that the instrument does not slip.

The best way to lance the gums of infants is to place two chairs near a window, so that the light falls on the operator. The child's nurse, sitting on one chair, should allow the head of the child to fall gently backwards on the operator's knees. Then the lancet may be easily used as mentioned above. If the child is restless, a shawl may be wrapped round its body to prevent the hands being raised to the mouth.

During teething there is a demand in the system for certain mineral matters, of which the principal is lime, which plays a considerable part in the construction of the teeth. Therefore, when teething is difficult, or when the maladies mentioned below supervene, a little lime-water may be given (*vide* Recipe 25). A few spoonfuls may be mixed daily with the food of the child if being fed by hand. Or if 'phosphate of lime' is procurable, a couple of grains should be given in a little water with each meal, instead of lime-water.

The principal maladies occurring during, or excited by teething, are as follows:—

1. VARIOUS FORMS OF SKIN DISEASES.—Almost any variety of skin disease may occur during dentition. Most frequently skin affections at such times take the form of 'breaking out,' or *eczema*, near the ears; or of 'rose rash,' or *erythema* (*vide* pp. 386, 396); or of *pompholix* (*vide* p. 398); or the glands underneath the chin may swell. It frequently happens that, in spite of any treatment, these skin affections persist during the whole period of teething, then getting well. They are seldom dangerous, and rarely need much medical treatment. They frequently serve as a relief to the system, and if they are suddenly checked, disease of some internal organ may manifest itself. It is generally better to abstain altogether from external medicinal applications. The parts affected should be kept perfectly clean by washing frequently with glycerine soap, after which a little cold cream or simple ointment may be applied. Maintaining the bowels freely open by castor oil or by citrate of magnesia, together with the careful regulation of the food, are the best means of curing these

eruptions. They are often increased by acidity of the stomach, and are then much benefited by 2 or 3 grains of bicarbonate of soda, or magnesia, given daily. If there is debility or feverishness, a grain of quinine may be added.

Rose rash, roseola, or *red gum*, and *erythema*, all skin affections occurring during teething, are described under *Skin Diseases*, pp. 386, 387.

2. THRUSH, or APHTHÆ (*vide* p. 446).

3. FLATULENCE (*vide* p. 273).

4. VOMITING.—Vomiting during teething is common, and may be connected with skin maladies, or with diarrhœa, or be a symptom of disordered stomach (*vide* p. 415), or may occur unassociated with other ailments. It may depend on indigestible food, or on too frequent feeding; or it may arise from that intimate communication between the different nerves supplying the teeth and stomach, as before noticed (p. 429), and by which the irritation arising in one part is conveyed to, and reacts on, another part of the body. Vomiting, therefore, is to be relieved by attention to the food, giving particular care to the cleanliness of the utensils used, if the child is taking other sustenance than human milk; by relieving constipation or diarrhœa by appropriate remedies; and by lancing the gums if they present the appearances described as indicating the use of the instrument (*vide* p. 434).

5. DIARRHŒA (*vide* INFANTILE DIARRHŒA, p. 172).

6. COUGH.—Cough of a short, dry, hacking character, often commencing soon after the child is put to bed, is caused by sympathetic irritation of the upper part of the air-passages, is of a nervous nature, and will be best relieved by bromide of potassium (Recipe 20). But cough of a different character, accompanied by wheezing of the breathing, and feverishness occurring during teething, must be looked upon with suspicion as the possible com-

mencement of *bronchitis* or *inflammation of the lungs*, and Recipe 57 should be given immediately.

7. Bronchitis and Pneumonia (*vide* pp. 105, 328).
8. Convulsions (*vide* p. 145).
9. Paralysis of Infants (*vide* p. 344).
10. Disorders of the Stomach (*vide* p. 417).

Teeth, Second or Permanent Set.—The advance of the second set of teeth causes the absorption of the roots of the temporary or milk teeth, and thus facilitates their shedding, the crowns falling off and leaving room for the permanent teeth to come forward and supply their places, in which process the following order is usually observed. First, between five and six years of age, the *first permanent molars* or grinders (four in number) appear, *immediately behind* the milk molars, and for a short time the child has four permanent and twenty temporary teeth. The front teeth, *middle incisors* (four in number), are next shed and renewed, usually when the child is between seven and eight. Then a year or so later the side or *lateral incisors* (four in number) are replaced by others. The anterior double teeth *molars* (in number four) are replaced about the ninth year by the *bicuspids*, or small or false permanent molars, and about the tenth year the posterior double teeth *molars* (four in number) are replaced by similar teeth. About the eleventh year the *canine* teeth (four in number) are replaced, these being the last of the milk teeth to be exchanged. Near the twelfth year four more true or large *molars* arise, and the appearance of these teeth is regarded as a sign that the child is twelve years old. The third double teeth (molars), or wisdom teeth (*dentes sapientiæ*), four in number, seldom appear until three or four years subsequently, and often later. The number of the second set of teeth when complete is thirty-two.

As a rule, no trouble attends the appearance of any of the permanent teeth, excepting the wisdom teeth. But sometimes the front teeth are too crowded, and the side teeth may grow so out of line as to irritate the mouth and require extraction. In many cases the individual may, by constantly pushing with the tongue, do much towards maintaining the teeth in an even row.

The cutting of the wisdom teeth is often attended with pain. The difficulty arises from the teeth appearing so close to the curvature or angle of the lower jaw that the mucous membrane of the mouth, where passing from the cheek to the jaw, is caught by the rising wisdom tooth, and nipped every time the mouth is closed. Ulceration is produced, and a troublesome sore may result. Sometimes there is stiffness, or even closure of the jaw in consequence. The best *treatment* is to nip away, with a sharp pair of scissors, any overhanging fold of membrane, so that the teeth may not press upon any part of the texture of the mouth when the jaws are closed. The ulcer will then heal, particularly if touched occasionally with a camel-hair pencil charged with strong alum water, or with vinegar.

TESTICLE, INFLAMMATION OF THE.—May arise from various causes, as injury, mumps, and gonorrhœa. The whole organ may be affected, or the posterior part may be chiefly implicated. The symptoms are heat, swelling, redness, great tenderness, pain between the legs, aching and dragging sensation in the loins, feverishness, nausea, and sometimes vomiting. If discharge has been coming from the penis, it ceases when the testicle inflames. Both testicles may be affected, but usually the right is attacked.

Treatment.—If an injection is being used it should be stopped. Perfect rest in bed is desirable, and the inflamed part should be raised on a small pillow. It should be assiduously fomented with hot poppy-water (*vide Appendix*, No. 81), and if the inflammation is violent, and the pain and tenderness unbearable, leeches should be applied (one for each year of the person's age up to thirty), not on the testicle itself, but along the course of the cord in the flexure of the groin. Magnesia draughts (*vide* p. 15) should be given to relieve feverishness. If necessary, the bowels should be well opened by successive doses of Recipe 2, and chloral (Recipe 64) should be given at night to relieve pain and afford sleep. The attack runs its course in about ten days, after which the testicle will require to be supported until all remaining hardness and swelling subsides, which may not be for some weeks. If a person with swelled testicle is unable to keep at rest, as advised above, the great thing is to support the parts well by a suspensory bandage, or with the handkerchief as described below. In severe cases the person is totally unable to move about, however much he may wish to do so, and in all cases the less he does so the more quickly will a cure be brought about.

When swelled testicle occurs to boys with mumps, the pain and swelling are usually moderate, and beyond raising the organ and fomentations, no treatment will be required. This form of swelled testicle subsides rapidly, without leaving any permanent swelling.

[If a suspensory bandage is not obtainable, a substitute may be formed by a broad bandage and a handkerchief. The bandage should be passed round the waist like a belt, and fastened. Then the handkerchief should be folded into a triangular form. The centre of the base of the triangle is to be passed under and behind the purse, as far as possible. Then the two lateral ends of the handkerchief are to be drawn up, and passed (on each side) first in front, and then over and behind the waist-belt, each end being then brought in front of that part of the handkerchief passing over the bandage. The two ends are then tied together. The front end of the handkerchief is then brought up, passed under the bandage, carried over it, and attached to the knot formed by the other two ends. In this manner a bag may be formed.]

TETANUS.—The disease usually commences with stiffness of the neck and about the jaws, which are opened and closed with difficulty. The person frequently regards this as due to cold, and thinks it rheumatism. There is often difficulty of swallowing, leading to violent ejection of fluids from the mouth or through the nose. In some instances the malady does not proceed further, and the patient may recover. But in other cases, in the course of a few hours or days the jaws become firmly closed, constituting 'lockjaw.' *Spasms* of the limbs and body also supervene, by which the patient may be bent like a bow, resting on his heels and the back of the head; or the body may be bent to either side. Sometimes the hands and forearms to the elbows escape these spasms. The face is contorted into a frightful grin, known as the *risus sardonicus*. There is agonising pain in the limbs during the spasms, and also at the pit of the stomach, shooting through to the back. The spasms recur at periods varying from a few minutes to hours; but during the intervals between the spasms the muscles remain hard, and do not thoroughly relax unless the patient sleeps. During the spasms the breathing is laborious, the skin is hot, and drenched with perspiration. The patient may die from suffocation, in consequence of spasm of the top of the windpipe (*glottis*), or from spasms fixing the muscles of the chest and preventing breathing, or he may die from exhaustion. The *causes* of tetanus are not well understood. It sometimes follows exposure to cold; in females, cold bathing during the monthly period has excited it; and it often follows wounds or injuries; but it would seem some peculiar irritable condition of the constitution must be present when tetanus occurs from such causes. It has been noticed at p. 438 that stiffness of the jaws may be caused by cutting a wisdom tooth, so that when symptoms of the kind present in young people, it will be well to ascertain if this is the case.

Tetanus may be mistaken for *hydrophobia* (*vide* p. 300), and *vice versâ*. But in hydrophobia there is generally *fear of water*, in tetanus there is no such fear. In hydrophobia there is no lockjaw, in tetanus lockjaw. In hydrophobia there is constant 'hawking' and spitting, in tetanus none. In hydrophobia there is complete relaxation of the muscles after any convulsive seizure, in tetanus the limbs remain more or less hard between the struggles. There is generally the history or mark of a dog-bite in the one case, not in the other; but probably the mark of some other injury.

Tetanus may also be mistaken for poisoning by *strychnine* (*vide* p. 586). In tetanus some exciting cause, as a wound, is often present. In tetanus the muscles of the jaws are first affected, which is rarely the case in poisoning by strychnine. In poisoning the spasms chiefly affect the extremities, and in tetanus the hands and forearms often escape. In poisoning, although the jaws may be firmly closed, the mouth can be opened during the intervals between the spasms, and there is no real 'lockjaw' as in tetanus. Tetanus comes on more gradually than the effects of strychnine, which presents in a few minutes after a poisonous quantity has been taken. In tetanus the spasms do not thoroughly relax even between the paroxysms; in poisoning the periodical relaxation is complete.

Hysterical convulsions have been sometimes mistaken for tetanus; but a reference to the description of hysteria (*vide* p. 305) will at once show the difference.

Treatment.—Chlorodyne, or chloral, to relieve pain and spasm, supporting the strength with good soups and stimulants (to give which a tooth must often be removed), are the requirements. Ice, if procurable, may be pounded, put in a bag or cloth, and applied over the spine.

[If the above remedies do not relieve the spasm, 5 drops of chloroform with 20 minims of tincture of opium in an ounce of water; this not seeming efficacious, morphia (Recipe 65), that medicine being repeated every four hours, which appears most soothing.]

INFANTILE TETANUS, or *tetanus neonatorum*.—Lockjaw, or even complete tetanus, sometimes occurs to infants, generally between the third and tenth day after birth, and when slight is spoken of by nurses as 'nine-day fits' (*vide* p. 145). It is usually preceded by premonitory symptoms, such as restlessness, whimpering, broken sleep, yawning, and hasty snatches at the mother's breasts, which are soon relinquished; but often such symptoms are not noticed, or referred to some other cause. Probably the first thing which attracts attention is inability of the infant to take the breast properly, which may be attributed to some fault of the mother's nipple, or to tongue-tie of the infant, until at length the infant's jaws are noticed to be stiff. When an infant has taken the breast properly and then does not do so, suspicion of lockjaw should arise, and the jaws should be examined for stiffness. *Roseola* or 'red gum' (p. 387) is sometimes associated. If the disease goes on, the symptoms as detailed at p. 440 present. The causes of the tetanus of infants are exposure to impure air, or chill, or mismanagement and irritation of the navel-string. The treatment consists in giving nourishment, the best being the mother's milk. The jaws must be gently separated by the end of a spoon protected by a little linen rolled round it; and then milk, diluted with one-third the quantity of lime-water (Recipe 25), should be given cautiously. If there is difficulty in swallowing, not more than half a teaspoonful, or even less, should be given at one time, but the attempt should be hourly repeated. An enema half milk, half lime-water (*vide* Recipe 25) should also be given thrice daily, and a warm bath (*vide Appendix*) twice daily. As medicine half a grain of chloral, and 1 grain of bromide of potassium dissolved in half a teaspoonful of water, every five or six hours.

THIRST.—Thirst is a symptom of disease (*vide* p. 37), and is always an accompaniment of fevers. Thirst also attends certain forms of dyspepsia, and is a prominent symptom of diabetes. Pure water may always be used to allay thirst. Citrate of magnesia is often beneficial (*vide* p. 15).

THROAT, DISEASES OF THE.—Sore-throat occurs as a symptom of various maladies, viz., diphtheria, scarlet fever, mumps, consumption, syphilis, inflammation of the windpipe, croup, thrush, small-pox. The principal affections of the throat itself are—1, *hoarseness*; 2, *elongated uvula*; 3, *inflammation and its results*; 4, *enlarged tonsils.*

1. HOARSENESS.—Hoarseness arising from cold depends on irritation about the top of the windpipe and back part of the throat. It is usually more pronounced in the morning, passing off as the day advances. For simple hoarseness unconnected with serious symptoms, flannel round the throat, a mustard poultice, the feet in mustard and water at night, and an expectorant (Recipe 57) are sufficient.

ess, caused by over-exertion of the organ by singers or public speakers, or by clergymen, is so common in the latter class as to be named 'clergyman's sore-throat.' It most frequently arises from straining of the voice by too long or too frequent speaking. The stiff band-like collar many clergymen wear presses on the throat when the head is bent, and produces constriction of the parts. The forward and downward inclination of the head when preaching, necessitated by the position of clergymen, is another cause, for barristers, who from their position when speaking look upwards, rarely suffer. Cold and damp churches, or passing from hot churches into the cold air, also tend to congest the throat. But in many instances of clergyman's sore-throat there is evidence from their anæmic appearance of constitutional debility. Clergyman's sore-throat is rarely connected with any inflammatory action. But the throat may be red and congested and feel sore. The only effectual remedy is *rest*, and then gradually bringing the voice into play, while avoiding the band-like stock and also looking down as much as possible. But a few days' rest is insufficient, some cases requiring weeks or months. When 'clergyman's throat' is feared, it is well for the throat to be 'hardened' from the first. While the beard is allowed to grow, as a protection against sudden chills, the throat should be rather exposed to the air than wrapped up in woollen 'comforters.' An alum gargle (Recipe 100) may always be used with advantage.

A piece of *borax of soda*, about the size of a pea, allowed to melt in the mouth, before speaking, often affords temporary relief. *Chlorate of potash* tabloids may be used for hoarseness, and have the advantage over gargles that they are gradually dissolved in the saliva, and are thus constantly brought into contact with the affected parts. Children take the tablets readily, as they have no unpleasant taste; while the convenience of carrying them in the pocket commends them to travellers. Burroughs and Wellcome's 'voice tabloids' of cocaine with potash and borax are recommended. When, in addition to huskiness or hoarseness, the tonsils are red and swollen, a solution of nitrate of silver (strength 8 grains to 1 ounce of water) may be applied to the tonsils, with a camel's-hair brush, twice daily. Quinine and iron (Recipe 70) may generally be taken with advantage.

2. **Throat, Elongation of the Uvula of the.**—The *uvula* is the appendage to the soft palate, which may be seen hanging in the centre of the back of the throat. Its office is to prevent fluids regurgitating by the nostrils during swallowing. When the uvula is affected by cold, or from public speaking, or sometimes participating in a deranged state of the stomach, it becomes relaxed and *elongated*, so as to extend down to the back of the tongue. This produces irritation, with huskiness of voice, and a peculiar hacking cough, especially when air is inhaled through the mouth in reading or speaking, and often also nausea or even vomiting. Alum powder, or nitre, may be applied night and morning with a brush, and attention should be paid to the state of the bowels.

[If this does not succeed, 10 grains of nitrate of silver dissolved in an ounce of water should be applied with a camel's-hair brush or feather twice daily. These means failing, one-third of the length of the uvula should be cut off by the surgeon.]

3. **Throat, Inflammation of the.**—Dangerous forms of inflammation of the throat are mentioned as occurring in *Scarlet Fever* and *Diphtheria*. Sore-throat is also a symptom of venereal disease. But when the throat is affected by such causes, other symptoms will be present, as detailed under the headings mentioned. Here is considered that inflammation of the throat which arises from cold, and to which fatigue, anxiety, and depression, and the foul air of sewers and drains predispose. Sore-throat from cold may be mild or severe. When moderate it constitutes a common sore-throat; and may or may not

be attended with some degree of hoarseness of the voice, which shows that the parts behind the throat are more or less implicated. When sore-throat is severe it constitutes *quinsy*. In this case generally one, but sometimes both, tonsils are affected. The part attacked becomes much inflamed and swollen, and often either *ulcerates* or '*gathers.*' When ulceration takes place, there is increasing soreness, swallowing is painful, and the ulcers may be seen as raw deep sores on the tonsils. When 'gathering' or suppuration occurs, there is increasing swelling, much *throbbing* pain in the throat, pain in the ears, headache, great difficulty of breathing and of swallowing, constant desire to swallow, while fluids put into the mouth may run through the nose. The process of 'gathering' occupies three or four days, when the abscess breaks, discharging thick fetid matter, which affords immediate relief.

Treatment.—Mild cases of sore-throat are sufficiently met by a mustard poultice applied externally, an occasional aperient (Recipes 1 and 2), and an alum gargle (Recipe 100). *Ulcerated sore-throat* requires touching with concentrated alum solutions (powdered alum 3 drachms, water 1 ounce). *When the tonsils gather*, fomentation should be used outside; the throat should be frequently steamed; ice may be given to suck; *calmative* doses of chloral (*vide* p. 10) may be used to allay pain and procure rest; and, if possible, the abscess should be lanced by a surgeon.

[Nitrate of silver solution (strength 10 grains to an ounce of distilled or boiled water) may be used in preference to alum solution.]

4. Throat, Enlargement of the Tonsils of the.—Enlargement of the tonsils is frequently the result of repeated attacks of inflammation. But enlargement of the tonsils often occurs gradually to children and young persons, and more commonly if there is any constitutional scrofulous taint. Residence in marshy damp localities

favours this affection. The tonsils become enlarged and hardened; there is some difficulty in swallowing, heavy breathing, and often more or less indistinctness of speech, with a peculiar nasal twang. Some degree of deafness may be present, and the person sleeps with the mouth open, snoring loudly. The patient is liable to acute attacks of sore-throat, from slight exposure to cold. This enlargement of the tonsils is more common in cold than in tropical climates; but it often presents in children during the cold season of the northerly provinces of India where the nights are characterised by a low temperature. It also occurs in the colder climates of the hill stations. The *treatment* consists in avoiding cold and chill, and in improving the general health by tonics, of which probably citrate of iron and quinine (Recipe 70) will be the most beneficial. The diet also should be nutritious. Alum gargle (Recipe 100) may be used; but local applications do little good. As a rule, enlargement of the tonsils will decrease as the patient grows older and stronger.

Painting with solution of nitrate of silver, or of iodine, as frequently recommended, has in some instances appeared to irritate, and thus favour the growth of the tonsils. Excision, or cutting off the tonsil, is sometimes advocated. This operation is, however, seldom really necessary, and never so unless the parts become white, hard, and so enlarged as to interfere distressingly with swallowing or speech.

Great caution ought to be exercised in taking a child from India to Europe with enlarged tonsils. Unless other ailments forbid, enlargement of the tonsils would afford a good argument for keeping the child in India for 'another year.' In any case, care and warm clothing on passing out of the tropics are essentially necessary; for an increase or recurrence of the malady is very likely to take place as the colder climate is entered, or even after some length of residence therein.

THRUSH, or APHTHÆ.—This is a disease sometimes called 'white mouth,' and generally affecting children, especially those brought up by hand, and particularly if there is a scurvy taint (*vide* p. 381). It commences with peevishness, feverishness, and often disordered bowels. It consists of an eruption on the tongue, lips, cheek, and gums, of small *white* vesicles, which discharge a whitish mucus like morsels of curd, for which they are often mistaken, and which consist of microscopical vegetable *parasitic* growths (named *Oïdium albicans*). This mucus adheres for some days, and, then falling off, discloses small ulcers. As a rule, thrush is not dangerous; but it sometimes spreads into the throat, inducing difficulty of breathing and of swallowing; and occasionally, in very weakly children, spreading ulceration, *gangrene*, or mortification of some part of the mouth, may result. The *parasite* noted above is probably generated in a dirty, sour condition of the feeding-bottles. Then such causes as debility, improper food, sour milk, impure air, irritation from teething, produce a disordered state of system, from which originates an unhealthy condition of the mouth suitable for the lodgment and growth of the parasite. *Treatment* should be directed towards the recognition and removal of the causes. If the bowels are costive, citrate of magnesia should be given (*vide* p. 15); but if, as more usually happens, there is diarrhœa, Recipe 18. If there is great debility, Recipe 66, and as soon as procurable Recipe 70 instead. The source and preparation of the food must be specially investigated (*vide Feeding of Children, Chap. V., or Index*), and a little lime-water (Recipe 25) should be given with the food. The child should be removed from any source of impure air, and if it is teething and the gums are swollen, they should be lanced (*vide* p. 434). The child should be fed frequently, as sucking is painful, and the pain causes the child to refuse the breast. Cleanliness is most essential, and after every meal the mouth should be washed out with warm water. The secretion in the mouth should be removed by frequently, but gently, washing the mouth with a piece of lint, firmly fixed on a stick of whalebone, and moistened with hot water. No force should be used to detach the flakes, only those loose being taken away. Afterwards alum, 1 drachm mixed with honey 4 drachms, should be applied, which will tend to destroy the parasite.

Sometimes an appearance resembling thrush is found at the outlet of the bowels, when the thrush is popularly said to have 'passed through.' The parts should be washed with alum solution (Recipe 97).

[If this does not succeed, the eruption should be brushed, twice daily, with a solution of *hyposulphite* of soda 1 drachm, water 1 ounce, which is reputed to destroy parasites.]

TOOTHACHE.—Toothache is generally caused by irritation or inflammation of the nerve of the tooth. Decay of the tooth until the nerve is exposed is the most frequent cause. The decay commences on the outside of the tooth and saps inwards. Frequently a slight chip or injury of the enamel initiates the decay. But the decay of food undergoing decomposition between the teeth, or in the natural depressions of the teeth, chemically affects and destroys the enamel, acting much in the same manner as acids. A fungoid growth (*Leptothrix buccalis*) found in the mouth attacks carious teeth, and helps the decaying process. Decay is often very insidious, and the fact of it being present is frequently only known by the occurrence of pain. It would be well if the teeth were systematically examined several times a year. A warning of pain, however slight, should never be neglected, and should lead to investigation and to such measures—stopping or otherwise—as may be required. The teeth of women during the period of pregnancy (*vide* p. 359) are apt to decay rapidly, and are peculiarly sensitive—a good reason for having them put in order previous to that event. In young people decay runs a more rapid course in consequence of the structure being softer, the shell thinner, and the pulp larger than in the teeth of older persons—an additional reason why the teeth of young people should be especially attended to. The great preventive of decay is keeping the surfaces of the teeth clean of the food, tartar, and mucus that lodge between and about them, and the use of the tooth-brush should be taught as soon as there are teeth. As a rule, and especially when there is a thick, sticky saliva, a saponaceous tooth powder, or soap, should be used. Many tooth powders are not only useless but actually injurious.

A *tooth powder* should be alkaline; finely pulverised, that it may not mechanically abrade the teeth: antiseptic, to destroy microbes; should contain nothing irritating to the gums; and should be pleasant to the taste. Pumice powder is too gritty; camphorated chalk makes the gums spongy. The following is a good recipe:—Precipitated chalk 1 ounce, powdered Castile soap 1 drachm, oil of eucalyptus 1 drachm, and, if no objection to the taste, carbolic acid half a drachm.

Although decay of a tooth is the most common cause of toothache, it may present without any deterioration of the kind. Toothache is sometimes *neuralgic*, coming on at regular intervals, and then sound teeth are attacked. This will require purgative medicine, followed by quinine. In some cases the crown or body of the tooth is unaffected, but the fangs or roots are diseased, causing the tooth to feel big and tender. This is usually associated with a succession of gum-boils (*vide* p. 290), and extraction of the tooth is generally necessary.

A large number of nostrums are sold as cures for toothache. But there is no specific cure. A hollow tooth may often be kept easy by filling it with beeswax. When there is a large hollow, and pain is severe, a good application is a mixture of camphor and opium, of each one grain, made into a paste, with which the hollow tooth should be filled, the cavity having been previously dried by means of lint or cotton-wool. Or a few drops of spirits of camphor (*vide* p. 24) may be applied on a small roll of lint. Strong snuff, or a small quantity of black pepper, snuffed up the nostrils, often affords temporary relief.

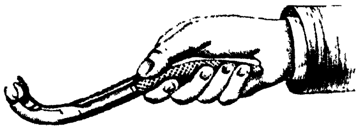
In addition, the following may be procured. For application to the inside of the tooth on lint, a drop or two of creosote, chloroform, laudanum, oil of peppermint, oil of cajeput, or oil of cloves. Cotton-wool wet with chloroform, placed in the ear, often gives relief. A mixture of 10 grains of alum dissolved in half a drachm of chloroform may be applied to the tooth by means of lint or cotton-wool. Equal parts of chloral and camphor form a syrupy liquid, which may be used both to put in the tooth and to rub the face with. Collodion is also a good application. The cavity in the tooth is first to be carefully dried by means of a little lint, or the collodion will not adhere. One or two drops are then introduced, which, while liquid, exactly fill the cavity. As the ether contained in the collodion evaporates, the pain is assuaged, and a protective layer of collodion is formed in the hollow. A mixture of creosote three parts and collodion two parts forms a kind of jelly. Placed in the tooth it dries and forms a hard mass, which protects the decaying parts from the air, and thus relieves the pain. Nitrate of silver scraped to a point and applied to the interior of the tooth will, if well managed, be sure to afford relief. Burroughs & Wellcome's 'Cocaine Tabloid,' containing one-sixth of a grain, placed in the cavity of the tooth and covered with cotton-wool, is much recommended. Liniments, as Recipes 89, 90, applied externally, are also often useful. But if a tooth is too far gone to be stopped, and is the site of periodical pain, the only certain relief is extraction.

TOOTH-DRAWING.—To be able to draw a tooth moderately well would often prove a useful knowledge. A few plain directions may enable the amateur to relieve a class of sufferers often glad to incur some risk rather than endure the continuance of the pain.

The front and eye teeth may be best pulled out with straight forceps. The gum should be first separated from the neck of the tooth, by passing a gum-lancet to the extent of less than a quarter of an inch between the gum and the tooth. Then the blades of the forceps are to be placed, one before and one behind the tooth, and the ends made to clip just where the tooth dips into the gum. The right hand then grasps the handles of the forceps, while

the forefinger is at the same time thrust in between the handles, thus preventing too great pressure being made, by which the tooth might be snapped off. If it be an upper tooth, the operator may steady the patient's head by getting it beneath his left arm, and then pulling down, giving the tooth a lateral twist at the same time, by which it is soon drawn if the pull be steadily made. If it be a lower tooth, the operator steadies the head in the same way, but with the thumb of his left hand on the sound teeth, presses the jaw down, whilst his right hand pulls up, twisting as he pulls the tooth. The mode of extracting from the upper jaw is here shown.

Drawing a back tooth is a more difficult matter, and is effected with forceps of different shapes, the claws being turned downwards instead of being straight, as shown in the following diagram of the forceps clasping an extracted molar or back tooth. The forceps must be applied round



the neck of the tooth, as described for the front teeth. The forceps should be grasped firmly, the tooth moved from side to side with a twisting motion, and then pulled straight out. In extracting teeth with the forceps, three things should be kept in view: *first*, to prevent the forceps pressing too heavily round the neck of the tooth, by which it is liable to be broken; *secondly*, to loosen the tooth by a twisting or lateral motion; *thirdly*, to pull it straight out. But the pull should not be made with too great violence or suddenness, otherwise, the tooth escaping from the socket suddenly, the forceps may hit against and perhaps break other teeth.

It may be desirable to draw back teeth with the 'key' when they are much decayed and cannot bear the pressure of the forceps, or when, the crown being lost, there is little hold for the claws of the forceps. But the key is an instrument with which more harm may be done than with the forceps, and therefore its use is not described.

TONGUE AND MOUTH, ULCERS OF THE.—May arise from *salivation*, *aphthæ*, *scurvy*, *venereal disease*, *cancer*, *debility*, or from *dyspepsia*. When ulcers arise without any evident cause they are usually dyspeptic, and the best application readily obtainable is a concentrated solution of alum (powdered alum 3 drachms, water 1 ounce), applied several times daily with a feather or brush; or, this not succeeding, strong vinegar may be used in a similar manner. Accompanying dyspepsia or other ailments should receive appropriate treatment.

[*Dilute* sulphuric acid, applied with a feather to the ulcer, will be found a better remedy than alum. It causes acute pain for a few moments, but the ulcers are much less sore afterwards, and heal more quickly.]

TUMOURS.—The term is applied to almost any swelling, and does not, as popularly supposed, signify any particular disease. There are therefore many kinds of tumours, some of which are mentioned under the maladies of which they form parts. A common form is the *fatty tumour*, which may occur in any part, and frequently developes in the scalp. *Rhinophyma*, or 'hammer nose,' is the term applied to a swelling which sometimes forms on the nose, usually in the shape of a front and two lateral lobes. The term *aneurism* is applied to a pulsating tumour resulting from the rupture of an artery. Aneurism most frequently occurs in the artery of the thigh (*vide* p. 502). When firm pressure is made in the course of the artery *above* such a tumour the pulsation stops, which is a distinctive sign. The only cure of most tumours is by surgical procedure.

ULCERS.—Ulcers are raw open sores, generally hollowed out lower than the surrounding skin, which may result from any inflammation of the surface of the body, as, for instance, from boils, or from injuries. Ulcers of a peculiar kind are caused by scrofula, venereal disease, scurvy, cancer and gout. Chronic ulcers of the legs are common in elderly people, and are frequently caused in the first instance by varicose veins (*vide* p. 456). Ulcers require different treatment according to their cause or condition. The most universally suitable application is water dressing (Recipe 85), or, if procurable, carbolic acid lotion (Recipe 119). When an ulcer will not heal readily, unless it be the chronic ulcer of the leg of old people, some constitutional taint may be suspected.

URINE, DISEASED CONDITIONS OF.—The *quantity* of urine passed by a healthy adult in twenty-four hours is from thirty to forty ounces. But it varies with the amount and influence of fluids, and of some solids consumed. Also with the weather, being more copious in cold weather, when there is less sensible and insensible perspiration from the skin. The *quantity of urine is increased* in diabetes, also often in hysteria. It is *scanty* in inflammation of the kidneys, in albuminuria, and in most fevers. It is *retained* in stricture, sometimes in hysteria, and sometimes by infants. It is *suppressed* (i.e. there is none secreted) in collapse, and in cholera. It is *passed more frequently* when there is enlarged prostate, gravel, stone, irritable bladder, or inflammation of the bladder or kidneys. It is *passed painfully* in most maladies connected with the urinary organs, excepting diabetes and Bright's disease.

The *colour* of healthy urine is a pale straw or amber, and it should show but a very slight quantity of mucus, which appears as a filmy cloud. A heavy whitish deposit, clinging to the utensil when turned, indicates much mucus, which forms in chronic affections of the bladder. A yellowish-brown colour is characteristic of bile and jaundice. A smoky hue denotes the presence of a small quantity of blood; a dark brown colour more blood; and a distinct red colour much blood. Blood in the urine (or *hæmaturia*) may occur from a great number of causes. Such causes may be either local affections of the urinary organs themselves, as stone or tumour in the kidneys or bladder; or such causes may be general, as scurvy, the presence of a parasite in the blood, fevers, &c. In the fevers of Africa blood in the urine occurs so frequently that it has been specially designated *hæmaturic fever*. Blood in the urine has been noticed as occurring in Indian fever (*vide* p. 260), but it is not ordinarily present. High-coloured urine attends most fevers, which may be difficult to distinguish from blood without the aid of a microscope. A *milky appearance* indicates the condition known as *chyluria*. Matter, or *pus*, renders urine turbid, and it does not clear on boiling. The *smell* of urine is faint and peculiar. In diabetes there is a sweetish whey-like odour. In various chronic maladies of the urinary organs there is an ammoniacal smell. Blood or bloody discharge causes a smell like that of faintly tainted meat.

The principal salts seen as deposits in the urine are given under *gravel*, p. 285, and *oxaluria*, p. 341. The methods of detecting invisible unnatural conditions, chiefly albumen and sugar, are given at pp. 101, 164.

Caution.—On standing healthy urine undergoes change. After a variable time, according to the temperature, it becomes cloudy, and emits a characteristic odour. This is not indicative of disease.

VARICOCELE.—An enlarged condition of the veins within the *scrotum* or purse, which feel soft like a bag of worms. The swelling is irregularly pyramidal, the base resting on the testicle, and the apex pointing upwards.

It is most common on the left side, and it is accompanied by a dull aching pain, by a sensation of weight, by a dragging pain in the back and loins, and sometimes by glairy discharge from the privates. If the person lies down the swelling *gradually* subsides, with relief of the painful feelings. It is worse if the bowels are constipated, and is in some cases caused by constipation. Often no particular cause is evident, but bicycle-riding tends to induce it in those constitutionally predisposed. After it has existed some time, it is apt to cause neuralgia of and wasting of the testicle. Varicocele may be mistaken for *rupture* or for *hydrocele*, and the distinguishing features are given at p. 593. The disease may be palliated by wearing a suspensory bandage (*vide* p. 439), by bathing the scrotum daily with cold water, and by regulating the bowels to avoid constipation. Such measures are generally sufficient, although sometimes a surgical operation is necessitated.

VEINS, INFLAMMATION OF THE.—This, technically termed *phlebitis*, may occur in any part of the body, but the limbs are most frequently affected. It may originate from injury, from exposure to wet and cold, or from *thrombi* or clots of blood forming in a vein. The veins of the part affected are hard, swollen, knobbed, painful and tender. There is stiffness and difficulty of moving the part, and often swelling of the whole limb. There is also fever, and the temperature may be 100° or upwards. If the superficial veins are affected, they may be seen of a red or purple colour. In severe cases abscesses may form in the course of the veins, or absorption of putrid matter may take place producing blood-poisoning (*vide* p. 587). Perfect rest should be enforced. Hot poppy-head fomentations (Recipe 81) should be used assiduously, and Dover's powder and quinine (Recipe 17) should be given twice daily. If necessary chloral at night to relieve pain. The bowels should be kept open by Recipe 2. If abscess forms it should be treated as given at p. 41. The diet should be strengthening from the first.

VEINS, VARICOSE.—This term is applied to an enlarged, dilated, and tortuous condition of the veins. Varicose veins of the leg are noticed at p. 360, as a result of pregnancy. *Varicocele* (*vide* p. 454) is also a form of varicose veins. *Piles* (*vide* p. 347) is a similar condition of the vessels of the part. The cause of varicose veins is some sluggishness of the, or impediment to the circulation of, the blood through the veins, which (*vide* p. 500) *return* the blood from the extremities of the body *to* the heart. Hence the veins of the legs, which have the largest columns of blood to support, are most likely to become varicose. Sluggishness or feebleness of the circulation may depend on debility from many causes. Impediments to the circulation, particularly of the legs, are various; such as pregnancy, or constipation. Occasionally varicose veins are found in other parts of the body. The part affected is attacked by dull aching pain, and the varicose veins may be seen—looking dark-coloured—and may be felt—like soft, prominent cords—ramifying under the skin in different directions, or clustered in raised knots. The leg swells, particularly in the evening or after exertion. Often the veins appear at the point of bursting, and, if the disease is neglected, the skin may give way, and a copious bleeding may take place, which continues until it is stopped by pressure, or until the person faints, after which an *ulcer* may form on the leg.

Treatment.—The part affected should be frequently sponged with cold water; if the leg, *it should be kept raised*, and friction with soap liniment should be used for ten minutes three times daily, the leg being rubbed *gently upwards*, from the ankle towards the knee, so as to assist the venous circulation. Moderate walking exercise may be taken, but only after the precaution of a well-applied bandage (*vide* p. 495), which should be put on when the limb is elevated and not swollen, over a thin angola or silk stocking. If there is debility, generous diet and tonics, of which iron is the best, should be given (*vide* p. 24). If the varicose veins appear connected with constipation, Recipe 2; or if with inactive liver, Recipe 1 is required. In such cases mineral waters (Friedrichshall or Hunyadi Janos) are often of great value. If the varicose veins are connected with *pregnancy*, while the precautions as above are taken, it will not be desirable to give any medicines except castor oil for the relief of constipation. Varicose veins from pregnancy usually disappear after the birth of the child, but varicose veins from other causes, if neglected, may increase to such an extent as to require surgical treatment. If a vein should burst, *vide* p. 512.

If procurable, Recipe 71; and Recipe 12 instead of Recipe 1 if the liver is inactive. For sponging instead of cold water, tincture of hamamalis one ounce, in one pint of water. An elastic stocking should be procured. The measurements required are. 1. Round the thickest part of the instep. 2. Round ankle bone. 3. Round small of leg. 4. Round thickest part of calf. 5. Round leg just below knee. 6. Length of leg from heel to just below knee. The measurements should be taken when the veins or leg are least swollen.

VENEREAL DISEASE, or SYPHILIS.—This disease is the consequence of contagion, and there are two kinds of sores. One usually presents in about ten days, but may appear at any time up to a month after exposure. It first shows, on some part of the genitals, in the shape of a small red pimple, which about the fourth day becomes a watery vesicle with an inflamed base. Then a little matter forms, and, discharging, leaves a *painless* sore or ulcer, with a hard margin, elevated edges, and depressed centre. The other kind of sore usually appears within four or five days after exposure, commencing as a pustule, or containing matter from the first. It is not hard, but more painful than the first description of sore.

Next, about fifteen to thirty days after the commencement of the sore, or after the sore has healed, there may be swelling and tenderness of the glands in the groin, eventually forming a *bubo* (*vide* p. 109). If this occurs, it may either subside or form matter, which then points like an ordinary abscess. The bubo is most likely to form into an abscess if it occurs after the softer description of sore. The *secondary symptoms*, referred to below, are most likely to present after a hard sore. The sore on the privates, and the swelling in the groins, complete the symptoms of *primary syphilis*.

But the person affected is not free from disease. Weeks, months, or years afterwards, *secondary symptoms* may occur. On an average, the period of their appearance is in about six weeks, and in the majority of cases the sequence is much as follows. The person grows dispirited, is probably troubled with rheumatic pains, particularly in the shin-bones, and complains of loss of appetite and want of sleep. Then either skin diseases, or sore-throat, or ulcers of the tongue or mouth, or all these affections, appear. The mildest variety of sore-throat is simple redness, or soreness; but very often there are ulcerations. The patient has a hoarse, guttural way of speaking, and may complain of pain in the ears. Next, or at the same time as the sore-throat, appear eruptions of the skin, of various descriptions. Perhaps the most common venereal skin affection is a scaly eruption very much as psoriasis is described (*vide* p. 401), and which often attacks the palms of the hands. The nails may also be affected, loosening for some distance from their extremities, and becoming rigid transversely, or marked with faint oval spots longitudinally. But these are not the only results of secondary syphilis. It not unfrequently attacks the internal nostrils, producing a foul discharge, and it may ultimately destroy the bones of the nose. Or it may attack the shin-bones, the surfaces of which swell, become very painful, and form what is termed *nodes*. These *nodes* sometimes gather, burst, and leave deep foul ulcers, at the bottom of which is *carious* or diseased bone. The windpipe may also be implicated, producing huskiness or loss of voice, which may become permanent. Internal organs, as the brain, spine, or liver, may also become diseased, giving rise to various anomalous symptoms, only to be recognised by the experienced practitioner.

But even this is not the end of venereal. Women frequently miscarry as a result of syphilitic poison in the system. Children of diseased parents are often born diseased. When a child is born syphilitic, it is weakly and shrivelled, with hoarse cry, snuffling respiration, discharge from the nostrils, and copper-coloured blotches on the skin, especially about the privates. It has a prematurely aged look, and often suffers from *pemphigus* (*vide* p. 398.) In other cases such symptoms appear a month or so after birth. If the child of syphilitic parents escapes such maladies in infancy, it is more liable than other children to suffer from *atrophy* (*vide* p. 66), and when growing up the individual is much more likely to become consumptive or scrofulous.

Treatment.—If the means mentioned in the small type are not at hand, the parts should be kept perfectly clean, an alum lotion (Recipe 97), or if available carbolic acid lotion (Recipe 119), should be applied, and the patient should be kept as quiet as possible, taking aperient medicine, as Recipes 1 and 2. Then if the sore is not a syphilitic chancre it will get well; and if it is, the best method, in the absence of medical aid, will have been pursued. For the treatment of bubo, *vide* p. 109.

[If the pimple is observed *before* it becomes a sore, or *chancre*, it will be advisable to destroy it by the careful but thorough application of nitrate of silver. Then the part should be treated with water dressing (Recipe 85). If, however, the ulcer or *chancre* has formed without this being done, black-wash (Recipe 88) should be applied with lint, and, provided the patient is not broken down in health by previous disease, blue pill should be given, in 3-grain doses, three times a day, until there is a metallic taste in the mouth, or the gums become slightly sore. If the blue pill acts on the bowels, one quarter of a grain of extract of opium should be combined with each dose. Meanwhile the patient should live regularly, but not too low; the clothing should be warm, and but little exercise should be taken.

For *secondary* symptoms, the best remedy is iodide of potassium in five or eight-grain doses. But the Protean varieties of secondary syphilis demand the advice of a surgeon.

A syphilitic infant should be brought up by hand, so that it may not imbibe further poison from its mother, nor infect a nurse. Half a drachm of mercurial ointment may be spread on a piece of flannel, to be tied round the child's waist every morning till the symptoms disappear.]

VOMITING.—Vomiting is a symptom of disease rather than a disease itself (*vide* p. 37), and consists of an inverted action of the stomach, accompanied by faintness. It may be caused by unwholesome food, or by intemperance. It is an ordinary symptom of disorders of the stomach and bowels, but it is also often indicative, especially in children, of some head affection. It often occurs at the onset of fevers, and especially at the commencement of small-pox. It is a symptom of rupture, of dyspepsia, of colic, of gravel, and of cholera. It also occurs from the violence of whooping-cough; it may be produced by poisonous agents, as arsenic; it occurs in sea-sickness, and is often very troublesome to pregnant women. The colour, smell, and taste of vomited material are instructive and characteristic. Thus, in *cholera* the fluid vomited is whitish. In *hæmatemesis*, or bleeding from the stomach, it is black. In certain diseases implicating the *urinary* organs the odour is ammoniacal. When there is *stoppage of the bowels*, fæcal matter is often vomited. When *bile* is vomited, the taste is acid and bitter, and the colour yellowish. In some forms of *dyspepsia*, fluid looking and tasting like sour water is brought up.

WARTS.—Warts are growths from the skin, often occurring without assignable cause, particularly on the hands of the young. Frequently if left alone they gradually disappear. When warts grow with a thin neck a piece of strong waxed thread may be tied tightly round the narrow part. After a day or two the wart will fall off, and the part should be afterwards daily touched with alum.

[Pure acetic or nitric acid carefully applied every day to a wart will destroy it. The acid may be applied with a stick of cedar wood, and care must be taken that it does not touch the healthy skin, or it will act as a caustic and destroy that also. The use of the acid may be continued daily, so long as no pain follows the application.]

WETTING THE BED BY CHILDREN.—Sometimes it depends on thread-worms; less frequently on the presence of a stone in the bladder; sometimes from a long foreskin, under which dirt and discharge accumulate. It often depends on irritability of the bladder, perhaps caused by a too acid condition of the urine; it is sometimes connected with irritable condition of the nervous system, causing the child to wake frightened and screaming, as described under *Convulsions* (*vide* p. 146). It sometimes occurs from idleness and indisposition to get out of bed. The *treatment* consists in attacking the cause. If there is no evidence of other maladies, but there is night screaming, bromide of potassium (Recipe 20) may be given with advantage. The urine should be examined with litmus paper. Healthy urine is slightly acid, and should turn blue litmus paper slightly red; but if the paper becomes instantly of a bright red colour the urine is too acid, and it will be advisable to give citrate of magnesia (*vide* p. 15), which should be continued until the urine only colours litmus paper slightly. When there is no assignable cause, the child should be made to empty the bladder immediately before going to bed, and he should be provided with a little vessel which may be taken into the bed. If the practice be persisted in, either idly or unconsciously, the child should be roused in the middle of the night for the purpose of emptying the bladder. He should also be induced to hold the water as long as possible in the daytime, so that the bladder may become accustomed to being full, and no fluid should be allowed for two or three hours before bedtime. The child should also be induced to lie on the sides and not on the back, in which latter position any urine in the bladder presses on the most sensitive part of that organ, and induces desire to make water. This may be accomplished by fixing a cotton reel behind by a string passed through the hole in the reel and round the waist, the pressure from which will cause the child to turn on his side.

[Instead of citrate of magnesia obtain Recipe 35. Benzoic acid may be obtained and tried in one-grain doses up to two years old, and in two-grain doses above that age, thrice daily. Electricity to the spine is sometimes useful.]

WHITES.—This signifies an increased secretion from the female private parts. The discharge is of a white or faintly yellow colour, and may amount to several ounces daily. Sometimes it assumes a glairy appearance, more like white of egg. The appetite is impaired, the bowels generally constipated; there are often palpitations, giddiness, fainting, or neuralgic pains, with flatulence, pain in the back or in the left side, pallor, and hysterical symptoms. The causes are difficult menstruation, chronic inflammation of or displacement of the womb, frequent childbearing, want of exercise, luxurious living, and other causes of general debility. The *treatment* consists in attention to any menstrual disorder, or womb affection, which may be present. But if such causes are not evident, and the discharge appears to result from debility, treatment must consist in attention to the general health, to diet, and to the state of the bowels, in regular hours, proper exercise, and change of air. Cold bathing, or at least pouring cold water down the spine, is also advisable, except when the woman is pregnant. To arrest the discharge, alum lotion (Recipe 97) may be used as an injection. Infusion of green tea is a good injection, and may be made by pouring a pint of boiling water on half an ounce of green tea, macerating, straining, and using the injection cold. For the method of giving a female injection, *vide Appendix*, 'Injections.'

[Recipe 107 may be used if the alum lotion or tea infusion is not beneficial.]

WHITLOW.—There are several kinds of whitlow. The slightest form occurs on one side of the root of the nail, beginning with a little inflammation and throbbing. By degrees a whitish semi-transparent bladder is formed extending more or less round the nail. If not opened the fluid separates the scarf-skin from the true skin underneath, through which it bursts, discharging watery matter, when the finger may get well. But if the matter has been pent up for some days it frequently ulcerates the true skin, and a little red body sprouts up through the opening in the scarf-skin, which is excessively tender, and is vulgarly called 'proud flesh.' If this increases the nail may be destroyed. The blister should be snipped with scissors, and a bread poultice applied, followed in a day or two by simple dressing or oiled rag. If red proud flesh forms, the dead scarf-skin should be removed, and alum should be lightly applied to the part.

The Second Form of Whitlow occurs in the bulbous ends of the fingers. This is much more severe, and the matter is deeper seated beneath the true skin. No blister forms, but the finger swells and is red, afterwards becoming white as the matter approaches the surface. The pain extends into the hand and arm, and the nail is usually destroyed. The finger should be deeply lanced on the inside, in the direction of its length, and a poultice applied. When matter ceases to flow, the part should be plastered.

The Third Form of Whitlow, called *thecal abscess*, is the most severe. The sheath containing the tendons of the finger inflames, becoming hot, red, and terribly painful; the finger swells, and unless quickly attended to, the inflammation spreads into the hand and arm, and the tendons, or one or more bones of the finger are injured, and may slough out. Leeches, bathing the part in hot water, and hot linseed-meal poulticing should be used. The inflamed part should be lanced *to the bone early*, within twenty or thirty hours from the beginning of the attack. To secure perfect rest the finger should be placed on a splint, which may be cut out of any soft piece of wood, or made from a piece of perforated zinc. The splint should extend from the end of the finger to the wrist, and under the finger should be the breadth of the finger, but it will be more comfortable if made wider under the palm. It should be wrapped in cotton cloth, to be changed daily, when the splint should also be well washed. After the lancing, poultices should be applied till the matter ceases to flow, and afterwards plasters. However skilfully treated, either from a piece of bone being lost, or from contraction of the tendons, some deformity often results. In *all* cases of whitlow the hand should be kept in a sling, with the fingers pointing to the opposite shoulder.

An excellent plan to secure the advantages of position and immobility in such cases is to bend the elbow at an acute angle, and raise the hand towards the opposite shoulder. Then, pinching up the top of the coat-sleeve at the wrist, fix it to the coat with a strong safety pin. The sleeve then acts as a sling. If greater immobility is required attach a fold of the sleeve to the coat, just under the elbow, with another safety pin, and attach the inside of the arm sleeve to the body of the coat with a third safety pin (*vide* plate).

WHOOPING-COUGH.—Whooping-cough is called also *Kink-cough* and *chin-cough.* It is a contagious cough, happening generally to young children, but sometimes to adults, and usually only once in life. It has been thought to depend on a microbe, which breeds on the membrane of the throat and nose. It commences as a common cough, but after some days the cough comes on in fits, after which the breath is drawn in with a long effort, and accompanied by a peculiar 'whoop.' In bad cases there may be twenty paroxysms in a day, and several fits of coughing without the whoop being heard. A child with whooping-cough soon learns when the paroxysm is commencing, and is frightened. He rushes to the mother or nurse; or, if of a more advanced age, stamps his feet in a state of agitation, and clutches some article of furniture by which to steady himself. Vomiting frequently attends the fits of coughing, and the suffocation of the child may appear threatened, when suddenly the characteristic whoop is heard, which terminates the paroxysm, and the child returns to its play. From the vomiting, children with bad whooping-cough frequently cannot retain sufficient food in their stomach to supply the wants of the system, and may suffer from starvation. Simple whooping-cough is never fatal; but unfortunately whooping-cough may excite other maladies. The force of the cough may cause blood-shot eyes, bleeding from the nose or from the ears, and sometimes *rupture of the drum* of the ear (*vide* p. 214). Occasionally also *rupture* (*vide* p. 589) is caused by the force of the cough. In most cases there is some degree of *bronchitis* attending the complaint, shown by hurried breathing, feverishness, and by wheezing heard in the chest (*vide* p. 105). In some cases *inflammation of the lungs* is induced (*vide* p. 328). In other instances, from injury to the lungs from the force of the cough, the foundation of *asthma* or emphysema is laid (*vide* pp. 60, 330). Or there may be, especially in weakly children, tendency to *hydrocephalus*, marked by sudden startings from sleep and rolling of the head (*vide* p. 88). *Convulsions* may also be excited, the approach of which is indicated by contractions of the fingers or toes, or by turning in of the thumb to the palm of the hand (*vide* p. 145). Lastly, *diarrhœa* may supervene (*vide* p. 172). The ordinary time after exposure to infection that the disease presents is fourteen days. The average duration of whooping-cough is about six weeks, but it may get well in a few days or weeks, or continue for months. The danger of infection lasts six weeks after recovery.

Treatment.—During the paroxysms of cough the child's back should be supported with one hand, and the forehead should be supported with the other. Mucus coughed up, or anything vomited, should be wiped away from the mouth, and the back should be gently rubbed. In the intervals between the cough the chest and back should be daily rubbed with equal parts of brandy and salad oil. The bowels should be regulated by castor-oil or senna; and ipecacuanha wine in small doses according to the age of the child (*vide* p. 15) should be given. If the child is old enough to understand, half a drachm of salt dissolved in an ounce of water snuffed up the nostrils may be beneficial. If the spasms of cough are severe, and there is no chest complication, a bath at 98° Fahr. for ten minutes every night will be salutary. This will strengthen the child, by increasing the action of the skin and enabling it to do its part towards throwing off the disease, while it allays irritability and causes better nights. In those cases where the cough appears principally of a dry spasmodic character, bromide of potassium (Recipe 20) will be advisable, and this may be given with the ipecacuanha wine or at different times. To lessen the depression caused by the fits of coughing, 4 drops of sal volatile should be given to an infant one year old, and 8 drops to a child three years old, after each fit of coughing, in a little milk-and-water. The diet should also be well attended to, and no indigestible food allowed. In cases where vomiting is a prominent symptom, strong broth or soup should be given immediately after the paroxysm of coughing, so that there may be time for some digestion of food to take place before the next attack. In the latter stage of obstinate whooping-cough nothing is so serviceable as change of air. But in the earlier periods there is often feverishness and tendency to bronchitis. When such conditions prevail the patient should be kept warm, and the exposure which change of air necessitates should not be thought of. Complications, as bronchitis, convulsions, affections of the head and bowels, must be treated as mentioned under such headings.

[Instead of brandy and oil, procure soap and opium liniment to rub the back with: and remember it is *not for internal use*. Instead of ipecacuanha wine procure Recipe 57. Numberless remedies have been tried to cure whooping-cough, but none will always succeed. In very bad cases 20 drops of chloroform may be placed on a handkerchief, which is to be held *half a foot* from the child's face *during the fit*. Recipe 60, 61, 62, 63 may be procured and tried in succession. Inhaling the spray from an atomiser of a solution of 1 drachm of carbolic acid in 14 ounces of water may also be tried. A solution of Condy's fluid, 1 drachm to a pint of water, may be snuffed up the nostrils from the palm of the hand. Whooping-cough frequently causes great debility, and tonics, as quinine and iron (Recipe 70), should then be given, in doses corresponding to the age of the child (*vide* p. 6).]

WOMB, DISEASES OF THE.—Many causes combine in inducing a great tendency to womb disease in the European female in India—some preventable, others less so, inasmuch as the latter consist of climatic influences. One of the first effects of hot tropical climates on the system of the European is a greater tendency to affections of the abdominal organs, in which condition the womb partakes. Hence the necessity of increased care, especially as regards exposure to cold, or injudicious exertion, during the monthly period. *The most common maladies* which arise from these various influences affecting the womb are as follows.

AMENORRHŒA, *Scanty* or *Suspended Flow*, or *Failure of the Monthly Courses.*—The monthly affection of women commences about the age of fifteen, and ceases about forty-five. In the natives of India it generally commences and ceases a couple of years earlier. It may be suspended or fail under the following circumstances:—1st, *it is not present as a general rule during pregnancy or suckling*; 2ndly, *instead of appearing at the usual age, it may be retained or delayed*; 3rdly, *the menses may be secreted for a time, and their recurrence prevented*; 4thly, *the non-appearance of the discharge may depend on some mechanical obstruction, or on disease of the womb*; 5thly, *it may be concomitant with 'change of life.'*

1st, *when the cause of the failure of the monthly course is pregnancy*, there will be other symptoms of such condition, and nothing is required to be done. When the flow is not present during *suckling* it is in accordance with nature, and nothing is required to be done. If the flow appears during suckling it is a sign that suckling should be discontinued, as the system cannot bear two drains (*vide Over-nursing*, p. 655).

2ndly, *when, instead of appearing at the usual age, the discharge is delayed*, the girl will probably be pale, weakly, and debilitated, the bosoms will be little developed, and there may also be dropsical swellings of the legs, arms, or face. Periodical pains in the back and loins, irregular recurring headaches, white discharges, palpitations of the heart after slight exertion or on any agitation of mind, capricious appetite leading the patient to eat such articles as chalk or cinders, and irritability of temper are also usually noted. The face may appear 'grubby' from pustules of *acne* (*vide* p. 400); or there may be small elevations or pimples which do not contain matter, and *eczema* or *erythema* (*vide* pp. 386, 396) may appear on the legs. In bad cases the complexion becomes sallow, dark, or greenish, the condition of the patient soon becoming that described as 'green-sickness' (*vide* p. 50). Under such circumstances tonics are of the greatest service, especially those preparations which contain iron; and in the absence of other medicines, 3 or 4 grains of sulphate of iron (*vide* p. 24) may be given in an ounce of water three times a day during the intervals, but not for three days before or after the expected period. Moderate exercise in the open air, especially on horseback, but without tiring the patient; a generous but wholesome diet, with a little wine; cheerful society without excitement or late hours; the avoidance of close rooms, and cold bathing during the intervals between the monthly periods will do much good. Change of scene by unfatiguing travel, and salt-water bathing, are also often beneficial. The bowels should be regulated by aperients, especially Recipes 1 and 3. Such medicines, together with hot foot or hip baths, to which a little mustard may be added with advantage, should always be taken a day or two before the expected period, at which time cold baths should not be used, and all kinds of excitement should be carefully avoided. If baths cannot be conveniently procured the patient should sit over hot water. When pain of back or loins indicates that nature is making an effort, and the hot baths are not successful, a mustard poultice may be applied over the lower part of the bowels for two or three nights in succession.

[Recipe 15 should be procured for use previous to the expected period, instead of Recipe 1; and Recipe 71 for use during the interval. If this does not succeed, permanganate of potash 2 grains, extract of gentian 2 grains, made into a pill, to be taken three times daily, commencing a week before the expected period.]

The above indicates the treatment when amenorrhœa occurs *in pale weakly girls*, but sometimes the menses are tardy in appearing, the patient being rosy and robust, and the bosoms and form well developed. In such cases there will probably be roughness or sometimes scaliness of the face, and often at each period pain of the back and loins, flushing of the face, giddiness, and headache. Before this comes on the patient should take Recipes 1 and 2 for two or three nights and mornings in succession, and a mustard poultice should be applied to the lower part of the bowels. If these measures do not succeed, three or four leeches should be applied to each groin, the bleeding from which should be encouraged by fomenting. These means should be repeated every four weeks until the menses do appear; and after this occurs, a warm bath should be taken at night at the approach of each period, for some time afterwards. The food should be principally farinaceous; and ale, porter, and wine should be avoided. Exercise both on foot and horseback may be freely taken.

3rdly, *the menses may have been secreted for a time and their recurrence prevented.* The discharge at an early period often does not occur regularly at the end of every four weeks. The constitution seems to require the influence of habit, and for some time slight causes will induce suppression. Damp feet, sitting on damp ground, cold bathing, standing in a draught, fatigue, passion, excitement of any kind, fright, or severe mental work, will often suddenly check the discharge if present, or prevent its reappearance. When the discharge is suddenly checked or prevented, there is usually headache, lassitude, and probably pains in the lower part of the bowels; and it has been noted at p. 440 that the sudden check of the discharge by cold bathing has been known to cause tetanus. If there is repeated failure of the monthly flow, the constitutional condition becomes the same as, or even worse than, the state occasioned by the non-appearance of the flow at the usual time of life (*vide* p. 468).

The *interruption* of the menses may be caused by the debilitating effects of other diseases, such as consumption, Bright's disease, and some forms of hæmorrhage. But such stoppages are less abrupt, and are not followed by the peculiar symptoms above detailed; while there are the symptoms of the other disease which may be present, which will serve to point out the cause of the prevention.

Treatment.—When the stoppage of the monthly flow occurs as a consequence of other debilitating diseases, no special treatment directed to excite the flow will be desirable. But when the stoppage occurs to otherwise healthy women, the following measures may be adopted. Females of full habit require means that deplete or lower the circulation; and, on the contrary, delicate patients must be invigorated by means which inprove the state of the blood and give tone to the system. If sudden suppression or stoppage of the menses occur after they have been established, a hot bath at 106° Fahr. is suitable for every constitution, and, if taken immediately after exposure to cold or other cause of obstruction, would often prove successful. In other respects the treatment detailed for delicate or plethoric persons under the second heading may be adopted (*vide* pp. 468, 470).

4thly, *the non-appearance of the discharge may depend on some mechanical obstruction*, or on disease of the womb. Obstruction chiefly occurs in young girls; disease to older women. The means directed in the foregoing remarks having failed, after a fair trial, to produce the desired effect, no delicacy of feeling should prevent application to a medical man in order that it may be ascertained if any anatomical obstruction is in the way, or if any disease exists. If such is the case, medicine may increase the evil, and delay will increase the difficulties.

5thly, *stoppage of the monthly courses from 'change of life'* is considered under that heading (p. 481).

CAUTION.—In any kind of delayed or suppressed discharge, medicines which excite the flow of the menses are best dispensed with excepting under medical advice. Some may prove dangerous, and, when administered by quacks or well-meaning but ignorant friends, have often done much injury. Suspended flow may usually be overcome without the use of such medicines, and, if the individual is otherwise in good health, need not be the subject of much anxiety, and should not be rashly interfered with. The fear of 'decline' or other malady, as the *consequence* of delayed menstruation, is not well founded. The delay is more frequently the *result* than the *cause* of such maladies being in the constitution.

DYSMENORRHŒA, or *Painful Menstruation.*—This is even more common in India than the former condition, and is generally symptomatic of congestion about the womb or ovaries. In *exceptional* cases it results from the womb being flexed, or otherwise out of place, or from narrowness of the mouth; and in some few instances it appears to be connected with a gouty condition. The symptoms are—tenderness and pain in the lower part of the bowels, especially a little above the groin, and often most felt on the left side. Frequently the pain is of a very acute, darting character, shooting down the thighs, coming on in severe paroxysms, sometimes so violent as to cause the person to roll about as if suffering from colic. There may also be nausea, vomiting, diarrhœa, sudden desire to void, and pain when passing, water. When the pain and tenderness in the groins are prominent, it indicates that the *ovaries* are principally implicated, and the malady is known as *ovarian dysmenorrhœa.* The patient is also frequently hysterical. Such symptoms may precede the monthly period by a few hours, or sometimes days; often twenty-four hours previously is the most painful time. The symptoms may disappear on the first flow of the discharge, or they may continue with the passage of clots of blood or membranous shreds until the discharge ceases. As a rule there is most pain when there is least discharge. Females who suffer thus at the monthly periods are frequently dyspeptic during the intervals; or they may suffer from cough, palpitation, face neuralgia, fixed pain in the head, or from pain in the left side, or under the lower part of the left blade bone, or in the very lowest part of the spine. They may have attacks of menorrhagia (*vide* p. 474), and *whites* (*vide* p. 462) are frequently present.

The *treatment* consists in maintaining the bowels moderately open (Recipes 1 and 2), in avoiding all exposure to damp and chill, or excitement of any kind, for three or four days previous to the expected period; while at the same time guarding against idleness and want of occupation, which, especially in young women, tend to induce a mental and nervous condition favourable to the malady. When pain occurs, a warm bath at the commencement of the attack seldom fails to give relief. After leaving the bath the patient, being well dried, should go to bed, and keep up the soothing effects of the bath by the application of flannels wrung out of hot water over the lower part of the bowels and privates. Or, if the bath is not available fomentations should be applied to the lower part of the bowels, and chlorodyne in 30-minim doses may be given. If nervous or hysterical symptoms are present, sal volatile may be used, or, if not obtainable, wine or brandy-and-water will prove temporarily beneficial. But it is not desirable to give either wine or brandy if it can be avoided, and the dose should not be repeated, but bromide of potassium (Recipe 19) should be given every second or third hour. If the pain assumes a neuralgic periodical character, returning daily, or twice daily, quinine (Recipe 66). During the intervals exercise short of fatigue should be taken, and the patient may walk or drive out in a carriage, but horse exercise is improper. Late hours should be avoided, and a generous but wholesome diet should be adopted, with great attention to the ventilation of the sleeping apartment.

[Instead of Recipe 1, obtain Recipe 15 as an aperient pill. Instead of sal volatile or wine, Recipe 39. If not successful, *four* drops of tincture of Indian hemp may be taken in a little water every two hours for seven or eight times for the relief of pain. Recipe 73 should be obtained for use during the intervals, with or without the sulphate of soda, according as the bowels require aperient medicines or not. But if the iron in Recipe 73, as is sometimes the case (*vide* p. 25), appears to induce nervous irritability, or other unpleasant symptoms, Recipes 74 and 75 may be taken *together* instead. If there is any suspicion of gout, Recipe 52.]

When *dysmenorrhœa* is persistent and not relieved by medicines and regimen as above, it should be ascertained if any displacement or obstruction exists.

MENORRHAGIA, or *Excessive Menstruation*.—This is when the flow returns with unusual frequency, or continues longer than ordinary, or is more abundant than natural at the proper period. The flow should naturally occur once in every twenty-eight days; the average time of its continuance is three days, and the amount of fluid lost is about four ounces. There are exceptions to these general rules, but usually when such conditions are interfered with something wrong will have occurred. *Excessive, too frequent, or too long-continued menstruation* may be the result of two quite opposite states of the system, viz. *plethora* in some instances, and *debility* in others. *An immoderate flow arising from plethora* is usually preceded by shivering, pains in the head and loins, flushed countenance, and febrile symptoms. *An immoderate flow from debility*, which is most usually met with in India, is attended by paleness, languor, feeble pulse, fainty feelings, neuralgic pains, depression of spirits, flatulence, and disordered bowels, with dull aching pain in the back, loins, and thighs. Excessive menstruation is very likely to occur to women who have suffered much from over-nursing, or from frequent pregnancy, and sometimes when a doubt of pregnancy exists, it may be difficult to distinguish this affection from miscarriage (*vide* p. 362). Soft, luxurious beds, heavy skirts hanging from the waist, much standing about, and moist warm rooms predispose to menorrhagia.

Treatment.—In all cases of profuse menstruation, *rest in the horizontal posture is indispensable*, with perfect quietness; and in severe cases cold wet cloths laid over the lower part of the bowels and between the thighs. If the patient is of plethoric habit, indicated by a florid countenance and considerable muscular development, the diet should be low, consisting chiefly of milk and light puddings, the drink being a little weak claret-and-water, or lime-juice-and-water flavoured with sugar. If the patient be of a delicate constitution, indicated by pallid countenance and deficiency of muscular development, a more liberal diet, with a little claret or port wine, may be allowed. *But excepting in rarely severe cases, when there is very profuse bleeding*, stimulants should not be given with the view of combating faintness, as their action, by exciting the circulation, would tend to increase the discharge, and fainty feelings will pass away if the person keeps lying down. Everything should be given cold or very cool, taking hot drinks when the discharge is on being calculated to increase it. Quinine (Recipe 67) should be always used, as quinine has an action on the womb (*vide* p. 17), and would tend to correct any injurious malarious influence so often present. The liver is generally inactive, and the bowels are often costive. Constipation, if prevailing previously to the attack, should be removed by sulphate of soda (*vide* p. 20) for plethoric persons, and castor-oil for more weakly persons. Provided that movement does not cause renewed bleeding, the patient should as soon as possible get into the open air, taking at first only carriage exercise and not walking at all. During the intervals the greatest attention should be paid to ventilation of the sleeping apartment; the bed should be hard and the clothing light; the bowels should be kept moderately open (Recipes 1, 2), and usually sulphate of iron (*vide* p. 24) will be advisable.

[If the immoderate discharge arises from a plethoric state, in addition to low diet and purgatives recommended above, Recipe 4 should be procured and taken, *with the quinine*. In severe cases astringent medicines combined with sedatives (Recipe 45 or 47) should be used, the latter being the more powerful. In still more violent cases it may be necessary to use injections of ice-cold water to stay the bleeding: or if this does not suffice, astringent injections, as Recipe 98.

If during the interval hysterical and nervous symptoms are present, bromide of potassium (Recipe 19) may be used. If the loss of blood occurs only at the monthly period, the medicine should be commenced the week before, and when the discharge ceases it should be discontinued. If the loss of blood occurs at irregular periods, the medicine should be given continually until the loss is controlled, and after the first five days the dose should be doubled. If symptoms such as pallor, debility, and palpitations seem to require iron, *ferrum tartaratum* may be procured and taken in 6-grain doses *with* the bromide of potassium.

WOMB, INFLAMMATION OF THE.—Inflammation of the womb may be either *acute* or *chronic*. It may occur in connection with disorders of menstruation, or without such prior ailments. When acute, the malady commences with cold or shivering, followed by quick pulse and fever. There is pain, increased by pressure, over the lower part of the bowels, which sometimes spreads over the whole of the bowels, the patient lying in bed with her knees drawn up as described under *Inflammation of the Bowels* (*vide* p. 79). There is pain about the loins and thighs, difficulty and frequency in making water, which is hot and scalds and becomes turbid as it grows cool, a sense of weight or 'bearing down,' swelling of the abdomen, more or less fever, and often nausea and vomiting. After the first two or three days there is a light-coloured discharge, which gradually becomes darker, imparting a yellowish-red stain to the linen. There is also often diarrhœa, and if the person is subject to piles they may inflame and add to the distress. The *causes* of inflammation of the womb are cold, particularly cold taken after confinement or during the monthly period, blows or falls, menstrual irregularities, the use of too strong injections, or the use of unsuitable pessaries, too frequent sexual intercourse, injuries during childbirth, too much exercise on horseback, or too long standing, walking, or dancing.

The *treatment* consists of leeches (one for each year of the patient's age) over the tender part of the belly, followed by fomentations; or in less severe cases counter-irritation by mustard poultices. Saline medicines, as citrate of magnesia (p. 15), should also be used, and the bowels should be opened by castor-oil. Unless there is diarrhœa, which sometimes accompanies, castor-oil should always be given, as hardened fæces in the lower bowel may press against the womb and mechanically irritate that organ. The diet should be chiefly fluid, and the drink toast-water, or rice-water. Rest in bed is indispensable, as walking, standing, or even sitting in the erect position is injurious, and has often caused a relapse. If neglected, inflammation of the womb may terminate in the formation of matter somewhere in the neighbourhood of the organ, which will be very injurious to the constitution. This may be suspected if a recurrence of shivering takes place during the existence of pain and tenderness as above described. In such a case it will be well for the patient to take a warm bath at 100° Fahr., this temperature being kept up for half an hour or longer, until faintness supervenes, as the best means of checking the inflammation. After the bath, the patient, being well dried, should be covered by blankets, take 10 grains of Dover's powder, and two hours afterwards drink freely of toastwater to promote perspiration. The bowels should also be again opened by another dose of oil. Perfect rest, attention to diet, and maintaining the bowels freely moved are the main points to be afterwards attended to; but the opinion of a surgeon should be sought.

WOMB, CHRONIC INFLAMMATION OR CONGESTION OF THE.—This is a minor degree of the acute form described above. It may come on gradually, or it may remain after the acute form has subsided. There is more or less pain and tenderness about the lower part of the bowels, with 'whites,' a sense of 'bearing-down' pain in the loins, and painful monthly periods; the condition being often more or less associated with *ovarian dysmenorrhœa* (*vide* p. 472). More or less dyspepsia is always present. If long continuing, it may lead to structural alterations about the womb, such as enlargement, displacement, suppuration in the neighbourhood, or ulceration of the mouth. The person should apply mustard leaves or poultices to the lower part of the bowels daily, or as often as can be borne. The recumbent posture should be maintained for several hours daily; tendency to constipation should be watched for and relieved; piles, if present, should be treated; cold hip-baths should be taken, or cold water should be poured down the spine daily. Tonics, as iron and quinine, and generous diet will generally be required. In this, as in all affections of the womb, horse exercise should be forbidden. When symptoms as above are persistent, it should be ascertained if there is falling, or displacement, which requires treatment by a surgeon.

[It will be desirable to procure iodide of potassium mixture (Recipe 21). Instead of mustard poultices, iodine paint should be applied as often as can be borne (*vide Appendix*, No. 111).]

WOMB, DISPLACEMENT OR FALLING OF THE.—This consists most usually of a falling of the womb below its natural position. But the womb (which is pear-shaped) may be bent either *forwards*, or *backwards*, or to *either side*.

In such cases the thin neck bends, and the heavier body inclines in one or other of the directions mentioned. Displacement of the womb is most frequent in women who have borne large families, or who have got up too soon after confinements. Tight-lacing, which produces forcible downward pressure on the womb, is a fertile cause. It may occur in the first instance suddenly after exertion, as lifting heavy weights, or from retention of urine (*vide* p. 361), or it may come on gradually from local weakness of the ligaments of the womb, or from weakness of the general system. It happens in *every degree*, from very slight falling to the protrusion of the womb externally; or from a slight inclination from the proper position to injurious pressure against the adjoining bladder, rectum, nerves and blood-vessels. The symptoms are feelings of weight and bearing-down pains, with a sensation of fulness of the belly, tenderness or aching about the groins and thighs, and 'whites,' the painful sensations being much relieved by lying down. There is often frequent desire to make water, or in some cases inability to do so, caused by pressure on the bladder, when the womb is displaced in the direction of that organ. Constipation may occur from a similar cause, when the womb presses on the rectum. All these symptoms are more or less severe as the organ is more or less displaced. The digestive organs are influenced injuriously by falling of the womb, so that the ailment is frequently associated with liver and stomach derangements, and this, reacting on the nervous system, produces a depressed and impaired state of general health. Displacement is often associated with *dysmenorrhœa* (*vide* p. 472). It may also be complicated by *ulceration*. Displacement, especially when combined with these two latter ailments, is a frequent cause of sterility.

Treatment.—This varies with the degree of displacement. In the less severe cases medicines should be administered with the view of strengthening the system (Recipes 66, 67). Prolonged rest in the horizontal posture should be enforced, and about a pint of cold water should be injected night and morning, the patient being in the recumbent position at the time. If this treatment is insufficient, injections of other kinds, as mentioned under the head *Whites*, should be tried. If *dysmenorrhœa* is present, it should be treated (*vide* p. 473). If the displacement of the womb is considerable it may require replacement by the hand. When displacement of the womb has occurred it is liable to return, and instruments may be necessary to retain the part in position. But pessaries are used too often, and their continued use often gives rise to a nervous irritable condition of system which is erroneously supposed to be due to the malady. Pessaries may also become the cause of ulceration.

[When chronic affections of the womb are attended with various dyspeptic symptoms, acid (Recipe 34) taken before meals, pepsine with the meals, and soda-mint tablets after the meals, will prove serviceable. If the flavour of soda-mint tablets is objectionable, 5 or 6 grains of bicarbonate of soda may be substituted.]

WOMB, ULCERATION OF THE.—Signifies a sore at the mouth of the womb, which may be a mere abrasion or a deep ulceration. It arises from numerous causes, the most common being chronic inflammation or displacement. The symptoms of a mere abrasion are unrecognisable, and when there is deeper ulceration the symptoms are not well defined, ranging from nervous irritability to those detailed as characterising chronic inflammation or displacement, with which it is usually associated. It cannot be positively stated that ulceration exists without examination, and a great deal too much has been made of ulceration as a separate ailment. It very rarely exists as a separate ailment, and if it does it will get well without treatment. If it exists in connection with other ailments, they should be treated, and not the ulceration they cause.

CHANGE OF LIFE.—The monthly discharge of females commences about the fifteenth year, terminating about the forty-fifth. It is to the period of cessation that the term *change of life* has been applied. This period is popularly supposed to be fraught with danger to the female, and there is doubtless often considerable suffering at such times, and in some women a more than ordinary liability to various ailments. Other women pass through this period of their life without any sensible derangement of health; the monthly flow gradually becoming more scanty until it ceases altogether. Other females may, when about forty-two or forty-three years of age, begin to suffer from periodical fainting fits, from palpitations of the heart, from despondency, from swelled legs, from swelling of the bowels, from nervous headaches, from flushings, or from night perspirations, from pain in the breasts or in the left side, from eruptions, especially *eczema*, from numbness of the extremities, from bleeding at the nose, or from bleeding piles. Drowsiness by day and sleeplessness at night are common complaints. There may also be hysterical symptoms, or hysterical fits. Some suffer from frequent desire to pass water, and from inability to hold it, a little escaping on any exertion, or even on sneezing or coughing. The temper, formerly the reverse, may become irritable, and the disposition may appear temporarily changed. Then the monthly flow may either be scanty or it may not appear for several months, and then it may return in considerable quantity. The course to adopt is first to ascertain if there is any special disease, such as chronic inflammation, displacement, or falling, which may give rise to the symptoms. If the patient has not begun to suffer until the period of change of life, the idea of such causes existing may generally be dismissed. Then the symptoms should be treated as they arise, and as detailed under the headings named. Care should be taken to keep the bowels regular, more especially when women of plethoric habit are the patients, in order to guard against any tendency to 'fits' or other maladies sometimes supervening. For such purpose, for plethoric women Recipes 1 and 2 may be recommended. For more feeble patients citrate of magnesia and tincture of ginger (*vide* p. 15).

[When there is no special disease to account for the symptoms, they may be treated as follows. For headache and drowsiness, eau de Cologne saturated with camphor may be rubbed on the forehead and temples; or the head may be sponged with the following Recipe:—solution of ammonia 2 ounces; salt 2 ounces; spirits of wine, 3 drachms; water 32 ounces. Sleeplessness and despondency indicate the use of bromide of potassium (Recipe 19). Palpitations and flushings require tonics (Recipe 70); hysterical symptoms, valerianate of zinc, in 2-grain doses.]

WORMS.—There are three common varieties of worms infesting the human intestines.

Tape-worms are most common in adults, *round-worms* in children: *thread-* or *maw-worms* may occur in either children or adults. The variety of worms present can only be *positively* ascertained by actual observation, the symptoms arising from either class being very similar. The stools should be carefully washed and examined daily, when either joints of the tape-worm, or a round-worm, or maw-worms, will eventually be discovered if the unhealthy state arises from such parasites. It should be a rule not to give any medicines for worms until their presence has been actually ascertained.

TAPE-WORM, of which there are several varieties, lives in either the large or small intestines, sometimes stretching throughout their whole extent. Its length is therefore sometimes very great, varying from six to twenty feet or more. It is a flat, ribbon-like worm, of a white colour, from one-third to one-half of an inch broad at the widest part, and composed of segments or pieces about an inch long, each segment fitting into the preceding one, and a fully developed worm numbers 1,100 of these joints.

Each joint possesses a male and female organ, and each worm is therefore a chain of individuals. Towards the head the worm tapers very much, and the segments are shorter. The head is triangular in shape, about the size of a pin's head, and is further known by four black spots which are the suckers by which the worm clings to the bowels. The worm increases in length by fresh segments, developed at the neck, while the fully formed segments at the tail drop off, and pass away with the stools. The pieces thus expelled contain myriads of ova in which are embryos provided with a boring apparatus. On the extrusion of the joints putrefaction sets in, liberating the ova, which are carried by wind, water, or other agencies, wherever accident may determine. These ova may be taken into the stomachs of animals (such as rabbits, pigs, or oxen) with their food. When thus swallowed by an animal the egg breaks, and the embryo, by boring, lodges itself in the flesh, there developing into a bladder-like substance or 'cyst,' and causing the affection known as 'measles.' The measle when eaten with meat attaches itself to the human intestine, and there grows into a tape-worm. Several animals—as, for instance, the dog—are subject to tape-worm, and help to propagate the disease in the manner described. The tape-worm embryo may also be eaten with vegetables on which it has been accidentally deposited.

The principal *cause* of tape-worm is eating very underdone meat, which from unclean feeding may contain numerous germs. It is also believed to be conveyed into the human system by using some kinds of fish, especially pike, and in India the 'singharee,' as food. It has been ascertained that fair cooking destroys the vitality of any ovum, although it may escape destruction when meat is only half-cooked.

The *symptoms* of any kind of worms vary greatly, some persons being unaware of the presence of worms until attention may be directed to the passage of pieces by the stool. The indications commonly present are uneasiness in the bowels, sometimes amounting to pain of a gnawing character. There is frequently irregularity of the bowels, straining at stool, fœtid breath, furred tongue, nausea, variable appetite, irritable bladder, and itching at the nose and fundament. The patient grinds his teeth when asleep, and children often awake frightened and screaming. There is frequently headache and giddiness, dry cough, palpitation, fainty feelings, a depressed or hypochondriacal condition, and, in women, hysterical symptoms. Pieces of the worm are occasionally passed with the stools, and are the most certain, and only conclusive, proof of the existence of the parasite; but caution is necessary that pieces of white *mucus* sometimes passed should not be mistaken for worms.

Treatment.—Tape-worm is best treated by some specific remedy as mentioned below. The reason of success or failure of worm medicines depends much on the manner of taking them: if they reach the worm they kill, or at least expel it; if not, they fail. In the case of tape-worm it is particularly necessary that they should reach the head of the worm, for, although many yards of tape-worm may be voided, if the head remains it will grow again, and the old symptoms will return. But the head is exceedingly tenacious of its hold, and is protected by the thick mucus which the irritation of its presence causes the intestines to secrete. It is therefore necessary that preliminary steps should be taken before giving worm medicines. Three days previously the patient should be put on a light diet of meat, eggs, milk, toasted bread, and green vegetables; avoiding such articles as potatoes, pastry, puddings and farinaceous food generally. The third day only beef-tea or thin soup should be allowed. Then on the third night an aperient should be taken, which may be castor oil for children, and Recipes 1 and 2 for adults. Next morning, or after these medicines have operated, the specific remedy is to be taken on an empty stomach. In the absence of the medicines mentioned in the small type, this may be decoction of pomegranate-root bark, prepared as detailed at p. 26. Two fluid ounces should be taken fasting, and a similar dose should be repeated every half-hour, until six draughts have been taken. For children, doses according to the table of proportions at p. 6. If it excites nausea or vomiting, a mustard poultice or leaf may be applied to the pit of the stomach, and this should not prevent repetition. Then, if the bowels are not freely acted upon after four hours, a dose of castor oil should be used. The worm will probably pass away with the motions thus produced. But the head of the worm should be sought for, and if it cannot be found the treatment should be repeated, after intervals of three days, until the head is found, or until all symptoms disappear.

[Better remedies are oil of male fern (also called liquid extract), spirits of turpentine, and Kossou. The dose of oil of male fern for an *adult* is one drachm, one-third part to be given at intervals of half an hour in some thick gruel, congee water, or mucilage. Of spirits of turpentine half an ounce, of which half should be given first, and the remainder thirty minutes afterwards in some thick fluid. Of powdered Kossou half an ounce after steeping for five minutes in a tumbler of hot water, the whole of which should be taken when lukewarm, first well stirring, that the powder also may be drunk. These remedies should be taken on an empty stomach after preliminary treatment as detailed above, and only liquid food should be allowed for twelve hours, but a dose of castor oil should be taken three or four hours afterwards. Kossou is not recommended for *children*; the best medicine for a child of four or five years old being from twenty to twenty-five minims of oil of male fern divided into three doses, and taken at intervals of half an hour, as recommended for adults. Or sixty minims of spirits of turpentine may be taken in three divided doses. Or santonin may be used as directed for round-worms: the precautions regarding liquid diet and a following dose of castor oil (as for adults) being taken. It is advised that if one remedy fails the others should be employed, in the order named both for adults and children.]

ROUND-WORMS.—May exist in any part of the intestines, and even in the stomach, from which they may be vomited or passed by the mouth. They are most common in children from three to ten years of age, who may be infested with one or many. In shape they resemble the common earth-worm, and are of a pale pink or white colour, and semi-transparent. There is a circular depression behind the head, and the latter presents three small elevations, between which lies the mouth. The symptoms they produce are very similar to those of tape-worm. The certain proof of the existence of round-worms is the sight of one passed with the stools.

Round-worms do not require, like tape-worms, to complete their life cycle by passing through the body of an intermediary animal. The ova of the worm, being discharged, is conveyed again into the system chiefly through the medium of insufficiently washed vegetables.

Treatment.—In the absence of the remedies mentioned below, the treatment by decoction of pomegranate-root bark, as detailed for tape-worm, may be pursued.

[If obtainable (after preliminary treatment as for tape-worm, *vide* p. 484) give for an *adult* 6 grains of santonin powder at bedtime, the same quantity early next morning, and a table-spoonful of castor oil one hour afterwards. This failing, turpentine may be used, as for tape-worm. For *children*, the best plan is to give a dose of castor oil the first thing in the morning, and to allow nothing but liquid food during the day. In the evening another dose of oil should be administered, and then santonin, for a child of two years old, in two-grain doses, three times during the next day; increasing the quantity by a quarter of a grain for each year of age. The santonin may be mixed, and taken as a powder, with white sugar. While taking the santonin still only liquid food should be allowed. Lozenges containing various quantities of santonin can be procured from the chemists.

Santonin should be kept in a bottle protected from the light by being pasted over with brown paper, as exposure to light deteriorates the medicine. Peculiar effects have followed taking santonin. The urine may acquire a reddish tinge, giving rise to suspicion of blood in that fluid. Or vision may become affected, every object appearing yellow or green. These effects pass off without leaving permanent ill-result. Should santonin fail, oil of male fern and turpentine may be used as for tape-worm.]

THREAD-WORMS.—Thread-worms, also called *maw-worms*, are about one-third of an inch long, slightly bent, white and semi-transparent. They almost invariably infest the lower part of the bowels near the fundament, where they create much itching and irritation; but their headquarters, where they principally breed, is higher, in or about the cæcum (*vide* pp. 29, 81). They are not only passed with the fæces, but crawl out during the night on the clothes, in large numbers; they also excite mucous or bloody stools. In females they may crawl into the private parts, creating irritation and discharge (*vide* p. 364). They may also crawl under the foreskin of males, with a similar result (*vide* p. 364). Their presence is sometimes attended in children with a milky appearance of the urine. They may also originate protrusion of the bowel (*vide* p. 84). They are most common in weakly, dirty children who may pass hundreds, or even thousands, of worms.

Treatment.—Thread-worms are best expelled from adults by giving some saline aperient with iron, as Recipe 3, and by injecting the lower gut daily with 20 grains of quinine dissolved in 8 ounces of lukewarm water, or with a table-spoonful of common salt in 8 ounces of water. Children should be given a dose of castor oil in the evening, and an enema containing 6 or 8 grains of quinine, or a tea-spoonful of salt, the next day after the action of the oil has ceased. (For the method of administering enemas to children, and the quantity to be injected, *vide Appendix, Injections.*) It is not advisable to give specific remedies, as santonin or turpentine, for thread-worms, which inhabit the lower part of the intestines, and which, therefore, are not so much exposed to the action of remedies given by the mouth as other kinds of worms having their habitation in the upper portion of the bowels. Personal cleanliness is essential, especially avoiding putting the hands to the mouth after application to the anus, which the itching induces, as the ova may be thus directly re-transferred to the system.

[It is also desirable to apply round the anus, salad oil and carbolic acid, in the proportion of a drachm of the latter to 2 ounces of the former, which will tend to destroy any ova deposited outside. If the injections mentioned above are not quite successful, an enema of infusion of quassia may be used. This not destroying the worms, an enema composed of two drachms of tincture of the sesquichloride of iron in 6 ounces of water may be employed. If these measures fail, turpentine given by the mouth should be tried.

Other effects of Worms.—In addition to the distressing symptoms previously enumerated which they usually excite, tape-worm especially may be the concealed cause of anæmia (*vide* p. 46), of hypochondriasis (p. 304), and of nervousness (p. 340). In children round-worms especially may cause a progressive emaciation (the food, although taken in fair quantity, not doing any good), with swelling and hardness of the bowels, a condition which may be mistaken for atrophy (*vide* p. 66). Convulsions (p. 145), paralysis (p. 344), St. Vitus's dance (p. 422), and infantile remittent fever (p. 263) may all be excited in children by worms, generally round-worms. Round-worms have also crawled into the air-passages and caused suffocation, and into the gall-bladder and caused liver disease.

Prevention.—The means of prevention of all kinds of worms is avoiding underdone animal food, especially beef and pork, from which tape-worms originate; and avoiding eating imperfectly washed vegetables, from which other varieties may be introduced. A liberal allowance of salt with the meals is desirable. The stools of those suffering from worms should be disinfected (*vide Appendix*, No. 126) and buried, to prevent the ova being taken into the bodies of animals used as food. Persons with worms should occupy separate beds, or the malady may be immediately communicated.

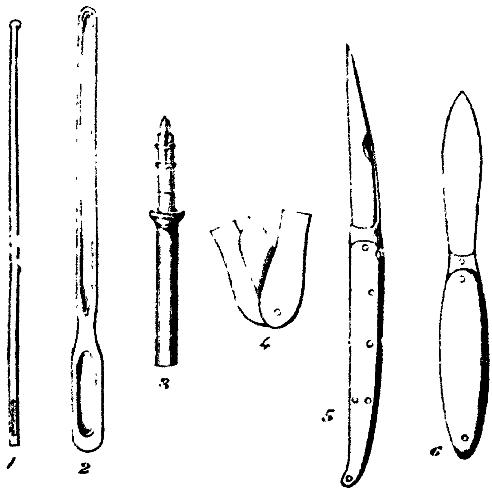
WORMS IN THE NOSE.—The affection generally described as worms in the nose, or *Peenash*, is in reality maggots in the nose. It is a malady almost entirely confined to the lower class of dirty natives. A fly enters the nostrils and deposits larvæ or eggs within, which eventually become maggots. If any disease causing discharge from the nostrils exists, the flies are attracted, and are most likely to effect entrance. Anyone may daily notice flies clustering about the eyes and nostrils of dirty natives, particularly children, the latter taking little trouble to rid themselves of the nuisance. At such times, or during sleep or weakness from disease, the flies enter the passage and maggots in the nose is the result. Sometimes one or two maggots are passed daily, at others several dozens may be passed or extracted. They sometimes consume not only the interior of the nostrils, but even eat their way through the skin of the nose and into the mouth. A good application is lime-water (Recipe 25), injected by means of a syringe. When visible, the maggots should be extracted with forceps. Maggots may also present *in the ears*, the symptoms and treatment being the same.

[But better injections are 'black wash' (Recipe 88) and carbolic acid lotion (*vide Appendix*, No. 119), which may be obtained and used alternately several times daily.]

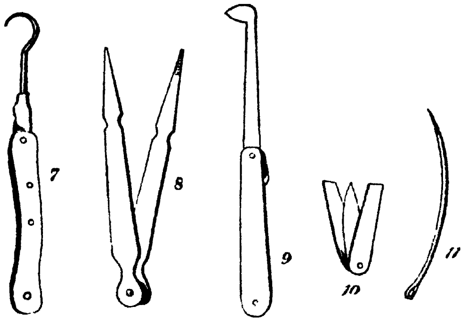
CHAPTER III

ACCIDENTS AND INJURIES

INSTRUMENTS REQUIRED.--The instruments and appliances required in ordinary surgical practice are—



1. THE PROBE.
2. THE DIRECTOR.
3. THE CAUSTIC CASE, OR HOLDER.
4. THE ABSCESS LANCET.
5. THE CURVED KNIFE, OR BISTOURY.
6. THE BLUNT KNIFE.



7. The Tenaculum.
8. The Forceps.
9. The Gum Lancet.
10. The Vaccinating or Bleeding Lancet.
11. The Curved Needle.
12. Scissors.

These instruments may be contained in a small leathern case, in which also a little lint, ligature silk, and plaster should be carried.

1. The Probe is a piece of silver wire, sufficiently flexible to bend without breaking, and used to ascertain the depth of wounds, or if foreign bodies are present or not.

2. The Director is a thicker piece of silver wire, deeply grooved on one side, and used to guide the surgeon's knife when opening sinuses or *fistulæ*. The director is first passed where it is wished to cut, and the knife is then thrust in the groove of the director.

3. The Caustic Case, or Holder, is a silver tube for holding caustic.

4. The Abscess Lancet is a large lancet, with broad-shouldered blade, used for opening abscesses.

5. The Curved Knife, or Bistoury, is a thin knife, approaching the semicircular shape, used with the director for opening deep sinuses or

6. THE BLUNT KNIFE, or SPATULA, is chiefly used for spreading ointments or plasters.

7. THE TENACULUM is a curved piece of steel wire, set in a handle, and used for seizing bleeding vessels.

8. THE FORCEPS are pincers, with or without a spring, used for taking off dressings, seizing foreign bodies, &c.

9. THE GUM LANCET has a small cutting surface projecting from the end, used for lancing the gums.

10. THE BLEEDING or VACCINATING LANCET is used as its name implies; also for opening small abscesses. But the instrument employed either for bleeding or vaccinating should not be applied to any other purpose.

11. THE CURVED NEEDLE is a bent, flat-shaped needle, used for applying stitches to wounds.

12. THE SCISSORS should be sharp and pointed.

In addition to the ordinary instruments described above as contained in the pocket-case, the following articles will be required in the medicine-chest for use in surgical cases:—

1. CATHETERS, FLEXIBLE.
2. BANDAGES.
3. PLASTERS.
4. LINT.
5. SPONGE.
6. TOURNIQUET.
7. LIGATURE SILK.

1. CATHETERS, FLEXIBLE.—Catheters are instruments for drawing off the urine, and three of different sizes of the flexible—not metallic—kind should be carried in the medicine-chest. The use of silver or metallic catheters, or of flexible catheters *with the wire inserted*, requires special surgical skill, and should not be attempted. The sizes of the catheters recommended for the travelling-chest are those known as Nos. 2, 4, and 8. But as flexible catheters are liable to get stiff and break from age and heat, their condition should always be carefully examined before being used. It sometimes happens after accidents, as, for instance, fractured thigh, or from spasmodic

stricture (*vide* p. 420), that the person cannot make water and may require the catheter passed. And although this is an operation demanding surgical skill, it will be better for it to be attempted without special skill than for the patient to be left without endeavours towards relief, and exposed to the risk of the urinary passages bursting, with often fatal consequences.

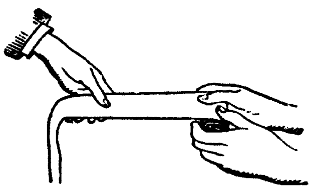
By attention to the following directions, and with a flexible catheter, injury can scarcely be inflicted. The wire should be taken out of the tube of the catheter, and the latter should be warmed in *tepid* water, then dried and oiled. If the water is too hot the instrument will become too soft to pass without the wire. The patient should lie on his back with the head and shoulders raised, and the knees elevated and separated. The operator should stand on the left side of the patient. Next, let the head of the penis be grasped with the fingers and thumb of the left hand, and the organ extended upwards and forwards. Next, hold the catheter in the right hand, and insert the point into the orifice of the urinary passage; then press steadily on, and the instrument, in the absence of permanent stricture, will pass into the bladder, and urine will probably flow. The passage is between eight and nine inches long, and if, when the instrument has been passed so far, urine should not flow, the catheter should be withdrawn for about an inch. If urine is still absent, the probability is that the eye of the instrument is stopped up and requires cleansing. After use the instrument should be carefully washed with hot water and carbolic solution (*vide Appendix*, No. 119).

A condition known as *catheter shock* or *collapse* (*vide* p. 520) sometimes follows the passing of an instrument. The person may be merely faint, or there may be more decided symptoms of collapse. The treatment should be as for collapse (*vide* p. 521). Sometimes a shivering fit occurs after the passage of an instrument, followed by fever, pain in the back, loins, and limbs, and perspiration. To this condition the term *catheter fever* has been applied. Treatment as for ague (*vide* p. 255).

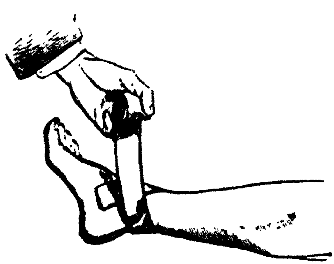
2. Bandages, or Rollers, are made of strips of linen, calico, or flannel, or of porous or solid rubber. A bandage for the arm should be about two inches wide by eight yards long; a leg bandage two and a half inches wide by ten yards long; and a bandage for the body five inches wide by twelve yards long. A bandage ought to be made

of one continuous piece without any joinings, and the selvedges should always be torn off. The surfaces and

edges should be smooth and even, and there should be nothing which can press unequally on the skin. Bandages should be kept ready tightly and longitudinally rolled up; hence their name 'rollers.' This may be done perfectly well by hand, another person

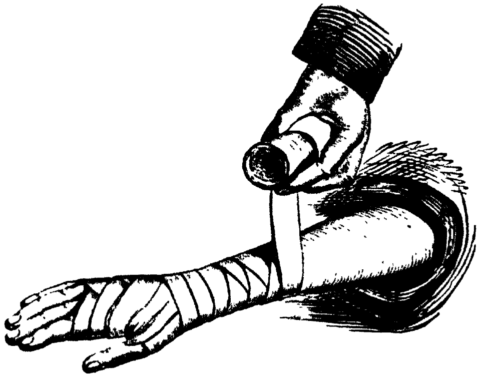


holding the end of the strip of cloth; or it may be fastened to the leg of a table, or at any fixed point. Unless this is done, there is a difficulty in rolling the cloth smoothly. Besides the roller there are compound bandages, as the T-shaped bandage, described under *Protrusion of the Bowel* (*vide* p. 85), the figure of ∞ shaped bandage, described under *Fractured Collar-bone* (p. 560), and in another form under *Bubo* (p. 109); the four-tailed bandage, described under *Fracture of the Jaw* (p. 559), and various other forms. The principal uses of bandages are

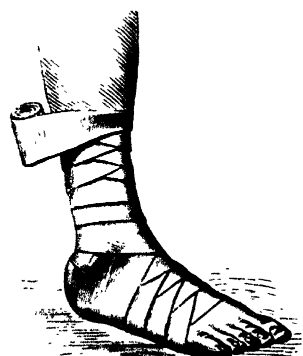


to keep on dressings, to protect diseased or wounded parts from injury, to place restraint on motion of injured parts, and to afford support to muscles and vessels. In applying a bandage the first thing necessary is to obtain a point on which the required traction may be made. Therefore a turn round the *arm* or *ankle* should be taken before is applied symmetrically to the *hand* or *foot.*

Then the roll should be held in the manner represented below, and it should be passed from one hand to the



other as it encircles the limb. A bandage should always be first applied to the extremity of the limb, where it should be tightest, gradually becoming more slack as it ascends, and each fold should overlap about one-third of the previous one. No part must be 'skipped' or left uncovered by the bandage, or swelling of such part will very probably occur, and the roller will become loosened and easily detached (*vide* figures above and the one opposite).



Where the limb increases in size the bandage must be turned on itself, as represented in the sketches. When a bandage is changed, the part over which it has been applied should be sponged with soap and water and then dried, both for cleanliness and also to prevent irritation from the bandage. When a bandage has to be applied to the head, the hair ought to be combed, so that it may lie flat, and not make unequal pressure on the scalp. When a bandage is used to give support, or to make pressure, great care should be taken that it is not too tight in any part of its course, as mortification of the limb has been caused by too tight a bandage. It is particularly necessary to bear this in mind when applying a bandage to a limb that has been recently fractured. In such cases the parts are liable to swell, and a bandage which at the time of its application was sufficiently easy may soon become so tight as to cause a dangerous constriction, and this is especially liable to happen if the limb is allowed to hang down. In cases of bad fracture, or any severe injury, the bandage should be applied loosely in the first instance, particularly in the neighbourhood of the injury, and as the swelling decreases the bandage may be tightened. As the nails are always left uncovered in the application of bandages, it is a good test of the state of the circulation to make pressure upon them. If the circulation is free, the white mark which is made by pressing upon the nail ought to disappear at once when the pressure is removed. But if it lingers and fades away slowly, the injured limb is too tightly bound, and bandages and splints should be loosened.

3. PLASTERS are made by spreading the material on calico or on leather. Plasters are spread on leather when it is required to afford more support to the part affected than would be given by calico--as, for instance, to fractured limbs after the splints are dispensed with. Adhesive plaster is the variety generally used for wounds. Plaster may be carried ready spread, but should be rolled up with oiled paper to prevent sticking.

4. Lint is required for cleansing wounds, for making small pads, and for spreading ointment on when a thicker substance than linen is desirable as a covering for wounds.

5. Sponge is useful for the purpose of conveying a stream of water to a wounded or diseased part. But sponge should *not* be used for cleansing wounds, as it is liable to become contaminated by the discharge. Lint, tow, or linen rag, which should be afterwards destroyed, may be used for cleaning away discharges. The artificial antiseptic sponge prepared by Messrs. Burroughs & Wellcome is recommended for all long cases.

6. Tourniquet.—This is a strip of strong cloth about an inch and a half wide, furnished with a buckle and pad,

as here shown. It is used to stop bleeding or *hæmorrhage* by being buckled round the limb *above* the bleeding part, the pad being placed *over* the main artery. Or a tourniquet may be extemporised as figured at p. 509.

7. Ligature Silk.—This is used for sewing up wounds and tying bleeding blood-vessels. Prepared catgut is the best, but both hemp ligature and silver wire are used. In the absence of prepared catgut, strong well-waxed thread or silk may be substituted.

THE IMMEDIATE AND GENERAL TREATMENT OF ACCIDENTS AND INJURIES.—1. The history of the accident should be ascertained by a few clear questions, addressed to the patient if he is sensible and able to speak, or otherwise to the bystanders.

2. If the patient is insensible, place him on the ground or floor, lying rather on the right side, and with the head raised to the level of the body by a pillow, folded coat, or

other soft substance. This will render the breathing more easy than it would be if the patient lay on the back. Then split open or unbutton any clothing pressing upon the neck, chest, or bowels.

3. The face and chest should be sprinkled with cold water and then wiped dry, and some cold water may be drunk if the power of swallowing remains. Wine or brandy should not be hastily given, without evidence of their being needed, even if there is bleeding.

4. Examine the head and limbs one by one. If there is bleeding, note where it comes from, and follow the directions given under *Bleeding* (*vide* p. 504). The prominent parts of the limbs may be examined with very little movement of the body, and any change of form will probably be recognised by the eye, after the clothing has been taken off, which should be accomplished by cutting open, not pulling off. If necessary to remove clothing, do so first from the uninjured side.

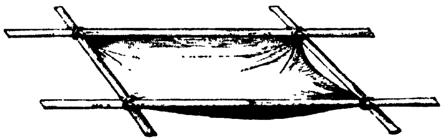
5. If there be local injury, it should be treated, if possible, at once, as described under the different headings.

6. Allow no useless talking to, or in the hearing of, the patient, and send away all except those necessary for his attendance. See that he has plenty of fresh air.

7. In all cases of serious injury aid should be procured immediately. When sending for a surgeon the message should be as clear as possible, and if practicable a written one.

8. If it is necessary to move a person after injury, especially of the head, the patient should be carried while lying down. He should not be allowed to mount a horse, to sit upright in a vehicle, or to walk. *An exception to this rule is injury to the arm or forearm* (*vide* p. 499). A hurdle, or shutter, or door, or *charpai* covered with straw, coats, or blankets, may be converted into a litter. If poles are procurable they may be fixed beneath each end

of the litter, which will thus be carried long distances more easily. If neither hurdle, door, *charpai*, nor shutter can be obtained, a good substitute may be made by fastening four stout poles together, and tying a blanket securely to them, as shown below.



The foot of the litter should be placed at the patient's head in a line with his body. Two people should then place themselves one on either side of the patient, and join hands underneath the body and hips. Another person should take charge of the injured part. The patient should be then lifted, carried backwards over the litter, and then lowered on to it. The litter should be carried by the hand, and not on the shoulders, as the patient would be out of sight. The front and rear bearers should start with opposite feet, which prevents lateral motion. In ascending a hill the patient's head should be in front, in descending behind, except in the case of a broken leg, or thigh, when such a course would throw the weight of the body on the injured part. Much harm is often done by moving a person, without taking any means to protect an injured limb, and especially so in fracture of the lower extremities. If the leg or thigh is broken, the person should be placed on the other side, the broken limb should be placed exactly on the sound one with straw or something soft between, and the two limbs should be tied together with handkerchiefs. The sound limb then acts in some degree as a splint for the broken one and prevents motion.

When the arm or forearm is broken, the least painful and injurious position is resting the forearm in a broad handkerchief slung from the neck with the elbow bent, and with a small pillow or pad between the arm and the side. A person so injured will be able to walk with less pain than he would suffer from movement in a carriage.

COURSE OF THE BLOOD-VESSELS.—The circulation of the blood throughout the body is carried on by the heart, as the central receiving and propelling organ, and by blood-vessels connected with it. These blood-vessels consist of two distinct divisions, named ARTERIES and VEINS: the *former* carrying *bright red* arterial blood *to* the different parts of the body *from* the heart, and having a *distinct pulse* at each beat of the heart; the *latter* carrying *dull red or dark blood from* the various parts of the frame *back* to the heart, and *not possessing any distinct pulsation*. The main *arteries* pursue a tolerably direct course to the various limbs, and are placed, as a rule, not very near to the surface of the body; the position they occupy is the sheltered one on the *inside* of each limb. The *veins* run in two sets: *superficial*, which are abundant in number, communicate freely with each other, and run a tortuous course; *deep*, which for the most part are situated side by side with the large arteries, and are more direct in their course. The veins and the arteries are connected in the skin and in the other textures of the body, by a system of very minute vessels termed *capillaries*. A knowledge of the course of the principal blood-vessels may be obtained by seeking out their course on the living subject by the pulsation they afford; and an outline of the course of the main vessels will not be difficult to remember, and will be a necessary guide to the ready arrest of bleeding.

In the following drawings (Figs. 1, 2, 3, 4, and 5) the *dark* vessels represent veins, and the *light* vessels arteries. The letter *a* in the drawing signifies artery, the *v* signifies veins.

There is on each side of the neck a large artery (*carotid*, Fig. 1) which carries blood *from* the chest *to* the neck and head. It runs in a line from the inner end of the collar-bone to the angle of the lower jaw, and the pulsation is throughout fairly evident to the finger. The *deep jugular vein* lies very nearly parallel to the artery; the *superficial jugular vein* is near the surface, and can be seen under the skin.

The large artery (*subclavian*, Fig. 2) which supplies the arm and hand with blood *passes out of the chest directly over*

Fig. 1

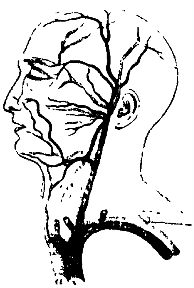
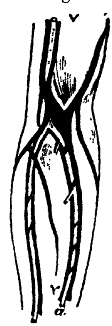


Fig. 2

Fig. 3



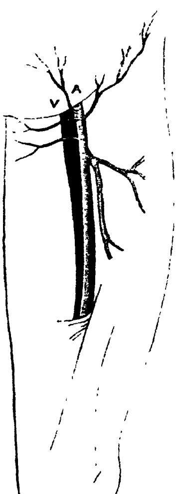
the uppermost or first rib, and then curves downwards. In the armpit the artery (here termed *axillary*) may be felt beating by pressing against the arm-bone near the top of the hollow of the armpit. From this point it runs onwards to the elbows, *keeping on the inside of the arm*, and to the inner side of the prominent muscle (*biceps*) of the arm (where it is termed *brachial*). It is accompanied by parallel veins.

Just below the bend of the arm the artery (Fig. 3) divides into two; one (now called *radial*) taking the line of the *outer bone of the forearm*, the other (*ulnar*) *lying almost parallel* *with the inner bone.* In the upper part of their course pulsation is not well felt, as they are covered with muscles. At the wrist joint both vessels may be felt beating.

Fig 4

Other branches pass onwards (Fig. 4), forming arches in the palm of the hand and in the ends of the fingers.

Fig. 5



The large artery for the thigh, leg, and foot (*femoral*, Fig. 5) passes *out from the groin, lying about the middle of the crease of the groin*, and almost at rightangles to it. From this point it runs onwards, *inclining to the inside*, and turning round a *little below the middle of the thigh-bone* into the ham. A line drawn from the centre of the fold of the groin to the inner side of the knee marks its course. In the upper three inches of its course the artery lies very superficial, and may be felt pulsating. It then becomes deeper-seated, but may still be compressed against the thigh-bone. The artery is accompanied by a large vein which lies at first to the inner side, but afterwards behind. Several smaller and one large branch are given off as the artery passes through the thigh (*vide* Fig. 5).

The main artery at the knee divides into two (called the *anterior* and *posterior tibial*); one passing down the inner front of the leg, the other through the calf. Both are deeply seated and covered with muscles, and their pulsation, except near the ankle joint, is not easily detected.

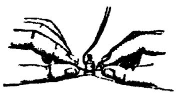
The foot, like the hand, is supplied with small branches from the two arteries.

BLEEDING or HÆMORRHAGE, VARIETIES OF.— *Bleeding from arteries* is ordinarily recognised by *vividly scarlet blood rushing out in jets, or jerks. Bleeding from veins is known by the black appearance* of the blood, and by its *flowing in a continuous stream,* and not in jets. When, however, an artery is wounded deep in the substance of a limb, the jet, or jerk, may be absent, and from retention in the deep wound the blood, although arterial, may become darker than it would otherwise be. At p. 500 it is stated that arteries carry blood *from* the heart to all parts of the body, while veins take the blood *back* to the heart. The practical application of this knowledge is, that bleeding from arteries is further distinguished by the facts that *pressure on the side of the wound nearest the heart stops the flow of blood from arteries; while pressure on the side of the wound furthest from the heart stops bleeding from veins.* In other words, bleeding from arteries *in the limbs* is to be stopped by pressure above the wound, and bleeding from veins by pressure below the wound. But for bleeding in the head or neck the reverse obtains. Bleeding from a large artery is dangerous, and will not stop without surgical treatment; but bleeding, except from a wounded artery of considerable size, is seldom dangerous to life. It generally stops on the application of pressure to the part (as afterwards described), or when the person becomes faint. Bleeding from veins is not often dangerous, and will generally stop without surgical treatment. The reasons why arteries continue bleeding and veins do not are found in the difference of structure, and in the manner of circulation of the blood.

As the matter is important, the distinctions between bleeding from arteries and from veins are placed in contrast.

Bleeding from Arteries	*Bleeding from Veins*
Blood scarlet.	Blood dark.
Rushes out in jerks.	Flows in a continuous stream.
Pressure on the side of the wound nearest the heart stops the flow.	Pressure on the side of the wound furthest from the heart stops the flow.
Dangerous from a large artery, and will not stop.	Not often dangerous, and generally stops.

BLEEDING, MEANS OF STOPPING. WHEN NOT VIOLENT.—*Bleeding from a wound when not violent* may generally be stopped by sponging the part with *cold* water; or, if more copious, by *pressure* with the finger, or with a bit of cork or a hard linen pad; especially if the wounded part is over a bone, where pressure can be made against the bone. At the same time the bleeding part should be raised as high as possible above the level of the heart. But if this does not succeed, each edge of the wound must be lifted up, carefully examined, and the mouth of any bleeding *artery* should be seized obliquely with the forceps, or with a pair of pincers out of a pocket knife, so that the whole is in the grasp of the instrument, and then *twisted* round, but not so completely as to cause the end of the artery to be broken off. If the bleeding is not thus stopped, the artery will require *tying* as described and sketched below. When the artery can be seen by turning up the flaps of the wound, the point of a tenaculum (A) should then be applied as nearly as possible to it, and the spouting mouth (B) drawn up sufficiently to pass a strong catgut ligature, silk, or thread round it below the tenaculum. One end of the ligature should then be passed through the other, and both ends drawn steadily till the blood

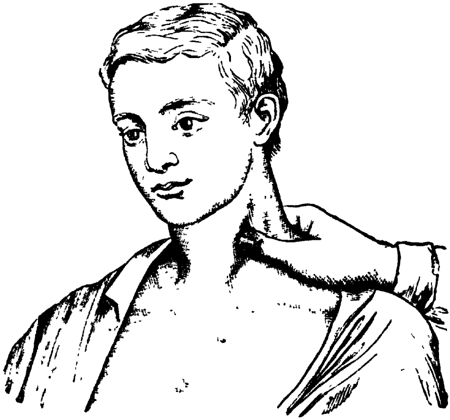


ceases to flow from the vessel, the mouth of which is then seen gaping, open, and white. The knot should then be completed. After which, if the bleeding cease, the wound may be brought together by plaster, the ends of the ligature remaining *outside* at the most dependent point of the wound. The ligature will come away with the discharge in five or six days' time, or at an earlier period if on a small vessel. Instead of the tenaculum, forceps may be used to take up the mouth of the artery, or even a strong piece of wire sharpened at the end.

If a small bleeding vessel cannot be stopped by cold, pressure, twisting, or tying, a *graduated pad* should be placed over the wounded part. This is made by rolling a small piece of lint or cotton cloth into a pad to fit into the wound, then placing four or five increasingly larger pads over one another. The whole should be secured by a bandage, which will probably stop the bleeding, at least till surgical aid arrives. The whole should remain for twenty-four hours, when the dressing may be cautiously soaked with lukewarm water and removed, after which plaster may be applied; or, if there is no plaster, a soft rag wet with cold water.

BLEEDING, MEANS OF STOPPING WHEN VIOLENT.—*When blood is flowing fast*, or when if *not* violent it cannot be stopped by cold, pressure, twisting, or tying, the first thing to do is to compress the artery supplying the part with blood as shown in the following sketches. The procedure after the flow of blood has been commanded by pressure of an artery, is given at p. 510.

BLEEDING FROM A WOUND IN THE HEAD OR NECK. Moderate bleeding from any part of the *head or face* may be stopped by placing a *graduated pad* (*vide* p. 505) over the wound and bandaging firmly. If very copious or from the neck it will be from some branch of the carotid artery. Firm pressure should be made in the neck over the course of this artery (*vide* p. 501), in a direction rather inwards and backwards, so as to press the vessel against

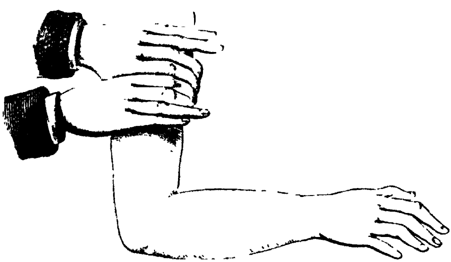


the side projections of the bones of the neck. The pressure is best accomplished with the fingers or thumb.

BLEEDING FROM THE ARM, NEAR THE ARMPIT.— A bystander should press his thumb firmly into the neck

behind the middle of the collar-bone, which will stop the flow of blood through the great artery of the arm as it is first coming out of the chest. As, however, the pressure thus made soon tires the thumb, the handle of a large key, or other object of similar shape, *wrapped in three or four folds of linen,* may be pressed behind the middle of the collar-bone, and held without fatigue for an indefinite time till surgical assistance can be obtained; or, if the bleeding comes from a small artery, until the blood ceases to flow, which may be ascertained by slightly and gradually diminishing the pressure.

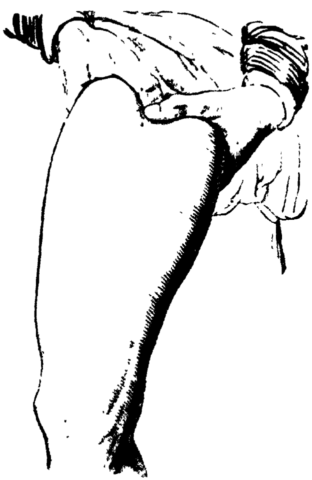
BLEEDING FROM THE LOWER PART OF THE ARM, OR FROM THE FOREARM BELOW THE ELBOW.—The brachial artery may be controlled by compression with the fingers on the inner side of the arm in the position of the



artery as shown above. More permanent compression may be made by the tourniquet if at hand (*vide* p. 497); or by the handkerchief and stick, as figured at p. 509, round the thigh; or by placing a thick ruler or stick *in the armpit* and then binding the arm tightly to the chest.

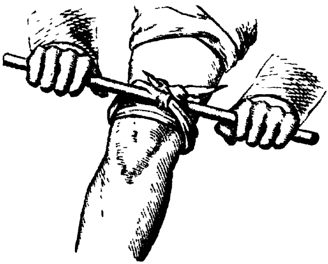
BLEEDING FROM THE PALM OF THE HAND.—A pad should be placed over the radial artery at the wrist (where the pulse is felt), and another pad over the ulnar artery on the other side of the front of the wrist (*vide* fig. 4, p. 502) and bandaged tightly. If this does not stop the bleeding, a *graduated pad* (*vide* p. 505) should be placed over the wounded part. Another thick piece of lint or cloth should be placed on the back of the hand. Then two pieces of wood, or two paper-knives, should be laid transversely, one across the front and one across the back of the hand, and their ends should be tied firmly together. The forearm should then be bandaged, the elbow bent, and the hand bound to the opposite shoulder. Or the pin sling may be used (*vide* p. 464). The whole should be allowed to remain for twenty-four hours, after which the part should be dressed as an ordinary wound. If pieces of wood, such as paper-knives, are not at hand, the bleeding may be stopped by binding the fingers over a ball of wood, or tightly rolled cloth, placed in the palm, then bending the elbow, and binding the hand to the opposite shoulder.

BLEEDING FROM THE UPPER PART OF THE THIGH. The great artery which supplies the limb should be pressed



so as to prevent the flow, by applying the thumbs with some force immediately below the middle of the crease of the groin. This pressure is made with less difficulty than when necessary behind the collar-bone, but the door-key or other convenient instrument may be used (*vide* p. 506).

BLEEDING FROM BELOW THE MIDDLE OF THE THIGH, or FROM THE LEG.—When bleeding is below the middle of the thigh, and a tourniquet (as figured at p. 497) is not at hand, a good substitute may be used, composed of a stout pocket-handkerchief and a piece of tough stick, which is to be applied as follows:—Pass the handkerchief once or twice round the limb, some distance,



if possible, above the wound. Then push the stick between the handkerchief and the skin, and twist the stick so that it screws the handkerchief until the blood ceases to flow. The twisting should only be continued till the bleeding stops, as the application of more pressure than is necessary to effect this may bruise the limb. A pad, or wine cork, placed underneath the handkerchief, over the course of the vessel, will lead to more direct and therefore more efficient pressure, without so much tightening of the bandage.

BLEEDING FROM THE SOLE, OR FRONT OF THE FOOT.—When there is bleeding from *the sole* a pad should be placed in the hollow behind and below the inner and outer ankles, and bandage tightly. If this does not stop the bleeding, a *graduated pad* should be applied to the wound as for bleeding from the palm of the hand (*vide* p. 507). When the bleeding is from the *front of the foot,* a pad and bandage should be tightly applied. In all cases of bleeding from the foot, it should be raised on a pillow above the level of the body.

BLEEDING, HOW TO PROCEED AFTER COMPRESSING THE ARTERY.—If the flow of blood has been commanded by compression of a distant artery, all clothing, bandages, or dressings should be removed from the wound, and all clots of blood should be washed away, with *cold* water, so that it may be seen exactly where the bleeding comes from. When the wound is quite exposed, the tourniquet or other means used for applying pressure *should be slightly relaxed.* The sides of the wound should be turned up, and any bleeding vessel seen should be sponged with *cold* water, *pressed, twisted,* or *tied,* and the wound should be dressed as described at p. 504.

BLEEDING FROM THE NOSE.—This may result from injury; or it may occur from a plethoric or too full condition of system; or, on the other hand, from a thin, poor state of the blood, as happens in scurvy, or as the result of venereal, fevers, malarious poisoning, and kidney or liver disease. It may also occur as a consequence of polypus (*vide* p. 355). If the bleeding arises from a blow, it will probably stop after a few minutes, and the application of cold water to the face and back. If it continue from any cause, a pinch of powdered alum dissolved in a couple of table-spoonfuls of cold water may be thrown up the nostrils with a syringe; or powdered alum may be snuffed up if a syringe is not at hand. In all cases of obstinate bleeding from the nose, the body should be kept in the upright posture, and the hands should be raised and held by other persons above the head. A bladder of ice or a cold wet cloth may be applied to the forehead and back of the neck; a piece of cold metal, as a door-key, to the back; and pressure should be made over the facial artery, by placing the finger in the angle formed by the side of the nose and cheek. The nostrils should also be pressed together with the thumb and fingers for half an hour. The feet and legs may be placed in hot mustard-and-water. If these measures do not succeed, plugging the nostrils will be required. The anterior part of the nose is easily plugged by inserting a roll of lint into each nostril, but the posterior nostrils can only be plugged by a surgeon acquainted with the anatomy of the parts, who would probably use an inflatible elastic tube. In some cases the blood may not pass from the nostrils, but, proceeding from the back of the nose, may trickle into the throat and be swallowed or spit out. In such instances plugging the posterior nostrils is still more necessary, as serious injury to the constitution, or even death, has occurred from prolonged bleeding from the nose.

If bleeding from the nose depends on too full a condition of system, recurring perhaps periodically, low diet, purgatives (Recipes 1 and 2), especially if costiveness is present, and astringent medicines (Recipe 42) are the proper remedies. Moderate bleeding from the nose may be regarded as salutary, when the person is red-faced, plethoric, and subject to headache or giddiness. It is then an effort of nature to relieve herself, and, unless violent, should not be suddenly restrained. If the bleeding appears to depend on too low a condition of the system, tonics are necessary, and the diet must be liberal; while any scorbutic, malarious, or venereal condition should be treated (*vide* pp. 380, 266, 458). Bleeding from the nose frequently occurs to children, and in the majority of cases a thin, depraved condition of blood is the cause, and the complaint must be treated accordingly. If bleeding depends on a polypus the growth should be removed (*vide* p. 355).

[Hazeline may be used with a syringe. A cotton-wool plug saturated with a strong solution of antipyrin (antipyrin thirty grains, water a teaspoonful) may be inserted into the nostril. When the bleeding is connected with a plethoric condition of system, sulphuric acid (Recipe 43) is a better remedy than the alum mixture (Recipe 42) mentioned above. When the bleeding depends on simply a feeble state, without special taints as referred to above, iron mixture (Recipe 71).]

BLEEDING FROM THE SOCKET OF A TOOTH.—This is sometimes very troublesome or profuse after the extraction or accidental loss of a tooth. It may be stopped by applying a plug of lint to the part, shutting the teeth close, and running a bandage round the chin and head to prevent the mouth being opened for several hours, during which time the pressure thus exerted stops the bleeding. Or the extracted tooth may be returned to its socket to act as a plug, the chin being bandaged as above.

BLEEDING FROM VARICOSE VEINS OF THE LEG.—Profuse bleeding may occur from the bursting of enlarged or varicose veins in the legs, especially of pregnant women. The person should lie with the leg higher than the body, and pressure should be made on the bleeding part with a pad of lint or cotton cloth soaked in cold water, till the bleeding stops. Afterwards a pad, and bandage from the foot upwards, should be applied (*vide* p. 495).

BLEEDING FROM LEECH-BITES.–Leech-bites, whether made for curative purposes or by leeches attaching themselves to travellers or sportsmen, sometimes give much trouble from bleeding. If the person is moderately strong, and the loss of blood is only from one or two wounds, it may be allowed to go on, and it will stop in a few hours. But if in delicate people or children, the loss of blood must be stopped at once; more especially if the patient is to be left during the night. This is usually effected by the application of cold water, or by pressure with the finger, through which bleeding cannot take place, continued, if necessary, for an hour. If this does not succeed, a pinch of powdered alum should be pressed into the bites.

[Other means, are pledgets of lint dipped in spirits of wine, which may be pressed into the bite; or the latter may be touched with a finely pointed stick of caustic. Occasionally, it has been found necessary to pass a needle through the skin under the bite, and to tie a ligature below the needle in the form of a figure of ∞ knot.]

BLEEDING, INTERNAL.—This occurs from injury or disease of internal blood-vessels. The bleeding may take place into the lungs, when the blood is *coughed up*; into the stomach, when the blood is *vomited up*; into the bowels, when it is *passed by stool*; into the bladder, when it *escapes with the urine*; or into other cavities of the body, from which there is no outlet, as, for instance, within the skull. Internal bleeding, excepting when into the cavity of the skull, is accompanied by great depression and faintness, by cold perspirations, by feeble intermittent pulse; the condition described as *collapse* (*vide* p. 520) being present. When bleeding takes place within the head, laboured breathing and insensibility, as described under *Apoplexy*, are the chief results. Perfect rest, acid drinks, as lemon juice and water, keeping the body cool and the feet warm, are the principal requirements.

BLEEDING, CONSTITUTIONAL, or **HÆMOPHILIA.**—This is a disease, often hereditary, to which males are most liable. It is characterised by immoderate bleeding after very slight injuries; and it sometimes occurs without any injury, especially from the gums or nose. The joints often swell when bleeding takes place. It may commence in childhood, and several of a family may be subject to it. A rag spread with powdered alum should be pressed on the bleeding part, and Recipe 67, or, if obtainable, 71, should be given internally.

BLEEDING, GENERAL TREATMENT OF, AND WHEN TO GIVE STIMULANTS.—Stimulants, as wine and brandy, should not be hastily given even if there is faintness. Faintness is nature's method of staying bleeding, and stimulants, by exciting the circulation, tend to increase bleeding. On the other hand, if faintness passes beyond a certain limit, it may be fatal. When faintness occurs in a case where there *has not been much bleeding*, and when *no large wound exists*, if there is no internal bleeding the faintness will probably be more from fright than loss of blood. The person should *keep the recumbent posture*, and he should be placed between blankets, bottles of hot water, or hot bricks, wrapped in flannel, being placed near the feet and in the armpits, taking care that the heat is not sufficient to burn the patient. Warm brandy and water should be given frequently in small quantities, the brandy being diluted with an equal quantity of water. *But if there is profuse bleeding, brandy must not be administered so freely*, and it should be given cold. With respect to the actual amount of brandy to be given, no positive rule can be laid down. A table-spoonful every half-hour, if there is no bleeding, and a tea-spoonful if there is, may be accepted as some guide. If brandy is not at hand some other spirit, as whisky or rum, should be used. Until the bleeding has been stopped, warmth should only be applied to the feet; and while faint, *the person must not be raised to an upright position.* Under all circumstances milk or broth may be given, but while there is any fear of bleeding everything must be given cold.

BLISTERS.—This term signifies the formation of watery fluid between the upper and middle layers of the skin. They generally result from friction, as of an ill-fitting boot, on the toes or heel. Or they may be produced by irritating substances applied to the skin, or arise from burns or scalds. The proper method of treating a blister, however produced, is, if very small, to smear it with a mixture of spirits of wine and tallow or mutton fat, and then to let it alone, when the contained fluid may be absorbed, and the upper layer of the skin will eventually peel off, leaving a healed surface below. If the blister is large, it should be pricked at the most dependent position, and the water should be allowed to drain out, and a piece of worsted may be passed through the blister and tied in a loop, which will prevent the aperture closing up before the water has drained away. The loose skin above should be preserved as long as possible, as it forms the best covering for the tender surface below. It should be protected by simple ointment (Recipe 86), or olive oil spread on lint, and the part should be carefully guarded from any injury.

To prevent blisters on pedestrian excursions, thin woollen hose and a well-made boot with broad sole, so cut that the upper leather does not unduly compress the foot, are desirable, and the socks should be well soaped previous to long walks. After some hours on the road, changing or turning the socks is desirable. If walking must be performed while blisters are present, take all pressure away from the part by cutting a hole in the leather of the shoe over the blister.

ULCERS OF THE TOES AND HEELS may result from neglected blisters, or from a bad state of health. These are troublesome to heal, requiring perfect rest of the part, great cleanliness, dressing with simple ointment (Recipe 86), and attention to the general health.

[Often such ulcers require a stimulating dressing, and when simple dressing does not suit, procure the ointment (Recipe 93).]

BRUISES.—Bruises are injuries in which the skin is not broken. They may be slight or severe. In the first variety the surface of the skin only is injured, but the little blood-vessels therein contained being ruptured, blood becomes effused in the skin, and discoloration occurs. This is at first bluish-black, then it passes through shades of violet, green, and yellow, until, by the end of ten days or a fortnight, it disappears. The familiar instance of a 'black-eye' will illustrate this description of bruise. If the injury is more violent, a similar rupture of blood-vessels, and escape of blood, takes place in structures beneath the skin. Or, as sometimes happens, the skin may escape injury, and the deeper parts alone suffer. In this case discoloration does not become apparent until twenty-four hours, or longer, after the injury. For slight bruises, such as occur to children falling down, the old-fashioned remedy of brown-paper steeped in brandy is not a bad application, or spirits of camphor, or tincture of arnica may be painted over the injured surface. For more severe bruises, keep the bruised part well raised, if practicable, lying on a pillow, and fomented continually with hot water and flannels. If the bruise is of a serious nature, blisters will now probably form on the surface of the skin. These must be snipped with sharp scissors at the most dependent part, and the contained water allowed to drain out. But the raised skin or cuticle should *not* be taken away. After the first two days hot fomentations may be *gradually* discontinued, and a cold lotion, composed of 1 ounce of vinegar in 4 ounces of water, may be employed. At a still later period, rubbing the part with brandy and salad oil in equal parts, or, if obtainable, with soap liniment, may be adopted.

Sometimes bruised parts are so injured as to inflame, or a large blood-vessel may be ruptured, and much blood escapes into the tissues. Abscess may form, the skin may burst, and mortification may occur. Poultices of bread and charcoal (*vide Appendix*) should be applied, until the mortifying parts separate, and the wound becomes clean. Surgical interference, in the form of incisions to promote exit of matter, is not unfrequently necessary.

Bruises or contusions of the head are frequently followed by effusion of blood beneath the skin, which is called a *blood-tumour*. This is frequently seen on the heads of newly-born children (*vide* p. 638), caused by the pressure during a prolonged or difficult labour. A blood-tumour, occurring to an adult after an injury, may give rise to a suspicion of a fracture with depression of the bone, as the blood-tumour has generally a hardened base, with a softness or depression towards the centre. There will, however, be an absence of the symptoms of fracture (*vide* p. 556), and firm pressure with the finger on the hardened part will discover the uninterrupted surface of the harder bone beneath. In ordinary cases of bruised scalp, followed by blood-tumour, time and the application of a cold lotion (Recipe 83) will effect a cure.

BURNS AND SCALDS.—The effect of burns and scalds on the skin is, in the first instance, the same.

Three different degrees of burning or scalding include all varieties. *1st.* When the contact with fire or water has been slight and the injury is that of redness, or inflammation of the skin. *2nd.* Where blisters have formed from a greater amount of heat. *3rd.* When there is destruction of the skin or underlying structures, or where they are changed into a black or yellow mass, and all vitality destroyed.

A slight burn or scald may be treated by the application of lint, or cloth, or plantain leaf soaked in salad oil; or ice pounded or scraped, made as dry as possible, mixed with lard or butter or oil, spread on cotton cloth, and kept on until it melts; or if not available, the part may be covered with a layer of cotton-wool secured by a bandage. Severe burns most frequently happen from the clothing catching fire. The sufferer should not run about, as every draught of air will fan the flame. He should lie down on the floor, and roll, or be rolled in a rug, table cover, carpet, or any convenient article sufficiently voluminous and thick to stifle the flames. Or, such not being available, the person should roll on the floor, until the flames are mechanically put out. If water is at hand, it should be dashed on the person. Then the patient should be laid on a bed, and if there is much shock (*vide* p. 520), which always follows severe burns, and is indicated by cold, shivering, pallor, and faintness, some hot coffee, or wine and water, or brandy and water, whichever may be first available, should be given at once, and bottles of hot water should be applied to the feet. After the first shock has passed away, chloral may be given to relieve pain, in doses according to age (*vide* p. 10). The clothing should be removed by cutting it away from the injured parts. If the skin adheres to the dress, the piece of the latter should be left, rather than the skin be torn in taking it away. The stockings must be removed with great care, lest the upper layer of the skin separate with them, which would increase the sufferings of the patient. It will facilitate the removal of the stockings if they are first soaked with salad oil. In the case of burns or scalds of the hands or feet, it is a good plan to immerse them, with the gloves or stockings on, in cold water. After a few minutes they should be removed, and partially dried with a towel. A mixture of equal parts of tepid milk and water should then be frequently dropped on the glove or stocking. After five or six hours the coverings may be cut carefully away, and the blisters may be snipped. Then, in the absence of the *carron oil* mentioned below, the parts may be covered with lint wet (preferentially) with salad oil, or with milk. But severe burns should, as soon as possible, be dressed with carron oil (Recipe 87), which should be warmed, and then spread thickly on lint or linen rag. Cold applications to extensive burns or scalds should be avoided as most injurious. The first dressings should not be removed for two days, after which the part should be dressed daily, and 5 grains of crystallised carbolic acid should, if obtainable, be added to and well mixed with every 4 ounces of the carron oil. At each removal of the applications the parts must be well cleansed by permitting a stream of warm water to flow over them from a sponge, but the injured parts should not be wiped with the sponge. All blisters should be snipped, but no wrinkled skin or raised cuticle should be removed. In dressing extensive burns, care should be taken to avoid exposing more than a small part at one time, or the cold will be injurious. The cotton-wool dressing, or the plan of dusting burns with fine flour, frequently employed in Europe, is not recommended for severe burns or scalds in India. As such applications are used on the principle of excluding air, they must be suffered to remain *in situ* several days, becoming hard, dry, irritating, and liable to harbour maggots. When the surface becomes red, healthy, and clean-looking, nothing will be more beneficial than simple water dressing, *id est*, lint soaked in tepid water, laid on the part, and the whole covered with oil-skin. If granulations become exuberant, growing above the surrounding skin, and forming what is popularly called 'proud flesh,' they must be lightly touched with alum.

Superficial burns and scalds, although only producing redness of the surface, are, if extensive, and particularly if occurring to children, very dangerous; stupor and insensibility are especially liable to occur to children after extensive burns; burns of the body are more dangerous than those of the limbs; shivering is a bad symptom; insensibility to pain, stupor, and twitchings of the limbs, are the usual precursors of death. Persons with bad burns are peculiarly liable to attacks of bronchitis, or inflammation of the lungs; to diarrhœa, accompanied by ulceration of the intestines; also to *pyæmia* (*vide* p. 587).

Burns or Scalds of the Fingers and Toes must be treated with great care, that the different parts may be kept separate, so as to prevent the raw surfaces of the fingers or toes touching each other. This may be readily effected by different dressings.

INTERNAL SCALDS OF THE THROAT, affecting the upper part of the windpipe or *glottis*, are very dangerous, from the swelling they occasion inside the throat. Such injuries most frequently occur to children, the symptoms being suffocative cough and difficulty of breathing. Ice to the throat, ice to suck, water and milk to moisten the mouth and throat, and a tea-spoonful of salad oil every three hours are the best remedies. But such cases frequently require the windpipe opened by a surgical operation.

BURNS FROM CORROSIVE LIQUIDS, as oil of vitriol and mineral acids, should be treated in the first instance by copious washing with water, or if available with soda and water; and afterwards as ordinary burns.

BURNS AND SCALDS, SEQUEL OF.—As burns heal, there is always tendency to contraction of the parts, especially if the injury is about the neck or joints. During healing every endeavour should be made, by bandaging, pads, and splints, to keep the parts in their natural position, and thus oppose the tendency to deformity. Cicatrices, disfiguring scars, contracted joints, and deep ulcers, sometimes the results of burns and scalds, require treatment by a surgeon.

COLLAPSE, SHOCK, or **PROSTRATION.**—This is an accompaniment of severe injuries, as gunshot wounds, laceration of joints, blows on the stomach or privates, bad burns or scalds, and great losses of blood. Collapse may also be produced by fear, by cold, and from large doses of certain poisons. The condition is very similar in appearance to fainting (*vide* p. 234). In some cases there are nausea, hiccough, and vomiting from the first. Occasionally the person is bewildered and incoherent, as if intoxicated. Vomiting is often a prelude to recovery, the first sign of which is called the *reaction*. Favourable signs are, returning warmth of the surface of the body, and slight restlessness on the part of the patient, with inclination to lie on the side. After a few hours there may be fever indicated by a hot skin, a flushed face, and rapid pulse. These symptoms in favourable cases soon pass off. In unfavourable cases the febrile symptoms increase, and after a few hours signs of nervous excitement and of *exhaustion* appear. There is trembling of the tendons of the wrist, restlessness, and generally delirium. The pulse becomes feeble, the skin cold, and there may be hiccough. Patients who have been accustomed to take considerable quantities of beer or spirits frequently present, during the stage of *reaction*, a condition very similar to *delirium tremens*. In individuals who are naturally weak and delicate, *reaction*, although favourable in its progress, may be slow, so that complete recovery is not attained for several days.

Treatment.—The requirements are to keep up the action of the heart and lungs, and to maintain the temperature of the body, until the effects of the sudden shock to the brain and nervous system have passed away, but the treatment should differ with reference to the *presence or absence of bleeding* (*vide* p. 514, *general treatment of bleeding*). If there is no bleeding the person should be placed between blankets, bottles of hot water or hot bricks wrapped in flannel being placed near the feet and in the armpits, taking care that the heat is not sufficient to burn the person. Warm brandy (or other spirit) and water should be given frequently in small quantities, the brandy being diluted with an equal proportion of water. Until *reaction* has well advanced, *the patient must not be raised to an upright position.* After reaction is established, and the patient becomes feverish, purgatives (Recipes 1 and 2) and cooling medicine, as citrate of magnesia, will probably be required. The treatment of unfavourable symptoms of *exhaustion* consists in support by nourishing broths or beef-tea, and in allaying nervous irritability by sedatives, of which chloral (Recipe 64) is one of the best.

CONCUSSION OF THE BRAIN, or **BRAIN-SHAKE.**— This condition, commonly called 'stunning,' signifies sudden interruption of the functions of the brain, by a blow or other injury to the head, either direct or indirect. In the mildest form the patient experiences a sudden weakness and trembling in the limbs, cannot walk without staggering, and there is a ringing sound in the ears and dimness of sight. These symptoms soon pass away, after the person has rested for a time in a darkened room. In the *more severe* form of concussion the person falls, and lies motionless, pale and unconscious. The skin is cold and the pulse weak. The eyelids are closed, the pupils of the eyes contracted, and the arms and legs generally bent on the body. The breathing is feeble and sighing, and, if the patient is roused and questioned loudly, he opens his eyes and answers hastily, and again relapses into insensibility. *The two facts stated in the last paragraph mainly serve to distinguish concussion from compression of the brain* (*vide* p. 525), when the breathing is heavy and laboured, and the patient cannot be roused. After a variable time, ordinarily about an hour, the patient moves uneasily, vomits, and recovers his senses, but remains giddy, confused, and sleepy for some hours. In a *still more severe degree* of concussion, the patient is more profoundly insensible, the surface of the body pale and cold, the pulse not only weak but also intermittent, and the breathing drawn in sighs. If the patient cannot be temporarily roused, if the pupils of the eyes are insensible to light, and if the legs are not drawn away, when the soles of the feet are tickled, the condition is very unfavourable.

Concussion of the brain often leaves mischief which may be permanent and of serious import. There may arise an irritability of the brain, marked by hasty, violent temper, or by very speedy excitement after drinking spirits or wine; there may be defects of sight, hearing, smell, or speech, muscular weakness and nervous debility; or temporary or permanent insanity may result. These sequences are due in many cases to indiscretion on the part of the patient, who as soon as the symptoms of concussion have passed away, and while the brain is still irritable and enfeebled, returns to his former habits, and probably to brain work.

Treatment.—No case of concussion, or of partial concussion, is so trivial that it may be neglected with impunity. The patient should be placed on a bed or couch in a quiet, darkened room, the neck and chest should be freed from articles of clothing, the head should be slightly raised, and a cold wet cloth should be applied to the forehead. In more severe cases, when the surface of the body is cold, the patient should be placed between blankets, bottles filled with hot water and wrapped in flannel should be applied to the feet and armpits, and the legs, hands, and arms should be well rubbed. Stimulants must *not* be administered, but as soon as the patient can swallow, a little water may be given, or, if procurable, milk, broth, or beef-tea. If there is long-continued insensibility or imperfect rallying, an assafœtida injection (Recipe 105) should be used. Natural sleep should be encouraged. The after-treatment consists of perfect rest both of body and mind, and in maintaining the bowels freely open by aperients (Recipes 1 and 2), with a mild nutritious diet. Stimulants of all kinds must be avoided, and the person must return gradually to former occupations. If headache or feverishness comes on, or any impairment of the mental faculties is observed, a strong mustard poultice (or, if procurable, a blister) should be applied to the back of the neck, and the bowels should be still more freely purged. If unfavourable symptoms persist, it may be necessary to cut the hair close, and to apply leeches to the temples.

CONCUSSION OF THE SPINE.—Usually occurs from severe shakings, as happen on carriage or railway accidents, or from blows on the spine. Concussion of the spine is marked by more or less severe pain at the seat of injury, bodily prostration, weakness of the lower limbs, or difficulty of walking, numbness in the feet, and diminished sensation of the lower extremities. In more severe cases there may be difficulty of making water, and swelling of the bowels, due to their distension by gas. If the injury has been only shaking of the spinal marrow, and nothing has been torn or ruptured, these symptoms usually subside in the course of two or three weeks, and the patient recovers. In some instances permanent weakness of the lower limbs, or even complete palsy, with difficulty or inability of making water, results. The *treatment* consists mainly in keeping the patient in bed, in applying leeches to the painful part of the back, and in giving tonics and nourishing food.

Severe shakings consequent on *railway accidents* have resulted in a peculiar condition of the spinal cord, to which the term 'railway spine' has been applied. The rapidity of the movement causing the injury, the momentum of the person injured, the suddenness of its arrest, the helplessness of the sufferer, and the natural fear occasioned, are all circumstances in railway accidents greatly increasing the severity of the injury to the nervous system. A person is often unaware that anything serious has happened, feeling perhaps only violently jolted and a little giddy and confused. After a day or two, he becomes excited, cannot sleep, and feels bruised all over, or as if he had gone through some violent exertion. After another few days he finds he is unable to undergo any exertion, or to attend to business. The thoughts become confused, the temper irritable, the sleep disturbed, and there are often noises and singing in the ears. The senses of hearing, taste, and smell sometimes become perverted. There is also a loss of freedom of movement, and the gait becomes uncertain and 'straddling,' while one or both of the feet may be unusually cold. The first requirement is *complete rest*, both for body and mind, and cold lotions or ice should be applied over any part of the spine in which pain is felt. Internally, the bichloride of mercury, with quinine and bark, are perhaps the most satisfactory remedies.

A similar condition arises from fright, as during the bombardment of cities, from fires, or from lightning-stroke.

COMPRESSION OF THE BRAIN.—This results either from blood being effused beneath the skull, or from a piece or pieces of bone being detached or depressed, and driven down on the brain or its membranes, which the blood or other substance *compresses*. Both conditions may be the result of injuries. At a later period compression may result as the consequence of 'matter' formed within the skull as a sequence of an injury. When, after the symptoms of *Concussion of the Brain* (*vide* p. 522), or after severe injuries without such symptoms, the patient does not revive; or reviving, afterwards sinks into stupor, from which he cannot be roused; with heavy laboured breathing, accompanied by puffing movement of the muscles of the mouth, with one or both pupils of the eyes dilated, with the surface of the body becoming warmer, and the pulse quicker and full, and perhaps with bleeding, or watery discharge from the ears and nose, serious injury of the brain may be suspected. Stimulants must *not* be given, but a cold lotion may be applied to the head and purgative injections (Recipe 105) should be administered. The condition requires skilled advice, as the operation of 'trepanning' may be necessary.

The principal distinctions between *concussion* and *compression* of the brain are given below.

Concussion	Compression
Insensibility takes place immediately on receipt of injury.	Insensibility, although sometimes present from the first, generally comes on gradually.
Breathing feeble, intermittent, diminished in force, often sighing, never stertorous.	Breathing slow and laboured, often stertorous, and accompanied with puffing movement of the lips and cheeks.
Pulse small, thready, intermittent, sometimes quick.	Pulse slow, full, and bounding.
Pupils of the eyes generally contracted.	Pupils generally dilated.

Concussion	Compression
Skin sensitive to prick of pin, or to pinching.	Skin not sensitive.
Surface of body cold and pale.	Surface of body warm, moist, and of natural colour.
Patient can be roused so as to answer questions.	Patient cannot be roused.
Retching and vomiting are very constant symptoms.	Retching and vomiting absent.

DISLOCATIONS.—A bone is dislocated, or, vulgarly, 'put out,' when the head of the bone slips from the socket in which it plays. Therefore the injury must be at a joint.

Symptoms.—1. Pain. 2. Deformity; there being an alteration of the normal shape of the joint; such as an unnatural prominence in one part, and a depression at another, with generally *shortening*, but in some varieties *lengthening*, of the limb. 3. Loss of the proper motion of the joint.

Dislocations are distinguished from fractures near the joint; *first*, by the absence of *grating* on movement of the injured parts; *secondly*, a fractured bone is more freely movable than natural, a dislocated bone is less so; *thirdly*, if a fractured bone is drawn into its proper place it will return as soon as the 'extension,' or pulling, is discontinued; but a dislocated bone drawn into its proper position will remain there; *fourthly*, by measurement of the *bone* supposed to be broken, which, if fractured, will be shortened, while the dislocated bone is of the natural length. Comparisons of the length should be made with the bone of the sound limb.

Dislocations are distinguished from sprains (*vide* p. 596) by pressing the swollen part steadily and firmly. If it be a dislocation the end of the bone is felt firm and hard; while the swelling caused by a sprain is soft and yielding. Also by the facts, that neither *lengthening* nor *shortening* are caused by the sprains; while natural motion of the joint, although painful, is possible.

Treatment.—The immediate treatment of any injury is given at p. 497. Dislocations must be 'reduced,' or returned into place. Sometimes this can be effected by placing the parts in such a position that the muscles will draw the head of the bone into the socket. Most dislocated bones may be readily returned into place by pulling the limb and manipulation, *immediately after they are put out.* But when any time has passed and the faintness usually caused by the accident is recovered from, a greater degree of force, or chloroform, are required to put the bone in place. Dislocations should, therefore, always be reduced as soon as possible, before the muscles swell or contract and fix the bone in its new position. When an hour or so after the accident has passed, or when all faintness has subsided, it would be wiser to delay any attempt to reduce a dislocation till assistance could be obtained, provided it could be available within twenty-four hours. The harm that ensues from the delay is more than compensated for by the great good secured by the use of chloroform or other anæsthetic. But if chloroform and surgical aid cannot be secured within a reasonable time, it will be better to make careful attempts to put the bone in place, even although the first effects of the accident have passed away. After reduction the limb should be kept at rest and fixed by bandages. Fomentations will usually be necessary to relieve inflammatory pain and swelling. When all pain and swelling has disappeared the joint may be *gently moved by another person,* in order to prevent the formation of adhesions which might eventually cause a stiff joint (*vide* p. 597).

Compound Dislocation is the term applied to those cases where an external wound communicates with the dislocated joint, and such injuries are always most dangerous.

DISLOCATION OF THE LOWER JAW.—This may be caused by a blow on the mouth, or from spasmodic action of the muscles, when a person gapes. The mouth is open and cannot be shut. Speech and swallowing are scarcely possible, the saliva dribbles away, and the chin protrudes forwards, so that the lower row of teeth project beyond the middle teeth of the jaw above. Sometimes one side

only of the bone is dislocated, and then the teeth are displaced laterally *away* from the side of dislocation.

Treatment.—Put the patient in a chair, with the back of the head against a wall. Then let the operator wrap a napkin or handkerchief round each of his thumbs. Place the thumbs thus protected on the *back teeth of the lower jaw,* on each side, the fingers clasping the under part of the jaw outside. Then press the thumbs firmly downwards and backwards, elevating the chin at the same time with the fingers. The jaw will generally return into its proper place with a snap, and, if the thumbs of the operator were not protected, they would probably be injured by the patient's teeth. Afterwards a four-tailed bandage, as described for a broken jaw (*vide* p. 559), should be worn for a week, during which time the patient should have only fluid food.

DISLOCATION OF THE COLLAR-BONE.—This usually occurs from falls on the shoulder. The dislocated head of the bone may be felt as a protrusion over the upper part of the breast-bone, and the arm cannot be raised. To restore it, the shoulder should be pressed *upwards, outwards,* and *backwards.* This may be accomplished by drawing back the shoulders with the hands, while pressing against the spine with the knee. If necessary the end of the bone should also be pressed *upwards* with the finger and thumb into its place. To retain it there, bandages should be applied as for *fractured collar-bone* (*vide* p. 560), but a pad should be also placed *over the end of the bone,* and the bandage should be broad, to keep the pad and bone in position. This should be worn night and day for five or six weeks; but in spite of every care, some deformity often results, as it is usually difficult to retain the bone in position.

DISLOCATION OF THE SHOULDER-JOINT.—The *humerus,* or arm-bone, may be thrown from its socket in several different directions, but most commonly it slips by the side of the socket, or below the socket, into the armpit. If the bone slips by the side of the socket, the arm is slightly shortened; if below the socket the arm is lengthened. A hollow is seen or felt under the tip of the shoulder, where the head of the bone should be, and the whole shoulder looks flattened. The elbow projects out from the side, and cannot be brought to touch the side. The head of the bone can be felt in the armpit, becoming more evident if the elbow is raised. There is also great pain, and numbness of the fingers, caused by the pressure of the dislocated head of the bone on the nerves of the arm. The patient leans over to the side of dislocation, and endeavours to support the elbow of the injured side with the opposite hand.

In addition to the above-mentioned signs (or without such features, if the dislocation is in other directions), the shoulder may be recognised as 'out of joint,' if the fingers of the injured limb cannot be placed by the patient, or by some one else, on the sound shoulder, while the elbow touches the side. In the natural state of the parts this can be easily done; and if it can be accomplished there is no dislocation. Again, the shoulder should be measured, by carrying a tape round the prominent bone at the tip, and under the armpit. If the shoulder is out, the injured side will measure about two inches more than the sound one. Thirdly, if there is a dislocation, a straight stick or rule will touch both the tip of the shoulder and the elbow at the same time, which it cannot do when the bones are in their natural places.

Treatment.—There are several methods by which this injury may be righted; *but if grating should be felt or heard on moving the injured limb, attempts at replacement should not be continued, as there is probably also fracture* (*vide* p. 561).

First. If the person is seen immediately. Put a cloth or shawl round the patient's body close under the armpit, and let some one hold the ends to steady the body. Then raise the arm gently to a right angle if possible. Then pull from above the wrist, steadily with moderate force, and the bone will probably slip into its place. If not successful the next methods may be tried.

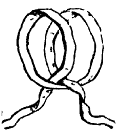
Secondly. By the heel, or foot, in the *axilla* or armpit. The patient lies down on a bed, or on the floor, and the operator sits on the edge of the bed, or on the floor, at the patient's side. The operator then places his *unbooted* foot in the armpit, pressing upwards and outwards, at the same time grasping the hand and wrist, which he pulls

steadily towards him, gradually carrying the hand across the patient's body. When commencing to pull, he should tell the patient to make some change in his position, in order to take his attention away, by which the resistance of the muscles implicated in the dislocation will be lessened. The head of the bone will then probably pass into its place. The left foot should be used if the left arm is to be operated on, and *vice versâ.*

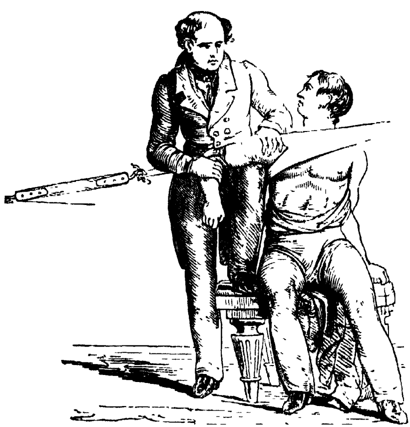
Thirdly. Have the patient seated on a chair, rest your foot on the chair, and place the bent knee in the armpit. The positions necessary are shown in the sketch accompanying the fourth method. Then depress the elbow with the hand, and at the same time raise the head of the bone with the knee, and it will probably glide into its place.

One or other of these methods will usually be successful in persons who are not very muscular, or when the shoulder has been dislocated a second or third time in the same person. But if not successful, or for muscular persons, the most certain plan is with the towels as described below, by which more force can be applied.

Fourthly. A long strong towel, or other piece of cloth, should have a slit made in the centre. Through this slit

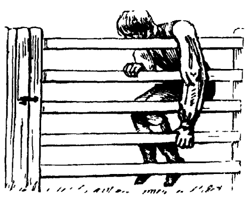


the hand and arm must be passed, until the towel presses on the chest below, and on the upper part of the shoulder above. Another long towel, or piece of cloth, must be fastened round the arm above the elbow. When fixing this, the knot called the *clove-hitch* should be used, as it does not tighten round the limb when pulled (*vide* sketch). The patient should then sit on a low stool.



Then, let the chest towel be firmly held, while the arm towel is *gradually* pulled by assistants, the operator standing behind the arm. After the extension has been continued for two or three minutes the operator should lift the head of the bone with his knee, when it will probably pass into the socket. The positions necessary are shown in the preceding drawing.

A person who has repeatedly dislocated his shoulder, and the accident is always more liable to happen after having once occurred, may, if he have courage to bear a little pain, manage to reduce it himself. By getting his arm over the top rail of a gate, or over any other object affording similar purchase (which, should be first covered by some article of clothing), seizing one of the lower rails with the hand of the injured



arm, letting the whole weight of the body hang over the other side of the gate, and then making some movement to change the position of the body while its weight still tells on the top bar, the bone will probably slip into its place. The principle is the same as when the heel is put into the armpit, and the arm pulled. The head of the arm-bone is moved towards the edge of the socket from which it has escaped, and the muscles pull it into its place. The position is shown above.

After a dislocated shoulder has been replaced, the *elbow and arm* should be put in a sling, and the arm should be confined for a fortnight to the side by a bandage passing lightly round the body. When the person begins to move about, the 'pin sling' (*vide* p. 464) may be used.

DISLOCATION OF THE ELBOW.—This may occur backwards, or to either side, and one or both bones of the forearm may be displaced. In complete dislocation there is much deformity and swelling, the joint being bent at a right angle, and remaining almost immovable, while the elbow protrudes, the end of the arm-bone can be felt in front of the elbow, and the thumb and outer surface of

the wrist are turned forwards. In dislocation to one side there is more deformity on that side. In dislocation of one bone only the deformity is less. Dislocation of the elbow is chiefly to be distinguished from fractures about the joint by the absence of grating.

Treatment.—One person must take firm hold of and steady the upper arm above the elbow. Another must pull from the wrist. After extension for about two minutes, the elbow must be suddenly bent by the person holding the wrist, when the bones will resume their natural position. The arm should be kept in a sling for seven or eight days, after which the joint should be gently moved.

It often happens that in injuries of this joint one or other form of dislocation is combined with one or other form of fracture, especially of the bones forming the point, and side prominences of the elbow. This complicates the case; splints are generally required, and the services of a surgeon should be procured. Until professional aid is obtained, the best plan is to lay the elbow, bent almost at right angles, on a pillow, and apply a cold lotion (Recipe 83).

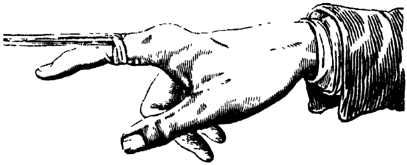
Partial Dislocation of the Elbow in Children.—The forearm of children from a fall or drag upon the wrist, is subject to a displacement caused by the head of the smaller bone (or *radius*) slipping forward and lodging against the front part of the bone of the arm, where it may usually be felt. The arm thus injured hangs down, and the hand is supported by the other. The hand is also turned inwards and downwards. Attempts to move the hand give considerable pain. The position which the child thus injured naturally assumes, as the most easy posture, namely, supporting the injured forearm with the sound hand, gives an appearance at first sight very much resembling the characteristic posture assumed by persons with fractured collar-bone. But on feeling the latter bone it will be found there is no fracture there. To remedy this accident at once, take hold of the upper arm firmly with the left hand, and the patient's hand with the right hand, in such a manner that the back of the patient's hand lies in the palm of the operator's. Now bend the elbow-joint quickly, turning the forearm outwards, so as to bring the palm of the patient's hand to front his upper arm. A crack will probably be felt, and the child will be able to use the arm. A bandage should be applied, and the arm kept at rest in a sling for some days, as the bone is liable to slip again.

DISLOCATION OF THE WRIST.—This may be distinguished by the altered position of the hand, which is thrown backwards or forwards, or is twisted, if only one bone is dislocated.

Treatment.—Extension of the hand, and if the natural position is not retained the application of splints as for fractured forearm. Fractures of the lower end of the forearm are sometimes mistaken for dislocations, and it often happens that when the large, or under bone of the arm is dislocated, the small or upper bone is broken. In all cases of doubt, after extension, it will be best to apply splints as for fracture. (*Vide Fracture of the Forearm*, p. 565.)

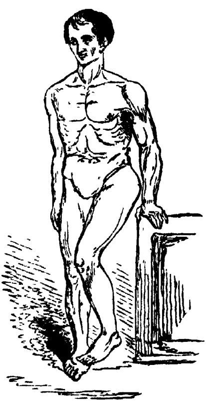
DISLOCATION OF THE THUMB AND FINGERS.—These accidents are known by the deformity present, and in consequence of the strength and tightness of the ligatures fixing the joints such injuries are often difficult to treat.

Treatment.—If the dislocated bone does not return into position by simple extension with the hand, a firm hold must be obtained by a piece of tape fastened as represented below, by the clove-hitch knot (*vide* p. 532). Then the



wrist must be held by one person, while another pulls the tape till the bone slips into its place.

DISLOCATION OF THE HIP-JOINT.—There are four principal varieties of this dislocation, but the dislocation *upwards* is the most frequent. The injured limb is from one inch to one inch and a half *shorter* than the other. The toes rest on the upper surface of the foot, or on the instep of the sound limb, the knee is turned inwards, and is advanced on its fellow, the hip generally appears flattened, but the dislocated head of the thigh-bone forms an unnatural prominence above and behind the situation of the hip-joint, the limb cannot be moved, and if force is applied to straighten the limb the patient's back becomes arched.



Fracture near the head of the thigh-bone is distinguished by these differences: In fracture the limb can be moved more freely; it is turned outwards instead of inwards; it can be drawn down to its natural level, but becomes again shortened as soon as the extension is discontinued; whereas a dislocated bone requires forcible extension to place the limb in its natural position, from which it does not again escape. The position of the limb, when the hip is dislocated upwards, is shown on the opposite page, and may be compared with *fracture*, p. 570.

To recognise and treat other, and less frequent forms of dislocation of this bone, so much special knowledge is necessary that no other variety is here described.

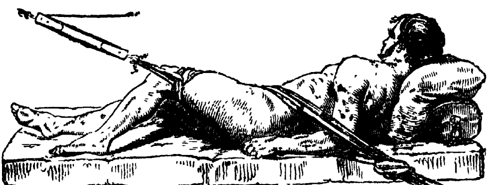
Treatment.—Dislocation of the hip is an injury urgently requiring treatment by a surgeon who may probably, when the patient is put under the influence of chloroform, replace the bone by manipulation, without the employment of force. Surgical aid being impossible, the following plans may be carefully tried. Either measure will be more likely to succeed if the patient can be put under the influence of chloroform. If chloroform is not available, 1 grain of tartar emetic may be given in an ounce of water every half-hour till nausea is produced, and which is attended with relaxation of the muscles.

First. Place the patient upon his back on the floor, with a pillow under the head. Then the operator should stand over him between his legs and opposite the knee-joints. The operator then clasps his hands below the knee of the injured limb, raises it, and places the ankle of the patient between his own thighs, the upper part of the patient's foot pressing against the operator's buttocks. He then lifts steadily, until the patient's body as far as the shoulders is raised from the floor, in which position it should be held for half a minute, or if possible a minute, when a click heard may denote that the head of the bone has slipped into its socket.

Secondly. Place the patient on his back on the floor, and, while he is firmly held by the shoulders, grasp the foot and ankle firmly, and by gradual extension parallel with the body, and rotation of the limb outwards at the same time, the head of the bone, if recently dislocated, will probably slip into its place.

Thirdly. If these methods do not succeed, more force must be used. A strong towel or sheet must be passed round the upper part of the thigh, and so adjusted that it does not interfere with or press on the private parts. This towel must be secured to a hook or ring in the wall, or to a tree. A bandage must next be applied over the thigh, as a protection to the skin, and then another towel or sheet must be fixed by the clove-hitch knot (*vide* p. 532) to the same part. When all is prepared extension must be firmly but gradually made, so as to draw the thigh across the opposite one a little above the knee. After a couple of minutes the knee should be gently turned, and the head or upper part of the thigh lifted up, when the head of the bone will perhaps return into its socket.

The position for the reduction of a dislocated hip is shown below.



After the reduction of the hip the knees should be tied together, and the patient should be kept in bed. No movement should be allowed for three weeks, and then only gentle movement, for if this rule is not attended to, re-dislocation may occur. After such injuries it sometimes happens that the patient is unable to make water. Fomentations over the bowels will perhaps relieve this condition; otherwise the catheter must be passed (*vide* p. 493).

When no attempt can be made to reduce a dislocated hip, or when attempts fail, the patient should lie on the back, and his thighs should be fastened together with a broad bandage.

DISLOCATION OF THE KNEE-CAP.—This bone may be dislocated either inwards or outwards, most frequently in the latter direction. In some cases it is half-twisted on its axis, so that its outer or inner edge rests upon the front of the lower extremity of the thigh-bone. A twisted knee-cap is the worst form of this injury, and it occasionally becomes so immovably fixed that it cannot be replaced. The symptoms are that the knee cannot be bent, and the bone may be felt in its new position, while there is a depression in the natural position of the bone.

Treatment.—It should be replaced by placing the patient on his back, straightening and well raising the leg, so as to relax the muscles in front, and then lifting the bone with the thumb and fingers into the middle of the joint, after which a splint should be applied loosely *behind* the knee. Then the patient must be put to bed, and fomentations should be employed to prevent inflammation. The person should not attempt to walk for a month, and then use a bandage round the knee, or an elastic knee-cap. The injury is likely to recur unless great care is taken.

DISLOCATION OF THE KNEE-JOINT.—The leg may be displaced from the knee, forwards, backwards, or to either side, but owing to the large extent of the opposed surfaces forming the joint, and to the strength of the ligaments, dislocation of the knee is always partial. In lateral displacement there is an unnatural projection of the inner or outer extremity (condyle) of the thigh-bone on the one side, and a projection of the inner or outer extremity of the leg-bone on the other, while the foot and leg are generally more or less twisted. Dislocations of the knee-joint, either forwards or backwards, are still more serious injuries, and are associated with much tearing of ligaments and soft parts surrounding the joint. In the backward dislocation the lower end of the thigh-bone projects in front, and the hollow at the back of the joint is occupied by the displaced head of the leg-bone. The dislocation forwards is rare, and is accompanied by much laceration of the soft parts, and often by rupture of the hamstring tendons.

Treatment.—The thigh should be fixed by being tightly held while the patient lies on his back. Then extension should be made by pulling steadily from the ankle. After the parts have resumed the natural position, fomentations should be applied, and the patient should be kept in bed for at least three weeks.

DISLOCATION OF THE SEMILUNAR CARTILAGES OF THE KNEE-JOINT.—The semilunar cartilages are two flat gristly structures of a horse-shoe shape, which are fixed to the margins of the upper surface of the leg-bone. One (usually the internal) or both may, in consequence of a sprain or twist, become detached and slip out of place, or a piece may be broken off. The symptoms are sudden, severe, *sickening* pain in the knee, and inability to walk. But the leg, though stiff and painful when the person is erect, can be generally moved when he lies down. After the accident the knee begins to swell, and remains swollen for some days. When the swelling subsides a painful spot is usually left, generally at the inside of the joint, where sometimes the displaced cartilage, or the piece broken off, may be felt or seen projecting, if it has not been properly replaced. If the patient is seen immediately, before the joint begins to swell, reduction of the cartilage may be readily effected by extending the leg, and pulling with some force from the ankle, when probably the cartilage will resume its place with an audible click. If this does not suffice, the leg when extended, should be suddenly bent backwards at the knee, until the heel almost touches the corresponding buttock, the other hand of the operator being placed on the front of the knee. Afterwards fomentations and rest for some time will be necessary. If the patient is not seen until the knee is swollen, fomentations and rest should be had recourse to, and the cartilages may gradually assume their natural position. But if a piece has been broken off, it may remain for months until eventually absorbed. The patient should not attempt to walk until all pain and swelling have ceased. This injury having once happened is very liable to recur from slight causes, and the person should wear a stout long bandage or a tight knee-cap for months afterwards. A bandage is better than a knee-cap, as it affords more support. If a knee-cap is used, it should be made of perforated india-rubber.

DISLOCATION OF THE ANKLE.—This is generally caused by jumping from heights, or from carriages in motion, and is nearly always complicated with fracture of the small bone of the leg above the ankle. The dislocation may be either inwards or outwards, and the swelling on either side will be the chief distinguishing mark. The dislocation outwards, involving fracture of the small bone on the outside, generally two or three inches above the ankle, is the most common variety. The shape of the limb will then be as opposite, presenting a hollow on the outer side at the site of the fracture of the small bone, the sole of the foot being turned rather inwards.

Treatment.—The person should be placed on his back, with the thigh raised and the knee bent. Then, while an assistant steadies the knee, the operator must grasp the instep with one hand and the heel with the other, and pull gradually and firmly till he has restored the parts to a natural shape. Then the limb should be bound up with splints on each side, as for a fractured leg; care being taken to keep the great toe on a line with the inner side of the knee-pan. The patient should lie on his back, although some surgeons prefer treating this accident by placing the patient on the side corresponding with the injury, the knee being bent. (*Vide Fractures of the Leg*, p. 575.) The splints should be retained for six weeks, and afterwards gentle mòvement of the joints should be made; but the person should not bear any weight on the limb for another month.

DISLOCATIONS OF THE BONES OF THE FOOT.—Such injuries are the result of great violence, are mostly attended with fractures, and will require the attention of a surgeon. Until this can be obtained the parts should be placed as far as possible in the natural position, perfect rest on a pillow should be enjoined, and fomentations applied.

DROWNING.—The injurious effects of submersion in water may be varied. If the water is warm, the principal hurtful effect will be the suspension of respiration, or suffocation; but if, as is often the case, the water be cold enough to extract heat from the body, a very powerful depressing action is added. Again, persons falling into the water may die from fright or syncope (*vide* p. 234); or they may be stunned (*vide* p. 522) if they fall from a great height. Those who sink at once are usually affected in one of these two ways. In the treatment of drowning, ARTIFICIAL RESPIRATION should be promptly resorted to and perseveringly continued. The following rules are those sanctioned by the Royal Humane Society:—

Send immediately for medical assistance, blankets, and dry clothing, but proceed to treat the patient INSTANTLY, securing as much fresh air as possible. Under no circumstances hold the body up by the feet.

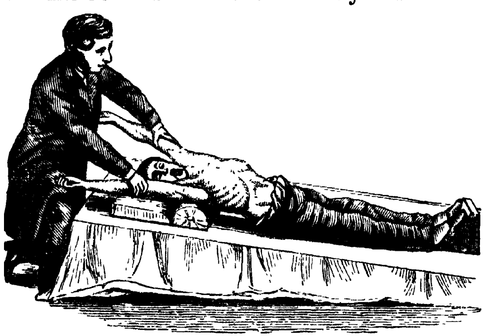
The points to be aimed at are—first, and immediately, the *Restoration of Breathing*; and, secondly, after breathing is restored, the *Promotion of Warmth and Circulation.*

RULE 1. *To adjust the Patient's Position.*—Place the patient on his back on a flat surface, inclined (if possible) a little from the feet upwards; raise and support the head and shoulders on a small firm cushion or folded article of dress placed under the shoulder-blades. Remove all tight clothing about the neck and chest. Prevent unnecessary crowding round the body, especially if in an apartment.

RULE 2. *To maintain the Free Entrance of Air into the Windpipe.*—Cleanse the mouth and nostrils; open the mouth; draw forward the patient's tongue, and keep it forward; an elastic band (from a purse or pocket-book) over the tongue and under the chin will answer this purpose, or the tongue may be held by the fingers of a bystander wrapped in a handkerchief. Do not allow the body to remain on the back unless the tongue is secured.

RULE 3. *To imitate the Movements of Breathing.*

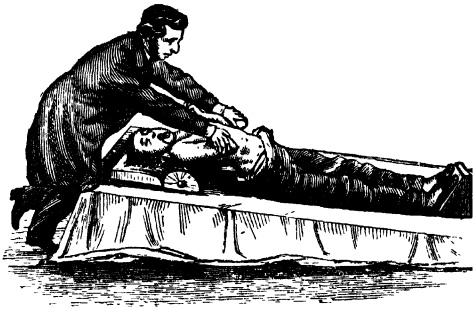
First—INDUCE INSPIRATION.—Place yourself at the head



INSPIRATION

of the patient, grasp his arms, raise them upwards by the sides of his head, stretch them steadily but gently upwards for two seconds. [*By this means fresh air is drawn into the lungs by raising the ribs.*]

Secondly—INDUCE EXPIRATION.—Immediately turn down the patient's arms, and press them firmly but gently



EXPIRATION

downwards against the sides of his chest, for two seconds. [*By this means foul air is expelled from the lungs by depressing the ribs.*]

Thirdly—CONTINUE THESE MOVEMENTS.—Repeat these measures alternately, deliberately, and perseveringly, fifteen times in a minute, until a spontaneous effort to respire be perceived. [*By these means an exchange of air is produced in the lungs similar to that effected by natural respiration.*]

RULE 4. *To excite Respiration.*—During the employment of the above method excite the nostrils with snuff or smelling-salts, or tickle the throat with a feather. Rub the chest and face briskly, and dash cold and hot water alternately on them. Friction of the limbs and body with dry flannel or cloths should be had recourse to. Should a galvanic apparatus be at hand, apply the sponges over the heart and back of the neck.

The efforts to restore life must be persevered in until the arrival of medical assistance, or until the pulse and breathing have ceased for at least an hour. For appearance indicating death (*vide* p. 38).

When a spontaneous effort to respire is perceived, *cease* to Imitate the Movements of Breathing, and commence to Induce Circulation and Warmth (*as below*).

Treatment after Natural Breathing has been Restored.—*To induce Circulation and Warmth.*—Wrap the patient in dry blankets, and rub the limbs upwards energetically. Promote the warmth of the body by hot flannels, bottles or bladders of hot water, heated bricks, to the pit of the stomach, the arm-pits, and to the soles of the feet. When the power of swallowing has returned, a teaspoonful of warm water, small quantities of wine, warm brandy and water, or coffee should be given. The patient should be kept in bed, and sleep encouraged. During reaction, large mustard plasters to the chest and below the shoulders will relieve the distressed breathing.

FOREIGN BODIES IN THE NOSE.—Peas, beans, small stones, slate pencil, insects, &c., may be thrust into the nostrils by children, or may be accidentally inserted. They may be frequently discharged by compressing the clear nostril with the fingers, and then blowing forcibly through the obstructed nostril. If this does not succeed, snuff may be given to excite sneezing, or the nostrils may be syringed with warm water. These measures failing, a mustard and water emetic may be given, and when vomiting occurs the mouth should be stopped by the hand. A rush of fluid will then take place through the nose, and probably dislodge the foreign substance. If no effect is thus produced, a probe or piece of wire, bent into the form of a loop, or hook, may perhaps be passed *above* the substance so as to hook it down. Or it may sometimes be seized with a pair of forceps. Care must be taken not to push the foreign body backwards, and digging attempts *upwards* towards the head should be avoided. When a foreign body cannot be extracted, it will frequently work out if left alone. If a *leech* gets into the nose, a solution of 2 drachms of salt in 2 ounces of water, should be snuffed up or injected.

FOREIGN BODIES IN THE EARS.—The first thing is to examine the ear (*vide* p. 210), to make sure there is really anything inside, as well as to ascertain its size and situation. Unless the foreign body is something which might swell from moisture, as a pea, for instance, syringing with warm water (*vide* p. 210) should always be first tried. When ordinary syringing fails, the patient should lie with the head over the side of a couch, the affected ear being most dependent; so that gravity may be called into play, and the ear should be again syringed while in this position. The form of the canal of the ear is so peculiar, being curved and widest at each extremity, the shapes of foreign substances are so various, and some of them swell from moisture, that efforts to remove them by other means than a current of water should be most carefully undertaken. If syringing does not succeed, the best plan is the use of a wire loop. Take two pieces of fine flexible wire, double them, and then pass the loops into the ear, keeping them against the upper surface, then lower them gently until the foreign body is within one of the loops and then extract. The loop is less liable to injure the internal part of the ear than forceps. But in some cases the substance may be easily seized and extracted by a pair of thin forceps. In other instances a probe end, with a little cotton-wool attached, dipped in carpenter's glue, has been held firmly against the foreign substance, until the glue dries, or for about half an hour, when all was removed together. Great care must be taken not to injure the drum of the ear by pushing the foreign body, or the probe or wire used for its extraction, inwards—or by too forcible syringing.

Insects may be generally removed, or at least killed, and the pain they create therefore diminished, by pouring a little warm salad oil into the ear; or, if oil is not at hand, a saturated solution of salt and water.

After the removal of a foreign body from the ear, if much manipulation or syringing has been required, the ear is painful, and sensitive to cold, from which it should be carefully guarded by the use of cotton-wool for some days; otherwise inflammation or abscess might occur.

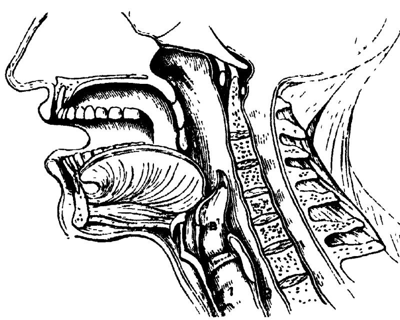
FOREIGN BODIES IN THE EYES may be often removed by raising the upper eyelid, drawing it down over the lower, and allowing the lids to separate themselves. Blowing the nose vigorously will sometimes effect removal. Otherwise, the eye must be opened, and the offending substance removed with the corner of a handkerchief, or camel's-hair brush, or a feather. But if the lodgment is under the upper lid, the eyelid must be turned inside out. This is done by placing a probe or knitting-needle on the middle of the eyelid *horizontally*, seizing the lashes with the fingers, and turning the lid back over the probe, when the inside of the lid will be exposed, and the substance, which generally lodges just above the margin of the upper lid, may be removed.

When *lime* has got into the eye, its effects are irritant and caustic, and the treatment should be prompt. The eye should be held forcibly open, and every particle gently picked away with a feather, the eye being frequently washed with vinegar and water, or lemon-juice and water, in the proportion of one-third of the former to two of the latter.

When a particle, as of metal for instance, is so firmly fixed in the *cornea*, or central part of the eye, that it cannot be readily detached, it should be left to separate by the natural process of inflammation which will be set up. If it be a piece of iron (as from a blacksmith's forge), the surface of the eye should be bathed with a solution of sulphate of copper (strength, 3 grains of the sulphate to 1 ounce of water). This may be applied with a camel's-hair brush, or with a syringe, and will tend to dissolve and loosen the iron. Sometimes particles of iron or steel may be removed by a magnet.

After the removal of any foreign body from the eye, light should be excluded, and a drop of salad oil placed in the eye will relieve the smarting usually present.

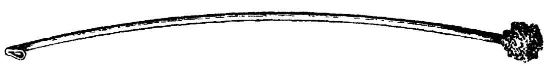
FOREIGN BODIES IN THE THROAT AND GULLET.—People are sometimes choked, and have been killed, by portions of food sticking in the gullet and preventing the air passing into the windpipe. As in the diagram below, showing a section of the parts, the windpipe (1)



and the gullet (2) lie close together, the entrance to the former being protected by a little valve, A, the *epiglottis*. This remains open and upright except when the act of swallowing is performed, when it shuts down over the opening into the air-passage or windpipe, B, allowing the food to glide over it. When a person eats quickly or carelessly, pieces of food may pass beneath the valve into the windpipe, a circumstance popularly spoken of as 'going the wrong way.' Or a piece of food may lodge above the gullet and epiglottis, shutting the latter down, and thus producing suffocation. This may happen when masticating stringy meat. Two pieces may be attached like chain shot; one piece is swallowed while the other remains entangled in the teeth, and the connecting string shuts down the little valve at the top of the windpipe, and stops the breathing. The effects are spasmodic cough, protrusion of the eyes, blood or froth issuing from the mouth and nose, the person turning blue in the face and falling down insensible.

Treatment.—Place the patient where the best light falls from a window or lamp into the mouth, and then boldly and quickly examine the back of the throat and the base of the tongue, by passing the forefinger well down. Probably the foreign mass may be touched and hooked up if a hard body, or pushed down if a soft one, with the finger. This will be facilitated by directing that the tongue be put forward, well out of the mouth, and there retained, being grasped by the patient's own fingers covered with a handkerchief. This procedure mechanically draws forward the arches of the palate, and allows the operator to sweep his finger well across from one side to the other of the throat. If the finger does not reach the foreign body, a sharp blow on the back should be given with the flat of the hand. If the patient is a child, it will add force to the blow if the child is taken between the knees, so as to compress the belly; otherwise much of the impetus of the blow is lost by transmission to the yielding walls of the abdomen. Thus fish-bones, or other bones, or various foreign bodies lodged high up in the gullet may often be removed by the fingers. Or they may be, perhaps, brought up by the vomiting occasioned by passing the fingers into the throat in their search, or they may sometimes be dislodged by pressure with the fingers outside. Hard, angular, or pointed substances, such as false teeth and teeth-plates, should always, if possible, be got up; and in some instances they may be laid hold of with a long pair of curved forceps. But softer substances, when lodged low down, may sometimes be impelled onwards into the stomach by swallowing large pieces of food, or they may probably be ejected by an emetic (Recipe 54).

If these measures fail, a *probang* must be passed, to push the intruding substance into the stomach. This instrument is a long stick of whalebone, slightly bent, with a piece of sponge attached to one end, and a small hook to the other, as below. If such an instrument is not available, a substitute may be extemporised as follows:—Obtain a slip of whalebone or cane, and tie firmly to one end of it a knob of sponge about the size of a marble. The patient is made to sit with the head well thrown back,



and the tongue should be put out, when the operator introduces the probang, sponge end first, into the throat *so as to touch the back part*, and then pushes it gently onwards and downwards towards the stomach, so as to displace and send before it the foreign mass into the stomach. Or the hooked end may be passed, under the hope of bringing the foreign body upwards. Or a number of loops of thread may be attached to the hook and passed down the throat, as foreign substances have sometimes been thus caught and brought up when other means have failed. But these operations can scarcely be performed except by a surgeon; although they should be tried, rather than a sufferer be left without attempts at relief.

Needles swallowed, if not easily removable, should be left alone: they will probably work out harmlessly through some part of the skin.

FOREIGN BODIES IN THE WINDPIPE cause difficulty of breathing and violent cough, and are sometimes expelled by the latter. If the patient is a child, he, or she, should be held up by the legs with the head down, and the back should be gently tapped. If an adult, the patient should be placed on a slanting board or a tilted table, as far as possible in the same position, and the back slapped. Coins and similarly shaped bodies have thus been got rid of. If these means do not succeed, and difficulty of breathing is urgent, nothing but a surgical operation will afford a chance of relief. Otherwise, if there are no urgent symptoms, the patient must be kept quiet, and the foreign substance becoming coated with mucus, or becoming softened, may be coughed up.

FOREIGN BODIES IN THE STOMACH.—When any foreign substance has passed into the stomach, as, for example, a coin, a marble, a piece of glass, or artificial teeth, the object is to allow it to pass through the intestines well enveloped in food, and as it passes on in fæcal matter. Therefore no purgatives should be given. The person should abstain from fluids, but otherwise the usual diet should be taken. A change of diet to rice pudding, cheese, and hard-boiled eggs with the view of producing hard consistent stools, enveloped in which the foreign body may pass without injury to the bowels, is sometimes recommended. But such changes of food often induce looseness of the bowels, and do injury. If metal has been swallowed, nothing acid should be taken, as it might dissolve the metal and produce poisonous compounds.

Leeches have sometimes been swallowed, giving rise to very unpleasant symptoms. A table-spoonful of salt dissolved in four ounces of water should be immediately taken, and repeated in half an hour, when the leech will be probably killed, or vomited up. If salt is not at hand, half a wine-glassful of sherry every ten minutes.

FOREIGN BODIES IN THE SKIN.—Splinters of wood, thorns, needles, fish-hooks, nails, &c., may be embedded in the skin. Splinters of wood or similar shaped substances should be, if possible, seized by forceps and dragged out.

To accomplish this, slight enlargement of the wound with a lancet may be necessary. Or they must be left a day or two and the part poulticed, when, becoming loose, they may be more easily extracted. Needles and fish-hooks in the person will be generally more easily extracted by pushing them out by the points, care being taken that they do not break. Needles introduced beneath the skin often travel to distant parts of the body, and therefore no operation should be undertaken for their extraction, unless the substance can be plainly felt.

To take a tight ring from the finger.—Hold up the hand for three minutes. Then wind a moderately broad piece of elastic round the finger, commencing at the nail. Still keep the hand well up; take the elastic off after five minutes, and if the ring will not come away repeat the procedure.

FOREIGN BODIES UNDER THE NAILS.—Thorns, splinters of wood, &c., must be extracted after gradually paring down the nail until the foreign body can be seized by forceps. If this cannot be effected after the nail is pared to the quick, the outside end of the splinter should not be wasted by fruitless picking at it, but the nail immediately above should be scraped as thin as possible; after which a small triangular piece may be cut from the top, when the splinter may be readily seized and drawn out. If all this cannot be accomplished, it will be best to poultice for a day or two, when probably the intruding substance will be loosened, and may be extracted.

FOREIGN BODIES IN OTHER PARTS.—Foreign bodies sometimes become impacted in the *private parts or fundament*, and may consist of substances which have been swallowed, as fruit-stones and fish-bones, or of articles introduced from without. As they cannot be extracted easily the assistance of a surgeon will probably be required.

FRACTURED OR BROKEN BONES.—These accidents are spoken of as *simple fractures,* when there is no external wound leading from the surface of the skin to the injured bone. When there is such a wound they are called *compound fractures* (*vide* p. 580). Compound fractures are much more dangerous than simple fractures. When the bone is broken into several pieces it is called a *comminuted fracture* (*vide* p. 580). Fractures *implicating joints* are the most dangerous (*vide* p. 580).

The usual symptoms of all fractures are pain, swelling, alteration of shape, *grating* of the broken ends of the bone on movement, and more or less inability to move the limb. But sometimes, in children, bones are bent, not broken, when, although there will be no grating, the deformity or bent shape of the limb will sufficiently indicate the injury. For the signs distinguishing fracture from dislocation, *vide Dislocation,* p. 526. Fractures near the joints are distinguished from simple *sprains* (*vide* p. 596) principally by the presence of grating.

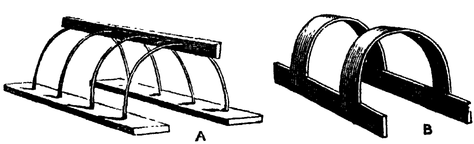
Treatment.—The *immediate* treatment after any accident is given at p. 497; of fractures at 499. *The after principles of treatment of all fractures* are to place and retain the fragments in perfect rest in their natural position until they have united.

The surface on which the patient with a fractured limb has to lie should be firm and level, and therefore no feather or very soft bed should be allowed. The lighter and cooler the method of fixing the limb, the less unpleasant will it be. The irritation when the part is thickly covered, and there is no escape for the perspiration, is often intolerable. It is also of importance to be able to undo the apparatus easily, to see the state of the limb, and to keep it clean with soap and water.

In the treatment of fractured bones the following articles are required:—Splints, bandages, pads, tapes, sometimes oiled silk, and simple ointment, or olive oil. Splints may be made of wood, or, except for the thigh, of gutta percha, of telegraph wire, of thick pasteboard, of newspapers, of bandboxes, or even of strong straw tied into a bundle. Bandages should be made of linen or calico (*vide* p. 493), or of old sheeting. Pads may be formed of pieces of blanket cut into the shape of the splints, or of cotton-wool, or tow, or of cocoa-nut fibre, chaff, or husks of grain in bags. Before attempting to treat a fracture everything required should be made ready. When adjusting splints, much care must be taken that there is no great pressure on prominent parts, as the bones of the ankle or elbow; otherwise blisters and sores will form. This is to be effected by making the pads fit the limb, or they may be fitted on the limb of another person, or on the sound limb. Before applying splints, the limb should be washed, dried, and dusted with violet powder or starch. Although frequent moving of splints when once applied is not desirable, it is still necessary to secure cleanliness, and to ascertain whether any wound is forming from pressure, or whether blisters have formed from the violence of the injury. It will, therefore, be necessary to move the splints with great care about the third day, when the limb will be probably found showing the discoloration described under *Bruises* (*vide* p. 515), and also presenting various blisters. These should be snipped at the most dependent part; the limb should be gently sponged and cleansed with warm water and carbolic soap; a little simple ointment (Recipe 86) or salad oil spread on lint or soft rag should be laid over the blistered part; and if pressure has occurred, the pads and splints should be carefully readjusted, so as to avoid it. Similar attention will be required in another day or two; and afterwards, the limb should be gently sponged every few days. If all this is done with care, no motion of the fractured parts need be entailed.

If there is great swelling of the parts, or much bruising, or escape of blood into the tissues (*vide* p. 580) apparent at first, broken limbs should not be bound on splints for the first three or four days. If limbs in such a condition are bandaged up tightly, much pain results, and, if the bandages are not slackened, serious injury or mortification may follow. It is best at first, if there is much swelling, to lay the broken limb in as comfortable a posture as possible, and as nearly as can be in its natural direction, and it may be lightly bound to a single splint merely for the purpose of keeping it steady. The arm, whether broken above or below the elbow, will lie most comfortably half bent on a pillow. The thigh or leg will rest most easily on the outer side, with the knee bent. It will always be proper to apply fomentation or lotion, or to use irrigation, while swelling continues (*vide Appendix, Cooling applications*), and as a rule it will be best to foment during the first two or three days, and then to gradually substitute a cooling application. Speaking generally, all fractures should remain in splints during one month, after which sufficient support may be obtained by a starch bandage (Recipe 112), or by plaster spread on strips of leather (Recipe 113).

In treating fractures of the lower limbs, and also sometimes for the arm, the use of a 'cradle' is necessary to keep the bed-clothes from pressing on the injured parts.



A 'cradle' may be constructed of some curved iron wires, passed through three slim pieces of wood, as in figure A. Or one may be made as figure B, by cutting a barrel hoop in two or three pieces, and nailing them to two pieces of wood.

FRACTURE OF THE SKULL.—If it be a simple fracture, or crack in the bones of the skull, nothing more will be required, beyond attention to the external wound, as mentioned under *Wounds of the Scalp* (*vide* p. 601). Such injuries are, however, generally attended by *concussion* (*vide* p. 522), and this state, if present, must be treated as there mentioned. If any portion of the bones of the skull is broken and *depressed* below the other part, the symptoms described under *Compression of the Brain* (*vide* p. 525) will be present; and the operation of trepanning may be required. For distinction between bruise and fracture (*vide* p. 517). When, after an injury to the head, there is bleeding or escape of watery fluid from the ears, or from the nose, in addition to insensibility and laboured breathing, *fracture of the base of the skull* has probably taken place, and the case generally ends fatally. In all injuries of the head there is special danger of inflammation of the brain, and therefore perfect rest from the first should be insisted upon, with a darkened room, low diet, cold lotion to the head (Recipe 83), purgative medicines (Recipes 1 and 2), and abstinence from all stimulants.

FRACTURE OF THE SPINE.—The fracture is usually partial, and frequently associated with dislocation of one bone, or of part of one bone. The symptoms are partly *local*, and partly *nervous*, depending on the nature and amount of injury which the spinal marrow has sustained. The *local* symptoms are pain, loss of power, and irregularity in the course of the spine at the seat of injury. Sometimes the bones of the spine, ordinarily felt as a succession of regular hard prominences in the back, are found to be unnaturally separated at the injured place, or one or more of the bones may be felt to be depressed *beneath the level* of those above and below. If the spinal marrow is so far injured that its functions are interfered with, there will be either partial or entire loss of both motion and sensation *below* the point of injury.

If the fracture is situated about the loins, the lower part of the body, the bladder, the rectum, and the lower limbs will be paralysed, the person being unable to move, or to make water, or to pass motions at will, both coming away involuntarily. The arms and upper part of the body remain unaffected. The patient may live for months or years, death eventually taking place from exhaustion, caused by bed-sores (*vide* p. 69), or from disease of the bladder (*vide* pp. 71, 74).

If the injury is higher up, about the shoulder-blades, the muscles of the chest will be also paralysed, and breathing will be carried on with difficulty. Under such circumstances the patient may live a few days, but the lungs soon become congested, and the person dies suffocated.

If the injury is still higher, or at the lower part of the neck, the arms are also paralysed.

If the injury is still higher up, about the upper part of the neck (above the origin of a nerve called the *phrenic*), death takes place instantly from cessation of respiration. Such cases are popularly talked of as 'broken neck.'

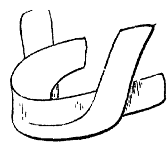
Treatment.—When the injury is in the lowest part of the back, much may be done to make the person more comfortable, and to prolong life. The sufferer should be placed, if possible, on a water bed, and kept perfectly clean. The tendency to bed-sores (*vide* p. 69) about the buttocks and back from pressure, and about the privates from irritation by urine, or by fæces dribbling away, should be held in mind, and the parts should be protected by variously shaped pillows, and by suitable coverings of oiled silk. As the person cannot make water, the urine accumulates in the bladder, until, that organ being filled to distension, it dribbles away; but the bladder remaining always full, the urine contained therein becomes offensive.

ammoniacal, and doubly irritant to the inside of the bladder, and to the skin which it may run over outside. From the first, therefore, the urine should be drawn off with the catheter twice a day, and if a surgeon and the necessary instruments are at hand the bladder will probably be washed out daily. No medicine, except an occasional purgative, such as castor oil, will be required. But the rectum should be washed out every two or three days by an enema of soap and water (Recipe 104). When the injury is higher than the loins, very little can be done to alleviate the sufferings of the patient, and no medicine is of any use.

FRACTURE OF THE BONES OF THE NOSE.—This is known by the nose being flattened, and by the grating of the broken bones when the nose is raised to its natural position. The bones should be pushed into their proper place by passing a pair of forceps or piece of wood into the nostrils, and lifting up the fractured parts. If they do not remain *in situ*, a plug of oiled lint must be placed in the nostril. If the fracture is compound, that is, presenting an external wound, and any splinters of bone are loose, they should be removed with the forceps. Bleeding, if violent and protracted, must be stopped, as mentioned under *Bleeding from the Nose* (p. 510).

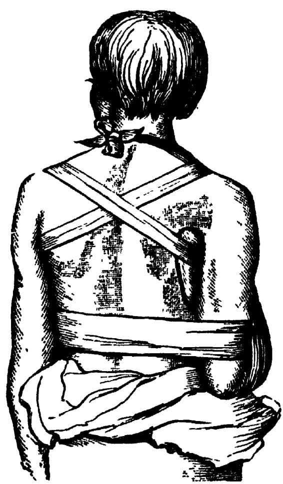
FRACTURE OF THE LOWER JAW.—This usually occurs at about the middle of one side of the part in which the teeth are placed, and is known by pain, swelling, inability to move the jaw properly, and irregularity of the teeth; the front teeth being drawn *down*, and the back teeth *up*, by the action of the muscles. The point of fracture may be easily felt, and the saliva dribbles from the mouth. On moving the jaw grating will be felt. If the fracture is compound, there will also be bleeding, from laceration of the gums, and probably one or more teeth may be knocked out or loosened.

Treatment.—If teeth are only loosened they should be left, and may perhaps be secured in their places, by silver wire, passing round adjacent teeth. If teeth, or fragments of bone, are wholly detached, they had better be removed. Then the teeth should be brought into a natural line. Then a piece of gutta percha, or thick pasteboard softened by hot water, should be accurately fitted to the jaw (previously shaved, if necessary), and extending from ear to ear. The gutta percha should be about eight inches long, and should be split up the middle from each end to within an inch of the centre. When applied, the lower portion should be doubled on the upper, by which means there is a double support at the part most requiring it. The gutta percha must be secured by a four-tailed bandage, made by taking a yard and a half of calico roller about four inches wide, tearing each end longitudinally, so as to leave about eight inches in the middle, in which should be a slit for the reception of the chin. This slit should be about an inch from the anterior margin, so that the latter may not rise so high as to cover the lower lip, or get into the mouth. Two of the tails are then tied over the crown of the head, and two at the back of the neck; or the latter may be crossed and brought round and tied in front. The bandage may be rendered more secure by a circular one round the head above the ears, the two being secured by pins where they cross. The mouth is thus closed, and the patient must be fed



entirely on fluids for the first fortnight. The cure occupies about five weeks. Dribbling of saliva, and fœtid taste in the mouth, are a great nuisance to the patient. Frequently washing the mouth with carbolic solution (Recipe 119), or with myrrh gargle, is desirable.

FRACTURE OF THE COLLAR-BONE.—The person cannot raise the arm upwards towards the head; the broken part of the bone may be seen and felt prominent; grating of the broken ends occurs on movement of the shoulder; the shoulder is flatter than the other, and falls forwards and inwards; the person supports his elbow and forearm with the opposite hand and forearm. This accident frequently occurs to children.



Treatment.—Place a big cone-shaped pad in the armpit, then bandage the shoulders so as to draw them well backwards. This is effected by a figure of ∞ bandage, passing several times round each shoulder and crossing behind. The arm must be then bound to the side by another bandage, with the elbow well back, and lastly *the elbow* must be supported by a handkerchief, used as a sling round the neck. Thus the shoulder is kept *up* by the sling, *out* by the pad, and *back* by the bandage, bringing the broken ends of the collar-bone into position. When the bandages are adjusted, they should be stitched in several places, as they are liable to slip. They should be tightened when they grow loose. They should be worn a month, after which plaster on strips of leather (Recipe 113) may be applied over the injured part. The preceding diagram represents a broken collar-bone bandaged.

It is difficult to keep this bone, when broken, at rest and in exact position, unless the patient lies on his back, with his arms confined to the side of the body, and keeps his head quite still. For ladies, when it is a matter of importance to prevent deformity, the recumbent posture in bed should be maintained three weeks, till union has fairly taken place. But such a position for days, for such an injury, would be to most people intolerable. With the bandages as above described, a broken collar-bone unites speedily and strongly, although some little deformity must be expected.

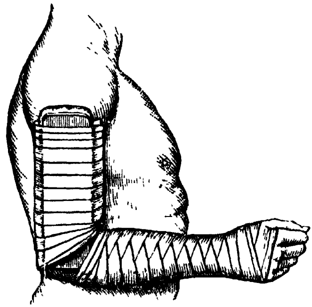
FRACTURE OF THE HEAD, OR UPPER PART OF THE ARM-BONE.—There are various kinds of fracture of this part, but the one now described is the most common. The arm is slightly *shortened*, and the broken end of the bone may be felt in the front of the armpit, while the round *head* of the bone is felt in its right place, and does not move when the elbow is turned. The shoulder, when compared with the other, will be seen to have lost its rounded form. Grating will also be felt when the elbow is pulled downwards, so as to restore the broken parts to their natural position. There is severe pain from pressure on the nerves. The following features distinguish this accident from dislocation. Although the shoulder loses its rounded form, it does not present the sharp angle of dislocation; the head of the bone is felt in its natural position; there is grating; the broken end is felt in the armpit; and the parts return to their unnatural position after becoming right by extension; none of which signs present in dislocation.

Various other Injuries affecting the Shoulder Joint occur, presenting symptoms very similar to fracture of the head of the arm-bone, or to some forms of dislocation (p. 529). In any case of doubt, it will be well to apply the crossed bandage as for fractured clavicle, and to keep the arm to the side, until the advice of a surgeon can be obtained.

Treatment.—If there is no reasonable doubt that the head of the bone is fractured it should be treated as follows. If, as often the case, there is great swelling, it will be advisable to put the patient to bed, and to use fomentations for a few days until the swelling subsides, before applying splints. Then, or at first, if there is no swelling, a well-padded splint should be prepared, about three inches wide, and long enough to reach from the armpit to the elbow-joint. Another splint of gutta percha or strong leather should be made by moulding the material, when softened by immersion in hot water, on the shoulder of some one of similar size, in the form of a cap. The tail of this splint should be nearly three inches wide, and long enough to reach to the outside of the elbow, where it should be well padded. When all is prepared, the limb must be first restored to the natural position by raising the arm parallel with the shoulder, and then by pulling or extension from the bent elbow. The splints should be secured by tapes above and below, taking care that the tapes do not cut the skin between the splints, which they will not do if the splints are broad enough. Then, a bandage should be applied, commencing from the hand, passing over the forearm, and then over the splints. This prevents swelling of the hand and forearm. Lastly, the *wrist and hand* should be comfortably supported by a sling, but the *elbow should be allowed to hang down,* its weight tending then to prevent the lower part of the bone being dragged upwards by muscular action. Splints should be worn for six weeks, after which plaster spread on leather may be applied across the shoulder, from near the middle of the chest to near the middle of the back; after which the joint may be gently moved.

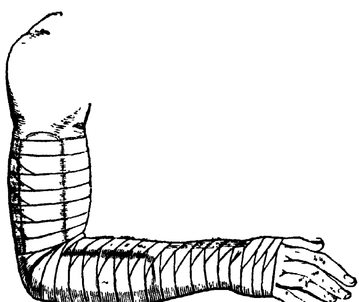
FRACTURE OF THE MIDDLE OF THE ARM-BONE is easily detected from the deformity, the grating, the bone being movable at the broken point where it should be firm, the local pain, and the inability to use the arm.

Treatment.—The parts should be restored to their natural position by raising the arm parallel with the shoulder, and then by pulling or extension of the bent elbow. Then four carefully padded splints should be placed, one in front, one behind, and one at each side. These splints must be long enough to reach from the top to the bottom of the arm, and the *outside* one should be the longest, as it should rest above on the shoulder, and below on the outside of the elbow. Great care must be taken that this splint does not press too much on the prominence of the elbow—to be avoided by well padding opposite the hollow of the arm *above* the elbow. The skin of the armpit and the inside of the elbow is also liable to be frayed by the inside splint, which must be avoided by care and padding. Similarly the skin of the forearm may be blistered by the lower end of the front splint. The splints, when properly adjusted, must be secured by tapes tied round at the top and the bottom. Then a bandage should be applied from the hand upwards. The arm thus treated is sketched below. The wrist and hand should be supported by a sling and the elbow allowed to hang down.



After about six weeks a starch bandage (Recipe 112) may be applied instead of splints.

FRACTURE OF THE LOWER PART OF THE ARM will be known by the elbow being drawn backwards, by its



being restored to the natural position by pulling the hand, by its returning to the unnatural position if the hand is not pulled, and by the grating.

Treatment.—The parts should be brought into proper position by pulling from the hand, the elbow should be bent, and an angular splint made of gutta percha or leather softened in hot water applied on each side. The hand and forearm must be bandaged, and the elbow and forearm supported by a sling from the neck. The part thus bandaged is figured on opposite page. Splints should be worn for a month, after which the joint should be gently moved.

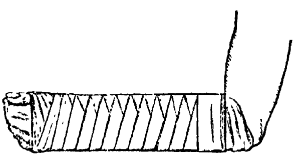
FRACTURE OF THE PROMINENCES OF THE ARM-BONE.—The prominences of the arm-bone on either side, just above the elbow, may be split off. The broken piece of bone forms a swelling towards the back of the joint, and there is difficulty in the motion of the joint. When these prominences are broken there may be much pain from injury of nerves. The injury should be treated as advised for fracture of the lower part of the arm.

FRACTURE OF THE PROMINENCE OF THE ELBOW. There is a depression at the back of the joint, above which the broken end of the bone will be felt detached from the body of the bone, and the person is *unable to straighten* the arm. This injury should be treated by placing the arm *straight*. A well-padded splint, long enough to reach from the middle of the forearm to the middle of the arm, should be placed *on the front* of the elbow, and secured by a bandage. The limb should be kept up on a pillow, otherwise the hand will swell. This injury does not unite by bone but by ligament, so that there may long be some imperfection of movement. After four weeks the joint should be gently moved.

There are other Injuries of the Elbow Joint, presenting symptoms of fracture, or of dislocation. The precise nature is difficult of detection; but in case of doubt keeping the arm *bent at right angles*, resting on an angular splint, will be the best plan, until the arrival of skilled aid.

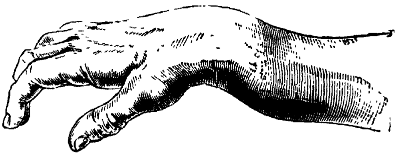
FRACTURE OF THE FOREARM.—The two bones of the forearm may be both fractured in any part or only one may be broken. There will be pain, loss of power of turning the hand, grating on movement, and the arm will be misshapen; the more so if both bones are broken.

Treatment.—One person should hold the elbow and another pull the hand, *keeping the thumb of the injured limb upwards.* Then well-padded splints, a little *broader* than the arm, must be applied *from the fingers to the elbow* on each side, and the whole secured by tapes and bandages. The splints should not be removed, except to sponge and clean the arm, until after three weeks, when shorter splints may be substituted, and a little movement of the wrist allowed. During the whole time the arm should be supported in a sling. In two weeks the short splints may be left off, but some support in the shape of a starch bandage, or leather plaster (Recipes 112, 113), will be required for another week or two. The forearm bandaged is shown below.



In Children the Forearm is often Bent, rather than quite broken. In such cases it must be forcibly straightened, during which, grating will be felt, and then splints are to be applied, and worn for three weeks. This injury is called 'green stick' fracture.

FRACTURE OF THE FOREARM CLOSE TO THE WRIST. This is an injury chiefly occurring to elderly persons and from which recovery is tedious. The limb is peculiarly bent, as in the accompanying sketch, and there is generally much swelling, while grating is felt on extension of the hand. The lower fragment of the broken bone forms a marked projection at the back of the limb, and leaves in front, just above the line of the wrist-joint, a corresponding depression. It is distinguished from dislocation by grating being felt when the hand is extended and slightly moved.



Treatment.—The thumb must be placed upwards, the elbow steadied, and the hand pulled until the natural position is restored. Splints should be applied, the inner one extending from the elbow to the palm of the hand, the outer one curved as in the accompanying diagram, and

extending to the ends of the fingers. This position of the hand brings the fractured parts into better contact, when it should be secured by tapes and bandages round the splints. In this injury occurring to a person up to thirty years of age these splints should not be used more than three weeks, nor more than four weeks for an older person; after which they should be shortened so as to allow the fingers to be gently moved. In another week splints may be left off, after which the wrist should be gently moved daily, otherwise the joint is liable to become stiff.

Other injuries about the Wrist Joint occur, difficult of detection, involving often both the small bones of the joint, and the ends of the bones of the forearm. In the absence of surgical skill, when there is doubt, it is best to treat the case as for fracture of the middle of the forearm.

FRACTURE OF THE BONES OF THE HAND AND OF THE FINGERS.—These injuries are known by the attendant swelling pain and grating. The best method of treating fractures of the *bones of the hand* is by laying the extended hand on a wooden or gutta-percha splint, cut to the shape of the part. The *inner* or palmar surfaces of the bones of the hands are *concave*, and the splint should therefore be well padded, so that it may adapt itself to their form. Sometimes, in order to maintain the broken parts in better contact, a small splint is desirable on the back of the hand. Then, a bandage should be applied so as to keep the hand and fingers immovable. In some instances, the broken bones are brought into more natural position when the hand is closed. If this is the case, the injury may be treated by causing the patient to grasp a ball of tow, or other soft substance, about half the size of a cricket-ball, or so large as to permit the thumb and fingers meeting within an inch. The closed hand, with the ball of tow inside, should then be secured in such position by a bandage. The hand should be kept bound for about three weeks, and supported by a sling as noted below.

When a bone of the finger is broken, it may be treated by binding the finger to a narrow splint of wood or gutta percha, or, best of all, perforated zinc, which should reach to the wrist. If the injury is very severe, or several fingers are involved, it will be needful to lay the whole hand on a wooden splint cut to the shape of the hand, thumb, and fingers. The inner surfaces of the bones of the fingers are concave, and the splints should therefore be well padded. *In all cases of fracture of the bones of the hands or fingers,* the limb should be supported by a sling, so disposed as to raise the hand a little above the level of the elbow.

FRACTURE OF THE RIBS.—The ribs are liable to be broken by falls or blows, or by a crushing weight, as from a wheel passing over the chest. When the injury results from direct violence, the rib is generally broken at the seat of injury; when from crushing or squeezing, it breaks at the bend, or middle of the bone. The patient complains of severe pain on drawing a deep breath, and there is a grating sensation in the side, evident to the patient, and which may be felt on applying the hand flat over the part, unless the patient is very stout. Grating is also felt if the person coughs, and there is generally a short, hacking, frequent, but suppressed cough. If the fracture is near the spine, or the patient corpulent, detection will be more difficult. But if, after an injury to the chest, cutting pain is complained of, the treatment for fractured rib should be pursued. The principal danger from fractured rib is, lest the lung or its covering (the *pleura*) may be injured, when there may be spitting of blood, or *emphysema* (*vide* below), or pleurisy (p. 352), or pneumonia (p. 325).

Treatment.—Diminish motion of the chest, by passing a broad roller, eight inches in width, and about twelve feet long, tightly round the body, from the pit of the stomach to the armpit. The bandage will require shoulder-straps to maintain it in position. The patient should be kept in bed on spare diet, and if cough occurs, Recipe 57 should be given. The bowels must also be kept open (Recipes 1 and 2). Chloral may be given at night to relieve pain. The bandage should be worn for three weeks, after which leather plaster may be applied over the seat of injury. Pleurisy, or inflamed lung, caused by fractured ribs, should be treated as advised for such ailments (*vide* pp. 353, 327).

Emphysema, or Air Entering Beneath the Skin.—This sometimes results from the fractured ends of the ribs wounding the lungs. Emphysema forms a soft puffy swelling of the skin, sometimes extending to the neck, which crackles when pressed. For this complication, a pad of lint should be first placed over the seat of injury, and the bandage should be tightly applied over the pad. The necessity for perfect rest must be more especially enjoined; for the occurrence of *pleurisy*, or of *inflammation of the lungs*, is more likely.

FRACTURES OF THE UPPER PART OF THE THIGH are of various kinds, but the one described is the most common. It is marked by inability to stand, shortening of the leg, and turning out of the toes, the heel of the injured limb pointing to the instep of the sound member, as shown in the sketch. If the foot is drawn down to its proper length, and turned about, while a hand is placed on the hip, grating will probably be felt. This accident frequently happens to old people. The figure may be usefully compared with the drawing representing the aspect of the limb in dislocation of the same bone. (*Vide* p. 536.)

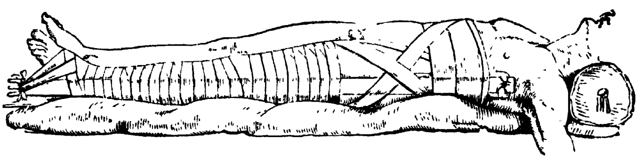
Treatment.—Unless the person is old and feeble, the limb should be bandaged, as detailed on next page for fracture of the middle of the thigh. If the patient is old and feeble, health would be sacrificed, and probably bed-sores formed by long confinement in bed, under the treatment by splints. The patient should be kept in bed for a fortnight, with one pillow under the whole length of the limb, and another rolled up under the knee. When pain and tenderness abate, which will be ordinarily in about a fortnight, the patient may be allowed to sit in a chair, and to use crutches. What is called 'ligamentous union' will take place, and although the leg will be shorter than before, it will be fairly useful, and the shortening may be remedied by a thick-soled shoe. This 'ligamentous union' consists in the junctions of the broken ends of the bone by a tough leather-like substance, but not by bony matter.

FRACTURE OF THE MIDDLE OF THE THIGH.—This accident is readily distinguished by shortening of the limb, by great swelling, and by grating when the ends of the bones are placed in contact by extension, or pulling from the foot; which also restores the natural shape of the limb.

In young children this fracture is often incomplete, the bone being only bent. In such cases there is no grating, and pulling the foot does not restore the natural shape of the thigh, which must be bent back with the hands into position, much in the same way as a stick would be bent.

Treatment.—For all cases of this kind, and for fractures of the upper part of the bone, up to fifty years of age, the long thigh-splint must be used. This is a narrow board of a hand's breadth for an adult, but narrower and slighter for a younger person. It must be long enough to reach from just below the armpit to four inches below the sole of the foot. At the upper end must be a hole, at the lower end two deep notches with a hollow or hole just above for the reception of the ankle-bone. First the splint must be thoroughly padded, with layers of blanket or otherwise. Then the limb should be evenly bandaged from the toes up to the knee, and then gently extended to its proper length and shape by pulling the foot. Next, the lower end of the splint is to be fixed to the ankle, by passing a bandage round the foot, and through the notches of the board.

Next, the splint is secured to the limb by a bandage passing upwards. During all this time an assistant must keep the limb in proper position by pulling the foot. Lastly, this extension must be maintained by 'the perinæal band.' This band is formed of a large handkerchief or piece of silk, doubled cornerwise, and rolled round a long thin pad. This is placed between the legs, one end passing over the groin, the other under the buttock, and the ends are tied through the holes at the top of the splint. This mechanically pushes the foot down, and so keeps up the extension. A roll of broad bandage should also be passed round the



body and upper part of the splint, to keep the latter close to the person. The perinæal band is likely to gall, and constant attention must therefore be directed to this part; particular care being taken that it does not press on the privates, or become wet with urine. And as considerable pressure is exerted on the ankle, padding and manipulation are necessary at this part to prevent blisters or sores forming. It is also sometimes necessary to apply short splints, both on the inner side and on the front of the thigh, when the bones have a tendency to project in either direction. The figure above shows a thigh thus bandaged to the long splint.

It often happens that the bandage round the foot, notwithstanding careful padding, causes pain, or blisters from the pressure, which, when the band between the legs is drawn tight, is considerable. Or the band may cause soreness between the legs. Under such circumstances it may be necessary to continue the treatment without these aids, and this may be effected in the following manner. A fixed point, in the shape of a foot-piece, must be attached firmly to the foot of the bed, so that the sole of the foot of the injured limb may rest against it as the patient lies on his back. Then several long broad strips of plaster must be carried down the leg from the seat of fracture on the one side, round the foot-piece, and up the leg to the same point on the opposite side. By this means the pressure and extending force will be so diffused that the person will be scarcely sensible of it. But something is still wanting as the extending force, in place of the perinæal band. And this difficulty is to be overcome by tilting up the lower end of the bed about twelve inches from the floor, and placing blocks of wood below the feet of the bed. The patient then lies on an inclined plane, and the body having a tendency to slip towards the head of the bed, while the foot is fixed by the plasters to the immovable foot-board, the desired extension is thus maintained at the seat of the fracture, the body itself being the counter-extending force. As a further precaution, small splints should be applied round the thigh at the point of fracture. The best method of applying the foot-board is to procure a piece of wood, about half an inch thick, as broad as the sole of the foot, and in length sufficient to reach from the floor when the bed is tilted to the extremities of the toes of the patient as he lies with the heel downwards. The upper portion should be cut into the shape of a foot-piece, and the board should then be firmly screwed to the cross-piece of the bed. A little adjustment by cutting the latter, or the foot-piece, or by inserting a wedge between the two where they meet, will be necessary, in order that the upper part of the board to which the sole of the foot is bound may be perpendicular, and not participate in the tilt of the bed. To render it still more firm, a nail may be driven in the floor, in front of the lower end of the foot-board.

After any variety of fracture of the thigh it often occurs that the bladder is temporarily paralysed, and the person cannot make water. The passage of water should therefore always be inquired about, a few hours after an injury of the kind. If no water has been passed the bowels should be fomented (*vide Appendix*), and if this does not succeed the catheter must be used (*vide* p. 492).

However a fractured thigh is treated, the patient must remain in bed for five or six weeks, and must then go about on crutches, not putting his foot to the ground for another two or three weeks. In almost all cases some shortening of the limb occurs; and occasionally this is not apparent until the patient begins to walk.

When a fracture of the thigh happens away from home, a gun, a rifle, a broom-handle, or any long stick, wrapped in clothing, may be used as a temporary splint.

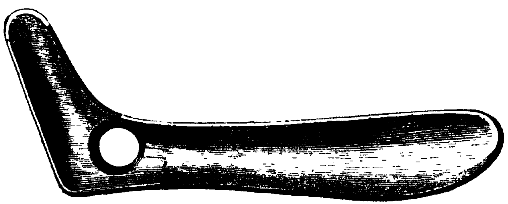
FRACTURE OF THE KNEE-PAN.—This generally results from spasmodic muscular action, as occurs from missing a step in coming downstairs. A sharp pain is experienced, accompanied by an often audible crack or snap. The person falls, and cannot stand. The knee cannot be straightened, and a hollow, or chink, is found between the broken parts a little above the knee.

Treatment.—The patient must be put to bed, and the limb extended on a light well-padded wooden splint or board reaching from the buttock to the heel, and having a hole at the end to receive the latter part, and a small piece, projecting at right angles from the end, to receive the sole of the foot. The heel end of the splint should then be raised about a foot and a half, which has the effect of relaxing the muscles, and so allows the broken parts to come into contact. The foot and leg must be lightly bandaged to the splint. Or the leg may be laid flat, the body of the patient being propped by a slanting board or bed-rest, in the semi-recumbent posture, which has a similar effect on the muscles. Or when one position becomes irksome, it may be exchanged for the other; or one may be maintained during the day, and the other at night, care being taken not to *lessen the angle* at the hip when changing posture, so that the muscles may be constantly relaxed. This may be readily accomplished by raising the body before lowering the foot, or by raising the foot before lowering the body. In some cases the broken parts of the knee-cap cannot be brought into satisfactory contact until both the heel is raised as above and also the body propped in the semi-recumbent posture. Whatever position is chosen, if there is much swelling and bruising, fomentation should be first used. Afterwards a bandage should be applied round the knee in the form of the figure of ∞, which will have the effect of bringing and retaining the broken parts together. A month at least should elapse before the patient attempts to move the knee. All movement should be made very carefully and gradually, as the union between the broken ends does not take place by bone but by the formation of a ligament, which may afterwards stretch. The person should go about on crutches, and wear an elastic knee-cap for some months. There is, notwithstanding all care, frequently permanent limping after this accident.

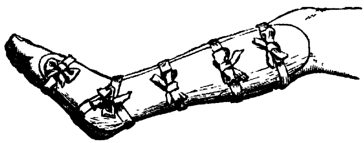
FRACTURE OF THE LEG.—May occur in any part of the leg, and one or both bones may be broken. When both bones are broken, the fracture may be generally easily detected by running the fingers down the shin, when an irregularity or prominence will be felt at the fractured part. There is also swelling, grating when the limb is moved, deformity, and when both bones are broken inability to stand. Sometimes the displacement of the bones may be masked, and the presence of fracture rendered doubtful by great swelling of the soft parts.

Treatment.—When there is great swelling, and the existence of fracture is not to be ascertained without subjecting the patient to great suffering, the limb should be as nearly as possible brought into a natural position, and then gently placed on a well-padded splint or on a pillow, to which it may be lightly tied by broad tapes. The person should lie on the side, so that the leg may be placed, with the knee bent, on its *outer* side. Then the limb should be well fomented for several days, or until the swelling subsides, when the broken bones, if not already in place, may be properly adjusted, or 'set,' and splints applied, as advised below. When this fomentation is desirable, it will be necessary to prevent saturation of the bed by placing an india-rubber sheet, or some oiled silk, or waxed cloth, under the part affected.

There are *two* positions in which a person with fracture of the leg may be placed, viz. *on the side* as above described, or *on the back.* Sometimes the nature of the fracture decides this point, the bones coming into better contact in one position than in the other. The position, however, may be ordinarily determined by the wish of the patient, some persons lying and sleeping more comfortably on the side, others on the back. *If it be determined to place the patient on the side,* splints should be first prepared wide enough to rather overlap the leg, long enough to reach from the knee to the foot, and provided with foot-pieces. If wooden



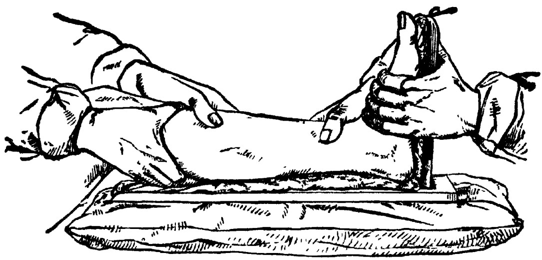
splints in the shape of the diagram are not available, they may be made of thick pasteboard, or of gutta percha, or they may be cut out of tin. The two first-named materials should be soaked in nearly boiling water, and moulded to the shape of the leg, by placing them for a short time on the corresponding leg of another person of about the same height. Then the splints should be well padded with cotton-wool, sewed in calico bags of the same shape as the splints. When all is ready, the knee of the patient should be fixed by an assistant holding it firmly with both hands, and the broken ends of the bone should be brought into position by steadily but gently pulling the foot, as shown in the sketch on p. 578. When under this operation the leg assumes the natural shape, the outer side should be gently laid upon one splint, and the other splint should be placed on the inner side; the whole to be secured by tape as shown in the figure. The leg being laid on its *outer* side, the knots must be tied on the *inner* side, and



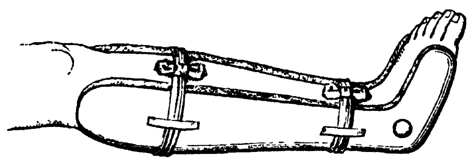
care must be taken that they are not, especially at first, drawn too tight, as the injured part will probably swell for a few days, and the pressure of the tape, especially on the shin bone, may produce blisters. To avoid this the splints should be rather wider than shown in the sketch. Knots are more easily loosened and tightened than a bandage, and further allow of the splint on the inner or upper side being lifted off, and the leg examined without disturbing the whole limb. After three weeks, if all swelling has disappeared, and the fractured part is firm, a starch bandage (Recipe 112) may be applied, and should be worn for a fortnight, after which it will be well to support the parts with plaster (Recipe 113) and a bandage for a week or two longer. The person may walk with crutches after the starch bandage is dry, being careful to rest no weight on the limb, until at least six weeks after the accident.

When the person is to be placed on the back it is desirable, although not positively necessary, that the leg should be laid on a splint with a *rectangular foot-piece* for the sole of the foot, as shown on next page.

If such a splint is obtainable, foot-pieces to the side splints are not so necessary, and the outside splint at least may be cut off above the hole for the ankle-bone. If a rectangular foot-piece is used, care should be taken that the ball of the heel, the ball of the great toe, and the ball of the little toe, *all* press against the pad of the splint, to which the foot should be securely bound. When the limb



is brought into its natural position by extension of the foot as above described, the well-padded splints, reaching from knee to ankle, must be applied on each side, secured with tapes, and (if necessary) a bandage. The person



should be placed in bed, and the limb with the heel downwards, a small pillow being adjusted *under the hollow* of the ankle, to prevent the heel bearing the whole weight of the leg. Then, especially if there is no rectangular splint to which the foot may be bound, two bricks wrapped in cloth, or two bags of sand, should be placed on each side for the purpose of steadying the limb, and preventing it rolling round, to either side. Every endeavour should be made to keep the inner side of the ball of the great toe *in a line with the inner side of the knee-cap,* otherwise deformity will ensue. After about three weeks, a starch bandage or leather plaster may be applied, and the patient may move, but no weight should be borne on the limb for double that period.

FRACTURE OF THE LEG IMMEDIATELY ABOVE THE ANKLE.—One or both bones may be broken. In the second case the position of the foot is as sketched below.

But often only the small bone (the one on the outside) is broken, when the deformity will not be so evident, and the swelling will be chiefly on the one side.

Fractures of this description should be treated with two splints, the patient lying either on the back or on the side, as for fracture of the upper part of the leg.

In treating cases of fracture of the small bone of the leg, or any injury near the ankle-joint, splints ought not to be used for more than a month or five weeks, for fear of stiff joint. At the end of that time the joint should be slightly moved daily, in order to secure mobility.

FRACTURES OF THE FOOT.—These injuries are difficult to detect and generally occur from great violence: the soft parts are frequently also much injured, and such cases necessitate surgical advice. Usually they do not require splints, placing the part as nearly as possible in the natural *position*, rest, fomentations, and lotions being the proper remedies.

FRACTURE, COMPLICATIONS OF.—1. *From rupture of blood-vessels, a quantity of blood may escape into the tissues of the limb.* If small it constitutes a bruise (*vide* pp. 515, 554) But it may be so large as to cause the limb to swell, and eventually abscess. In the absence of surgical advice, the injured limb should be kept at rest in an elevated position, and fomentations should be applied.

2. *Comminuted fracture.*—This is when the bone is broken into several small pieces. It is generally the result of direct violence, and the soft parts are usually a good deal bruised. The treatment is the same as for simple fracture, although there will be more trouble in keeping the parts in apposition, and much care must be taken to avoid pressure on the bruised parts, lest a wound results.

3. *Compound fractures.*—When there is an external wound communicating with the fracture it is called *compound*. Compound fractures are more dangerous than simple fractures, and are also more troublesome, as in addition to treating the *fracture* in the manner described, the wound must be cleansed and dressed daily, or more frequently, involving in every case different adjustment of splints and bandages in order to get at the wound easily without moving the fractured bone. When it is necessary to fix a limb with *compound fracture* on a splint, the seat of the injury should, as far as possible, be left uncovered by the bandage. If requisite, a second bandage may be applied over the first one, to retain poultices, dressings, &c. In this way local treatment may be used, without disturbing the position of the limb, and the progress of the wound can be watched, without causing unnecessary pain to the patient.

4. *Fractures implicating joints* are most dangerous, owing to the greater shock with which they are attended, and the risk of inflammation of the joint. They are also liable to be followed by some stiffness of the joint. Such cases require very careful treatment; at *first* absolute immobility of the injured bone and joint being the essential point, while inflammation is combated by fomentations. The *second* point is early *passive* motion of the joint, which should be gently moved by another person after the lapse of four weeks, in order that any adhesions which may have formed, may be broken down.

5. Other dangers from bad or compound fractures are inflammation of the veins, tetanus, and blood poisoning.

FRACTURED, TORN, OR CUT TENDO ACHILLIS.—The large thick tendon, thus called, which connects the heel with the great muscles forming the calf of the leg (and which are the main instruments in keeping the lower limbs erect and straight when we stand, and in throwing the body forward when we walk), is liable to be torn or cut. It may be torn in making a false step in walking, or running, or in coming downstairs, or when dancing. The tendon tears without warning, and the person drops to the ground with the sensation of a smart blow on the part. On attempting to rise he finds himself unable to rest the least weight on the foot, and a gap will be distinguished where the tendon is separated, into which the finger drops in passing it from the heel up the leg towards the calf.

Treatment.—This consists in putting the patient to bed and laying the leg on the outside with the knee much bent, and the *toes much pointed,* by which position the torn ends of the tendon are brought as nearly as possible together. This posture must be preserved for a fortnight, to give time for the production of the new substance by which the tendon is repaired. To secure this position it will be necessary to bind a piece of thin board, about four fingers wide, extending from below the knee-cap to beyond the toes, upon the *front* of the leg, taking care to have the board well padded so that it may not rub. The board must be confined by a bandage to the foot, and above to the calf. Or the same position may be secured by the patient wearing a slipper attached by a band fixed to the slipper heel, to a buckle and strap, fixed above the knee. Cold lotions may be applied. No bandage must be put on where the tendon is torn. After a fortnight or a little longer the gap mentioned above may be filled up with a firm substance. The person may then get up, the leg be straightened gradually, and a shoe with a very high heel worn, which may be gradually cut down till in some months' time the leg may be quite straightened.

When the 'Achilles tendon' is cut, which may happen from the blow of a scythe or sickle, or sword, the case is more serious. The person is in the same condition as a beast which is 'houghed,' and cannot stand. When the wound has been brought together, by placing the limb in the position above described, the edges of the loose skin drop into the wound, so as to interfere with union. It is therefore necessary to nip up both edges of the cut skin, so as to make their *under* surfaces touch, then passing a needle and suture to keep them in such position. The limb must then be 'put up,' as described for simple rupture, and the stitches may be taken out on the third or fourth day. The wound should also be protected by plaster cut into long narrow strips, and applied *lengthwise* on the leg.

CRUTCHES.—Crutches should be just long enough to enable the person to raise the injured leg off the ground while he stands firmly on the other. The cross-bar should be oval-shaped and well padded, otherwise the pressure may strain the nerves of the arm. The ends of the crutch should be tipped with leather to prevent them slipping. If the state of the injured limb is such that the patient ought not to use it at all, support it with a bandage passed under the foot, the ends being brought up evenly in front and tied behind the neck. In this way a sort of sling is made, which assists the patient in keeping his foot from the ground.

GANGLION.—This is the term applied to a swelling of the membrane inclosing the tendons of the wrist. It may appear gradually, and it may arise suddenly, after a strain or twist of the part, and may attain the size of a marble or a small egg. Similar swellings also sometimes appear from blows or other injury, on the back of the hand, on the tip of the elbow-joint, on the side of the knee, and on the knee-cap. If the swelling is on the wrist, or back of the hand, and free from tenderness, it may burst by pressure with the thumbs, or by a blow with an unbound book. Then a pad made of a coin, or piece of lead wrapped in lint, should be bandaged on the part and worn for some weeks, to prevent re-formation. If there is any tenderness, the swelling should be first fomented and the part rested, in order to prevent inflammation. If on other parts of the body, blisters and other surgical treatment will probably be required.

HANGING.—Life may be destroyed at once, if the body falls any considerable distance, by dislocation of the neck. If the force of the fall does not cause this, pressure of the rope on the blood-vessels of the neck, preventing the flow of blood, may cause rupture of some vessel in the brain, when the person dies from apoplexy. Such cases, especially the first, are generally immediately fatal. Thirdly, the hanging person may die slowly from pressure of the cord on the windpipe, causing suffocation. If this occurs (and it depends on the position of the cord whether death takes place in this manner or by apoplexy) and the body be soon cut down, the person may possibly be revived by 'Artificial respiration.' (*Vide* p. 542.)

LIGHTNING-STROKE.—A person struck by lightning is suddenly, more or less completely, deprived of consciousness. But this may be either from fright, or from the electric fluid. If from fright, the condition quickly passes off, the person recovering as if from collapse, or shock (*vide* p. 520). Lightning may cause burns, sometimes of a deep and obstinate character, sometimes merely blistering, or redness of the surface. Occasionally arborescent marks are discovered, appearing as if trees or other objects had been photographed on the skin. Other affections caused by lightning are, fractured bones, wounds like stabs, partial loss of sight, smell, speech, hearing or taste, and paralysis, which may or may not be permanent. Usually, however, persons not killed on the spot, recover. The immediate treatment of persons struck by lightning should be as recommended for *Collapse* (*vide* p. 521). Burns, or other injuries inflicted, must be treated as recommended under the respective heads.

The following are useful rules concerning danger from lightning:—

1. Lightning always chooses the best conductors on its descent to the earth; consequently we should know what things are better conductors than man, and what are not such good conductors as man. Near the former we are safe; the latter should be carefully avoided.

2. It is dangerous to stand near any high object, such as a tree, spire, or large building, because its height is likely to discharge the electric fluid passing overhead, and it is not as good a conductor as a man would be; consequently the lightning, having been discharged by it, would pass through the man's body, which offers a better passage to the earth.

3. It is dangerous to stand near running water if no higher object than yourself be near, as water is an excellent conductor, and a man's height may be sufficient to discharge the lightning, in which case it would choose him as its conductor to the water.

4. It is dangerous to be in a crowd, as the vapour arising from a mass of people affords great attraction to the lightning.

5. It is very dangerous to carry jewellery or pieces of metal about the person—rings, brooches, keys, or watches—as they offer strong attraction to the lightning to take them on its downward course, but are not sufficient to carry it to the earth.

6. If you are driving on a carriage during a storm, do not lean back, but sit upright, as the lightning might run down the sides of the carriage.

7. Indoors the safest place is the middle of the room, as, if the house were struck, the lightning would run down the walls.

8. Mattresses and hearthrugs, &c., are non-conductors, and sitting on these you are comparatively safe.

9. A person lying on an iron bedstead is comparatively safe, as it is a better conductor than the human body.

10. If you are out walking during a storm and your clothes become wet through with the rain, you are free from danger, as wet clothes will conduct the electric fluid harmlessly over the body.

11. During a storm, a person is safer in the open, although a wetting may be experienced, than under trees, or in sheds, which may attract the lightning.

PRIVATE PARTS, INJURIES OF THE.—In the male, the testicles are liable to be injured by blows, or by the patient being thrown forward on the pommel of the saddle. The effect is swelling of the parts, accompanied by great pain and tenderness, with faintness immediately after the injury. At first a stimulant, as wine, or brandy and water, will probably be required. Afterwards fomentations and rest will in the great majority of cases effect a cure.

POISONING.—Poisoning by almost any agent is best treated by making the patient vomit at once. If the person can swallow, give a mustard or salt emetic (Recipe 54) and repeat every five minutes till vomiting occurs. If the person cannot swallow, endeavour to excite vomiting by tickling the inside of the throat with a feather. After vomiting, or immediately if vomiting cannot be induced, give the *antidote* as below, if available, in water.

POISONS AND ANTIDOTES.—The subjoined table affords at a glance guidance in cases of poisoning. The Indian poisons referred to on the next page are in italics.

Irritant Poisons	*Antidotes*
Mineral acids, as vitriol or sulphuric acid, nitric acid, spirits of salts, hydrochloric acid	Magnesia, chalk, or whitewash scraped off walls; washing soda in milk or water.
Alkalis, as potash, soda, ammonia, sal volatile, smelling salts . .	Equal parts of vinegar and water, lemon-juice, oil.
Alum	Washing soda, smelling salts in water.
Antimony, as tartar emetic . .	Tincture of kino or catechu, magnesia, tannin or gallic acid.
Antimony, butter of	Magnesia, washing soda, chalk.
Arsenic and its salts . . .	A mixture of oil and lime-water, soap suds, milk, flour and water, powdered charcoal in water, rust scraped off old iron.
Baryta and its salts	Epsom salts, in water.
Copper salts, as blue vitriol, verdigris	White of egg in water, milk, wheat flower in water.
Iron salts, as sulphate of, or green vitriol	Soda, or smelling salts, in water.
Lead salts, as sugar of lead, white lead	Epsom salts, or vinegar diluted.
Mercury salts, as corrosive sublimate	White of egg in water, wheat flour thick in water.
Silver salts, as nitrate of, or caustic .	Common table salt in water freely.
Zinc salts, as sulphate or acetate of .	Milk, soda, magnesia, in water.

Narcotic and Deliriant Poisons	*Antidotes*
Aconite, chloral, *dhatura*, hemlock, morphia, *opium*, *hemp*, fungi .	Strong coffee or tea, motion and means to prevent sleep, artificial respiration.

Other Poisons	*Antidotes*
Prussic acid	Ammonia, sal volatile, smelling salts, hartshorn.
Strychnine	Powdered charcoal in water, chloral.

INDIAN POISONS.—The principal poisons made use of in India are as below, and the prominent symptoms caused by each are contrasted.

Poisons	*Prominent Symptoms*
ACONITE Vernacular: *metha-thelia, dakra, bish*	Numbness and tingling of the tongue and lips, burning of the throat, spitting, hawking, frothing at the mouth, vomiting, pupils dilated, but contracting on exposure to strong light, delirium, stupor, paralysis, insensibility, convulsions.
ARSENIC Vernacular: *sunkiah, saffed sumbhul.*	Faintness, nausea, violent vomiting and purging of material streaked with blood, burning in the throat, stomach, and fundament, thirst, cramp of legs, feeble pulse, cold skin.
DHATURA Vernacular: *kala* or *Krishna dhatura.*	Headache, faintness, dimness of sight, giddiness, thirst, excitement, voluble talking, laughter, fatuity, dilated pupils, insensibility, stertorous breathing, frothing at the mouth.
INDIAN HEMP Vernacular: *gungah, bhang*	Appears like a drunken person, fits of laughing alternating with intervals of stupidity, which gradually increase to insensibility.
OPIUM Vernacular: *offeem, umal*	Giddiness, drowsiness, stupor, succeeded by total insensibility and stertorous breathing, skin cold, face pallid, eyes closed, pupils contracted.
STRYCHNINE Vernacular: *koochla, koochla-bij*	Feeling of suffocation, difficulty of breathing, twitching of the limbs, locked jaw, convulsions, the body being bent back, features drawn into a characteristic grin.

POISONING BY GASES, *as carbonic acid, carbonic oxide, sulphuretted hydrogen, &c.*—Persons going into pits, wells, drains, &c., are sometimes poisoned by unrespirable gases. The symptoms vary. In slight cases there is faintness and vomiting. In more severe cases there is more or less insensibility, and generally stertorous or snoring breathing, and sometimes convulsions. Removal to fresh air, stimulants, and in bad cases artificial respiration (*vide* p. 542) are required.

POISONING OF THE BLOOD.—Blood poisoning may occur under a number of varying circumstances. The blood is more or less poisoned in many diseases of which typhus and typhoid fevers are the type. But the term 'blood poisoning' is more conveniently applied to conditions in which a diseased or injured part secretes an unhealthy material, which may be absorbed into the system; or from which minute portions (called *emboli*) of *thrombi* or clots formed in the neighbouring veins may be transferred to different parts. The term is still more popularly applied to cases in which a sore surface of one person has come into contact with the diseased discharges of another person, or with those of some animal or insect.

According to the latest researches, when a poisoned wound is made certain blood cells known as *leucocytes* crowd to the spot, block up the avenues by which poisonous microbes seek to gain entrance, and engulf and destroy them. The poisonous microbes at the same time multiply with rapidity, endeavouring to destroy the blood cells and force a passage. This local war, which under the microscope is stated to be 'as realistic as one of Homer's battles,' is defensive inflammation. If the blood cells prevail there will probably be only a local abscess; if the poisonous microbes prevail, and gain access to the circulation, there will be blood poisoning.

When poisonous matter enters the system it may cause a condition known as *septicæmia*, which occurs more especially from the absorption of chemical products resulting from the decomposition of inflammatory material. Or it may cause a condition known as *pyæmia*, which occurs more especially from the circulation of some animal poison in the blood.

Thus 'blood poisoning' may result from bad forms of dysentery, when, deleterious matter being conveyed from the bowels, abscess forms in the liver (*vide* p. 323), being determined to that organ by peculiar anatomical configurations. Or it may result from putrid matter from the womb during puerperal fever (*vide* p. 630); or from unclean and lacerated wounds, especially from burns and scalds (*vide* p. 519); or from bad or compound fractures (*vide* p. 580); or from wounds inflicted by wild animals (*vide* p. 607); or from the circumstances giving rise to one variety of carbuncle (*vide* p. 113); or especially from wounds received during the manipulation of diseased bodies of living or dead animals. Blood poisoning is attended from the first with great depression; there are repeated shiverings, quick pulse, hot skin, dry tongue, sallowness of the surface, peculiar odour of the breath, thick ammoniacal urine, profuse perspirations, and the cessation of discharge from any wound. If *pyœmia* results soon after the first symptoms, sometimes in twenty-four hours, throbbing pain, or swelling in different parts, point to the localisation of the mischief by *abscess* which may form in the liver, lungs, skin, joints, or other parts. When blood poisoning occurs, the requirements are to support the strength by nourishing diet and stimulants, to give chloral to relieve pain, and to favour the formation of matter, where pain and swelling indicate its localisation, as detailed under *Abscess*, p. 41.

RIDER'S BONE, or **SPRAIN.**—This consists of rupture of fibres of the *adductor* muscle, situated at the inner part of the thigh. It may occur to those riding a great deal, without any extraordinary exertion. But it commonly results from violent efforts to grip the horse when making a jump; or to *football*-players. A snap is felt, followed by pain and tenderness on the inner surface of, usually, the right thigh, close to the trunk, and sometimes extending to the knee. There may also be bruise, coming on immediately, or not till some hours afterwards. The injury usually leaves some thickening or hardness of the tendons in the inner part of the thigh, which in some cases becomes almost like bone; hence the name 'Rider's bone.' Generally, the symptoms subside under rest and fomentations. If neglected, the hardness may become permanent, causing some lameness, and inability to ride far or fast. Supports are made for this condition, for which measurements round the body at the hip-bone, round the top of the thigh, and round the leg just above the knee are required, with intimation of which leg.

RUPTURE.—Technically spoken of as *hernia*; vulgarly as 'broken belly.' There are several varieties, but the most common appears in the *male* as a tumour in the groin; in the *female* as a tumour a little lower than the groin. This tumour is caused by the muscles over the bowels giving way, and letting some portion of the intestines escape outwards beneath the skin. The affection may come on gradually from natural weakness of the parts, but it more often happens suddenly during extraordinary exertion. A sudden sensation of something giving way is felt, and a soft elastic swelling appears. In the male, the rupture eventually makes its way into the purse. In the female, it remains as a smaller tumour in the groin. When a rupture has occurred, *the bowel may return or be returned into the cavity of the abdomen*, when it is said to be *reducible*. Or it may *remain down and cannot be returned*, when it said to be *irreducible*. Or, *it may be compressed and fixed by the ruptured muscular fibres through which it has passed*, when it is said to be *strangulated*. In the *first* result no symptoms present; but a rupture having once occurred, the tumour is liable to come down when the person stands or walks about; and although it may return when he lies down, or when pressure is made, there is always danger that *it may remain down and become strangulated*. A person with *reducible* rupture should avoid excessive exertion, and wear a truss.

A truss is composed of a pad connected with a circular metallic spring, and so arranged that the pad keeps the bowel from descending, the spring maintaining the pad in position, and allowing free movement of the body. A truss should be fitted to the person by the instrument-maker, under the supervision of a surgeon. But if obliged to send for a truss, the measurement of the body, one inch below the hips, should be unclean and lacerated wounds, especially from burns and scalds (*vide* p. 519); or from bad or compound fractures (*vide* p. 580); or from wounds inflicted by wild animals (*vide* p. 607); or from the circumstances giving rise to one variety of carbuncle (*vide* p. 113); or especially from wounds received during the manipulation of diseased bodies of living or dead animals. Blood poisoning is attended from the first with great depression; there are repeated shiverings, quick pulse, hot skin, dry tongue, sallowness of the surface, peculiar odour of the breath, thick ammoniacal urine, profuse perspirations, and the cessation of discharge from any wound. If *pyæmia* results soon after the first symptoms, sometimes in twenty-four hours, throbbing pain, or swelling in different parts, point to the localisation of the mischief by *abscess* which may form in the liver, lungs, skin, joints, or other parts. When blood poisoning occurs, the requirements are to support the strength by nourishing diet and stimulants, to give chloral to relieve pain, and to favour the formation of matter, where pain and swelling indicate its localisation, as detailed under *Abscess*, p. 41.

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given, and the side affected should be mentioned. Care should be taken that the spring is strong enough to control the rupture, and to ascertain this, after adjusting the truss, the patient should stand up, with his legs wide apart, and cough strongly. If the truss is not suitable, the rupture will come down. The truss and pad should be covered with leather, from which the skin is less likely to chafe.

If the truss chafes at first the skin should be bathed with alum water (Recipe 42), which will harden it. Wrapping a narrow thin calico bandage round the truss, which may be taken off and washed, is desirable for cleanliness, or a washable truss may be obtained. The truss should be put on *before* rising in the morning, and be taken off *after* lying down at night. The person should have two trusses, one for wearing when bathing, so that he may never be without the protection, and retain his truss in ordinary wear dry. It is generally desirable for a person, although only ruptured on one side, to wear a double truss, for there is often a weakness of the corresponding region on the opposite side, and with a truss upon one groin, a greater strain is thrown upon the other, which is therefore apt to give way. Unless a truss fulfils all the requirements as above, and unless it is used in the manner directed, it may do injury. Without a truss, a person with reducible rupture is in constant danger of life; with a good truss, properly used, he is safe. If, when a rupture first appears, a truss cannot be procured at once, a figure of ∞ bandage (*vide* p. 109) with a pad over the rupture should be used.

When the tumour remains down and cannot be returned, although not strangulated (*vide* below), there is a colourless, elastic tumour often penetrating to the purse, which causes disorder of the digestive organs, with colicky dragging pains, flatulence, and constipation. It is also apt to become strangulated or inflamed, or to be injured by external violence. The requirements are to render the hernia reducible if possible, to prevent it increasing in size, and to treat dyspeptic symptoms. The patient should be kept in bed on spare diet and ice should be applied to the swelling. Aperients (Recipe 1, 2) and iodide of potassium (Recipe 21) should be given. The rupture, if penetrating to the purse, should be supported by a suspensory bandage or bag.

When the tumour does not return, symptoms of *strangulation* are very likely to commence. The patient first complains of flatulence, colicky pains, a sense of tightness across the belly, desire to go to stool, and inability to evacuate. Some fæcal matter may, however, be passed if any happens to be present *below* that part of the intestines which has become strangulated. To these symptoms succeed vomiting of the contents of the stomach, then of sour bilious fluid, then of material like coffee-grounds, and lastly of matters having the odour, and often the appearances, of fæces. The swelling becomes tense and incompressible and does not move when the person coughs. If this state continues the inflammatory stage sets in. The tumour, and eventually the whole surface of the belly, becomes swollen and painful. The countenance denotes anxiety, the vomiting is constant, the patient restless and desponding, the pulse is small, quick, and wiry, and there is constant hiccough. After a variable time the parts mortify, the tumour becomes dusky red, the pain ceases, and the patient, having probably expressed himself relieved, soon after dies.

Treatment.—Purgatives either given by the mouth or as enemata will do harm. Therefore, the feeling of a desire to stool, causing entreaty on the part of the patient for something to open the bowels, should not be complied with. *The great point is to return the protruding intestine into the cavity of the abdomen.* The bladder having been emptied, the patient should lie down with his shoulders raised, and with both thighs bent towards his belly, and placed close together. This relaxes all the muscles. Then the operator grasps the swelling with the fingers if small, with the palm of the hands if large, and *gently* compresses it. This will dispel wind, and other contents of the swelling, into the belly. Then the swelling may be raised by its neck, *gently* pulled forward, and again compressed. This should be continued for a quarter of an hour if the swelling is not tender and there is no hiccough; but for a shorter period if the reverse conditions present. Much force must not be used, as the tumour may be injured or pushed between the muscles, instead of back into its proper place. If this does not succeed, the patient should be either put into a hot bath, or chloroformed, and similar endeavours made while the person is in the water, or when he is insensible from the chloroform. If there is no hot bath, or no chloroform, or no one to administer it, and symptoms of strangulation are not violent, 40 drops of chlorodyne, or 40 grains of chloral, or, if available, 40 drops of laudanum in an ounce of water, may be given; pounded ice in a bag, or if not available the freezing mixture (Recipe 83), may be applied to the part, the *foot* of the bed being raised two or three feet from the floor, and the patient let alone for two or three hours, when the rupture may return, or it may be put back by repetition of manual endeavours as above. When successful, the tumour usually disappears with a sudden gurgling, the pain is relieved, and the vomiting stops. A pad should be carefully placed over the part, and the figure of ∞ bandage applied (*vide* p. 109). The diet should be fluid, until the bowels have acted naturally, and no aperient medicine should be given; but if the bowels do not act in twelve hours, an injection of warm water and soap should be used (Recipe 104). If symptoms of strangulation are urgent, and the swelling cannot be returned, a surgical operation of an important character affords the only chance of recovery.

Rupture is liable to be mistaken for *hydrocele* (*vide* p. 308), or for *varicocele* (*vide* p. 454), or *vice versâ*. The distinctive features are therefore contrasted.

Rupture	Hydrocele	Varicocele
Usually comes on suddenly.	Comes on gradually.	Comes on gradually.
Disappears when the person lies down, and reappears when he stands up.	Does not disappear when the person lies down.	Disappears when the person lies down.
If the fingers are pressed on the *external ring* when the patient is lying down, and he rises with the fingers still pressed on the part, a rupture does not return. The *external ring* is the part through which the rupture passes, and is about an inch above, but to the side of, the root of the penis.	Pressure with the fingers makes no difference. The swelling remains as before.	Pressure with the fingers does not prevent the reappearance of the swelling, which gradually returns when the person stands up.
The tumour commences above, or in the groin.	The tumour commences below, or in the purse.	Commences from below, or in the purse.
Tumour tense, or elastic; or 'gurgling' may be felt or heard inside.	Tumour smooth, affording a fluctuating feeling, like water in a bladder.	Feels like a bag of worms.
When the person coughs the impulse communicated by the cough is felt in the tumour.	No impulse or shake from coughing felt in the tumour.	No impulse or shake from coughing felt in the tumour.
The tumour is opaque.	Tumour is translucent; that is, light may be seen through it.	The tumour is opaque.
No pain or tenderness in the tumour, unless	No pain or tenderness in the tumour.	Dull aching of the part.
The tumour does not obscure the testicle, which may be felt below it.	The tumour obscures the testicle, which is behind it.	The tumour does not obscure the testicle, which is below it.
No distinct separation between the tumour and the bowels.	Distinct separation between the tumour and the bowels.	Distinct separation between the tumour and the bowels.
Dangerous to life.	Not dangerous to life.	Not dangerous to life.

RUPTURE, INFANTILE.—Infants are sometimes born ruptured, or may become ruptured from natural weakness of the parts, and straining when crying, or from costiveness. If a truss is used it is necessary to procure several, in order to have a dry truss every time one gets soiled; and, besides, if the child thrives, the old trusses in eight or ten weeks will be too small and useless. But a figure of ∞ bandage, if properly used, is quite sufficient.

A skein of Berlin or lamb's wool, of 35 to 40 threads, may be crocheted into a flat band about two inches wide, and looped at the end. Then return the rupture by pressure, and place the looped end of the skein over the seat of rupture. Then pass the other end round the body and through the loop, which must be carefully adjusted over the seat of rupture. Then carry the end down between the thighs, bring it up outside the thigh, and fix to the loop. A pad may be used if necessary, but usually none is required.

RUPTURE AT THE NAVEL.—Most frequently happens to children, and infants are sometimes born with it. It may also occur to adults, especially to females. In children it may result from inattention to the navel after birth, or it may occur suddenly during paroxysms of crying, or straining. In adults it may be caused by violent exertion, or straining. It is known by bulging of the navel, which may assume the size of an egg in children, but is much larger in adults. When the person lies on the back the swelling subsides, and the circular opening through which it presents may be felt with the fingers. As mentioned of rupture at the groin (*vide* p. 589) it may become *irreducible* or *strangulated.*

Treatment.—For children, a large piece of cork covered with lint (or sometimes a rupee or piece of lead, being heavier, answers better) should be fitted over the swelling, and retained in its position with strips of plaster and a light flannel bandage 2½ inches wide. Fits of crying should as much as possible be prevented, as the rupture always protrudes more on such occasions. The child should wear the pad and bandage constantly. As the child grows, the tendency of the tumour to increase will lessen, and, by continually using pressure as above, the tumour will gradually disappear. An adult should wear a pad and belt, especially if engaged in an occupation involving much exertion, or if subject to chronic cough, and should avoid straining at stool. If a rupture at the navel becomes irreducible or strangulated, the measures mentioned at pp. 590, 591 should be adopted. If strangulation cannot be thus relieved, a surgical operation is requisite.

SPLEEN, RUPTURE OF THE.—When the spleen is diseased or enlarged it is excessively tender, and a very slight injury will rupture it, sometimes without any external mark. Occasionally the spleen ruptures from a fall, or even from muscular exertion. When the covering or *capsule* of the organ is ruptured, blood escapes into the cavity of the bowels, and the symptoms are those of collapse (*vide* p. 520), the person becoming faint, complaining of great pain, and the pulse rapidly growing imperceptible. Such injuries are nearly always quickly fatal, and no medical treatment is of much utility. Perfect rest, and the administration of stimulants, are indicated; but stimulants must be given with caution, and only when the pulse can scarcely be felt: otherwise, the excitement of blood-circulation they cause will add to internal bleeding (*vide* p. 514).

Though death from ruptured spleen nearly always takes place in a few hours, rare cases occur in which life is prolonged for several days. In these cases blood is not poured out into the abdomen immediately, the injured person appears to be in no danger, and the spleen is thought not to be injured. After an interval of some days, however, sudden symptoms of syncope are manifested, the abdomen becomes distended with blood, and death occurs within a very short time. The reason for the delay in the occurrence of death after a rupture of the spleen, is that although the spleen is ruptured at the time of injury, the *capsule* or covering of the organ does not give way till some time afterwards.

SPRAINS or STRAINS.—The terms signify a violent stretching of the tendons, ligaments, or muscles of the part. But some of the fibres of the tendons about the injured part are often ruptured or torn. Sprains generally occur to the joints, as the ankles, wrists, or knees. But similar accidents may occur in other parts, the 'lawn-tennis leg' being strain or rupture of some of the muscular or tendinous structures of the calf. The symptoms of a bad sprain are severe pain, and often faintness, followed by swelling and discoloration, with subsequent weakness and stiffness. If the part is not kept at rest, or if the diet be intemperate, or the blood impure, or if the knee or some other large joint is injured, there may be inflammation and fever, which, if neglected, may lead to serious results. How sprains are distinguished from *dislocations*, and from *fractures* near joints, is mentioned at pp. 526, 553. A minor degree of sprain, arising from continued minor concussions, rather than from one violent wrench, is known as the 'lawn-tennis arm,' and may occur in the shoulder, elbow, or wrist.

Treatment.—The most essential measure is *perfect rest.* If serious, the injured part should be confined by pasteboard or gutta percha splints. If the wrist is injured, it must be constantly suspended in a sling. If the ankle, the patient must lie or sit, with his leg on a couch or stool. Warm fomentations generally give more relief than cold lotions, but in this the patient's feelings may be consulted (*vide Appendix, Cooling applications*). If a large joint is affected, and inflammation and fever are high, leeches should be applied (one for each year of the person's age up to thirty), and cooling medicines, as citrate of magnesia (*vide* p. 15), may be administered. Subsequently, friction with soap liniment. After some time (as an average, a fortnight in sprains of joints), gentle movement of the part by some one else, then moderate exercise, and the support of bandages will be required. After a sprain the part remains weak, and liable to injury for some time. In delicate children sprains are frequently the origin of disease of the joints.

For minor sprains arnica or hazeline may be used. Persons who meet with a strain—lawn-tennis players, for instance—are often desirous to be strapped up and allowed to play again. This may succeed in some instances, but it is a bad plan. A sprained part must have time to recover itself, and this it will not do thoroughly while the muscles are in action, even if supported by strapping. A sprain thus treated is more liable to recur. For the 'lawn-tennis elbow' an elbow-cap has been devised, but it is not recommended, as it obstructs the veins of the arm below.

STIFF JOINTS.—May be caused by injury or from disease. Stiff joints from injury usually occur after dislocations, or fractures near joints, or after sprains.

When an injury is followed by local swellings, as happens in most sprains, this swelling is produced by an effusion of fluid into the tissues, and the fluid effused is of an adhesive character. The result is as if liquid glue had been introduced among the weakened and tender parts; and, if the sticky effusion has been abundant, or if rest be too long maintained, the resulting adhesions may prevent free movement, or any movement, of the joint concerned. In order to prevent such adhesions early *passive movement* has been recommended after all injuries liable to be followed by adhesions. When they do occur and prevent movement of the joint, rupturing them by forcible movement is the only cure. When ruptured a snap is felt and heard. These are the cases in which 'bone setters' are sometimes successful. The surgeon knows that by forcible manipulation he is often as likely to do harm as good. Occasionally by risking dangers from which the educated surgeon shrinks, the bone-setter is successful.

The proper treatment of stiff joints is gentle *passive movement* (*i.e.* movement of the joint by some one else), and rubbing with soap and opium liniment, until the advice of a surgeon can be obtained. The propriety of forcible treatment depends *both* on the condition of the joint, and on the constitution and general health of the patient.

TEETH, INJURIES OF THE.—When a tooth is broken, any sharp point should be smoothed with a fine, sharp file, which will prevent injury to the mouth or tongue, and render the tooth less liable to decay commencing from the seat of injury. The part should be afterwards touched several times daily for a week with spirits of wine, which renders the tooth hard and insensitive. If a tooth is loosened so much as to shake about, it should not be removed, as with care it will probably again unite to the gum. It should be replaced in its natural position, and the person should be instructed to avoid moving it with the tongue. If it will not remain *in situ*, a fine piece of wire or silk, or a horsehair, should be passed round it and the adjacent tooth, so as to prevent motion. Teeth knocked out of the mouth, or drawn by mistake, being immediately returned to the socket, have taken root. These facts led to the replanting of teeth as an operation of dental surgery.

URINE, RETENTION OF.—Retention of urine signifies an inability to pass water, *not a stoppage* of the formation of urine. Urine still flows from the kidneys where it is secreted, into the bladder, but cannot escape from the latter organ. Retention of urine may arise from stricture (*vide* p. 419); from an enlarged prostate gland (p. 366); from a small stone lodging in the passage (p. 73); from paralysis of the bladder (p. 74); from hysteria (p. 305); from fracture of the thigh or spine (pp. 573, 557). It may also arise from injury, such as falling cross-legged on a gate or wooden bar, which may cause bruise, swelling, or worse injury of the parts about the passage. The symptoms and treatment of retention from the different maladies named are given under the respective headings. When retention occurs from injury, fomenting between the legs and over the bowels with a dose of chloral (Recipe 64) will generally afford relief. Otherwise, the catheter must be used (*vide* p. 493).

WOUNDS AND CUTS.—Wounds may be *clean cut* with a sharp instrument as a sword, or made *jagged and ragged* by a blunt instrument as a saw, or *bruised* as by a rough club or stick, or *punctured* by a sharp-pointed instrument as a bayonet.

In *clean-cut or incised wounds*, bleeding must be first checked, and then all dirt and *débris* removed. To arrest bleeding, a raised position, the application of cold water, and pressure with a sponge will often suffice. But if an artery is wounded, and the bleeding prove obstinate, measures must be adopted as pointed out under *Bleeding* (p. 505). The removal of dirt and foreign bodies from the wound may be effected by a stream of cold water, the sponge, and the forceps. Having stopped bleeding and removed dirt, clots of blood should be taken away, and the wounded part placed in such position as will best favour approximation of the cut edges, which must be brought together and maintained in position by long strips of plaster; one end of the plaster being first applied to that side of the wound where the skin is most loose, and each strip should slightly overlap its neighbour. But the strips should *never* be long enough to encircle a limb, as they would then act as ligatures, and cause swelling of the parts below. Then a pad of lint wet with water should be placed over the wound, and a bandage applied to retain all in position. For a slight clean cut wound collodion may suffice. The edges of the cut should be held together while the collodion is applied with a brush. The collodion quickly hardens and contracts, and the wound heals beneath. For large wounds, or wounds of loose parts, as the eyelids or ear, stitches will often be required. But stitches should never be used to *drag* the edges of a wound together, and they should be removed on the third day, or inflammation may result. In stitching a wound the needle should be passed deep enough to obtain a firm hold, but should not penetrate any tendon or muscle; and, as a rule, one stitch will be required for every inch of wound.

In Jagged, Lacerated, or Contused Wounds, while restraining bleeding and removing foreign bodies may be easily accomplished, it will often be impossible to approximate the edges of the wound, either by plaster or stitches. But this should be effected as far as possible. In many wounds the laceration is so great that it is necessary to abandon all attempts to bring the edges together. Poultices, and afterwards water dressing, will be best. For pinches of nails bathe with hot water.

When dressing wounds, everything likely to be required should be ready before the wound is uncovered. Clean-cut wounds should not be opened the day after they are dressed, but may be cautiously re-dressed on the third day. Care must then be taken that the support of one strip of plaster or of the fingers is always afforded, otherwise the union taking place will be broken through. In removing the plasters the *ends* should be first raised, and *both* ends should be lifted up at the same time, *from the outside to the centre*, so that no dragging may separate the edges of the injured part. Care must be taken to thoroughly clear away all discharge, lest it become offensive; and it should be recollected that a wound which is doing well has no bad smell. After the third day all wounds in India should, as a matter of cleanliness, be dressed daily unless they can be treated antiseptically as below.

Although thorough division of a part may have taken place (*e.g.* a finger, or a toe, or a portion of the nose or ear may have been completely severed), still an attempt to unite the divided parts should be made and success will frequently follow the attempt.

If the appliances are at hand, it would be better to dress clean-cut wounds *antiseptically*. The procedure is based on putrescence being fermentation due to germs from the atmosphere, which is prevented by the antiseptic dressing. But antiseptic dressing requires appliances, only to be found in the possession of a surgeon. Still, if the whole procedure cannot be carried out, it is advisable that, when possible, antiseptic solutions should be used. The wound and skin around should be washed with a solution of 10 grains of crystallised carbolic acid to an ounce of distilled water, and it should be covered with lint, moistened in a solution of 20 grains of the acid in 1 ounce of salad oil.

The neglect of cleanliness of wounds is frequently followed in tropical climates by the appearance of *maggots.* When the wound permits easy access to all parts of the injury, the maggots may be picked out with forceps, or destroyed by injections of black wash (Recipe 88), or, this not available, lime-water (Recipe 25). If maggots have penetrated into a sinus stretching away from a wound, the use of the knife to open up the part may be necessary.

Wounds of the Scalp may be either cleanly cut or jagged. If the scalp is detached from the bone it should be carefully cleaned and replaced. In addition to restraining bleeding, clearing away foreign matter and clots of blood, the scalp should be shaved for several inches round the wound, to afford space for plasters. Wounds of the scalp, however slight, should never be neglected, as they are liable to be followed by erysipelas; and for a similar reason stitches should, whenever practicable, be dispensed with. If it is positively necessary to apply stitches, plasters may generally be dispensed with, the wound being covered by a pad of cotton-wool, or lint smeared with olive oil, or, if available, carbolic oil (Recipe 119). Rest, an aperient, and simple diet are advisable.

Punctured Wounds, *with which may be classed gunshot wounds and wounds of joints,* are the most dangerous—because deep-seated blood-vessels or nerves are often implicated; because the parts punctured must be also stretched and torn; in consequence of foreign bodies, as dirt, bullets, pieces of clothing, being often carried very deeply into the body; because there is often no free exit for matter formed; and because such injuries are more liable to be followed by lockjaw or tetanus. Punctured and gunshot wounds are attended with great shock to the system, so that brandy and water, or wine, will be required immediately after the accident. If a foreign body, as a bullet, a piece of cloth, &c., can be felt, it should be gently removed with the fingers or forceps. If faintness or loss of blood indicate wound of some important internal organ, or of a large artery, the case assumes a most serious aspect. But in all instances it will be best to apply cold-water dressing, to keep the patient lying on the wounded side, so as to favour escape of blood or discharges, to enforce perfect rest, and to give low diet. If the wound throbs and the sufferer becomes feverish, poultices, a purgative (Recipe 2), and cooling draughts of citrate of magnesia (*vide* p. 15).

WOUNDS OF THE BRAIN.—These injuries will be accompanied by *concussion* (*vide* p. 522) or *compression* (*vide* p. 525). Treatment accordingly, and Recipe 85 to any wound.

WOUNDS OF THE LUNGS.—There is difficulty of breathing and sense of suffocation, the countenance is pallid and anxious, and florid blood mixed with clots is coughed up. These symptoms may subside, or the patient may die from loss of blood; or, at a later period, from inflammation. In all such cases the only means to be adopted are keeping the person quiet, giving a stimulant in very small quantity at a time, and desisting altogether if the pulse becomes stronger. Under such measures, if the internal wound is small, the flow of blood may cease, and the patient recover. For the external wound, little more can be done than applying cloths wet with cold water.

WOUNDS AND INJURIES OF THE BOWELS AND OTHER ABDOMINAL ORGANS.—*Injuries of the muscles of the* *belly, the bowels, liver, spleen, kidneys, or other abdominal organs,* are marked by a fixed pain at the seat of injury, faintness and feeble pulse, or collapse (*vide* p. 520), from which death may result immediately. There are also other symptoms enumerated below, characterising injury of different organs.

BOWELS. The muscles of the bowels may be injured, but the *intestines* inside may not be touched. In cases of stabs or gores, the question is whether or not the intestines are injured. If the intestines appear through the wound, it may be seen whether or not they are injured. If they do not appear, the escape of fæces through the wound, the passage of bloody stools, and the vomiting of bile or blood, is evidence that the intestines are injured, and in such cases the collapse will be greater. If there is *no* reason to suppose the bowels are wounded, and they do not protrude, dirt and blood should be washed away with glycerine soap and lukewarm water, and as soon as bleeding has ceased (which probably will not be great), the edges of the wound should be brought together with long strips of plaster, cold lotion (Recipe 83) should be applied to the whole belly to prevent inflammation, and only fluid diets should be allowed. If there is reason to fear the bowels *are* wounded, or in all cases of punctured wounds such as by the horns of animals, a poultice should be applied. Also, in all cases it will be desirable to give a full dose of chloral.

If from a wound the bowel protrudes it must be carefully washed with warm water, cleansed from all impurity, and returned by pressure with the fingers. If the bowel itself is torn, the wound must be closed; if very small, by pinching up and tying; if large, by stitching it up. The edges of the wound should be *turned in*, so that the *outer* surfaces come into contact. Fine silk should be used, and small stitches taken. The ends of the thread should be cut close off, and the bowel then returned, as if it were uninjured. If the patient recover, the ligatures will drop into the cavity of the gut, and no ill consequences result The external wound should be closed up by stitches and plaster. Ice should be applied to the abdomen afterwards. Chloral should be given twice daily, but no solid food for three weeks.

LIVER. If the liver is injured in addition to the general symptoms enumerated above, there will probably be vomiting, white stools, and jaundice. *Treatment* as for wounds of the lungs.

KIDNEY. There will probably be blood in the urine, frequent calls to make water, the testicle will be drawn up, and the person will be unable to stand erect. *Treatment.*—Both loins and bowels should be alternately fomented with hot water. The bowels should be kept moderately open by Recipes 1 and 2, and small doses of chloral (Recipe 64) may be given to relieve pain. Thirst may be allayed by iced milk and water; beef-tea, arrowroot, tea, and barley water may also be given. When the urine assumes a lighter colour it shows that less blood is being passed, and that improvement is taking place; and this may occur at the end of a few days, or be delayed for weeks. During convalescence *albumen* should be tested for (*vide Bright's Disease*, p. 101), and the patient ought to be kept to the house until all traces of albumen are gone.

SPLEEN. (*Vide* p. 595.)

BLADDER. There is a feeling as if something had given way, with violent burning pain. There is desire to make water, but inability to do so. The person is unable to stand or walk. Soon the symptoms are those of extravasation of urine (*vide* p. 420), and the *treatment* should be the same.

WOUNDS OF THE THROAT.—These wounds are generally made with the intention of suicide, and are dangerous, both from the importance of the parts injured and from the desponding condition of the patient. They may be clean-cut, or lacerated; they may be superficial, or deep; they may implicate arteries, veins, windpipe, or the gullet. If the air-passage only is cut, recovery often takes place; but if large blood-vessels are cut, death occurs from profuse bleeding.

Treatment.—Any arteries wounded must be twisted or tied (*vide* pp. 504, 505), and bleeding from veins, known by the blacker colour of the blood (*vide* p. 503), must be restrained by pressure with the fingers. The patient should be put to bed in rather a warm room, and as soon as all bleeding has ceased, *but not before*, the shoulders should be raised on pillows, with the head bent forward. The head should be retained in this position by tapes passing from each side of a cap, or of a bandage round the head, to another bandage placed round the chest. *No* plasters or sutures should be used. If the wound penetrates the windpipe, it should be covered with a loose woollen comforter, or cotton-wool. If the gullet is wounded the patient will probably require to be fed with a tube. Thirst may be relieved by sucking wet rag or ice. As these injuries are generally inflicted with a suicidal intent, it will be needful to have the patient watched, or he may repeat the attempt. If the patient is unruly, and tries to tear open the wound, he may be confined by a strait waistcoat (*vide* p. 160).

WOUNDS OF THE EYES.—Any protruded part should be gently and carefully pushed back with a probe; the patient should be placed in a darkened apartment, the lid should be kept closed by a covering of cotton-wool and a light bandage, and cold water should be used as a lotion. Purgatives should be administered and abstinence from stimulants should be enjoined.

[It will be advisable to obtain a solution of *atropine* (strength 2 grains to an ounce of water), a drop or two of which should be dropped into the eye twice daily, in order to dilate the pupil, and prevent adhesions from inflammation.]

WOUNDS OF THE TONGUE.—Are liable to occur, in connection with other accidents, when the organ gets accidentally thrust between the teeth. As a rule, it is best to leave wounds of the tongue entirely to nature, as it is difficult to introduce ligatures, and plasters are inadmissible. But sometimes wounds of the tongue bleed very freely, and may require twisting or ligature of an artery (*vide* p. 504); or the actual cautery (a red-hot iron wire) may be necessary to arrest the bleeding.

WOUNDS OF THE PALM OF THE HAND.—Sometimes give much trouble from the artery of the palm being injured (*vide* p. 507). After bleeding has stopped, the wound should be dressed with plasters.

WOUNDS CAUSED BY THE BITES OF ANIMALS.

CAMEL AND HORSE BITES are attended with much bruising of the parts, and a sharp tooth may wound an artery, as, for instance, the artery of the wrist. If this occurs, the flow of blood must first be stopped, as directed under *Bleeding* (p. 504). Afterwards, or at first if no bleeding, the wounds require washing with warm water, poulticing, and rest. At a later period simple dressing, or water dressing. (Recipes 85, 86.)

DOG AND CAT BITES.—Are difficult to heal, from the wounds being punctured, contused, or lacerated. Such injuries should be washed with warm water, after which a bread poultice may be applied. If there is pain the parts should be fomented with hot infusion of poppy-heads (*vide* Recipe 81) previous to each change of poultice. When the wounds look clean and free from discharge, simple dressing, or water dressing should be used (*vide* Recipe 85). For the treatment of the bite of a mad dog, *vide Hydrophobia*, p. 301.

The idea that a person bitten by a dog will suffer from hydrophobia if the dog should *afterwards* go mad, is erroneous. The practice of killing a dog because he has bitten a human being, in order to prevent hydrophobia in the latter, is ridiculous and useless. If the dog goes mad *after* the infliction of the bite, there is no danger of hydrophobia.

WOUNDS FROM SCRATCHES BY A CAT.—These are best treated by well washing the part with warm water, then applying a poultice and afterwards a little simple dressing. Slight scratches, whether from the claw of a cat or from the tooth of a horse or dog, may be sucked, as the ready means of preventing future irritation.

TIGER OR BEAR BITES.—These injuries may involve deep-seated parts. The hand may be bitten to pieces; the chest may be seized, when the teeth or claws will probably penetrate the lungs. Or the thigh may be seized, and the large artery wounded. When such accidents occur, measures to arrest bleeding should be taken (*vide Bleeding or Hæmorrhage*, p. 504), after which the wounds should be thoroughly cleansed, and, if available, antiseptic lotion (*vide Appendix*, No. 119), or, if not, water dressing (*vide* No. 85) should be applied. If the injured person escapes with only superficial fang or claw wounds, poultices should be applied for the first few days, and afterwards water dressing, or, if available, oil and carbolic acid (*vide Appendix*, No. 119).

There is an impression that wounds from the teeth or claws of animals must be poisoned. This is not correct, and has arisen from the slow manner in which such wounds heal. Wounds from the teeth or claws of animals must be attended by laceration and contusion: conditions sufficient to account for slow healing. It is possible that the teeth or claws of a carnivorous animal, when inflicting a wound, may be impregnated with some deleterious material from rotting carrion, and so the blood may be poisoned (*vide* p. 587). But this is not usually the case.

WOUNDS CAUSED BY SNAKES.—There are in India 213 species of snakes, of which 33 are poisonous. Of the latter there are two varieties, the *Viperine* and the *Colubrine*. The *Viperine* poisonous snakes have stumpy tails, and triangular-shaped heads. The *Colubrine* poisonous snakes are hooded. Neither have the *loreal* shield, which is a crescentic-shaped scale, directly behind the nasal shield. Poisonous snakes have only two teeth in the upper jaw, and these are the grooved erectile poison-fangs. There are other teeth in the palate, but no other teeth in the jaw proper. The fangs of some species are perforated instead of grooved, and in addition there is an opening at the base, so that when the reptile bites, the poison is not only carried to the bottom of the puncture inflicted from the point of the fang, but it also escapes at the base.

Symptoms.—The bites of poisonous snakes, as a rule, show two marks thus ·· When there are more than two marks, :: it may be safely assumed that the reptile was not poisonous, or that the wound has not been inflicted by the poison-fangs. The parts most frequently bitten are the fingers, toes, ankles, and hands, and the person, if asleep, is aroused by the pain, which is of a stinging character, but not very severe at first. Faintness, sickness, loss of power in the legs, and perhaps vomiting, are the next *immediate* effects. Then the breathing becomes short and laboured, the pulse quick and intermittent, the powers of speech and swallowing are lost, the tongue protrudes, and frothy saliva issues from the mouth. Twitchings of the muscles also occur, followed by loss of power to move the limbs. The pain from the wound extends upwards towards the body; the absorbent vessels becoming inflamed, appearing on a fair skin as painful red lines stretching up from the wounded part towards the groin or armpit. Cold sweats and often convulsions succeed, and the patient, becoming insensible, sinks, sometimes in a few hours. More commonly, however, the case is prolonged several days, blood poisoning (*vide* p. 587) occurring. The wound becomes discoloured, the limb swells, blisters may form near the injured part, abscesses may occur in any part of the limb, and the glands of the armpit or groin (according to the limb injured) enlarge, inflame, and suppurate. Sometimes there is diarrhœa, at others bleeding from the snake-bite, or from scarifications made in the neighbourhood. In some cases there is also bloody urine, or bleeding from the nose, bowels or gums. The depressing effects of fear will aid the operation of the poison; and the symptoms will be more or less intense, according to the amount of venom inserted into the wound.

Treatment.—Although no antidote has yet been discovered, treatment may save life. But the measures indicated below, to be successful, must be applied *immediately.* If the bite is anywhere on the limbs, tie a tight bandage or string round the limb, a few inches *above* the wound. The ligature should be tight enough to arrest the circulation, which may be known by the part below becoming red, and then darker coloured. Then let the wound be *well* sucked; care being taken that the person performing this office has no sore on the mouth or lips; or, if a ligature cannot be applied (as, for instance, if the body is bitten), let the wound be sucked first. Afterwards, or previously if suction cannot be accomplished, make four or five punctures with a lancet, or sharp knife, a quarter of an inch deep, one across each bite and the others a quarter of an inch or so from the bite. (A surgeon would probably cut the bitten part out.) When puncturing care must be taken not to injure any *vein* which, if in the locality, will be recognised, blue and prominent underneath the skin. No *artery* is likely to be injured by the punctures, unless the bite were on the wrist close to where the pulse is usually felt, and this may be known by the beat (*vide Blood-vessels*, p. 502). Then encourage bleeding by, if possible, immersing the part in hot water, or otherwise by bathing with hot water. If the knife cannot be used, a live coal or stick, a red-hot iron wire, or a drop of nitric or carbolic acid, or a solution of permanganate of potash (5 grains to a tea-spoonful of water) may be passed into the wounds. If nothing of the kind is available suction should be continued.

The strongest stimulant at hand, whether brandy, whisky, rum, wine, sal volatile, or liquor ammonia (*eau de luce*) should be given at once. Eau de luce should be given in 30-drop doses, diluted in two table-spoonfuls of water; sal volatile in half-ounce doses; spirits in ounce doses, diluted with water, so that the stimulant used may be swallowed without difficulty. If wine is used, four-ounce doses should be given. Whatever stimulant is used, the dose should be repeated every fifteen minutes until the first depressing effect of the poison subsides. If the faintness is great cold water should be dashed on the face and head, and mustard poultices should be applied over the heart and stomach. During the whole time the patient should have plenty of fresh air, but he should be kept moderately warm, especially about the feet. At a later period poultices should be applied to the wound. If red lines form, stretching from the wound towards the body, they should be fomented. Fomentations and poultices must also be applied to any swelling about the armpit or groin; and if matter forms in such positions, it must be treated as an abscess (*vide* p. 41). As soon as the first effects of the poison pass away, the patient should have nourishment, soup, broth, or raw-meat tea.

When a ligature is applied, and no symptoms of snake-poisoning make their appearance in half an hour, the ligature may be relaxed; but if symptoms as above detailed present, it should be kept on until the part has been sucked, cut out, and bathed in hot water, after which the ligature serves no useful purpose and may do injury. But if the limb swells and grows a little cold, the ligature should be removed, even if the treatment has not been carried out.

If the person is not seen until the limb is swollen, the absorbent vessels are inflamed, and there is more or less insensibility, stimulants and poulticing afford the best chance.

WOUNDS FROM SCORPIONS AND CENTIPEDES.—The pain is at first like a prick from a needle, but in a few seconds it assumes an agonising form, as if many needles were being thrust into the part, and it also shoots towards the body, reaching a climax in about ten minutes. The parts injured swell; frequently the absorbent vessels running from the sting are implicated, as evidenced by a red line seen in the skin; and the joint above the part feels stiff. Death from scorpion-sting has been recorded, but to a person in good health such injuries are not dangerous. The best applications are poultices made of equal parts of opium powder and ipecacuanha powder; or, if both are not available, of ipecacuanha powder alone; or a rag steeped in vinegar, or in sal volatile, should be laid on the part; or a strong solution of common salt and water may be employed; or the part may be rubbed with a cut onion, or with wet tamarind seeds. The inflamed red line of absorbent vessels should be fomented, and it will be advisable to give some aperient.

WOUNDS FROM WASPS or BEES.—When a swarm of wasps attack a person, the number of stings inflicted may induce serious illness. Or in delicate persons, or children, several stings may cause faintness, nausea, vomiting, and purging. Under such circumstances a stimulant will be first required. Then the stings should be extracted by pressing the tube of a small key over the part, when the sting, if left in the wound, will probably start out, or a watery fluid will escape, carrying with it some of the venom. Then the best application is sal volatile, or vinegar-and-water, or eau de Cologne; or, if these are not at hand, moist snuff or tobacco may be rubbed in. If the stings are numerous chloral may be required to relieve pain. If sickness persists, one drop of ipecacuanha wine in a spoonful of water every hour. At a later period soap liniment may be used to remove any remaining swelling of the skin.

In cases of stings *inside the mouth* or in *the throat*, the sting should be sought for, and extracted if possible. Ice should be kept in the mouth, and leeches should be applied outside. If danger of suffocation appears urgent, opening the windpipe may be required.

WOUNDS FROM MOSQUITO-BITES.—The effect of a mosquito-bite does not altogether depend on the introduction of the proboscis of the insect into the skin, for so small an object, although containing six lancets, would scarcely create the irritation often following. The fact is, that there is not only the wound, but also the discharge of an irritating fluid into the wound. A mosquito-bite usually rises into a white hard lump, which may inflame and become an obstinate sore if the individual be out of health. The best application is sal volatile; or a strong solution of carbonate of potash in water; or, if these are not at hand, vinegar. Or water alone may be well rubbed into the part, so that some may enter the wound made by the sting, and dilute the poison. Any sore afterwards forming must be treated in the ordinary manner.

After a mosquito has fed on an individual or animal affected by *filaria* (a microscopical worm found in the blood), the insect's stomach contains living examples of the parasite. The latter escape, when the mosquito dies, in the water to which it betakes itself; and the parasites may thus find their way with water into the human system. It is probable also that *filaria* may be directly conveyed from one person to another by mosquitos. The influences which *filaria* in the blood exert are not well understood; but it is possible they may have more connection with certain diseases, especially leprosy, than has been recognised. However this may be, enough has been proved to afford another reason why persons in tropical climates should seek protection from mosquitos; also another reason why care, as regards purity of drinking-water, should be systematically practised (*vide* p. 678).

WOUNDS FROM LEECHES.—In some parts of India small land leeches abound. They are about one inch long and very thin, looking like little withered sprigs, standing out from the bushes. When distended they are much larger. They are of a yellowish-brown colour, streaked with black, with one greenish line along the whole length of the back, so that they are not easily seen when hidden among green leaves or grass. By a muscular effort they throw themselves from trees on passers-by, and insinuate themselves through every aperture of clothing, or down the back of the neck. Their bites scarcely inflict any pain at the time, but they cause much after-irritation, and in persons in a bad state of health often occasion ulcers difficult to heal. The bleeding should first be stopped (*vide* p. 512), and then a cooling lotion should be applied (Recipe 83). Any ulcer forming must be treated on ordinary principles. When passing through marshes, 'leech gaiters' may be worn, which are very long, closely woven cotton stocking, passing over the socks.

WOUNDS FROM FLEA-BITES.—Flea-bites are recognised by small darkish red spots surrounded by a circle of a paler colour, which fades before the central puncture does. Flea-bites have been mistaken for eruptions accompanying different kinds of fever or *vice versâ*. The smallness of the spots, their uniform character with central puncture (seen more certainly through a glass), and their decided isolation are sufficiently characteristic. Vinegar and water is the best application, and cleanliness is the best means of preventing fleas swarming in Indian houses.

WOUNDS FROM BUG-BITES.—These insects cause an itching swelling, sometimes red, sometimes white, almost resembling the mosquito-bite. Vinegar-and-water is the best application. Taking furniture to pieces and placing the ends in boiling water is the best method of destroying bugs. Pouring turpentine occasionally between the joints is the best method of prevention.

WOUNDS FROM LICE.—Lice-bites present an itching, whitish swelling. Lice generally inhabit the scalp, laying their eggs (called *nits*) near the roots of the hair. A method of killing lice is washing the head with a solution of carbolic acid (one part of acid to fifty parts of water). Or carbolic acid and oil may be used together in similar proportions. But neither measure may suffice to kill the eggs. If lice still appear the head should be shaved, and a mixture of equal parts of pomatum and mercurial ointment may be rubbed on the scalp every other day for three days, an oilskin cap being worn in the meantime.

OTHER INSECTS AND REPTILES which may cause annoyance and injury are, certain *caterpillars* which leave hairs in the skin; *sand flies* (*pulex penetrans*) which cause bright red, itching papules; the *peepsa fly* of Assam, which attacks the hands and feet, causing a red blister with much itching. The *common house lizard* may also cause redness or even blistering. For all these injuries cold lotion, Recipe 83, or vinegar-and-water, are the best applications.

CHAPTER IV.

PREGNANCY AND LABOUR

PREGNANCY.—The pregnant condition lasts from 273 to 280 days, or about 40 weeks. The following table is for calculating the period of pregnancy.

Nine Calendar Months			Ten Lunar Months		
From	To	Days	From	To	Days
January 1	September 30	273	January 1	October 7	280
February 1	October 31	273	February 1	November 7	280
March 1	November 30	273	March 1	December 5	280
April 1	December 31	273	April 1	January 5	280
May 1	January 31	273	May 1	February 4	280
June 1	February 28	273	June 1	March 7	280
July 1	March 31	273	July 1	April 6	280
August 1	April 30	273	August 1	May 7	280
September 1	May 31	273	September 1	June 7	280
October 1	June 30	273	October 1	July 7	280
November 1	July 31	273	November 1	August 7	280
December 1	August 31	273	December 1	September 6	280

The above 'Ready Reckoner' is used as follows. A woman has ceased to be 'poorly' on July 1, her confinement will be at soonest about March 31 (*the end of nine calendar months*); or at the latest on April 6 (*the end of ten lunar months*). Another has ceased on January 20; her confinement will be on September 30, *plus* twenty days (*or October 20 the end of nine calendar months*), at soonest; or on October 7, *plus* twenty days (*or October 27, the end of ten lunar months*), at latest.

SIGNS OF PREGNANCY.—1. *Morning sickness*, usually commencing about one month after conception, sometimes earlier. 2. *Cessation of the monthly flow* at the first month. which, however, in exceptional cases may not occur. 3. *Enlargement of the breasts*, generally after the first month; occasionally not till the third month; sometimes after the first few days. 4. *Dark appearance and soreness of the nipples and breast*, about the third month. Sometimes (usually at a later period) *oozing of milky fluid*. 5. *Enlargement of the abdomen*, about the third month. 6. *Quickening*, or movements of the child, felt about the fifth month, and often attended by fainty feelings. (It has been observed that if these movements are felt chiefly on the left side, there will be a male birth.) 7. *Pulsation of the child's heart*, which resembles the ticking of a watch under a pillow; heard first about the fifth month, and most distinctly at the centre of a line drawn from the hip-bone to the navel: sometimes on one side, sometimes on the other. 8. *Movement of the child*, which may be felt after the sixth month, on placing the cold hand over the lower part of the bowels. 9. *Variations in temper and disposition, capricious appetite, and 'longings,'* the woman often showing a desire for special, and sometimes improper, diet.

TREATMENT OF PREGNANCY.—Unless other ailments (*vide* p. 356), or unless any of the signs mentioned above, prevail to the extent of becoming serious inconveniences, pregnancy being a natural condition, the manner of living, if healthy, need not be altered. The diet should be ample, but simple, and the taste may be reasonably indulged. But the mother's blood yields nourishment to the unborn infant; therefore deterioration of the former must affect the latter, and capricious appetite should not be yielded to. Moderate exercise and exertion is not prejudicial, provided care is taken not to strain the body. If the pregnant woman is exposed to sudden strains, or to shaking, the womb may be excited to premature action, and *miscarriage* (*vide* p. 362) or other evils, such as *Cross Birth*, p. 628), are liable to occur. As the dangers of any disease are increased if it occurs during pregnancy, any unhealthy pursuit should be discontinued. It is especially deleterious for a pregnant woman to sleep in a badly ventilated apartment: for as the unborn child grows there is greater want of fresh air. The liability of pregnant women to be affected injuriously to themselves and unborn child by disgusting objects should be recollected, and such sights should be avoided. The clothing should be warm but easy. Stays may be enlarged by a gore of elastic in each side, and if there is a steel in front it should be removed. The breasts should have plenty of room, and if tender or irritable should be treated as directed at p. 360. In healthy pregnancies no medicine is required, excepting probably during the last few days, when it may be desirable to overcome constipation by castor-oil. Castor-oil is the best opening medicine during pregnancy, when powerful purgatives, especially those containing aloes, should be avoided. Neither should patent medicines, the composition of which is unknown, be taken during pregnancy, as they may contain drugs deleterious to that condition.

PRECAUTIONS PREVIOUS TO LABOUR.—Bath-rooms, water-closets, and drains, if any, should be well cleansed. Inquiry should be made where the sweeper takes refuse, and proper disposal of it should be insisted upon. The best ventilated room obtainable should be selected for the lying-in chamber, and it should not be kept too warm either before or after labour, as is generally the case in the cold season of northerly districts. The antecedents of the nurse should be inquired into. If there is the slightest suspicion of her having been recently (within four weeks) engaged with a scarlet fever patient, or with a blood-poisoning case, or with a woman suffering from puerperal fever, she should not be engaged. If she has been attending any other diseases, or burns or scalds, she should wash all over with 20 p.c. carbolic soap, and be given new clothing. Arrangements should be made for a supply of pure cotton wool, to be used instead of sponges if the latter are required during labour. If practicable, absorbent cotton, or artificial antiseptic sponges, and sanitary towels should be obtained. All these things, if used, should be burnt after labour. Plenty of ordinary napkins should be well aired and put ready to hand. Arrangements should be made that both hot and cold water should be ready; and if a first labour, and therefore likely to be long, some beef-tea should be prepared, and a drinking-cup obtained. A chamber utensil to receive the after-birth, and an enema syringe, should be in readiness. Other things which should be ready beforehand are, the bandages for the woman and child; a large square of flannel called the 'receiving flannel' for the child to be placed in at its birth; a waterproof sheet; a bed pan; the child's clothing; large and small pins; three or four ligatures to tie the navel-string with, as below; blunt-pointed scissors to cut the string with (*vide* p. 632); soft linen for dressing the navel (*vide* 633); glycerine soap and a fine sponge for washing the child (*vide* 633); cimolite powder and a puff; sound salad oil in a wide-mouthed bottle.

[The bandage for the woman should be made to fit at five months or pregnancy. It should be composed of strong unstarched calico, and reach from just below the breasts to a little below the hips. In length it should go round the woman's hips, with a hand's-breadth additional for over-lapping. It should be narrow above, wider below, and gored so that it will be a little narrower at the lower part than a few inches above, to prevent it from sliding upwards. If a binder has not been prepared, the bandage used should be fourteen inches broad and a yard and a half long.

The binder for the infant should be of thin flannel, about five inches broad, and long enough to go twice round the body.

The ligatures for the navel-string should consist of sewing thread, as cotton is not strong enough, and tape is likely to slip. Each ligature should be composed of ten threads, loosely rolled into one cord, and all of one length, so that they may not tie unevenly.]

A lady writer gives the following as the layette of an infant in India. 8 day shirts; 8 night gowns; 4 monthly gowns; 4 day flannels; 4 night flannels; 2 head squares; 5 flannel bands; 4 robes; 1 hood and veil; 2 dozen diapers; 4 long petticoats; 6 pairs wool boots; 12 flannel pilchers; 4 cradle sheets; 4 pillow cases; 2 blankets.

LABOUR.—Labour is the common term for a confinement. If the birth takes place before six months, it is called an abortion or *miscarriage*, and when between six and nine months, *premature labour*. A full-time labour, as a rule, being a natural process, is attended with little danger to either mother or child. The signs of *approaching* labour are a sinking of the size of the belly; a feeling of comparative lightness; frequent desire to make water; perhaps griping, and a sensation of squeezing; and a mucous discharge, sometimes streaked with blood, and known as 'the show'; all or any of which may occur some hours, or even a day or two, before actual labour-pains commence. On the symptoms of *approaching* labour, *the patient's bed* should be prepared. A hard or horsehair mattress is preferable. On this, over the usual blanket and sheet there should be placed a piece of oiled cloth or india-rubber sheeting; then on this 'guard,' a blanket folded four times, then a sheet doubled in similar manner, which is called the 'draw sheet.' All this is to absorb discharges, and to prevent the mattress, on which the woman has to lie afterwards, becoming wet. After the labour is over, and the oiled cloth and extra blanket and sheet are removed, the bed should be quite dry. A long towel should also be attached to the foot of the bed for the purpose indicated below. *The woman's dress* should consist of garments which may be easily removed after the labour. The best plan is for the woman to be undressed, with the night-dress rolled above the waist, so that it may not be soiled. A loose sheet should be spread over her, to be taken away with the 'guard' and 'draw sheet.' *If the bowels* have not acted within six hours, an enema (Recipe 104) should be administered. Emptying the bowels facilitates the action of the womb, and prevents discomfort; for the contents of the bowel may be forced into the bed during labour.

The *commencement of labour* is denoted by pains in the lower part of the belly, gradually settling in the loins and back, then passing to the thighs, and known as 'bearing down pains.' After such pains the waters generally break. There is also often shivering and vomiting. The patient may at first sit, or walk about, which accelerates the labour, and she should, if necessary, relieve the bladder and bowels. In a variable time, the pain returns at lessening intervals, while they increase in duration and violence. The patient should now take to the bed, and the position most convenient, both for the attendant and the woman, is for the latter to lie on her left side with the hips near to the edge of the bed, and the knees drawn up towards the belly, and a pillow may be placed between the knees. When violent pains occur, the patient should hold her breath, place her feet against the footboard of the bed, or against some person sitting at the foot, and pull hard at the towel (recommended to be) attached to the foot of the bed (*vide* above). This assists the expulsatory efforts of the muscles concerned. The time of labour varies from six to twelve hours, being generally longest in those having a first child. In ninety-five cases out of a hundred the head of the child first emerges, the rest of the body soon following. The main objects of care are: *First*, to support the *perinæum*, or that part of the person of the mother exposed to pressure as the head passes, which otherwise might be torn and lacerated. This support is afforded by applying the hand covered with a napkin in a moderately firm yet yielding manner. *Secondly*, to free the child's mouth from discharge or mucus. *Thirdly*, to see that the womb contracts as soon as the child is born. To secure this, when the head is born the hand of an attendant should be placed over the womb, making moderate pressure, which should be maintained until the *after-birth* comes away; or until the womb is well contracted, when it may be felt in the lower part of the bowels in the shape of a *round hard ball*. If the womb cannot be thus felt, bleeding may occur. *Fourthly*, to divide the navel-string (as described at p. 632).[1] During the labour, thirst may be relieved by cold water or cold tea, or, in prolonged cases, beef-tea may be taken; but solid food may cause vomiting. Sleep during the intervals between the pains should not be interfered with; and the face and hands may be sponged with cold water. As soon as the child is born, 6 or 8 grains of quinine should be given, which will tend to prevent malarious fever occurring, and assist in securing contraction of the womb.

In from ten to twenty minutes after the child is born the *after-birth* comes away, but it is sometimes longer, and the cord must not be pulled to hasten its progress. The after-birth is attended with renewal of pains, and if the interval between the birth of the child and the after-birth is long, it is accompanied by clots of blood. In other cases a more fluid bloody discharge occurs, which is of no consequence to the extent of a few ounces, but which, if profuse, amounts to *hæmorrhage* (*vide* p. 628). In some cases the after-birth presents at the orifice, but does not

[1] For the general treatment of infants after birth, *vide* Chap. V.

pass out. It may then be *twisted round*, and gradually extracted.

[The above refers to a straightforward labour; but sometimes labour is preceded for some days or hours by 'false pains.' Such pains are felt in the bowels, and not in the back; they are of a *straining*, and not of a *grinding* character, they are not accompanied by any 'bearing-down' efforts, and they come and go at *irregular* intervals. False pains are usually caused by intestinal irritation, and may generally be removed by castor-oil, followed by an opiate, as Recipe 64.]

Treatment after Labour.—When the after-birth is removed, the abdominal bandage (*vide* p. 617) should be applied. To do this, roll the binder up, and while the patient is on her back pass it under the small of the back, and let someone standing on the opposite side draw it out. The patient is not to give assistance. Draw the binder comfortably tight, and fasten with safety pins, pinning at the top first. It must act as a broad belt, and not like a cord. If the womb cannot be felt as a round hard ball, a napkin may be doubled into a pad, and placed over the womb underneath the bandage, by which pressure is exerted more directly on the organ: and the infant should be put to the breast, which also tends to insure contraction of the womb. The pad may be removed next day, but the bandage should be worn during the whole time the patient remains in bed. After adjustment of the bandage all soiled clothing should be taken away; the parts should be wiped dry, and a dry warm napkin applied; the night-dress should be brought down smoothly under the hips; and the woman should be allowed to turn round and go to sleep, or to lie still for an hour and a half, or for a longer period should any bleeding have occurred. It should be recollected that nothing is more likely to give rise to bleeding than permitting a patient to sit up soon after her confinement. There is often some loss of blood, so that a slight appearance of the kind need not excite alarm, especially if the womb can be felt hard, round, and firm. If the womb cannot be so felt, and if considerable bleeding occurs, the woman should be treated for *Bleeding after Delivery* (*vide* p. 628).

If after the birth of the child the mother is much exhausted, strong tea, *not too warm*, is the best stimulant After the woman has well rested, and perhaps slept a short time, the private parts should be washed with milk-and-water, and another dry napkin applied. Usually at this time, some bloody discharge, or clots of blood, may be found. This washing should be repeated several times daily, until after four or five days, when 1 ounce of vinegar to 10 ounces of tepid water may be substituted for the milk and water; or glycerine soap may be used. As a female after confinement is susceptible to cold, care should be taken to prevent draughts, although it is *essentially necessary* that the chamber be maintained cool and airy. Excitement from visitors should be avoided. None but the husband and the necessary attendants should be admitted for the first five days; and especial care should be taken that no one approaches the chamber from whom the occupant could incur the chance of contracting infectious disorder, to which lying-in women are peculiarly liable.

The patient should pass urine within six hours after delivery, and this should be done as nearly as possible in the horizontal posture. Or if it cannot be made in such position, the patient may turn on the hands and knees. If there be still difficulty, the lower part of the bowels and the private parts should be fomented with hot water. Owing to the distensible state of the belly, the patient will often wait longer than proper if not reminded to make water, and the consequences may be inflammation or paralysis of the bladder (pp. 70, 74).

The state of the bowels after delivery is of great importance. On the evening of the second or morning of the third day, if the bowels have not been opened, a tablespoonful of castor-oil, or a dose of senna tea, should be given. If there is reason to suspect accumulation in the lower bowel, as often occurs during the later days of pregnancy, and is known by the passage of hard round lumps, an enema of warm water should be administered. If the patient does not suckle her child, purgatives will be the more necessary for the relief of the breasts. In the latter case saline aperients, as Recipe 2, or citrate of magnesia (*vide* p. 15), which is a milder laxative, will be found most useful.

Diet.—Until the milk has come, and the period of milk fever (*vide* p. 629) has passed, the mother, *if in good health*, should live on gruel, tea, toast, and arrowroot. Afterwards the *diet* may be regulated a good deal by the inclinations of the patient. Good soup or beef-tea may be given on the third day, as there is no advantage in keeping a woman who has had a 'good time' on too low a diet. If there is decided disinclination for food, there is probably something wrong. On the fifth or sixth day, solid food may be given. Wine or beer is better delayed till the person gets up. *If the mother has been previously in feeble health*, it will be desirable for her to be supported by nourishing food, as soups and beef-tea, from the first.

Attention must also be directed to the discharge called lochia, popularly 'the cleansings.' The passage of this is accompanied by more or less 'after-pains,' generally felt about half an hour after delivery. During their presence the discharge increases, and black clots of blood may be expelled; especially when rising in bed to take food or make water. After-pains are, within certain limits, salutary; they prevent bleeding, diminish the size of the womb, and expel its contents. The application of the child to the breast often brings on or aggravates the after-pains. Unless very severe, no medicine should be given; but if troublesome, an opiate, as chloral (Recipe 64), may be administered, and the bowels may be fomented. At first this discharge is in black clots, or more or less red like blood; then thin and watery, changing colour to greenish-yellow, and at last appearing like soiled water. It has a peculiar odour, more powerful in some instances than in others. The quantity and duration vary a good deal. In some patients it ceases with the after-pains a few days after delivery. In other instances it does not cease till the end of a month. Its continuance is a sign of weakness, either general or local, and is a reason why extra caution and time in getting about should be taken, with additional attention to frequently washing. As this secretion is necessary, the *sudden* interruption is generally attended with evil consequences, such as suppression of milk, or fever.

In ordinary cases the breasts remain quiescent for about twelve hours, or longer in first confinements, but soon after begin to enlarge, with stings of pain, their substance becoming heavier and more tense. This depends on what nurses call the 'draught,' or the rush of blood to the breasts, to be converted into milk. There may be *shivering*, and the woman may be feverish. This usually subsides with the flow of milk. If *shivering* occurs the woman should be treated as directed under *milk fever* (*vide* p. 629). If simply feverishness, without shivering, attends the secretion of milk, saline purgative (Recipe 2) and citrate of magnesia draughts (p. 15) should be given, while the breasts may be fomented, and they may also be *gently* rubbed with salad oil every four hours; the greatest pressure being made when the hand is passing from the base of the breasts towards the nipple. Unless some bleeding occurs, and the child is put to the breast, as recommended at p. 621, to secure contraction of the womb, the breasts should not be interfered with in first confinements for five or six hours, when the infant may be applied. But if the breasts become rapidly full, as sometimes happens in persons who have borne children, or if the infant is restless and does not sleep (as mentioned at p. 634), it may be applied at an earlier period. If the breasts are flat and limp, frequent application of the child is not desirable, as fruitless sucking renders the nipple hot, irritable, and tender. If the nipples are short and badly formed, or the breasts swell so much as to prevent the child seizing the nipples, they should be drawn out by a breast pump; or a larger child or a grown-up person should suck them first. Or the cut bottle (*vide* p. 95) or the heated bottle (*vide* p. 98) may be used. The first milk is a watery fluid with yellow streaks in it. It is called *colostrum*, and acts as a purgative to the infant (*vide* p. 635). After twenty-four hours the milk becomes whiter, opaque, and has a sweeter taste.

Each time the child is about to suck, the nipple should be cleaned with soft rag and plain water; and again when the child ceases sucking. This is desirable because even a very little milk drying about the nipple may turn sour and irritate the part; or it may be received into and disorder the infant's stomach. The nipples and breasts should also be washed with warm water and soap morning and evening. By such care the chance of sore nipples and bad breasts (*vide* pp. 94, 96, 97) will be avoided. During the first week the mother should give suck while lying down. She can turn to one side, and, supporting herself on her elbow, let the nipple fall into the mouth of the infant. But afterwards the semi-erect posture should be taken, from which the infant swallows best. Both breasts should be equally used. For times of suckling, *vide* p. 635.

The mother should remain in bed till the twelfth day, and afterwards recline on a couch. She may be shifted from side of the bed to the other, and soiled sheets may be then taken away and clean ones introduced, but she should not get up, even to have the bed made—especially if there has been much bloody discharge—for the womb requires time to recover its normal size and condition. Debility, pain, and continued discharge, often spoken of as 'a bad getting up,' are among the least penalties consequent on imprudence after confinement. A too early return to the duties or pleasures of life often lays the foundation of chronic inflammation, or displacement of the womb. It is a mistake to suppose that women in the lower walks of life, or native women, attend with impunity to their avocations a few days after confinement. Those who have any tendency to womb affection should remain *recumbent* for a full month. If bloody discharge occurs after getting up, it is a warning to go to bed again. Throughout the whole period ventilation must be carefully attended to, no charcoal fire should be allowed in the room, and the immediate removal of soiled linen is essentially necessary.

When the mother resumes her dress, the corset should be so arranged as to prevent pressure upon, and give support to, the breasts. She must remember that her milk will be affected by any indiscretion either in food or habits, and that unless her health is maintained her infant will certainly suffer. Nursing women are especially liable to latent scurvy (*vide* p. 381), so that vegetables and milk should always form part of the dietary. There is no valid reason why potatoes should not be taken, against which there is a popular impression. A little malt liquor may generally be used with advantage; but women when nursing usually require *more fluid*, not *extra stimulation* from fermented drinks.

The foregoing relates to natural and straightforward confinements, but other circumstances may arise, which are now briefly noticed.

1. **The Labour may be Tedious and Long.**—This occurs to weakly females, the pains being feeble, or ceasing usually after the waters break. If four hours elapse without pains, assistance should be sought. In the meantime nourishing soup, and chloral (Recipe 64), should be given, and after rest and sleep the pains may probably return.

2. **Cord round the Neck** occurs once in about 12 cases. Frequently it is not of much consequence, as when the cord is round the child's neck it is usually long. It should be loosened by gentle traction, and the shoulders should be allowed to slip through the loop. Or, if the cord is long, it may be slipped over the child's head. In some cases it has been necessary to *saw* the cord through, to prevent the child being strangled. When so necessary, the cord should be *sawn* through with the finger-nail, and *not cut*, or it will bleed profusely.

3. **Presentation of the Breech.**—This occurs once in 60 cases, and the labour is tedious, because the infant, being doubled at the haunches, requires a larger space. As a rule no interference is required until the breech and feet are born, when the case becomes converted into *presentation of the feet* (*vide* No. 5).

4. **Twin Births.**—This occurs about once in 70 cases. The presentation generally varies, the first being the head, and the second a foot case, or the reverse. After the birth of the first child, the presence of a second is known by the slight reduction in size of the womb. Sometimes the after-birth of the first child comes away before the birth of the second, sometimes not till afterwards, and attempts should not be made to remove it, as there may be only one after-birth for both infants. After the birth of the first, the womb should be stimulated to contract by keeping up a grasping movement of the fingers and thumb on the lower part of the bowels. Sometimes the birth of the second child follows that of the first in ten minutes, but on other occasions not for some hours. Under such circumstances the woman should rest until pains return, and she may drink a little cool tea or arrowroot; the precaution being taken to examine frequently, lest bleeding may be going on. The second labour is usually quicker than the first, the soft parts having been already dilated. After the birth of the second child and the passage of the after-birth especial attention must be paid to the contraction of the womb. The womb should be pressed with the hand until it can be grasped as a firm hard ball, and the bandage should be applied (*vide* p. 621).

5. **Presentation of the Feet.**—One or both feet may come first, which happens once in 100 cases. The birth is generally safe for the mother, but not for the child, which is apt to suffer from the circulation of the cord being obstructed by pressure. Footling cases should not be hastened in the early stage, as the longer the buttocks are detained the greater will be the dilatation of the parts, and the birth of the head will be more easy. When the breech is expelled, the cord should be examined,

and, if the pulsation of the cord has ceased, the birth of the shoulders should be hastened by pulling the body steadily down during the next pain. The toes of the infant turned to the back of the mother is the most favourable position for the birth of the head; and when the breech is expelled, if the toes are turned forward, the assistant should seize the breech in both hands, and during the next pain endeavour to turn the child round. If circulation is restored in the cord after the birth of the shoulders, there is little cause for anxiety for the safety of the child; but if there is no pulsation in the cord, it is necessary to assist at every pain, and hasten the delivery of the head by pulling the shoulders down. The head being born, the assistant should examine the cord, and, if it pulsates, the child should not be separated for a few minutes until it begins to cry. If there is no circulation in the cord, the infant should be treated as detailed for *still birth* (p. 637).

6. Presentation of the Face.—Instead of the top of the head, the face may present, which happens once in about 230 cases. When it occurs, the labour is protracted. The child is seldom in danger, but the head and face are swollen and disfigured, and unless the mother is prepared, the appearance may give a severe shock. In the absence of medical aid, it will be best to wait patiently for the natural termination.

7. Presentation of the Hand, *or 'cross-birth.'*—Presentation of the hand, or the elbow or shoulder, occurs once in about 230 instances. The assistance of a medical man is urgently required, as the operation of turning the child will probably be necessary.

8. Bleeding or Hæmorrhage.—Bleeding may occur either *before* or *after* the birth, but does not happen to an alarming extent more than once in 300 cases. Bleeding occurring *before* the birth generally depends on the after-birth being seated over the mouth of the womb, so that, as the latter dilates, the vessels of the after-birth are torn. This kind of bleeding may occur at any time after the sixth month of pregnancy, but is more frequent between the eight and ninth month. In every case of bleeding during pregnancy, absolute rest is necessary; the patient's room should be well aired, her food should be farinaceous, her drink toast and water, or weak cold claret and water, and cold applications should be made to the privates. When bleeding happens during the last months of pregnancy the person should obtain medical advice, and the presence of a surgeon during labour.

Bleeding *after* delivery may happen *immediately*, before or after the expulsion of the after-birth, or it *may come on some hours or even days* after the confinement. *When bleeding occurs immediately after delivery*, it depends on feeble contraction of the womb. When the after-birth separates, loss of blood to some extent is the natural consequence; nor is the woman injured by a moderate loss, such as eight to ten ounces. But if the quantity exceeds such amount it produces fainting, the woman being pale, cold, and gasping for breath. The womb will be found soft, and to induce it to contract, firm pressure should be made over the lower part of the bowels, and if possible the womb should be firmly grasped in the hand through the skin. Cloths wet with cold water should be applied to the privates, iced or cold water given to drink, and the child should be put to the breast. Cold water may be suddenly poured on the bowels from a height of two or three feet; and if a syringe is at hand, cold water may be injected into the passage. Twenty grains of ipecacuanha may be given in a wine-glassful of water; or if not at hand, two-thirds of a wine-glassful of vinegar in four ounces of water; one-third of a glassful being given at intervals of a quarter of an hour three times afterwards. No stimulants should be given, and the person should not be raised into the upright posture, which might bring on fatal fainting.

When bleeding occurs some hours or days after delivery, it may depend on relaxation of the womb; or on the retention of some part of the after-birth, or of a clot of blood, preventing perfect contraction; or it may arise from fright or excitement. Cold wet cloths externally, and the injection of cold water, are the means of relief.

9. CONVULSIONS may occur before, during, or after labour. All clothing should be loosened, the patient should be allowed plenty of fresh air, and the face should be sprinkled with cold water. To prevent the tongue being bitten, a piece of soft wood should be held between the teeth. If the head is hot, cold applications should be used to the forehead. An injection (Recipe 105) should also be given.

10. LACERATION OF THE PERINÆUM.—The necessity of supporting the *perinæum*, or that portion of the person of the mother exposed to pressure, as the head passes, has been mentioned at p. 620. But in first labours, notwithstanding support, some amount of tearing often occurs. This is of little consequence, as it quickly heals, and no treatment beyond cleanliness is required. But in exceptional cases the tearing may be greater; and if the wound exceeds an inch, the patient should be kept in bed with her legs tied together, the wound being frequently cleansed until healing occurs. Occasionally the rupture extends to the anus, when a surgical operation is required.

11. EMPHYSEMA, *or entrance of air into the tissues of the neck*, may occur during labour. As a consequence of the straining, air escapes from the lungs, and penetrates the neighbouring structures. It is distinguished by puffy swelling of the parts, which crackle when pressed. A cold lotion (Recipe 83), or vinegar and water, should be applied.

12. MILK FEVER, or *Weird*.—In ordinary cases, the milk flows from twelve to eighteen hours after delivery; but the patient may, especially if exposed to chill, suffer from shivering, heat of skin, quick pulse, with pain and soreness of one or both breasts, the milk being delayed. When a woman after confinement takes a shivering fit, she should be attended

to instantly; hot bottles to the feet, warmer clothing, and Recipe 50 being the requisites to induce perspiration. For, although shivering is often merely the prelude to the secretion of milk, it may be the forerunner of milk fever; or of the still more dangerous puerperal fever; or of inflammation or abscess of the breast. The bowels should be well opened by castor-oil, chill guarded against, and hot fomentations applied to the breasts. If the breasts become swollen, knotty, and hard, they should be gently rubbed with salad oil, and the infant should be put frequently to them. If matter forms it must be treated as *Abscess of the Breast* (*vide* p. 96). Fever under such circumstances is sometimes accompanied by an eruption of small vesicles on the body, attended by itching, and profuse perspiration. This is called *miliary fever*, and sometimes occurs independently of any disorder of the milk or breasts. It is favoured by too warm beds or too warm rooms.

13. Puerperal Fever.—This is a very dangerous fever, sometimes occurring after confinements. It depends on poisoning of the blood from the absorption of putrid matter retained within the womb (*vide* p. 587). When a woman shortly after labour is seized with shivering, and this is followed by a hot and sweating stage with feelings of relief, when the breasts swell, and when the discharge or 'cleansings' are passing freely, it is the *Milk Fever* or *Weird*, as described above. But when, after perspiration, no relief is experienced, when the breasts become flabby and smaller, when the discharges lessen or cease altogether, and when the pulse remains above 120 beats in the minute, there is reason to fear puerperal fever. Such fear will become certainty if prostration of strength, difficulty of breathing, and suppression of milk come on. Pain and tenderness of the bowels are very frequent and prominent symptoms. There is bilious vomiting, thirst, and profuse perspiration. The tongue and breath are foul, the face sallow, and there is probably diarrhœa, marked by the passage of hard lumps of fæcal matter. At a later period *pyæmia* (*vide* p. 587) may occur, and one or more of the joints may become swollen and painful. Puerperal fever is highly contagious, and may be carried by attendants from one lying-in woman to another. The first thing necessary is to act on the bowels and skin. Recipe 1 should be given, followed after four hours by a purgative draught, Recipe 2. An injection composed of two ounces of castor-oil and ten or twelve ounces of soap and water should also be given. Citrate of magnesia draughts (*vide* p. 15) should be taken every four hours. Injections of warm water (with, if possible, 20 to 30 drops of Condy's fluid added) should also be thrown up the private parts. The belly should be covered with hot linseed-meal poultices. Great attention should be paid to the ventilation of the room, and disinfectants should be freely used (*vide Appendix*, No. 118). The diet should be strong soups and broths.

14. Malarious post-partum Fever.—At a later date than that on

which either *milk* fever or *puerperal* fever occurs, women after delivery are, in the tropics, liable to attacks of ordinary ague and fever to which the above term has been applied. This has been guarded against in the direction, at p. 620, to give quinine as soon as the child is born. If it occurs, it does so after milk has been secreted, the secretion of milk is not checked, and there is no tenderness of the bowels as in puerperal fever. It should be treated as ague (*vide* p. 251).

15. PHLEGMASIA DOLENS, or *milk leg*, is a painful swelling of one or both legs, beginning generally in the thigh, and extending downwards to the leg. It may come on from one to five weeks after delivery, with shivering, fever, thirst, quick pulse, nausea, furred tongue, and pain in the loins. The swollen part is hot and tender, and presents a pale, shining appearance, while the power of moving the limb is nearly lost. Such cases generally do well, although recovery is tardy; and the limb may be stiff years afterwards, with tenderness, perhaps the feeling of a cord beneath the skin down the inner part of the thigh, and swelling of the leg. The swollen part should be continually fomented with poppy-head infusion; saline purgatives (Recipe 2) should be given; and saline mixture (No. 50) to act on the skin and urine, while pain may be relieved by chloral. When pain and fever subside, the swollen parts should be gently rubbed twice daily with brandy and salad oil in equal proportions; iodide of potassium (Recipe 21) should be given, and the limb should be enveloped in flannel. Generous diet, wine, and tonics will be necessary.

86. PUERPERAL MANIA.—Occasionally attacks women shortly after child-birth, or at the period of weaning, especially when there has been *over-nursing* (*vide* p. 655). It may commence with a little feverishness, or it may follow convulsions or puerperal fever. It is often characterised by loquacity, laughing, singing, obscene talk, sometimes a tendency to murder the child, and it often terminates in melancholia. If there is any hereditary family tendency to insanity, recovery may be delayed indefinitely; but, in most instances, a few weeks restore the patient. In the majority of cases there are fæcal accumulations in the lower bowels, for which aperients and injections are required. The infant should be artificially fed. Tonic medicines, nourishing diet, and cheerful surroundings are necessary, and bad cases may require special restraint against homicidal or suicidal tendencies. As the disease is liable to recur, and as debility favours an attack, a woman who has once suffered from puerperal mania should never nurse again.

CHAPTER V

THE MANAGEMENT AND FEEDING OF INFANT

Treatment after Birth.—As soon as the child [1] is born, any froth hanging about the child's mouth should be wiped away, and the head placed in a position that it may not be covered with bedclothing or other substance. Then, provided the child cries (which it probably will do unless stillborn, p. 637), the cord should be tied and cut. Two ligatures (*vide* p. 618) should be tied rather tightly round the cord, one at the distance of two and a half inches above the child's navel, the other rather more than three inches above the navel. Then the cord should be divided, *between the two ligatures*, with blunt scissors. Do not hurry this operation, as it may be delayed until all beating has ceased in the cord, by which the child receives more blood, and is probably more vigorous. When the child is separated from the mother, a warm blanket or piece of flannel should be ready to receive it (*vide* p. 617), and care should be taken lest the child slip out of hands and be injured. To guard against this, the back part of the infant's neck should be seized in the space between the thumb and first finger of one hand, while the thighs are grasped with the other. Warmth is at this time of importance, as the infant has just passed from the temperature of the mother's body into a probably much colder atmosphere, but the eyes must be guarded from glare.

[1] For the treatment of the mother, refer to Chapter IV., Pregnancy and Labour, p. 614.

As soon as a warm bath can be prepared, the body of the infant should be immersed in warm water, of the temperature of 97° Fahr., and if a thermometer is not at hand, the elbow will afford the fairest test of the degree of heat, the hand not being sufficiently sensitive. Then the greasy substance adhering to newborn infants should be washed off. This will be found adhering to the armpits, groins, eyebrows, or other places where the skin is loose. Glycerine or Castile soap and a very soft sponge will suffice for this purpose, but care must be taken that neither the soap nor the soiled water gets into the infant's eyes, which may excite ophthalmia. The infant should not remain in the bath more than three or four minutes, whether the body is free or not from the greasy substance. Any remaining deposit will separate at future washings, and its adhering for a few days will do no harm. It should be recollected, when washing the infant, that its bones are soft and unable to sustain the weight of the body. It should therefore be allowed to rest on the bath, and not be held up by one arm. After the washing it should be put on a soft pillow on the nurse's knees, and be gently dried with soft warm towels, and then enveloped in a thin flannel wrapper. Some advise powdering the body of the child after washing, but as the only benefit is to secure dryness of the skin, this procedure, provided due care be taken, may be dispensed with.

Treatment of the Navel.—The navel-string next demands attention. The string with which the navel-cord is tied should be cut off near the knot, and the knot should be examined to ascertain that it has not slipped (which it may do from the escape of a jelly-like substance from the cord), and that there is no oozing of blood, in either of which cases another ligature should be applied. Then a piece of old, oiled soft linen rag should be doubled, and cut in a circular shape, four or five inches in diameter.

In the centre of this a circular hole should be made, through which the tied cord is to be drawn. The latter should be then folded in the cloth, and the mass laid on the belly of the child, in which position it should be secured by the belly-band (*vide* p. 618). After the binder is applied, two or three fingers should pass easily beneath it; the object being, not to impede breathing, but simply to maintain a slight pressure over the navel, which at this period is the weakest part of the infant's body. In order to provide against rupture of the navel (*vide* p. 594) the bandage should be used for four months, and even then not be left off should there be any prominence of the part. The rag mentioned above should be removed, and new oiled rag applied daily. In five or six days the end of the navel-string will come off, leaving a depressed sore below, which ordinarily quickly heals. But if the string does not separate in this time, it should not be pulled or interfered with, but allowed to drop off by the natural process.

Medicine for Newborn Infants.—Many nurses are in the habit of dosing a newborn infant with castor oil, treacle, or some other substance. But this is seldom necessary, and may be injurious. The infant should be allowed to sleep for a time (which it most usually will do), the eyes being protected from strong light, and the body from draughts or cold. From this slumber it should not be waked under the idea that it will require nourishment or physic. In five or six hours the infant will probably awake crying, and may be put to the breast, which will encourage the flow of milk, and tend to secure contraction of the womb. Or should there be no inclination to sleep, which may arise from the infant being cold, it may be put to the breast at any earlier period. The milk first secreted contains natural aperient qualities, and the child should take this milk instead of the dosing referred to. It is only in cases where the first milk of the parent is not obtained, owing to the child being put to a wet-nurse, or in cases of premature birth when no milk is secreted, or from the first milk failing to be sufficiently purgative, that the administration of any medicine is desirable. Then half a tea-spoonful of castor-oil is the best aperient. The bowels of a newborn infant contain a dark secretion called *meconium*, which generally passes a few hours after birth, often with the first flow of urine; and which, unless removed, may give rise to diarrhœa. But in the great majority of instances the first milk is quite sufficient to effect this; and medicine may do harm by exciting an artificial appetite. If on the third day the stools are still black instead of yellow, half a tea-spoonful of castor-oil may be given.

Food for Newborn Infants.—The practice of feeding an infant immediately after birth is not to be approved. An infant requires little, if any, nourishment until ten or twelve hours after birth. There is a sufficient secretion from the mother's breasts to serve the scanty wants of the child. In second confinements the mother will frequently supply milk within twelve hours. If not, or in first confinements when the milk is later in coming, the infant may be fed every three hours with milk-and-water, proportioned and sweetened according to the directions at p. 648. After the mother's milk appears, the infant should obtain nourishment from this source alone. When suckling the mother should lean over and support the breast, allowing the nipple to fall into the child's mouth. During the first ten days it will be advisable to suckle the infant when it awakes; for the next twenty days every two hours by day, and every three hours by night. Frequent suckling during the first month is also better for the mother's breasts, as it maintains them constantly relieved; the distension of the breast from retained milk being a cause of inflammation and abscess. After the first month the intervals between suckling should be gradually extended to four hours. By care and firmness the habit of not suckling from 10 P.M. to 5 A.M. may also be acquired, to the great comfort of the mother. Often, when an infant cries, it is from thirst not hunger, and it may be soothed by a tea-spoonful of boiled and cooled water. The infant should be applied alternately to each breast. Sometimes a child, from some inexplicable reason, prefers one breast, and the mother, to avoid contention, concedes the point; or, in consequence of a cracked or sore nipple, the mother puts the child more to one breast than the other, the result being distension by retained milk, and often abscess.

CLOTHING.—The clothing of infants should be light, loose, and warm—especially the latter—as the innate power of generating heat is at a minimum in the new-born infant. Thin flannel fulfils these requirements better than any other texture. The garments should fasten in front, and the skirt should attach to the bodice. Sleeves and armholes should be so made that twisting the child's arms into unnatural positions may not be necessitated. Infants are frequently caused pain by their tender arms being thrust through narrow apertures, and from their skin being fretted by rough and tight garments, or by the incautious use of pins, which has been known to excite convulsions (*vide* p. 149).

WARMTH.—For warmth it is desirable that the child should lie with the mother or nurse at first; care being taken that it is not overlain, or smothered with pillows. After the first three weeks the infant should sleep alone.

CLEANLINESS AND DRYNESS.—Cleanliness and dryness are of great importance. The bath at bedtime is most useful, as it cleanses the skin, equalises the circulation, and induces languor, the precursor of repose. The urine of the infant is very frequently passed, and the bowels are often moved, and if the discharges are permitted to remain, they irritate and inflame the skin. Napkins, which should never be of waterproof material, should be changed whenever soiled, never dried and used again, and they should be fastened with a safety pin. 'Cimolite,' or white fuller's-earth, is the best application for chafing. Wet bibs are likely to give the infant cold on the chest. No soiled clothes should be allowed to remain in, and no wet clothes should be dried in, the nursery.

Occasional Maladies and Conditions after Birth.—After the birth of an infant, various circumstances may give rise to uneasiness.

1. Birth, Still.—If the child is born apparently dead, or 'still-born,' and does not cry, it may present either of the following appearances: *First, the face may appear flushed and livid, the skin red, and the cord tense and pulsating.* The first thing is to wipe out the back of the mouth with a finger covered with a handkerchief, so as to clear it from sticky mucus or fluid; then tie one ligature round the cord upwards of three inches from the navel. Then place the second ligature round the cord an inch or so below, but do not draw the knot tight. Now divide the cord between the ligature tied tight above and the ligature laid loosely below. The latter is not to be tied tightly until a tea-spoonful of blood has escaped. This will often be followed by breathing, the child beginning to cry. If respiration does not take place, the child's body should be sprinkled alternately with cold and warm water, the limbs and spine should be gently rubbed, slight pressure should be made on the chest over the heart, and, lastly, artificial respiration should be tried (*vide* p. 542). *Secondly, the face may be pale, the features collapsed, the lips blue, the jaws fallen, the limbs cold, while no pulsation is felt in the cord.* Before the cord is tied and divided, warm and cold water should be sprinkled on the breast; the back of the mouth should be cleared; the face and buttocks may be tapped with the corner of a wet cloth; the nose and back of the mouth may be tickled with a feather; and if none of these means excite breathing, artificial respiration should be tried. While artificial respiration is being tried, a hot bath should be prepared (temperature 97° Fahr.), in which, after the cord is cut and tied, the child may be immersed. Infants have been recovered after upwards of two hours spent in such endeavours.

2. Breasts, Swollen.—In some infants, a few days after birth, the breasts are found swollen, and a whitish fluid is observed on the nipple. The swollen part should *not* be squeezed, which may probably cause a 'gathering,' but it should be frequently washed clean, after which salad oil, or, if much inflamed, a bread poultice, is the best application.

3. Cold in the Head is common, some infants sneezing immediately they are born. To avoid this, infants should be kept out of draughts.

4. Cleft Palate.—This means that the roof of the mouth is split. When this occurs to any extent the child cannot suck, and therefore cannot be fed in the ordinary way, as the food passes into the nostrils instead of down the throat. The infant must be placed in a semi-erect posture, and fed with a spoon, and the food must be tilted suddenly down the throat. The milk will then be swallowed without passing into the nostril. But, as soon as possible, nipples provided with artificial tongues or palates should be procured. With care an infant with cleft palate may be well nourished, and at two or three years of age the defect may be remedied by surgical operation.

5. Constipation. *Vide* p. 138.

6. Cyanosis.—In exceptional cases this condition may be present. The whole surface is preternaturally dark and cold to the touch. It depends on an organic defect in the heart, and is incurable, although the child may live for some years.

7. Head, Alteration of Shape of.—From pressure during birth the shape of the head may be altered; the face may be disfigured; or bluish swellings may be raised on the scalp. This need not excite apprehension. The head or face will gradually assume its natural shape, and swellings about the scalp seldom require more than bathing daily with milk-and-water (*vide* p. 517).

8. Lock-jaw and Tetanus. *Vide* p. 441.

9. Navel-string, Bleeding from the.—Arises from the cord being carelessly tied, or from tapes being used, which are liable to slip. The proper treatment is placing another ligature below the first. Or the bleeding may come on when, after six or seven days, the navel-string separates. To stop this bleeding, pressure should be applied by placing the finger on the part for a few minutes. If this does not succeed, alum (20 grains to an ounce of water) may be applied with a camel's-hair brush.

10. Navel, Erysipelas of. *Vide* p. 221.

11. Navel, Ulceration of the.—In some cases the navel remains red or ulcerated, presenting 'proud flesh,' and the irritation may give rise to convulsions. This is generally easily cured by the use of alum wash (Recipe 97) and simple dressing under the bandage.

12. Navel, Rupture of the. *Vide* p. 594.

13. Nine-day Fits. *Vide* p. 145.

14. Ophthalmia.—The eyelids stick together after sleep, the edges are red, the eyes are closed when exposed to light, the lids swell, and matter is discharged. This is often caused by uncleanliness, or from soap getting into the eyes during the first washing, or by the infant,

from lying in bed with the mother, getting perspiration or sour milk into its eyes, or by exposure of the infant to too strong a light, as from a blazing fire. The *treatment* is perfect cleanliness, frequently bathing the eyes with milk-and-water, smearing the lids with salad oil to prevent them sticking together, and keeping the child in a darkened room.

15. POMPHOLIX, or BLEBS. *Vide* p. 398.

16. RUPTURE. *Vide* p. 589.

17. SPINA BIFIDA.—This is a malformation of the spine, with protrusion, in the form of a tumour on the lower part of the back. The part should be protected from pressure, and it may gradually solidify.

18. SUFFOCATION OF INFANTS.—The danger of suffocation of infants is referred to under 'Warmth' at p. 636. Even the close wrapping of a child's head in a shawl to protect from cold may effectually smother it, without any convulsive struggle as indication of what is taking place. The mother should never go to sleep while suckling, as, the child's face being pressed on the breast, and both being asleep, the child may be slowly suffocated. To keep a child quiet a bag of wash-leather or of linen containing sugar is sometimes thrust into its mouth, which may also lead to suffocation.

The superstition that cats suck the breath of infants is not well founded. They may lie on the face, or accidentally draw some article of clothing over the face, and so cause suffocation. The moral, however, is the same: never to leave an infant in a room with the door or window open, or a cat therein.

19. THRUSH, or WHITE MOUTH. *Vide* p. 446.

20. TONGUE-TIE.—If the infant sucks and protrudes the tongue at all over the lower lip, it is not *tongue-tied*, even although for some days it may not suck vigorously. 'Tongue-tie' depends on the fold of membrane (or *frænum*) beneath the tongue being too far forward, and it may be seen in some cases extending nearly to the tip of the tongue, which cannot be raised by passing a finger under it, while the milk flows out of the mouth. The method of relief is the division of this structure for a quarter of an inch or less with a sharp pair of scissors. The snip with the scissors should be directed *downwards* towards the jaw, not upwards to the tongue, to avoid cutting a blood-vessel passing through the part, from which, when cut, a troublesome bleeding has proceeded. The operation is not advised in the absence of a medical man, unless in very bad cases; and the infant must be fed with a spoon, if possible with the mother's milk—or, if not obtainable, with milk-and-water (*vide* p. 646).

21. URINE, ACIDITY OF.—Infants sometimes expel urine frequently, although only a few drops at a time. This usually depends on *irritability of the bladder* caused by acid urine. The small amount passed quickly dries on the diapers, and there is no evidence by wetting of urine having passed. But the urine is highly coloured and leaves a stain which may

be mistaken for blood. Two or three grains of citrate of magnesia (*vide* p. 15) should be given twice a day.

22. Urine, Retention of.—Sometimes infants make no water during the first twenty-four hours. When this is the case, and the infant appears in pain, crying, and drawing up the legs, a warm bath, or fomentation over the lower parts of the bowels, will prove successful.

23. Vomiting.—Some infants vomit *immediately* after suckling, the milk returning *unsoured*, or without evident cause. This probably depends on a copious supply of milk, which the infant takes too fast or in too large a quantity. A finger should be placed near the orifice of the nipple, to prevent too rapid flow.

24. Red Gum, and Jaundice.—Red or yellow gum is the term popularly given to discolorations of the skin, which may occur to infants two or three days after birth. But all instances of discoloration of the skin are *not* jaundice, as the surface is often discoloured from the blood being congested in the skin, probably from the effects of cold, or owing to pressure from protracted labour, and such discoloration requires no treatment. When jaundice occurs the child's skin is yellow, the whites of the eyes are yellow, the urine is dark, staining the clothes yellow, and the stools are white. If the eyes are yellow, and if white linen is stained yellow by the urine, there is jaundice. It is due to the liver being engorged, from the lungs not acting properly at first. As a rule no medicine is required, the first milk of the mother being sufficient to open the bowels of the infant. In bad cases, when the whites of the eyes are yellow, and the bowels constipated, half a teaspoonful of castor-oil may be given. It is some days before the skin loses the yellow tinge.

Examination of Infants.—It is often difficult for a mother to know exactly when her infant first becomes ill, or even in some cases to be sure that it is really sick. It is often difficult to decide whether a fit of crying is due to bad temper, to passing discomfort, or to disease.

The *general demeanour and expression* are instructive. A flushed or a pale face, disinclination to play, drowsiness by day and restlessness at night, and unusual fretfulness, are signs of approaching illness; and may signify probably ague, or other maladies soon to be declared by their distinct symptoms.

The *cry of an infant* is often very characteristic of the malady from which the child is suffering. The cry of passion is a furious one; the cry of sleepiness is a drowsy one; when roused from sleep there is generally a sobbing cry; a shrill cry denotes hunger or thirst, and is often accompanied by movements of head and hands, as if seeking the breast; the cry of teething is fretful and intermittent; an infant with earache will cry in short, piercing tones, putting the hand to the affected ear, and perhaps rolling the head. If after giving a baby suitable nourishment or a drink of water it still keeps up a continued cry, there is probably pain in the ear. Bowel complaint causes a straining cry, with drawing up of the legs; in bronchitis the cry is gruff and husky; in inflammation of the lungs it resembles a moan; in croup the voice is hoarse, and the breathing sounds as if drawn through muslin; in inflammation of the brain the cry is often a piercing shriek at intervals, alternating with moaning. It should not be forgotten that crying may arise from a pin pricking, or a tight string, or a rough fold of clothing.

When necessary to examine a child, as to the existence of tenderness in the bowels, for instance, it is useful to bring the child suddenly before a bright light, as one of the apparently greatest pleasures of an infant consists in gazing at such an object. It almost always ceases to scream, and continues quiet while thus attracted, when the bowels may be examined by gentle pressure with the fingers. If the pressure causes the child to cry out, with frowns or contractions of the countenance, there will probably be some condition affecting the bowels.

A child should never be roused from sleep in order to give medicine. If a child, especially an infant, sleeps, it may be accepted as an indication of a mild form of disease or of a diminution of serious symptoms. With regard to the administration of medicine to children, if they are old enough, appeal to their reason, for if children are deceived they will soon become suspicious, and future trouble will be entailed. If too young to be reasoned with, and children will not take medicine, they should be compelled. Let a refractory child be laid across the knees, the hands, *nose*, and feet being tightly held. Then by means of a medicine spoon, or other spoon, pour the dose into the mouth, and it must be swallowed. Medicine should be made as palatable as possible for children, as giving nauseous doses excites a child, the passion probably doing more harm than the medicine forcibly administered does good.

The average weight of an infant at birth is 7 lbs., and the average length 18 inches.

It may also be mentioned that tears are not shed by infants until they are from three to four months old; and that the eyes of infants are blue up to the sixth or eighth week of age.

FEEDING OF INFANTS. PROPER FOOD, MILK.—Although a tropical climate is not so fatal to infants of European parentage as once supposed, still an amount of carelessness as regards food, which in England would give rise to minor maladies, will in India become the cause of fatal diseases. But with care as regards feeding, and under good hygienic conditions, there is no reason why European-born children should suffer in the future from passing the first years of their life in the tropics. At the time of birth the digestive organs of the child are in an immature state, and it is only gradually that their power becomes developed. For the first few months no saliva is secreted, there are no tears, and the stomach and alimentary canal are comparatively short. The teeth do not appear until the lapse of several months. All conditions pointing to feeble digestive capacity, and evidencing that the food must be specially adapted to the digestive powers. Of such food there is only one kind, namely, milk.

WOMEN SHOULD SUCKLE THEIR CHILDREN.—It is in accordance with nature that a *healthy* woman should suckle her offspring. The avoidance of this duty often reacts injuriously in various ways on the system of the mother. As nursing, generally speaking, prevents conception up to the tenth month, so it prevents the ruin of the mother's constitution by too rapid child-bearing. Moreover, it is advantageous to the breasts that their natural functions should be carried on, and may probably prevent the future development of breast diseases. But there are certain conditions of system, as a consumptive tendency, which forbid nursing, and the remarks apply only to healthy females. Notwithstanding the extreme desirability of *healthy* females suckling their children, there are a large number of Englishwomen in India unable to undertake this duty. In addition to those suffering from actual disease, or weakened by former attacks, there is a more numerous class who are debilitated, to a greater or less extent, by heat, malaria, and the relaxing nature of the climate. It is shown (*vide* p. 665) that the above influences lead to degeneration of the blood. And this is especially apparent in the weaker system of the female, particularly when child-bearing, parturition, and suckling are superadded as causes of debility. It may be broadly stated that, as a result of residence in India, the majority of European women are physically unable to nurse after the second or third confinement. On the first occasion they may be equal to the task, and should, when possible, nurse. But with every desire to fulfil such duties they find their strength unequal to the strain. Persistence in nursing after the appearance of the symptoms detailed at p. 655 is followed by gradual or sudden cessation of the secretion of milk.

QUESTION OF SUPPLEMENTING MOTHER'S MILK BY HAND-FEEDING.—When the mother finds her milk inadequate to supply the wants of the child, the question arises whether the mother's milk cannot be supplemented by hand-feeding. Many mothers are averse to delegating the duty of suckling to other women. In the minds of some people there is an objection to their children being suckled by a native female; but although the mother who bears a child may impress constitutional peculiarities on it, milk cannot subsequently do so. Others, again, may be unable to bear the expense of a wet-nurse or 'dhai'; or a suitable wet-nurse is not procurable. Such circumstances must sometimes lead to *supplementing* the milk of the mother by hand-feeding. But it is a practice which cannot be recommended. It is a fact that whenever the milk is not *sufficient* for the wants of the infant, it is also more or less *deficient* in qualities on which its nutritive properties depend; and it is therefore unsuited for use. The limited supply shows that the constitution of the mother is unequal to the tax, and milk of the best quality cannot be secreted by a person whose constitutional powers are failing. The sooner these facts are appreciated and acted upon, by the employment of a wet-nurse, the better it will be for both mother and child. But if from any cause a wet-nurse cannot be obtained, it will be advisable, on the appearance of the symptoms detailed at p. 655, for the mother to leave off suckling *immediately*, and to trust to hand-feeding. The child should then be fed as mentioned at pp. 646, 648.

COMPOSITION OF MILK, AND THE SELECTION OF A WET-NURSE.—One hundred parts of milk contain nearly 90 parts of water, the remaining being solid constituents, as *caseine*, or cheesy matter, sugar, fat, and various salts. The milk of women is liable to certain natural changes at different periods of suckling. The first milk differs from that afterwards formed in containing slightly purgative principles, the utility of which is referred to at pp. 625, 635. Until the end of the first month the amount of sugar is less than afterwards, and the *caseine* or *nitrogenous* matter is presented in a more easily digestible form than subsequently. From the eighth to the tenth month sugar is in excess. Caseine is most deficient during the tenth and eleventh months, and most abundant during the first two months. During the first month there is also more butter, or fat, and salts than at any other period.

From the above it is evident that when *selecting a wet-nurse* one of the requirements should be, that the milk should have commenced about the same date as that of the mother. The general health of the woman should be attentively considered; her teeth should be good and her breath sweet; and freedom from piles, from enlarged spleen, and from any skin disease must be ascertained. If either the woman or her husband has suffered from prolonged sore-throat, she should be rejected, as it is probably venereal. The condition of the child should be examined, and the mother of a weak, puny, badly nourished infant should be rejected; especially if there are sores about the buttocks, privates, or corners of the mouth, which are also probably venereal. No woman who has suckled any other than her own child should be engaged, unless the child is seen, for a woman may contract disease of the breast from one child, and convey it from her breast to another. It should also be ascertained that there is no epidemic disease where the woman comes from, as small-pox, scarlet fever, or measles. The condition of the woman's breasts should be examined, which should be round, prominent, with veins visible, and affording a rather hard, knotty feeling. It is not necessary that the breasts should be large, as those of a moderate size often furnish most milk; but it is important that the nipples should be well developed and projecting, and free from sores. A little milk should be procured, which should present a bluish-white colour, and possess a sweet taste. If tested with test-paper (*vide* p. 288) it should afford an alkaline, not an acid reaction; and if examined under a microscope, all globules should be seen floating about separate and free, and not massing together. Allowed to stand a few hours, it should give a thin film, resembling cream. Dropped in water, healthy human milk should form a cloudy mixture, and not sink in thick drops. The goodness of the milk may also be judged of by observation of the nurse's child. If it sucks heartily, the milk is most likely good; if it sucks laboriously, desists, and cries, the reverse is probably the case. Inquiry should be made as to whether the woman has been 'unwell' since nursing, for if so the milk is never good, and will probably soon stop altogether. Although the age of the wet-nurse's child should as nearly as possible correspond with that of the infant requiring wet-nursing, the age of the wet-nurse herself is not so important a matter. A woman from twenty to thirty years old is advisable. Native women commence having children at an early age, and cease to do so proportionally early; and neither a very young girl nor a woman approaching the termination of her child-bearing era is desirable. The woman should be of temperate habits, not addicted to over-eating or to drink, or to smoking opium or hemp. In certain parts of India, a moderate indulgence in tobacco-smoking must be permitted, as some women—Bheels, for instance—will rarely take service if debarred from the customary pipe. Cleanliness, equanimity of temper, cheerfulness, and an open, frank disposition are to be greatly desired. Lastly, the association of the woman with her friends and relatives should, if practicable, be stopped. If she becomes 'unwell,' or pregnancy occurs, the child should be taken from her. When a change of aymahs has to be made, the woman should not be told until a successor is at hand; as the tidings, perhaps exciting the woman, may influence the milk, and so injuriously affect the child.

The possibility of *deception* should be held in view. A woman by drinking largely, and by allowing the milk to accumulate, may present the appearances of breasts well supplied with milk, while in reality the daily amount secreted is not sufficient for a healthy child. Such deception may be suspected when a thin feeble-loooking woman appears with overflowing breasts. The only sure method of detection is applying a child to empty the breasts and watching the rapidity of the reaccumulation of the milk. It should also be ascertained that a child shown by a wet-nurse is not a borrowed one.

WET-NURSING FROM BIRTH.—The milk of a healthy woman is too rich for the delicate stomach of the infant during the first two or three days of its existence. It should therefore be fed artificially for the first seventy-two hours, in the manner detailed at p. 648; and on the first three or four applications of the child to the 'dhai,' it should be permitted to take only a small quantity of milk. If a wet-nurse confined at the same time as the mother of the child were available, the precautions as above would not be required; but this can rarely be the case. It is in instances of the kind, when the child does not take the first milk from the mother, that some aperient dose (*vide* p. 634) may be necessary for the infant.

It occasionally happens that, from some unexplainable cause, the milk of one woman disagrees with a child while that of another woman suits. Such exceptional case may be suspected when, after regulating the diet of an apparently healthy 'dhai,' and after any costiveness of the bowels of the woman has been removed by castor-oil, the child still does not thrive. Under such circumstances a change of nurses may be necessary. But alterations of the kind are often attended with much trouble and expense, and therefore should not be made on insufficient grounds. Very frequently when an *aymah's* milk disagrees, the reason may be found in the fact of the woman on becoming an *aymah* being able to indulge in a richer diet, while leading a more lazy life. Owing to the anxiety of parents that the nurse of their child shall be strong, too much or too rich food is often provided, the result being a change in the character of the milk, which therefore disagrees with the child. The fact of a child not thriving so well as could be wished cannot be immediately accepted as a reason why artificial feeding should be substituted, but must be regarded as indicating some dietetic error requiring amendment, and the desirability of some employment for the woman. Or, the child may not thrive from the fact of the woman surreptitiously suckling her own infant. Or, there may be a superabundance of thin poor milk, which is suggestive of its soon ceasing altogether (*vide* p. 655).

After ten days, it is desirable to teach the infant the use of the bottle. A tea-spoonful of goat's milk with four of water may be given once a day. This is *not* for nourishment, but as a *precaution* against interruption of the nurse's duties from sickness or otherwise, when it might be difficult to get the child to take the bottle.

HAND-FEEDING.—If the mother cannot suckle, and if a wet-nurse cannot be procured, *hand-feeding* must be adopted. Many, having known a successful instance of hand-feeding, regard it as generally applicable, but experience and statistics show the reverse. *However carefully conducted, it is a most fertile source of infantile disease and mortality.* Hand-fed children, although increasing in weight, and often *looking* fat and well, have not the harder flesh and stamina of breast-fed infants. They are more liable to diarrhœa, convulsions, rickets, and other maladies, and they do not recover from ailments so rapidly as the breast-fed. Human milk being the natural food of an infant, it will be preferable to somewhat relax the rules for the selection of a wet-nurse, rather than incur the risk of injuring the infant by other varieties of milk. Any ordinary healthy woman's milk is better for a child than the milk of a quadruped.

When hand-feeding is indispensable, it is expedient to modify the milk so as to make it resemble as much as possible that of a woman. The best substitute for delicate children is ass's milk, as in some respects it more nearly resembles that of woman, particularly in the high proportion of sugar and large amount of water it contains, although there is a great deficiency in solid matter. It is for this reason better adapted for the delicate stomachs of children reduced by illness than for the wants of a vigorous growing child. In India goat's milk is perhaps most desirable, which, although containing more solid constituents and less sugar than human milk, is more like the latter than most samples from the cow. The latter fluid contains more caseine, fat, and salts than either, and less sugar than ass's or woman's milk. Analysis of milk, however, varies, and different samples secreted by the same animal furnish somewhat different results, which must be influenced by feeding and the health of the animal. Hence it happens that sometimes goat's and at other times cow's milk agrees best with an infant. As a rule for India, goat's milk may be said to be the most suitable, and it is often the most conveniently procured.

Whatever animal is selected, it should be kept and fed for the purpose, as both the Indian cow and goat are very promiscuous and dirty feeders when hungry. It is best to see the animal fed, as servants may give inferior food. Grains from breweries should not be used, or the milk may cause diarrhœa. At the commencement of the rains, when green grass becomes plentiful, if the animal eats much of it a similar effect may be produced. The animal should be kept very clean, and should *not* be allowed to drink dirty water. The vessels in which the milk is received and kept should be scrupulously clean, put in a cool place away from sewers and smells, and protected from flies. The child's food should *never* consist of milk taken from two animals, even of the same class.

Supposing a child to be fed on ass's milk from its birth. For the first few days it should be given in the proportion of two-thirds milk and one-third water. After the first four or five days the quantity of milk may be gradually increased, until at the end of a fortnight ass's milk may be given pure. Ass's milk, being so rich in sugar, requires no addition of this kind. If cow's or goat's milk is used, it should be given for the first ten days mixed with one-half the quantity of water. After this period the amount of water may be gradually diminished, until at the end of the fourth month goat's milk may be given pure, and cow's milk almost pure. At the end of the fifth month cow's milk may be given pure. Both goat's and cow's milk, being comparatively deficient in saccharine matter, require the addition of sugar. 'Sugar of milk' is preferable, as it is not fermentable like other sugars, and is therefore less liable to turn acid on the stomach. If sugar of milk cannot be procured, pure white loaf sugar is best. Moist sugar should never be used, as it is certain to ferment in and disorder the stomach. Much harm is done by rendering the food too sweet. The desideratum is to form a compound resembling human milk. A moderate 'mawkish' sweetness is all that is required. The palate of the mother should be accustomed to the taste of good human milk, and the food prepared accordingly. A little variation in the sweetness or otherwise of an infant's food will make all the difference as to the food agreeing with the child or not. The *temperature* of an infant's food should be, as nearly as possible, that of the mother's milk; or, at least, it should not be below 96° Fahr. or above 98°. In addition to the above precautions, it will be desirable to test for acidity with litmus paper (*vide* p. 288). Woman's milk is slightly alkaline, and stall-fed cow's milk is often slightly acid. When this is the case a few tea-spoonfuls of lime-water (Recipe 25) may be added. It will also be desirable, when the infant vomits clotted material, to render cow's milk less rich in *caseine*. This is effected by exposing the milk to a gentle heat, in a wide open vessel, when a film of caseine forms on the surface, which may be removed with a spoon. Or sometimes cow's milk suits best if let stand for two or three hours in a tall glass, then dipping out the upper third, and using the lower two-thirds.

If the motions of a child fed on cow's milk contain specks of white undigested caseine or curds, a little barley-water added to the milk may correct this. Or, if the child is upwards of three months old, a *very little* farinaceous food, as Brighton biscuits, may be added, which, mingling with the curds, mechanically divides it, rendering it more digestible. This is a different thing from feeding on farinaceous food, which is highly objectionable (*vide* p. 652). Or the milk may be temporarily peptonised by Fairchild's powders, which have the property of rendering curds more digestible. Infants' milk may be peptonised as follows. Into a clean nursing-bottle pour ¼ pint of milk, ¼ pint of warm water, and ¼ of a Fairchild Zymine Peptonising Powder; place the bottle in water as hot as the hand can bear for *twenty minutes*; add a little sugar of milk to sweeten, and boil quickly; if this be not done a slightly bitter taste is developed.

IMPORTANCE OF FRESH MILK.—Milk given should be perfectly fresh, and not in the slightest degree soured, either by weather or by dirty vessels. Perfect cleanliness of the latter, and of the feeding-spoon or nursery bottle, cannot be too much insisted upon; and to secure this they should be washed in hot water containing a few grains of carbonate of soda, both before and after use, and be kept immersed in a similar mixture till again wanted. Sour milk, or soiled vessels, often cause bowel complaints. The least atom of stale milk sticking to the tube, or cork, or bottle will turn sour fresh milk touching it, and cause vomiting and diarrhœa. The crevices of corks are liable to hold atoms of decaying milk, and therefore a wooden stopper should be used. A ready method of turning the milk sour is allowing it to be in the bed, warmed by contact with the child's body. More milk than a child requires for the meal should never be put into the bottle. A grain of carbonate of soda added to the milk will prevent it turning sour for some time—a plan which may be adopted on a journey.

Importance of Pure Water.—This is dwelt upon at p. 678. But further precaution is required where infants are concerned. The water should be filtered and afterwards boiled. It should then be allowed to cool, and, when required for use, should be heated to the proper degree.

General Rules for Feeding.—A child should be fed from a bottle, and not from a cup; for the act of sucking, when feeding from the bottle, promotes the flow of saliva, mixes it with the food when the saliva appears, and thus assists digestion. Of various bottles 'the British feeding-bottle' may be recommended, as the infant using it cannot suck in air; or, still better, the Burroughs & Wellcome 'thermo-safeguard feeding-bottle,' which is graduated in ounces, thus enabling the nurse to estimate the exact quantity of food to be given. A strong thermometer embedded in the glass registers the temperature of the food. But the use of long tubes attached to bottles is not advised, as there is danger of some particle of the food remaining in the tube which will turn sour, in which case it will permeate the whole mass of food taken at the next meal and cause stomach and bowel troubles. The plain black rubber nipple is the best, and can be used upon any bottle having a heavy lip or rim. As a rule the food should be warmed by dipping the bottle in hot water, and not over a fire. An infant should be fed slowly in the semi-erect posture with the head slightly raised; and it should never be played with or dandled immediately after feeding; but it should be placed on its right side or back and kept quiet. It should be fed regularly every two or three hours during the day, and two or three times during the night; in the latter months of infancy, less frequently. The mother or nurse should always put the nipple to her lips the last thing before feeding the infant, and make sure that the nipple is clear and all is right.

The above are general rules for feeding an ordinarily healthy child. But it may happen that, from accidental causes, such as overloading the stomach, or from some deviation in the quality of the milk, temporary modification in the feeding, *generally in the way of further diluting the milk*, will be advisable. Both *over-feeding* and *too thick food* must be guarded against. It should be recollected that an infant quite as often cries from repletion as from hunger. If the child's stomach is overloaded, it will produce flatus, hiccough, indigestion, vomiting, diarrhœa, or other disorders. An infant under one month old will probably consume about two and a half pounds avoir. *per diem*, or from two to five ounces at each meal; at three months old about three pints daily; but no definite quantity can be directed for a child of any given age.

CONDENSED OR SWISS MILK.—While infants take readily to such food, on account, probably, of the sweet taste, and also grow plump, they are not in reality strong when so fed. A slight ailment renders them prostrate to a much greater degree than when fed on fresh animal milk. Still it may be necessary, on board ship, or when making long journeys, to use such food. Then for infants up to a month old a tea-spoonful of condensed milk to a teacupful of warm barley-water is the proper strength. After about six weeks it would be desirable to add to it some malted food as mentioned below. If on opening a tin of condensed milk gas escapes, it is bad.

WHEN A CHILD MAY BE FED WITH OTHER FOOD THAN MILK.—When a child is first given other food, it should only be used as an addition to the natural food, milk, and not as the main means of support. *Farinaceous* foods, as sago, arrowroot, rice, tapioca, gruel, often selected on account of their supposed lightness, are digested with difficulty by the infant, for they contain starch, which has no existence in milk. Such food excites eructation and vomiting, intestinal irritation, and diarrhœa. And not only are these farinaceous articles of food hard of digestion, but when reduced to their ultimate elements, as they must be in that process, they differ much from milk, the only natural food, and are thus rendered the most unsuited for the nourishment of the body. Food has two uses—one to afford matter for the growth of the body, the other to give material for the maintenance of the animal heat—and a child is not nourished in proportion with the bulk of the food swallowed. Health, and even life, cannot be long supported except on a diet in which the elements of nutrition and the elements of animal heat bear a certain proportion. In milk these are combined in the proportion of one to two. In arrowroot, sago, and tapioca, the proportion is one to twenty-six, in wheat-flour one to seven. Thus the child fed on farinaceous food is actually starved to death, for it is forced to supply from its own tissues the nitrogenous elements essential to the maintenance of life. This is a frequent cause of atrophy, diarrhœa, and convulsions.

From the above it is evident that a child should not be fed on other food than milk until some indication appears of the development of the digestive organs. The first sign is teething. As a rule, until the first teeth appear, no other food than milk should be allowed. After this period some kind of 'malted food' may be given cautiously, in small quantities, and at first only once in the day. These 'malted foods'[1] are really farinaceous, but the starch has been so treated by chemical process that the work of digestion has been partially performed.

It is not well to continue the use of 'malted food' too long. If we habitually rear children without putting them to the necessity of digesting their food, we shall evolve beings of weak digestion—Nature's revenge on organs not used. The proper use of malted food is as an aid to digestion at the period of transition from milk to other diet, and in cases of ailing children; but *not* as an ordinary food or as a substitute for milk, for without milk children are liable to become latently scorbutic.

After about a month ordinary farinaceous foods may be combined, those containing wheat-flour being, for the reasons above stated, the best; such as 'tops and bottoms,' or cornflour, or rusks, or Robb's biscuits, or prepared barley or soojee, sometimes one, sometimes another, agreeing best with the child. It will also be advisable to add a grain or two of salt to each meal. Animal food should not be given until two of the back teeth have appeared. As a preparation for animal food, especially for debilitated children, the following is advisable. Four ounces of milk, half an ounce of cream, a tea-spoonful of arrowroot, the yolk of an egg nearly raw, half a pint of warm water. For the first animal food, nothing is better than beef-tea in which sago has been boiled. Gradually the child may be accustomed to take chicken or mutton broth, eggs, rice, and dhall, and fine mince. Potatoes should be avoided, as unless very soft and mealy, lumps may be swallowed, which will irritate the bowels.

WEANING.—The propriety or otherwise of weaning a

[1] The Kepler Extract of Malt may be recommended.

child in India must be considered with reference both to the condition of the child and of the mother or nurse (*vide* Over-nursing). Speaking generally, weaning should not be commenced until the child has attained the age of twelve months, and then only provided the child is strong and healthy. If the child is not in good health, suckling should be continued until the child has cut at least twelve teeth. A good rule is, if dentition is backward delay the weaning; although suckling may be supplemented by some of the malted foods mentioned above. Weaning should not be commenced when a tooth is irritating, not in the autumn, the season of diarrhœas, and not when there is cholera about. When weaning is determined on, it should be a gradual process, and should be begun at night. The better way is to separate the child, and if it cries, it may be soothed with some tepid water. It will probably get very little sleep; but by the second night, if the mother has not yielded, half the work will have been done. The third night the child will probably sleep, or it will be satisfied with water. Too mixed diet should not be given after weaning, various articles being tried singly in succession for a few days, in order to ascertain which is most suitable for digestion. Milk-and-water thickened with baked flour or with well-baked bread, 'pish-pash,' or weak broth, suits most infants. No meat should be given for some weeks, and allowing a bone to suck is not recommended, as it will probably lead to a little meat and the daily demand of the child for more. When meat is given, it should be very finely minced.

The mother's breasts ordinarily give no trouble when weaning is performed gradually, but if necessary the dispersion of the milk may be assisted by a poultice of parsley leaves, by saline aperients (Recipes 2, 4, 6), by rubbing the breasts gently with soap liniment, or, if procurable, with belladonna liniment, and by abstinence from much fluid to drink. Drawing the breasts is not recommended, as it favours the continued secretion of milk.

OVER-NURSING.—The first signs are a dragging sensation in the back when the child is at the breast, and an exhausted feeling afterwards, often described as a 'sinking at the pit of the stomach,' and in exceptional instances there may be an *excessive secretion* of thin poor milk. In these cases, there is a constant oozing and loss of milk, which keeps the clothing wet, while the child suffers from its innutritious, watery character, and the mother from the amount of the discharge. These symptoms are accompanied or quickly followed by loss of appetite, constipation, or diarrhœa, sleeplessness, pain in the left side, often pain at the top of the head, or brow-ague, or throbbing of the temples, with giddiness, and depression of spirits, singing in the ears, disorders of the sight, palpitation of the heart, and a short dry cough. The monthly discharge may reappear, and may be irregular or excessive, with constant 'whites.' In extreme cases, the countenance grows pale and sallow, the body wastes, and there may be night perspirations and swelling of the ankles. When such symptoms appear it is useless attempting to support the strength by more generous diet, by ale, porter, or stimulants, as is often tried. The woman should cease suckling, otherwise Nature will take the case in her own hands, and the secretion of milk will stop—not, however, until the constitution is probably permanently impaired by the persistent drain which has been maintained. When *puerperal mania* appears long after a confinement, it is almost invariably in women debilitated by over-nursing.

WHEN CHILDREN SHOULD BE ALLOWED TO WALK.—The bones in a child's leg are soft, half cartilaginous, and easily bent. People who urge children to walk prematurely are often responsible for lasting injury. Long before soft bones ought to have any strain put upon them, infants are frequently made to stand and walk, so that the legs, especially if there is any rickety or scrofulous family taint, become bent. When children are a year old they should be encouraged to creep, but not to walk till after eighteen months.

CHAPTER VI

THE PRESERVATION OF HEALTH

THIS section is suggestive of the course to be followed to secure the preservation of health in the varying circumstances of residence and exposure in a tropical climate. Hence something of the following will be familar to those who have paid attention to sanitary demands. But to render the treatment of the subject such as will prove useful to all, the reader must be assumed ignorant of the topics to which the following pages refer.

The European is more or less rapidly—in these days much more suddenly than when so many doubled the Cape—transported from a climate where the mean temperature is low to one in which it is some twenty degrees higher (82° Fahr.), where the sun's rays are vertical, where the rainfall is violent, and instead of being spread over the greater portion of the year is practically confined to certain seasons, and where changes of temperature, both seasonal and daily, may reach 50°. The three great divisions of the year into hot, cold, and rainy seasons are found to be more or less correct throughout the whole Indian peninsula. But, consequent on periodical rains, mountains, sea coasts, rivers, jungles, varying soils, and sand tracts, most localities are found to possess a different climate, which is further influenced by cultivation. Thus local climates in India are more varied than at first would be supposed, and are consequently more or less inimical to the constitution of the European who sojourns therein.

It cannot be too much impressed on Europeans in India that the diseases incidental to the climate may be often escaped, or at least modified in severity, by attention to ordinary sanitary principles and to personal hygiene, especially by those newly arrived in the country. The Anglo-Saxon race is, perhaps, above all others endowed with a resisting power against the evil effects of adverse climatic influences; and this power may be materially assisted by care, and by avoidance of evident causes of disease. Improved habits of life and public sanitary measures of recent years have already increased the value of both European and Native health in many parts of India (*vide* p. 680).

In a hot climate the European must defend himself against three principal climatic enemies, and these are—HEAT, so-called MALARIA, and, paradoxical as it may appear, COLD. Keeping these three causes of disease prominently in mind, he must next look to the quality of the WATER he drinks; to the securing of a proper amount of SLEEP; to the quality and quantity of the FOOD he eats; to the amount of fermented LIQUOR he consumes; to EXERCISE; to CLOTHING; to the BATH; to the HOUSE he lives in; to the CONSERVANCY of his premises and neighbourhood; and to the CONDUCT OF THE PASSIONS. These subjects are now considered separately.

HEAT.—Heat will induce disease both *directly* and *indirectly*. *Directly*, as when an *immediate* fever or sunstroke is the result of exposure to the direct rays of the sun; or *indirectly*, as when *heat syncope* or fainting, *heat asphyxia* or suffocation, are excited by the sultry atmosphere of the Indian dog-days, or by the hot and vitiated air of crowded hospitals or barracks, *without any direct* exposure to the sun. *Long-continued heat* also acts still more *indirectly*, causing insidious blood-deterioration (*vide* p. 665).

Heat acting *directly* interferes with or suspends some of the most important natural functions of the body. Heat is continually produced within the body by chemical changes connected with respiration and nutrition, and this heat is regulated by evaporation and perspiration from the surface, and by the excretions. If anything prevents the latter opposing forces acting, natural heat accumulates in the body; which also, if unprotected by evaporation, absorbs heat from the hotter external atmosphere. Heat thus accumulating beyond a certain point causes paralysis of the nerves supplying the heart, or the muscles of respiration, or the brain. The hot dry atmosphere of Upper India is better tolerated than the hot damp atmosphere of Southern India, although the temperature is lower. For hot dry air favours evaporation, and this tends to keep the body cool, while in damp air evaporation decreases, and the natural cooling power is thus greatly diminished. But in any district the heat is too great, and too long continued, to be withstood with impunity, unless under precautionary measures. Hence the desirability of avoiding as much as possible exposure to the direct rays of the sun during the summer season, when, if practicable, the European should remain under the shelter of a roof between the hours of 9 A.M. and 4 P.M. Infants and children should be indoors by 7 A.M., for by that time the comparative coolness of the morning air is gone. Much of the fever and digestive ailments occurring to children is due to exposure to the sun. But such avoidance of exposure is not always in the power of every person. Work must be done and the sun must be braved. The surveyor or engineer must sometimes be abroad at such seasons looking after his works; the soldier must attend to the calls of duty, whether by day or by night; the doctor must obey the demands of his patients; the traveller pressed for time must proceed, whether the vertical sun shines fiercely or the frost of Upper India appears colder than that of Europe. On such occasions protection of the *head*, *back*, and *bowels* is the principal means by which exposure may be rendered less inimical. Therefore the adoption of a suitable headdress is a *sine quâ non*. But a material suitable for a headdress which will admit of compression without injury, and yet resume its shape, which possesses the characteristics of strength, durability, and lightness, is still a desideratum.

Thin leather is perhaps the only material, certainly the material more easily obtainable, most fulfilling the indications required. A low-crowned helmet, constructed of two layers of thin leather, is perhaps the most efficient headdress. The summit of the crown should be sufficiently elevated not to touch the top of the head. Where the helmet fits the head laterally, the separation of the two layers should be about a quarter of an inch. If the space is wider, as in many pith or wicker-work hats, the hot wind is allowed to pass in excess to the head, the hair and scalp are maintained dry by the immediate evaporation of the perspiration secreted, the head grows hot, and the person is thus predisposed to *coup de soleil*. On the other hand, if the headdress is so made as to admit of but very moderate ventilation, the head is maintained moist, a desideratum in all districts where the hot winds blow. The ideas prevalent, that the hair is injured by maintaining it wet with perspiration, and that baldness is thereby produced, are erroneous. Only a little extra cleanliness and care, with brush and comb, is necessitated. Sunstrokes will seldom occur when the head is *wet*, but when *dry* there is danger.

The *puggree*, or turban, should be some thin cotton texture, at least seven yards long, and, when doubled twice, eight inches broad. This may be wrapped according to fancy round the helmet, taking care that the greatest number of layers are over that portion where the helmet comes in contact with the head. But this is not the only use of the turban. When travelling, it should be worn as a 'cummerbund,' or protection to the bowels and loins at night. Thus the turban would defend two vitally important parts at that period of the twenty-four hours when each most requires defence, viz. the bowels by night and the brain by day. Also, when halting by day in the shade, with (as often is the case) a hot wind blowing, and converting the surface of the body into a kind of tatty, it is advisable to wind the turban round the bowels. This simple precaution will prevent chill, which otherwise may be the cause of bowel complaint. And for this use the turban is recommended to be sufficiently broad to reach over the whole bowels, and to be long enough to pass round the body several times. The protection of the head may be still further secured by wetting the 'puggree' with water before going into the sun, or by placing inside the hat a wet handkerchief, or green leaves, of which the best is plantain leaf. And the protection of the bowels may be rendered more certain by the habitual use of a flannel belt over the parts. This, with the addition of the turban, at the times and under the circumstances indicated above, will reduce the chances of bowel complaint, at least from cold, to a minimum.

The best and most simple belt is a piece of hemmed flannel of the ordinary breadth, and long enough to pass round the body, from the right hip to the left hip, where it may be pinned. This secures a double flannel over the bowels.

The *protection of the spine* is scarcely of less importance, for there is a species of *coup de soleil*, known as *heat asphyxia*, in which the origin of the evil is referable to the spinal cord. That part of the spine just below the neck, from which the nerves of respiration pass to the chest, becomes congested by the heat, the nerves become paralysed, the chest ceases to expand, and the person dies suffocated. Many cases recorded as sunstroke are, in fact, heat-suffocation. *A priori*, allowing the puggree to fall over the back would appear the most facile method of accomplishing the object. But there are several objections to this. The weight of the puggree hanging down becomes irksome to the wearer, who, when the puggree lies close to the coat, cannot move his head with freedom. On wind blowing, the puggree moves its position, and ceases to afford the desired shelter. The floating ends are also liable to entangle in adjacent objects, sometimes flapping round the wearer's face, and perhaps obscuring vision at a critical time. What is required is an immovable protection for the spine, which may be put on and off with the clothing. This is to be obtained by placing a pad about seven inches long and three wide from the collar of the coat to about the lower angle of the bladebone. This pad should be constructed of cork shavings—a material which, while acting as a non-conductor of heat, is light, and sufficiently soft not to occasion inconvenience even if lain upon. The shavings should be stitched, so that the position of the pad cannot alter. The thickness of the pad should be about three inches.

The protection of the whole body from direct heat is also necessary. For short distances there is the 'chatta,' or umbrella. Yet this can scarcely be used on horseback, when actively employed, or when in pursuit of game. But it should be recollected that what keeps out cold will, to a certain extent, also keep out heat. Or, stating the case scientifically, what is a bad conductor of heat *from* the surface of the body will be a bad conductor of heat *to* the surface of the body. Hence it is not advisable that the clothing of Europeans in India should be so thin as the majority of persons would suppose. Light it should certainly be, but the texture should be such as, while not inconvenient from weight, will yet afford some protection to the surface of the body. For the equestrian, even in the hottest weather, nothing will be better than cord breeches and flannel shirt, with overcoat of flannel or cotton. When less active exertion is anticipated flannel is also still desirable (*vide Clothing*, p. 688).

Exposure to indirect heat must be guarded against by ventilation of dwelling-houses, especially of sleeping-apartments. And this should not be done by rule and measure. The number of cubic feet available as breathing-space is a fallacious method of gauging the capabilities of a sleeping-chamber. Except in the coldest weather of the coldest part of India, and in some positions and localities during the rains and unhealthy season, some doors or windows defended by chicks should always remain open. The sleeping-cot need not be placed in a draught, but to one side, so that ventilation may be secured without danger of chill. The punkah, thermantidote, and tatty are also useful in guarding against the effects of heated atmosphere. In many parts of India the punkah is always grateful by day, while the thermantidote and tatty will aid in reducing the temperature of the whole house. But they should be so placed that the wind passing from them does not blow directly on the person, as various diseases not unfrequently result from sitting too near or sleeping in front of these contrivances; and the thermantidote hole should be lower than it is usually made, by which the cool air is distributed more equably over the room. The night punkah is also very necessary in some districts where the oppressive sultriness forbids sound and refreshing sleep. But this may become a source of danger. The punkah-puller may sleep when, the wind from the punkah ceasing, the European becomes drenched in perspiration. The punkah-man, suddenly wakening, commences a vigorous pull, and rapidly cools the sleeper by the evaporation thus produced, the result being chill and its consequences. Or, while cooled by the action of the punkah on one side, the other half of the body in contact with the bed is wet with perspiration. The sleeper turns, and the process of evaporation, as above described, commences, with perhaps similar result. There are many parts of India where, from the extreme oppressiveness and sultriness of the night at certain seasons, the punkah cannot be dispensed with, and the lesser of two evils, viz. the chance of chill and its consequences, must be chosen, instead of the certainty of the debility and destruction of health attendant on continued sleepless nights. But in the more northerly districts the night-punkah may often be dispensed with, and in other localities generally favoured with the sea breeze, it is scarcely required, except perhaps for a short time during the most sultry weather.

Sleeping in the open air, or even in the verandah, would at least secure due breathing-space, but it is a practice which cannot be generally recommended. In the early part of the night the person, unable to bear clothing, either designedly or unknowingly throws off everything. Towards morning there is a considerable fall of temperature just at the period when during sleep the least animal heat is produced, and when the vital powers are less than at any other part of the twenty-four hours. The person so indulging often awakes chilled, and probably gets so-termed malarious fever. In the so-called malarious and damper portions of the peninsula such indulgence should never be permitted, as in addition to the morning fall of temperature chills from land winds and sea breezes, or from heavy dews, are liable to occur, and any check to the perspiration from such causes may excite liver disease, dysentery, or fever. Moreover, malaria is supposed to be more powerful during the hours of darkness. But there are parts of India where sleeping in the open air during the very hot weather is permissible, if not more advisable than subjection to the uncertain action of punkah, thermantidote, or tatty. In those countries of Western India where the hot winds blow steadily in one direction by day, where heated, if not hot, winds continue far into the night, and where comparatively little atmospheric moisture exists, the cot may safely be used in the compound, with some chance of refreshing sleep. It is not advisable, however, to sleep anywhere in the moonlight (*vide* p. 335).

Long-continued heat acts injuriously on the person of a native of a temperate climate, producing blood deterioration or *anæmia* in various ways through the nervous, circulatory, and respiratory systems, which is briefly explained below.

Even in a temperate climate a season of extraordinary heat causes languor, debility, and loss of appetite. This it does by a depressant effect on the nervous system. There is, therefore, as the starting-point of tropical heat blood deterioration, that approach to the condition which results from extraordinary heat in temperate latitudes. The greater portion of the waste of the body is passed off by the lungs, liver, skin, and kidneys; in the breath, bile, sensible and insensible perspiration, and urine. The atmospheric oxygen taken in by the lungs unites in the delicate tissues of those organs with the carbon of the blood, which it thus cleanses of noxious or effete matter, returning it to the external atmosphere in the shape of carbonic acid. In a temperate climate a full-grown man thus gives off with the breath about 8 ounces of carbon every twenty-four hours. But the atmosphere of the tropics is, from the heat, more rarefied than in a cold climate, the result being that a given bulk of air must contain less oxygen in the former climate than in the latter. And as, generally, comparatively less exercise is taken in the tropics (owing to the small amount of cool suitable time available, and to the lassitude induced by heat), it follows that the breathing is less accelerated by motion, resulting in a diminished bulk of air being inspired, and hence again a smaller amount of oxygen. As a necessary consequence of these two distinct manners in which the supply of oxygen is curtailed, the carbon breathed out from the lungs in the shape of carbonic acid is diminished in quantity. In other words, the higher the temperature and the less the exercise, the less carbon is exhaled from the lungs. Then, owing to the greater heat, and the consequent increase of evident perspiration and invisible evaporation from the skin, there is a smaller quantity of urine, so that there may not be sufficient water to hold in solution all the effete material which should be passed off by the urine. The skin, debilitated by excessive action, although pouring out more water, eliminates less solid matter. The lungs, kidneys, and skin thus acting imperfectly, some other organ must perform compensating work, or the blood must become charged with noxious carbonaceous material. Doubtless, if persons entering the tropics accommodated their living to the altered circumstances in which they are placed, such results might be to a great extent prevented. But often people coming to India continue to live as before, or even take more rich food, or, in consequence of thirst, or under a mistaken idea of 'supporting the system,' more fermented drink than they had been accustomed to consume in Europe. But the effete matter not required for the nourishment of the body must be removed from the system, and so the liver has an additional strain put on its capabilities. As a consequence the liver may become congested, or even more seriously diseased; or, failing to perform its functions, the bowels may be compelled to compensating action in the form of attacks of diarrhœa. Such vicarious work does not, however, long suffice; more or less effete carbonaceous material remains in the blood, and by such retention the blood becomes depraved and deteriorated, and is, in fact, in a semi-poisoned condition. The red globules of the blood decrease in number; the skin becomes pasty, pale, or sallow; the circulation is languid; the nights are restless, and there is a predisposition to a variety of ailments, as boils, skin, spleen, liver affections, or fever. In some constitutions there is also a disposition to the accumulation of fat in the heart and elsewhere; a condition physiologically explainable by the want of oxidation or destruction of material, which becomes converted into fat in the body instead of carbonic acid in the lungs. There is also loss of appetite, which, consequent on the diminution of the demand for carbonaceous or combustive material, is erroneously attributed to the debilitating influence of climate, and an attempt is made to neutralise this by artificial provocatives, which, while affording temporary relief, in reality pave the way to further deterioration. As a secondary result the *nervous system* becomes more implicated; the mental faculties are less vigorous, lassitude and fatigue are felt on the least exertion, and the daily avocations are performed with difficulty. Such a debilitated condition (or *anæmia, vide* p. 46) may occur in those predisposed by constitution, temperament, and habits within even a few months or years; or it may be deferred for a much longer period. It is true we occasionally see Europeans who have lived on the Indian plains for many years without loss of health or vigour. But these are exceptional instances, and only illustrate the inherent power against climate possessed by some constitutions. As a rule, the climate *per se* does, sooner or later, debilitate the European, rendering change to some cooler latitude imperatively necessary, and this debilitation will the sooner occur the less careful as regards diet and exercise the person may be. (For remarks on *Diet* and *Exercise*, *vide* pp. 683, 687.)

The insidious and debilitating effects of *continued heat* may be guarded against and delayed, *first*, by avoidance of exposure to *direct* heat—for the person who has suffered from sunstroke is the more liable to become affected by

continued residence in a hot climate; *secondly*, by moderation in diet, especially as regards liquor; *thirdly*, by daily exercise short of fatigue; *fourthly*, by periodical change to Europe, or at least to some Indian hill station. A short periodical sojourn at some hill station, and a change to a European climate every six or seven years, would prevent many persons suffering from the effects of hot climates as here described. Those deferring such measures, after warnings of constitutional failure, frequently find a very long period necessary for the recovery of their strength. But the common error of expecting Indian hill climates to *cure* disease should not be entertained. As a rule, it is only those cases of ill-health when no specific disease exists which are benefited by change to the hills. But when lassitude, debility, loss of appetite, exhaustion after little exertion, and loss of energy and inclination for the daily avocation are the principal symptoms, the climate of the Indian hill ranges, particularly of the Himalayan stations, will generally prove most beneficial. Every mile the traveller advances from the plain into the hill ranges is eloquent of that change of climate which will soon effect a change of health. Vegetation, animal life, and even the appearance of human beings alter gradually but distinctly. As elevation is attained the air feels lighter, then crisp and exhilarating; the immediate relief experienced being a foretaste of that amelioration which soon takes place when the European is removed from the oppressing effects of a heated rarefied atmosphere affording a minimum proportion of oxygen, and in which he is frequently unable to take sufficient exercise. Also, innumerable impurities existing in the atmosphere of low levels are not found in the air of mountain regions. By such change the appetite and digestion are improved, the vital powers are stimulated, and the physical vigour is regained. Residence in the hills may, moreover, be regarded as exerting a sanitary effect not only on the body, but also on the mind; the freedom from the harass of daily work and the change of scene and society tending to raise and exhilarate the spirit, depressed by the continued influence of the climate of the heated plains. Much care, however, is necessary to guard against chill consequent on the lower temperature of the hills. The colder air checks the action of the skin, and the blood being driven within on internal organs, any weak part suffers from the strain. Although there is a comparative immunity from cholera, sunstroke, dysentery, and malarious fevers in the hills, there is usually a greater liability to bronchial affections, lung disease, rheumatism, and diarrhœa, while heart and kidney affections are usually made worse. Children are especially liable to throat or chest affections, or to diarrhœa; from which they may never have suffered on the plains. Warmer clothing should be put on *before* ascending a mountain, not *after* the ascent is made. However warm the hill climate may appear to persons fresh from the plains, the change of temperature involved, if made without care, is fraught with danger.

The hill stations may be divided sanitarily into *extra*-tropical and *intra*-tropical mountain climates, those in the Himalayehs belonging to the former class, the remainder to the latter. All hill climates, whether within or without the tropical line, are characterised by a summer season from ten to fifteen degrees cooler than that of the plains, by heavy monsoon rains accompanied by much mist and damp (rendering Mahableswar and Matheran, in the Bombay Presidency, uninhabitable during this period), by glorious autumnal weather, and in the *extra*-tropical stations by a winter season much colder than that of the plains, with usually heavy falls of snow about the month of January. On the *intra*-tropical ranges of hills the cold season is much less severe, and the changes of temperature are much less than on the Himalayehs, where the thermometer is influenced by cold winds from the snowy regions to the north. The Neilgherry Hills especially, from their altitude, their proximity to the equator, and their nearness to the sea, offer a cool climate, famed for evenness of temperature and consequent salubrity. The climate of most hill stations is, however, modified by neighbouring physical conditions, and the same mountains, or even the same station, may afford localities differing much in climatic respects. An account of the hill stations of India would therefore be a lengthy task.[1] All have excellences and defects; and many invalids have something special or peculiar in their ailments or constitution. The *intra*-tropical stations are preferable when there is tendency to chest affections or to incipient organic disease. When the ailment is simply debility from heat or from continued work, or convalescence from some malady which has merely left debility as a result, *any* hill climate, almost at any time, will prove beneficial.

Mal des Montagnes.—Some persons cannot ascend a mountain without suffering from troubled sleep, fatigue on slight exertion, muscular pains, quick pulse, hurried breathing, palpitations, giddiness, and perhaps nausea. It results from the oxygen of the blood being suddenly diminished *consequent* on a sudden move into a more rarefied atmosphere. Some individuals never become acclimatised to the mountain air. In others the effects are transient. An invalid known to suffer from *mal des montagnes* should not be taken to the hills.

CHANGE TO EUROPE.—Caution should be observed with regard to the more radical change to Europe, as a rapid journey to the British Isles is certainly not advisable for all Anglo-Indian invalids. In these days of quick transit, under the idea that the change home is all that is necessary, the tropical invalid too often rushes into the cooler climate of Europe or of the British Isles, the sudden change being in most instances as likely to do harm as good. The tropical invalid, especially if his malady is of long standing, or if he is organically diseased, cannot endure these sudden changes with impunity; and although it is often right that, as a last resource, they should be tried, they can only be attempted with a chance of success under the greatest care as regards regimen and protection from cold. It is doubly injurious for a person suffering from any predisposition to organic disease to return home in the winter. Invalids, especially with dysentery or 'liver,' should not reach England till after the vernal

[1] This has been attempted in the author's work entitled 'Health Resorts for Tropical Invalids; in India, at Home, and Abroad.'

equinox, for the gales at that time are often bitterly cold, and are apt to induce chill and consequent congestion of internal organs. Many would do better by sojourning for a period in Egypt, or Algiers, or at one of the Mediterranean or Continental 'health resorts,' most of which (like Indian hill stations) have excellences and defects peculiar to themselves. Such characteristics are fully set forth in books; [1] but a competent medical opinion is also desirable.

The subject of change of climate may be appropriately concluded by the hope that the time will come when all passenger ships will be better provided for the comfort and care of sick passengers. It is most painful to see a debilitated patient 'sent home,' as it is called, for the sufferings on board ship are manifold and continuous. Cabins with extra attendance, and good sick-cookery, would be a great boon to helpless invalids, especially when suffering from dysentery, diarrhœa, or lung disease. Such invalids ought to be in a cabin alone, not only for their own sake, but for that of others. To breathe constantly, in a confined and badly ventilated space, the same atmosphere as persons so affected is dangerous to the healthy, to whom disease may be propagated.

MALARIA.—*For an account of Malaria and its principal presumed characteristics, vide* AGUE, p. 252. Whether we regard malaria as a specific poison or entity, or as something yet undiscovered, or whether we deny its existence, there is no doubt that certain diseases do arise in certain localities, and that such diseases may be lessened, or even altogether prevented, by known agencies, the principal of which are indicated in the following remarks. In the uncertainty which exists whether or not there is such a poison as malaria, or whether or not that which is called malaria is really the operation of the various conditions

[1] The author's 'Health Resorts for Tropical Invalids.'

of climate and place by which we are surrounded, it is satisfactory to know that in using most of the precautions advised against malaria we are also protecting ourselves from such more recognisable evils as damp, cold, chill, bad air, and fatigue.

The measures to be taken to guard against the presumed effects of malaria—generally malarious fevers, or spleen disease, or malarious cachexia—are principally based on the avoidance of those localities in which residence or travelling is shown by experience to be most frequently followed by malarious maladies. But when necessitated to remain in, or pass through, malarious districts, the night air is to be as much as possible shunned. Wearing a silk handkerchief around the mouth and nose, or, better still, the charcoal respirator as sold, is a good plan when moving through very malarious districts. An efficacious form of respirator may be readily constructed by placing layers of charcoal, on cotton wool, between pieces of silk. Or keeping the mouth shut habitually and breathing through the nose, which, like a respirator, not only tends to prevent the entrance of malaria, but of all other atmospheric impurities, the convolutions or cells of the internal nostrils acting as a kind of filter, or entangling impurities which are afterwards expelled. Habitations or tents should never be placed to leeward of suspicious marshy surfaces. If obliged to sleep in unhealthy places, as malaria is supposed to be destroyed by fire, it will be well to keep large camp-fires burning. Also doors, windows, or tent *purdahs* should be closed, especially towards the malarious or damp locality, and particularly if wind comes from that direction. In some places safety from malarious fevers can only be secured in the autumnal season by closing all doors, the punkah or thermantidote being then necessary to procure sleep. Several writers state that mosquito curtains act as preservatives from disease. This, however, is not sufficient in the malarious districts of India. Unnecessary fatigue must be avoided. When either the body or mind is more than ordinarily fatigued, so-called malaria is more likely to produce bad effects. Similarly, depressing passions, as anger, grief, and prostration after intoxication, render the body more liable to malarious affections, as in fact to any other disease. The use of alcoholic liquors is not, however, to be entirely forbidden. When journeying by night through reputed malarious districts—which during the monsoon and after this season comprise nearly the whole of India —two or three table-spoonfuls of brandy not too much diluted will be beneficial. The stimulus thus afforded will give temporary support and lessen fatigue by preventing too rapid waste of tissue. The quantity is not sufficient to induce subsequent depression, while the advantage of local stomachic and slight general stimulation is obtained. It is worth mentioning that a stiff glass of brandy-and-water will sometimes cut short an incipient attack of ague. It must, however, be taken at the very commencement of the cold stage, otherwise it will be prejudicial.

Coffee is useful as a prophylactic against malaria, but is more adapted for general use during unhealthy seasons than for occasional consumption when passing through feverish districts. Coffee infusion is invigorating, and does not induce subsequent depression, the effect being confined to the first nervous stimulation. An infusion of unroasted coffee is a more powerful remedy against malarious influences than the roasted berry, and it may therefore be taken in malarious localities and seasons.

Tobacco-smoking in *moderation* may prove beneficial. Tobacco, like tea, coffee, and alcohol, restrains the waste of animal tissue, while it also exercises a tranquillising influence on those accustomed to its use. The wholesale denunciation of tobacco is neither in accordance with theory nor experience. But, as with alcohol, excess will, by the subsequent depression and nervousness so induced, predispose to those maladies against which moderate use may afford some preservative influence.

The diet of persons residing in malarious countries should be nourishing and liberal. Experience displays in a striking degree the prophylactic influence of a sound dietary against malaria. Where the inhabitants are poorly nourished, malarious disease, especially large spleen, abounds, and the manner in which natives of the country improve under better conditions of diet and living is a sanitary fact. Any scorbutic taint in the system, the result of food deficient in some requisite vegetable constituent, renders the individual more liable to malarious disease, and a due proportion of vegetable diet is therefore necessary. In malarious countries the stomach should be invariably fortified before going abroad in the morning by a cup of tea or coffee and a biscuit; and if a long journey is contemplated, a good meal is advisable. An early-morning meal has been supposed in some mysterious manner to prevent the noxious influence of malaria. But the benefit resulting is consequent on its rendering the system less liable to be affected by the chilly morning air, for the temperature of the body rises after food, although only in a small degree.

Quinine should be used as a prophylactic, once or twice a day, during the malarious seasons (*vide* p. 18); or a larger dose, as 6 grains, may be taken previous to passing through a malarious locality; or Recipe 76 may be obtained, which is a very efficacious pill for general camp use. If any constitutional idiosyncrasy, as referred to at pp. 7, 18, prevents quinine being used, the person should take 3 or 4 drops of the *Liquor arsenitis potassæ* instead: to be taken *after*, and not before, meals as advised for quinine (*vide* Recipe 75). Or Burroughs & Wellcome's arsenious acid tabloids, containing one-fiftieth of a grain of arsenic, may be similarly used.

Care should be taken not to drink water from wells in which leaves or other decaying matter have fallen. If necessitated to use such water, it should first be boiled and then filtered. It has been stated that water may hold malaria in solution, and that the poison may thus be introduced into the system.

It has been remarked that malaria is more powerful during the night than during sunlight. Whether this is correct or not, it is a fact that the human system is more likely to become impressed by any cause of disease during the relaxed condition of sleep than when awake and in action. It is also ascertained that individuals who have suffered from malarious fever may experience a relapse from exposure to cold. Hence the necessity of using, both by day and night, tolerably warm clothing, and especially flannel, than which no substance is better adapted to preserve the surface of the body from sudden changes of temperature, so often occurring in India, and especially during the night. It is asserted that malaria not only enters the system by the lungs and stomach, but may be also absorbed through the pores of the skin. When we recollect that every square inch of the skin contains upwards of 3,000 pores, and that thirst may be immediately relieved by immersion in water, which passes *into* the body through these pores, in the same manner as perspiration passes *out*, the theory that the skin may absorb malaria (if there is such an entity) seems plausible. As a protection against this danger, equally as against sudden vicissitudes of temperature, flannel is the best material, whether by day or by night.

Malaria is presumed to be heavier than atmospheric air. Examples are numerous where those living in lower stories suffered from fever, whilst residents in the same locality living in upper rooms retained their health. The damp and mist of night, or rather the descent of dew, has been presumed to retard the rise of malaria, and this mist is frequently only observable a few feet above the ground. Hence the desirability of sleeping in upper rooms in malarious seasons or localities, in order to escape the possible concentration of malaria near the surface of the ground, and the certain damper atmosphere.

Other *personal hygiene*, or *general sanitary* regulations tending to preserve from the effects of malaria, are:—Avoiding the cold bath when liability to febrile attacks is present, or when the body feels cold, and a warm glow does not occur after the bath. Avoiding unnecessary exposure to colds and chill. Attention to the disposal of bath-room water, which should not be allowed to sodden the ground in the neighbourhood of the house. Care not to live under rotting chuppers or thatch. Not to permit garden ground in the vicinity of the dwelling to become sodden by *over-irrigation*, as it then becomes a fertile source of damp, if not of malaria, although harmless when only sufficiently watered to assist the growth of vegetable life. Taking advantage of the power forest trees are said to possess in preventing the passage of malaria from one locality to another; and which should, therefore, be planted between inhabited places and adjacent swamps and marshes. For if trees do not protect from malaria, they modify and protect from cold damp winds. The *Eucalyptus globulus*, or Australian blue gum-tree, and the common sunflower, possess power in absorbing the malaria and damp of marshy places. Taking care that the locality is well drained. Periodical escape from the unhealthy Indian plains to one or other of the hill Sanitaria, where, from the absence of great heat, the constitution quickly becomes reinvigorated, and is thus better enabled to withstand what malaria may be present in the atmosphere of the mountains.

CHILL or **COLD** is in India a most fertile source of disease; fever and ague, or at least secondary attacks of fever, rheumatism, dysentery, diarrhœa, croup, and many other complaints arising from this cause. *A priori*, it would appear that taking cold in so hot a climate would be far from probable; but, in fact, the reverse is the case. *The heat renders the surface more impressionable* to falls of temperature, and it has already been shown (p. 657) how rapid and extended these may be. Of all the vicissitudes to which the climate of India is liable, none interfere more with health than the rapid changes of temperature, so that the Indian cold season has been spoken of as one of 'masked malignity,' especially to the old resident. There are old residents with a skin so debilitated by heat that they cannot stand five minutes in a draught without shivering or falling into a paroxysm of fever. Even those who attribute diseases to germs entering the system admit that a temporary depression caused by chill may give germs already in the system the necessary opportunity of developing themselves, when they would have been destroyed by inherent vital power had the chill not interfered. But chill is quite enough to excite disease without germs. The heat induces people incautiously to divest themselves of garments after exertion, and to sit in draughts for coolness, by which the blood is driven from the surface into the internal organs; whereas when in a state of perspiration, if the clothes cannot be changed, evaporation should be limited and chill prevented by putting on some other garments, and by avoiding draughts. In these or other ways persons constantly expose themselves to chill, with the almost inevitable results, a common cold, feverishness, or some worse disorder. A similar effect may be produced from the action of tatties, from the punkah, from the thermantidote, or from sudden breezes springing up and playing over the sleeping person. The advice given many years ago to the writer by an old Anglo-Indian, which may well be repeated, was never to lose sight of the blankets brought from Europe, which so many dispose of as no longer necessary; the fact being that protection from cold is even more necessary in India than in a cooler climate. It should be remembered that there is a considerable morning fall of temperature; that least animal heat is produced during sleep; and that the inherent power to withstand disease is then at a minimum. Hence the desirability of an extra covering being at hand, which may be drawn over the person in the early morning. It has certainly been questioned whether chill and cold in a tropical climate will excite *per se* an attack of ague; but experience has shown that it is quite sufficient to *re-excite* attacks of fever in the person who has once suffered from the disease. Whenever, as so often occurs in the autumnal and winter seasons, cold nights and hot days characterise the climate, then, without suitable protection by change of clothing, there will be danger of disease—fever, dysentery, or diarrhœa—and more especially so when the atmosphere is also damp. Chill is also a fertile cause of liver inflammation and abscess (*vide* p. 318). In short, exposure to cold, and especially to *damp* cold, is the most prolific source of disease in the tropics; meaning by cold, not a lowering of the temperature to the standard of temperate regions, but those sudden alterations from a very high to a lower standard so common, especially about the monsoon seasons, in India. The methods of protection from chill are so apparent that further remarks must be superfluous; while observations on the material for clothing will be found under that heading, p. 688. The brevity, however, with which this subject is treated must not be accepted as an index of its importance; for some authors have not hesitated to question the existence of malaria, attributing all so-called malarious diseases to chill alone. The author regards chill as 'The King of Causes of Disease.'

WATER.—Many diseases may be introduced into the system through the medium of water. Ague has been known to occur apparently from the use of impure water. Spleen disease may originate from similar cause. The introduction of the guinea-worm into the system is, probably, always by water. Dysentery and diarrhœa are excited by water containing either animal, vegetable, or mineral impurities. Dyspepsia will occur from a similarly impure fluid. Stone in the bladder, Derbyshire neck, or 'goitre' are other results of the continued use of bad drinking-water. Both cholera and typhoid may be propagated by contaminated water. Milk mixed with impure water has been the cause of outbreaks of disease. Intestinal worms may be propagated through the medium of water. The introduction of worms into the blood by the agency of mosquitoes and water is referred to at p. 612. When the filthy habits of many Indians as regards drinking-water are borne in mind, the European will find a *personal* supervision of his own supply the more incumbent. Drawn from a well generally uncovered, containing all kinds of impurities, and on the verge of which, or even in which, Natives wash themselves and their clothes; or taken from a tank in which men and women and animals drink, bathe, wash, wallow, and otherwise defile, the water next passes into the Bheestee's mussack, a receptacle made of untanned hide, kept when not in use in a dirty hovel, and probably never cleansed until rottenness from age and use renders its opening and repair positively necessary. Such water, if the European did not vigorously protest, would be daily given him to drink. Even vigorous protests would only result, as a rule, in the addition of another odour or taste to the fluid, by straining through a dirty cloth. Even should the water brought be seemingly unexceptionably pure and tasteless, it may still contain atoms deleterious to health. That the invisible germs of cholera, the ova of guinea-worm, or the spores of other maladies may exist in water will not create surprise when it is recollected that a single drop of water may contain five hundred millions of living infusoria, a number approaching that of the whole human species existing on the face of the earth. Hence the necessity of insisting by frequent personal supervision on drinking-water being boiled, then allowed to cool, and afterwards filtered. Boiling will not only destroy most organic impurities, but will also cause the deposit of inorganic salts or material held in solution. Neither does the double process destroy the taste and pungency of the water, which is restored during the time it is filtering by the reabsorption of air by the fluid. But all filters become in time foul and dirty, and, if not periodically cleansed, may be a breeding-ground for the germs they are designed to prevent.

Filters may be constructed in the form of three common 'gurrahs' placed one above the other, on a tripod stand, the two upper ones filled with layers of sand and charcoal, the lower one empty to receive the water straining through small holes in the bottoms of the others. If this kind of filter is used, an inverted cover with a small aperture drilled in it should be placed on each 'gurrah' to prevent the entrance of dust or mosquitos, and interference from birds, squirrels, &c. Or, what is preferable, a magnetic filter may be purchased, either sufficiently small and portable for camp use, or large enough to filter any amount of water. For travelling, the porous stone bottle is a good filter. Placed in a 'gurrah' of water, the fluid quickly finds its way into the interior of the filter, and drinkable water is obtained. A small portable syphon carbon filter may be useful on journeys. The home-made 'gurrah filter' of sand and charcoal will require changing at least *monthly*; others according to size and capability, which may be approximately ascertained when purchased. But much obviously must depend on the impurity of the water.

How to purify a filter.—Every two or three months (according to the kind of water) air should be blown through, and if the charcoal is in the block form it should be well brushed. Then six or eight ounces of Condy's fluid should be poured through; and an hour afterwards four gallons of distilled water (or, if not procurable, of the purest boiled and filtered water obtainable) in which an ounce of pure hydrochloric acid has been mixed. Then more pure water. Sponges should be washed in hot water every few days.

Condy's fluid is useful for purifying water when other means are not practicable. Eight drops, added to a gallon of water, will purify it, and render it more fit for household purposes. Condy's fluid is of a purple colour. When added to impure water the colour becomes brown, which forms a means of roughly testing the purity of water.

It is not always that there is any choice of water supply. If so, tank water should be avoided, as such places are liable to innumerable contaminations, especially if in the neighbourhood of villages. Surface and marsh water must always be rejected. Water from a well constantly being drawn is often the most satisfactory. But probably water from a swift-flowing river is best, as the motion of the stream and the exposure to the air tend to maintain the water good, notwithstanding the numerous impurities which find their way into rivers. Among the sanitary improvements of recent years is the introduction into many towns (especially in the Western Presidency, where the physical features of the country are favourable) of water supply from distant hills, rendering the inhabitants and travellers independent of the old sources of wells, tanks, or streams—a sanitary measure which more than any other tends to the preservation of the public health.

As a result of the heat of the climate, and of the consequent constant evaporation from the skin, Europeans are more thirsty, and require more to drink, than in their own country. But the practice of drinking largely, even of water, is not commendable. Thirst should be striven against, otherwise a habit of drinking deep draughts is contracted, which weakens the digestion and debilitates the skin, by the increased perspiration following excessive drinking. To allay thirst, there is no better beverage than cold, but not ice-cold, water. The evil effect of swallowing cold water when the body is heated (which often causes skin eruptions) is popularly recognised, but it is not understood that whatever harm a large quantity of cold water may do a smaller quantity of iced water may effect. If ice is placed on the back of the hand for a short time, the skin becomes pale, then reddened and hot. That which can be seen on the skin happens in the stomach, and hence taking ice-cold drinks congests the coats of the stomach and favours dyspepsia. With this condition, thirst returns in a double degree, and the relief gained by successive draughts is too dearly purchased. Neither should the injury to the teeth be ignored.

Many persons are under the impression that by drinking aerated water they will escape the ills so often the consequence of impure water. This, unfortunately, is not the case; for soda-water manufacturers in India are sometimes not particular what kind of water they use. It may contain lead, or oil from the machine; and if filtered, which is often neglected, the water aerated is seldom, if ever, boiled. Greater safety will be secured by supervision of the drinking-water than by the use of the so-called soda-water of the shops. Similarly, when it is mentioned that there are infusoria which retain vitality in boiling water, enough will have been said to dispel the popular delusion that the addition of liquors to bad water will render it less injurious.

SLEEP.—Not to sleep in comfort in India is to prepare the system for disease. Yet there are many hindrances to the European obtaining that refreshing slumber which is so desirable. During certain months, when the nights of the monsoon season are moist and 'muggy,' the European, after a restless night, arises tired, languid, and unrefreshed. In the fierce hot weather of Upper India, heated winds blowing almost to dawn, often accompanied by dust and sand, produce similar restlessness, and thirst. Then there are mosquitoes, which, although apparently insignificant, are capable of preventing, or at least disturbing, the slumbers of most Europeans. There are also the various noises which so frequently render the Indian night hideous. In addition, dinner taken late tends to produce restless nights. One or two nights of disturbed sleep would not much signify to the average robust European; but when the causes are in operation for months, the frame becomes debilitated, and is therefore placed in a condition favourable to disease. And, as before stated, malaria or chill is most powerful during the hours of darkness, or when the individual is most debilitated and distressed by vainly tossing throughout the night on a sleepless couch.

The measures to be adopted to secure comfortable sleep in India resolve themselves into protection from the causes of restlessness mentioned above. Protection from heat is to be obtained by sufficient ventilation of sleeping-rooms, by the judicious use of the punkah, or other artificial means of cooling the atmosphere (*vide* p. 663). By sleeping in upper rooms when practicable, where, at some elevation from the ground, air is often in motion, while all below is stagnant. By sleeping in some localities and seasons in the open air (*vide* p. 664). Protection from mosquitoes may be secured either by the mosquito curtains, or by the punkah, or to some extent by an elevated and breezy position. Protection from malaria has already been considered (*vide* p. 671). Protection from thirst is to be attained by avoiding improper diet and late dining, by keeping the mouth shut, and by putting a chlorate of potash tabloid in the mouth when retiring. It is much better to sleep on a hair mattress, or on a wire bed, or on a 'charpai' than on anything softer. It is also desirable that, especially for children, the head of the bed should point to the north; for there are electrical currents constantly passing from north to south, with which our nervous systems are in some mysterious manner connected, and which it is not well for the body to oppose. Sleeping in the day should be avoided, especially after a meal, as it tends to induce liver disease.

DIET.—Vegetable food is, generally speaking, better adapted to a tropical climate than animal food; not that it is quicker or easier of digestion, for it is slower, but because it is not so apt to cause plethora. Such considerations should induce the European, especially when newly arrived, to partake sparingly of animal food, which is not required to the same extent as in a temperate climate. It has been explained (p. 665) that carbonaceous material (of which meat, milk, eggs, fatty substances, contain a large proportion), taken into the system, is removed chiefly by the liver or the lungs, and that in a hot climate the lungs are less, and the liver more, instrumental in this process. Hence (as one means of avoiding disease of the latter organ) the necessity of caution as regards quantity of food taken. But following the example of some classes of the Natives, and abstaining from meat diet altogether, is not desirable. The custom of ages has habituated the Hindoo to taking large quantities of rice with pulses or corn; but a European would not digest this diet. Its bulk alone would prevent perfect digestion, even if aided by the large amount of condiments taken by the Native; which, in the unaccustomed stomach of the European, would also induce indigestion.

It can scarcely be necessary to lay down rules of diet, but some cautions may be added. Of all things, the most necessary is neither to eat too much, nor from too many dishes. The more simple the food, the better and longer will the stomach prove a good servant, rather than, as occurs when dyspepsia becomes confirmed, an irritable master. Avoid also eating too quickly, and masticate the food thoroughly, applying to the dentist for aid if the state of the teeth does not permit the grinding of the food. Also let all food taken be, although simple, of the best quality obtainable. The last remark especially applies to milk, in which the germs of various diseases may be conveyed, usually through the admixture of foul water with the milk. As regards the use of tinned foods, any which appear, when opened, wet, pappy, or emit a faint or putrid odour, or gas, should not be eaten.

Injury sometimes results from old 'tinned' provisions becoming impregnated from the 'sauder' (which contains lead) used to seal the cases. For symptoms of lead-poisoning, *vide* pp. 134, 344). It is advisable for all preserved provisions for tropical climates to be packed in glass capsules.

The protection of food from the myriads of flies abounding in India is urgently necessary; for no one can tell on what filth a fly may have previously settled, or what germ of disease it may not convey.

Attention should also be given to the meat, by which several maladies, and especially tape-worm, may be conveyed into the system.

As Indian butchers are not particular as to the meat they sell, it is well to know the characteristics of good meat. It should present a somewhat marbled appearance, from intermixture of streaks of fat with the muscle, a sign that the animal has been well fed. The colour of the flesh should neither be very pale nor very dark. If pale and moist, it indicates the animal was young or diseased; if dark and livid, it shows that the animal, in all probability, was not slaughtered, but died with the blood in it. Both lean and fat should be firm to the touch, not moist or sodden, nor showing white jelly-like spots, and the fat should be free from bleeding or dark spots. Fluid or juice exuding from the meat should be small in quantity, of a reddish tinge, and should be slightly acid, if tested with test-paper made for the purpose. The little bundles or fibres into which the meat is divided should not be large and coarse. The odour should be slight and not disagreeable even if chopped in small pieces and washed with water, which brings out the odour; or if a knife is thrust into the meat and smelled.

Bad meat is usually sodden and flabby, with the fat dirty or yellow-looking and the smell unpleasant or sickly.

The importance of looking to the condition of the cooking pots and pans used in India must not be forgotten.

The utensils used are copper, and, when properly lined with tin, are harmless. But the tin wears off, and exposing the copper may lead to copper-poisoning, the symptoms of which are usually pain in the bowels and diarrhœa, and, if much copper is taken into the system, also vomiting. If the cooking-pots are not properly *clean*, as well as not properly tinned, the chance of copper-poisoning will be increased, in consequence of the formation of *verdigris*, by the action of the acids and fats in the food remaining in contact with the metal. Cooking-pots used every day should be tinned at least every month, and examined periodically in order that it may be ascertained if the tinning is required more frequently. After tinning bran should be boiled in them before they are used for food. But these are not even sufficient precautions. Lead is cheaper than tin in the Indian bazaars, and the tin-workers will sometimes employ an alloy of tin and lead instead of the former metal. The symptoms of lead colic, or poisoning, and paralysis, are noted at pp. 134, 344. Either copper or lead, or both, may be taken into the system with the food daily, in very minute quantities, for an indefinite period. The characteristic symptoms of poisoning by either metal may not present in the unmistakable manner which results from large doses; but many cases of anomalous illness are either altogether due to, or are aggravated by, these often unsuspected causes.

LIQUOR.—It would be well if all, for at least some months after entering the tropics, would refrain from anything more powerful than a little claret and water, and perhaps a glass of sherry daily. Spirits should be shunned as poisons. Beer of good light quality is less deleterious, but is not necessary. As a rule, no beer, wine, or liquor should be taken excepting at meals. In the hot weather it is desirable that none should be taken till after sundown. It should be fully understood that in

India fermented liquors of any kind should only be taken for their tonic, *not* for their stimulating, effects. Physiological science and experience alike teach us that the condition of system most favourable to the development of zymotic poisons is set up by the presence in the blood of organic matter in a state of change, decomposition, or fermentation. Hence the blood of the intemperate charged with alcohol is in the condition *par excellence* favourable to attacks of such maladies as fever, cholera, and sunstroke. The liver also is liable to become affected from indulgence in spirituous liquors. Neither does the heart escape. One ounce of alcohol raises the pulse three beats per minute, or, in other words, causes the heart to beat, while its effect lasts, at the rate of 4,300 beats more than natural in the twenty-four hours. The heart cannot be made to do this extra work without suffering. The bad effects of the same agency on the brain might be portrayed with even greater force. But the loss of memory, the impaired intellect, the miserable thoughts, the imbecility, the loss of physical energy, so frequently resulting from *chronic alcoholism*, need not be dwelt upon here (*vide* p. 163).

Although so strongly condemning the practice of constantly using alcoholic beverages, the opposite extreme of teetotalism is not recommended. As a rule, Europeans in tropical climates require some amount of fermented drink as part of their daily *sustenance*. This is particularly the case with the old resident, and during the hot season when the heat destroys the appetite, and exerts its depressing and deteriorating influence on the system. When the quantity of solid food is not sufficient to supply the waste of tissue, and to counteract the 'wear and tear' of body—which it often is not during the exhaustion and loss of appetite caused by intense heat—an additional supply of wine may be taken with advantage. But this can only be safely used *for its tonic effects*, and *not for the temporary stimulation* it affords. It is the use, and not the abuse, of fermented liquors which is so much required. Moderation, instead of excess, is the great desideratum. But what moderation may be it is difficult to decide, so much depending on age, sex, temperament, habits, and occupation.

From experiment it appears that the body of a strong healthy man is capable of *appropriating* in a temperate climate 2 ounces of alcohol daily, as a *maximum*. If more than 2 ounces is taken, it may be chemically detected in the urine and breath. In a tropical climate, the power of appropriating alcohol is lessened. Approximately, 2 ounces of average brandy contain upwards of 1 ounce of alcohol; of sherry about 8 ounces, of champagne 14 ounces, of claret 16 ounces, of bottled beer 18 ounces, contain 1 ounce of alcohol. It will therefore be understood that the limit of appropriation of alcohol by the system may be reached by very moderate indulgence in wine or spirits. And there is every reason to believe that the limit of *benefit* to the system from alcohol is arrived at long before the limit of *appropriation*. But liquor, wine, and beer are made from many things, and many drinks sold in the Indian bazaars contain specially deleterious principles.

EXERCISE.—A due amount of exercise in India is even more necessary to health than in England. As a rule, the most healthy people are those who take exercise regularly. The circulation of the blood is thus equalised, and the tendency to congestions, particularly of the liver, is often checked; the bowels are excited to healthy action, and effete material no longer required in the system is thereby expelled; while more air being inspired as a result of quickened respiration, more oxygen is introduced into the system, and more carbon expelled (*vide* p. 665). There is, however, a very general feeling of languor, the effect of heat, which prevents many people taking that amount of exercise which is desirable. Walking, riding, shooting, badminton, are the best exercises—cricket, boating, tennis, rackets, involving for many too great a strain on the circulatory and muscular systems. Bicycle and tricycle riding on most machines tends to round the shoulders and contract the chest. Healthy as such exercise otherwise is for the young and strong, with unimpaired condition of circulatory organs, it becomes a dangerously severe exertion for persons who, advanced in life, have any heart or arterial imperfection; especially if they mount after a meal.

Whatever exercise is taken, it should not be sufficient to induce exhaustion. Fatigue carried beyond a moderate stage subjects the blood to a decomposing process through the infiltration into it of substances which act as poisons. Many persons feel fatigued during the day after exercise in the early morning, and this may be accepted as a sign that it does not agree with them. Weak and delicate persons should avoid exercise before breakfast, especially if they are employed during the day. Extremes of exercise should be avoided during seasons of epidemic, as fatigue tends to predispose the system to epidemic diseases. Children should not be wakened to be sent out. They should go to bed early, and will then wake early. And they should have a little milk and bread before going out.

CLOTHING.—The quality of dress in India depends on the season and the part of India in which the wearer is located, and on the duties to be performed. Clothes do not keep us warm by excluding air from our bodies, unless they are impermeable, as india-rubber textures. The textures most permeable to air keep our temperature most equable, air being a bad conductor of heat. Wool, being very permeable to air, is a non-conductor of heat, while linen and cotton are rapid conductors. An object covered with wool is less susceptible to changes of temperature than one covered with linen or cotton, which is the reason why ice is kept under blankets. Wet clothes in which the air is replaced by water keep us less warm than dry clothes, because water is a better conductor of heat than air. Hence the ease with which we get chilled in wet clothes. Evaporation also takes place more rapidly from cotton than wool, because wool does not absorb moisture so readily as cotton. If a piece of flannel is stretched over a glass of water so that it just touches the surface of the fluid, scarcely any moisture will be taken up by the flannel. Linen or calico so placed will quickly become saturated. This is another reason why chills more quickly occur with linen or cotton than flannel clothing. Perspiration penetrates at once to the external surface of the linen, and is acted upon by the atmosphere. With a woollen garment perspiration is more retained by the texture, and absorbed more gradually, and thus not so quickly evaporated from the surface. When the body is heated, a profuse perspiration wets the clothing, evaporation follows, causing chill, checking the perspiration, and so originating numberless cases of illness; and this is much less likely to occur when wool is used. Even when there is no perspiration visible, insensible perspiration is always occurring, and this passes through wool, in the form of vapour, to a much greater extent than through vegetable textures, which retain it on or near the surface. Wool is really cooler than vegetable fabrics, for heat is most felt when the skin cannot exhale freely through the clothing. The exhalations from the skin are the means provided by nature for cooling the body and maintaining an equable temperature, and wool is most pervious to such exhalations. Another advantage attributed to wool is the fact of its being a non-conductor of electricity. A woollen garment has the merit also of affording more protection to the back (the necessity of which has been already dwelt upon at p. 661) than either linen, silk, or cotton, which, although *looking cool*, afford no protection in this respect. Persons who say they cannot wear flannel next the skin may do so at first over very thin silk; but if the thin, flexible woollen clothing now manufactured is procured it will not irritate the most sensitive skin. It may be here remarked that there is no other special advantage to be derived from various advertised wool clothings which is not obtainable from good Welsh flannel. It would be well if all clothing were woollen, but underclothing is of more importance as regards health than external clothing, and this should consist of flannel next to the skin. It is one of the best safeguards against fever, dysentery, and various disorders, and it should be remembered that it is as useful to women as to men. But the resident in the south will not at any period of the year require the warm woollen clothing necessary for those residing during the cold season in the northern provinces, when the skin, irritable from prolonged heat, has to encounter the dry and piercing cold of the winters. Neither will the man devoted to office-work want the strong durable material desirable for the classes employed in outdoor occupation. Generally, light tweeds are the most useful external wear in India; but every person should possess warmer clothing, which may be required at any time. During the rains, especially with children, much care is required. Flannel clothing should be insisted upon, and jacket and trousers should be made in one, so that the dress cannot be kicked off. Lastly, clothing should be changed after exercise, and not allowed to dry on the body; or, if it cannot be changed, some other garment should be put over it to limit evaporation and so prevent chill.

BATHING.—The daily bath is an essential requisite in Indian life, and when the excessive action of the skin is recollected, and that in every square inch of skin there are some 3,000 perspiratory pores, the necessity of attention to this organ becomes sufficiently apparent. But besides these little tubes there are large numbers of small glands, secreting an oily substance, which is conveyed through other minute orifices to the surface of the skin, which it thus insensibly lubricates, while freeing the body of material no longer required in the system. It is therefore not only external impurity but also internal waste which finds its way to the surface, to the extent of about 10 grains per hour, which has to be removed. If this oily secretion and the perspiration are left undisturbed, the pores become blocked up, a safety-valve of health is closed, and some malady is almost certain to ensue. In India, moreover, there is at all times a greater action of the skin than in temperate climates, and if more attention is not paid to this organ the health will very soon suffer. The bath is, therefore, an essential part of the ordinary daily routine, if only as a matter of cleanliness. But it also may be regarded as a general tonic, imparting or maintaining vigour and energy, and fortifying the system against the influences of climate. Whether cold, tepid, or warm water is used, must be decided by the effect produced. There are many persons who after a cold bath feel a pleasurable glow over the whole surface. To these the cold bath cannot fail to be beneficial. On the other hand, there are numerous individuals who after a cold bath feel depressed, languid, and as if shrivelled, and whose cutaneous surface does not answer the shock of the cold water by any reaction. If this occurs, or if the fingers become at all cold or white after bathing, cold water must be abandoned, and tepid or even warm water substituted. Women who have miscarried should avoid too cold baths; neither are they advisable immediately before or during the monthly period. Some persons will bear a cold bath in the warm weather but not in the cold season. The extreme of too hot water must be guarded against; otherwise gradually the habit of bathing in very hot water will be contracted, to the enfeeblement of the skin and weakening of the system. A child's bathing water should be not cold enough to drive the blood from the surface, and not warm enough to induce the child to stay in the water. Bathing in 'chunamed' baths is not recommended, as the water there is often very cold, and the shock may be too great. Many persons have with truth dated the origin of fever or 'liver' to an imprudent plunge. Where there is a large lake or river, free from crocodiles, leeches, or other dangerous living things, bathing may be safely indulged in, with necessary precautions against the sun. When thus bathing, the body should be a little warm, not chilly, and the plunge should be made at once. The best time for bathing is a couple of hours after a meal. Bathing should be avoided when suffering from fatigue; and on leaving the bath, although the person may feel invigorated, too violent exercise should not be taken. Sea-bathing is not often practicable in India, but in many cases of debility sea-water may be beneficially used. For temperature of baths, *vide Appendix, Baths.*

HOUSES.—Europeans in India seldom have much choice of a house, the number in up-country stations being generally exceeded by the number of residents. And the majority of these Indian bungalows are not what is requisite for health or comfort. Although affording sufficient space, they are frequently not at all raised from the surface of the ground. Sometimes there is only an earthen flooring. They are mostly constructed of porous material, as inferior or sunburnt bricks and mud, and they are in many localities covered with an old, sometimes rotting, 'chupper,' or thatch. As a consequence, during the monsoon—especially in those parts of the country where the rains are heavy and the atmosphere saturated with moisture—damp rises from below, and damp permeates into and percolates through the walls, while not unfrequently the vitiated atmosphere caused by a mouldy, rotting thatch is recognised by the sense of smell. Most Indian bungalows in up-country stations have been originally built hurriedly, and as cheaply as possible. The majority of occupants being but temporary sojourners, few have cared to expend money on dwelling-houses. Many of the best houses have attained their dimensions by periodical additions to small temporary erections.

It is impossible to frame rules for the construction of a dwelling-house adapted for Europeans and suitable for every part of India, as the material available and the climate differ in various parts of the country. *Speaking generally*, a dwelling-house in India should be elevated four or five feet from the earth, by which greater freedom from damp and greater coolness are secured, and the entrance of snakes or other noxious living things is rendered more unlikely. The walls should be of masonry, as thin as compatible with strength. The idea that very thick walls prevent heat is a mistaken one, as massive walls, thoroughly heated by the sun's rays, do not cool during the night. The best material for floors is smoothly hewn stone of a non-porous description, Venetian tiles, or wood where there are no white ants. 'Chunam' is liable to break, to require constant repairs, and unless thickly covered it feels cold, while thick coverings harbour dirt and insects. But almost anything is preferable to the ordinary beaten earth floor, from which not only damp but bad air rises; for the atmosphere does not end where the earth begins, but permeates it in all directions. For the roof there is nothing better than well-fitting tiles, which should be large and heavy enough to prevent crows displacing them. Instead of lath and plaster ceilings, 'chuts,' made of whitewashed cotton cloth, are commonly used. To this there is no objection, provided the chuts are well secured, so as to prevent ingress into the space between the roof and ceiling of sparrows, bats, or pigeons. Similar care must be taken that all apertures between the wall and overhanging roof are well stopped; otherwise birds, squirrels, rats, bandecoots, and cats will find their way into the interior. Such intruders dying in the roof give rise to much trouble and to disagreeable effluvia; while the noise they make, especially at night, is anything but pleasant or conducive to repose. As a rule, Indian houses should possess chimneys and fireplaces. Such apertures tend to the ventilation of the apartment, and fires may be advisable on account of damp, while in the northerly districts fires are always acceptable, if not actually necessary, during the cold weather. Verandahs cannot be dispensed with, and their breadth can scarcely be too great. Doors and windows should be furnished with chicks opening in frames—serviceable alike for keeping out glare and insects. A sufficiency of light is a desideratum not always secured. For if the original construction admits sufficient, it is often shut out, under the idea of promoting coolness. The great importance of solar light is referred to under *Anæmia* and *Scurvy* (pp. 47, 381), both being diseases to which deficiency of light predisposes. Lastly, the colouring of the inner walls should be a neutral tint, instead of the glaring whitewash so often seen.

As regards *site*, the first thing to look for is natural drainage, and therefore a slight elevation of the ground will be the preferable locality. But the surface of some districts is so flat that this desideratum cannot be secured—so level, that good drainage is not even possible—and where this is the case elevation of the dwelling-house is the more requisite. The windward position to any marsh, pond, or native village, a gravelly soil, a dry substratum of soil, the absence of rocks or hills, which would radiate heat on the house, the facility of procuring water for garden purposes, the proximity of trees, not overhanging the house, but affording shade in the immediate neighbourhood, are all desiderata which should be if possible secured.

The position of the house is to be determined as far as possible by the direction of the prevailing wind and the diurnal sun-line. But as these do not generally correspond, that position should be taken which will secure the greatest amount of perflation by the prevailing breeze, through the front and back, and the minimum of sunshine passing directly into the house, in similar directions.

Space.—The space in European barracks found necessary for the soldier is 90 superficial feet and 1,800 cubic feet per man in the dormitories, and private houses should not give less. In European hospitals 120 superficial feet and 2,400 cubic feet are allowed, showing the greater necessity of fresh air and ventilation in the sick-chamber. But no artificial ventilation and no amount of cubic space will obviate the necessity of natural ventilation, and this is only obtained by open doors and windows. In the hot season, it is necessary to close the doors and windows during the day, to prevent the entrance of hot air; but on the approach of sunset doors and windows should be thrown open for the free admission of air throughout the whole dwelling.

The impurities found in air are mentioned at p. 732. At present, we are only considering the gaseous and organic emanations from the lungs and skin of persons resident in a house, and particularly of the occupants of a sleeping-room. The principal object of breathing is to maintain the blood in a state of purity, and to render it capable of affording to all parts of the body the materials necessary to maintain nutrition and vitality. When an adult is in a state of rest every breath conveys about 1 pint of air into the lungs, or 18 pints every minute, or 57 hogsheads in 24 hours. By the process of the circulation 8 pints of blood every minute, or 24 hogsheads every 24 hours, meet the air in the delicate tissues of the lungs, where the blood parts with the carbon or effete material it has received from the tissues, and takes the oxygen it receives from the air. The air when it leaves the lungs is composed principally of carbonic acid, which is a poisonous gas, and will neither support life, nor even the flame of a candle. But other matters besides carbonic acid are constantly thrown off by the lungs, and by the skin, viz., watery vapour, and microscopical atoms of organic matter. When the air of an inhabited room is thus vitiated to the extent of ·7 per 1,000 cubic feet of air, the vitiation becomes perceptible to the sense of smell. Persons sleeping under such circumstances wake in the morning unrefreshed and suffering from headache. They lose their appetites, become enfeebled, and more liable to various disorders. If the contamination of the air is still greater, some form of fever, probably typhus, will be excited. If the air is excessively charged with the products of respiration, and with emanations from the skin, those breathing it must die, as occurred in the Black Hole of Calcutta when, in 1756, out of 146 prisoners confined, 123 expired in one night. It may be stated as an axiom that the most ordinarily impure external air is less deleterious than that arising from overcrowding, or want of ventilation in dwellings, and especially in sleeping-apartments.

CONSERVANCY.—Persons cannot be too particular regarding conservancy. Otherwise, the sweeper will remove bath-room refuse and deposit it in any corner. Hence it may become the cause of disease, probably of *enteric* fever (*vide* p. 240). All bath-room refuse should be first disinfected by dry earth (*vide* p. 736) and then taken away and buried. It should also be recollected that Indian cattle and sheep will greedily devour human ordure, especially in the hot season, when grass is scanty. In this manner the germs of certain maladies—tapeworm, for instance—may be conveyed, with flesh food, into the human system (*vide* p. 483).

CONDUCT OF THE PASSIONS.—There is a proverb, borrowed from the Persians, that 'the proper devil of mankind is man,' and it is a fact that the state of health of Europeans in India depends much on the control exerted over the enemy within. Moderation in all matters, whether in eating or drinking, business or pleasure, is one golden rule; another, equally important, being the endeavour to avoid those fits of irritability to which the European, fretful from heat of climate, and often annoyed by the not understood, dilatory, or otherwise objectionable conduct of the Natives, is apt to give way. It is a fact that ague at least not unfrequently follows, in persons predisposed to the affection, fits of passion, or other mental excitement. The *mens sana* is even more than ordinarily desirable in India, as a security for the *corpus sanum*.

MANNER OF LIFE DURING EPIDEMICS.—When epidemic disease, as cholera, for instance, occurs, it will be best not to make any decided change in the manner of life. Caution as regards diet, exposure, fatigue, and local sanitation will be advisable, but any sudden change of habit which may tend to unsettle the system should be avoided. Neither should spasmodic sanitary measures be attempted at such times, as the disturbance of masses of filth during an epidemic season may be followed by increase of disease. Fear of disease should be guarded against, if not altogether dispelled, by the recollection that even during the worst epidemics immunity is the rule, and not attack.

CHAPTER VII

THE MANAGEMENT OF THE SICK-ROOM

Appearance of the Sick-Room.—The whitewashed walls of an Indian bungalow are not conducive to the repose demanded by a patient. The best colour for the sick room is a uniform neutral tint, such as light green, buff, or slate colour. The windows should be so arranged as to admit, except in some diseases of the eye and brain, abundance of light, or at least as much as is agreeable to the patient. Light is a stimulus to the body, and the mistake is often made of shutting out the light too much. The windows should not be surrounded by woollen curtains, a plain green blind, or 'chick' tempering the light sufficiently, and, if necessary, cutting off outside objects from the patient's view. All hangings and curtains, particularly woollen textures, should be avoided, as they may become harbourers of the germs of disease. For the same reason carpets should as much as possible be dispensed with, although it is advisable to have something to deaden the noise where the most traffic occurs. Each morning carpets or mats should be quietly taken out, and be thoroughly shaken and aired. The floor should be wiped with a damp cloth. If a chunam floor is broken up, it will absorb not only fluid and moisture, but probably also disease germs. Therefore any holes in the chunam floor of a sick-chamber should be repaired immediately. A wooden floor, if not polished, requires even greater care and cleanliness than the chunam floor. The porous brick flooring and the 'rammed earth' floor sometimes found in bungalows are in every way objectionable. *Leeping* or smearing an earthen floor with wet cow-dung, of which the Natives are so fond, is, from concealing dirt and the attendant damp, less desirable than simply sweeping. If a patient with a contagious disorder must be treated on an earthen floor, it will be advisable to slightly scrape the floor every day. In cholera, fresh dry earth should be placed around the bed. The less furniture in the sick-room, the more air there will be for the patient, and therefore furniture not required for use had better be removed. Cushions and covers should also be dispensed with. Beds having iron frames are less liable to harbour either the germs of disease or insects. The bed-head should if practicable point to the north, for the reasons given at p. 683. But it should not face a window so as to expose the patient's face to the light; it should not be side on to a wall; at least ten inches should intervene between the bed-head and a wall; and it should not be in any position, as between windows and doors or fireplaces, exposing the patient to a draught. The room should be made bright and cheerful by flowers, pictures, books, or other things pleasant to the patient. Such objects should not, however, be intruded on his attention, and if they create disgust, or excitement, or feverishness, they should be quietly removed.

Aspect of the Sick-Room.—When practicable, it will be most frequently advisable to take the coolest room. Unless in the cold weather of Northern India, when cold north-east winds often prevail, the room which admits the greatest amount of perflation by the prevailing breeze, and the minimum of sunshine passing directly on it, will be the apartment best suited for an invalid.

Cleanliness of the Sick-Room.—This can never be thorough when carpets are nailed down so that they cannot be removed to be shaken and aired. In fevers the bed-linen *under* the patient should be changed at least once a day. The upper sheet, if not soiled, may be used next day after airing as the under one. The pillow cases should also be changed daily. Patients suffering from contagious diseases should have the whole of their bedding changed every day (*vide* p. 703). Bath-rooms, closets, or cupboards should not be made the repository of unnecessary articles, and used clothing or bed-linen should never be put in such places. These things should be immediately disinfected (*vide Appendix,* No. 122).

CONSERVANCY OF THE SICK-ROOM.—Unless required for inspection, the dejections should be received in a utensil charged with some disinfecting agent and buried (*vide Appendix.* No. 126). When the dejections are preserved for inspection, they should be put in an outhouse, and not in a room or bath-room adjoining the sick-chamber. Great care should be taken that urine does not come into contact with the chunam floor of the bath-room usually found in Indian bungalows. The absorption of fluid by a broken chunam floor has been referred to (p. 697); but there is an additional reason why urine should not be permitted to come in contact with chunam. If this occurs chemical action takes place, and ammoniacal odours are emitted. This will happen even when the chunam floor is not broken up, but much more quickly and powerfully when holes exist.

DEODORISATION AND DISINFECTION OF THE SICK-ROOM. *Vide Appendix,* Nos. 118 to 125.

DIETETICS OF THE SICK-ROOM.—Although we now know better than to starve persons because they are sick, yet the sick cannot take the same food as the healthy. When a person has fever (the majority of diseases being thus accompanied), the appetite for solid food is gone, and therefore all nourishment must be given in a liquid form. Milk is an article which all may take in almost any illness; and in some cases of bowel complaint, milk diet alone is often taken with benefit (*vide* pp. 194, 244). If good fresh milk cannot be obtained, preserved milk may be tried. Cold milk is sometimes more agreeable than warm. It may require the addition of limewater when there is acidity of the stomach or gastric disease present, and it may be necessary to give the milk in small quantities, repeated often, and in this way, when ice-cold, it may be administered to irritable stomachs with the best effect. Cold water, and sometimes even ice-cold water, is a most beneficial drink, which patients may take as often as they wish, provided too much be not taken at any one time. Tea is often comforting to sick people, and may be given without harm if sufficiently diluted with milk. Other fluids suitable for invalids are beef tea, chicken, veal, or mutton broth, chicken jelly, bread jelly, flour and milk, Liebig's raw-meat soup, gruel, &c. (*vide Addendum*). Raw eggs beaten with milk are frequently useful, and *occasionally* arrowroot and other farinaceous foods.

When the appetite returns, and a desire for solid food is felt, much care should be taken for some days. Boiled fish, chicken or mutton, with bread and dry toast, will generally be the best diet. Vegetables are not recommended. Jelly, blanc-mange, light puddings made of tapioca, sago, or rice, may be given, and an egg for breakfast, or in the evening. But generally all preparations made from wheat flour, oats, grits, barley, are to be preferred in recovery from fevers, to tapioca, cornflour, rice, sago, or semolina. As a rule no stimulants need be given until the stage of convalescence, when two or three glasses of good port or claret may be taken daily. In instances when disease assumes a tendency to sinking, stimulants must be administered freely; but no general rules can be laid down (*vide* Enteric Fever, p. 245). When food is given to either the sick or convalescent, only a little should be brought at a time, and that in a tempting form, and frequently. A large basin of beef-tea or bread and milk is often refused, when a small quantity offered in a tempting manner would be taken. But the patient should not be too much pressed to take food, especially when it is apparent that he has no desire for it. Particular care should be taken that the patient is not neglected at night. Weak patients are often not able to take food till nearly forenoon, and an egg or beef-tea given during the night will probably prevent this; for there is a want of staying-power in sickness, which is particularly felt during the night. If food is declined the patient should be asked if there is anything he prefers, and if reasonable it may be provided, for the food most relished is generally that most needed. Food offered should always be fresh; it should never be left in the sick-room, and no cooking should ever be allowed in the sick-chamber.

When during convalescence the appetite is bad, tonics are generally desirable. To most invalids in India a large amount of quinine, or perhaps of arsenic, will have been given, so that more of these remedies will probably not be desirable (*vide* p. 267, small type). Under such circumstances, if the malady has been one affecting the bowels, acids may be taken with advantage, such as Recipe 34. If the malady has been fever (excepting enteric), malarial fever, ague, influenza, or neuralgic affections, an infusion of the Indian plants *chiretta* or *kreat*, may be taken, which possess tonic and anti-periodic powers. An infusion may be made by pouring a pint of boiling water on three ounces of dried chiretta and standing for half an hour. Dose of the stained infusion, one to two ounces. A concentrated tincture has been prepared called *kreat halviva* which is an excellent tonic after the maladies named above; also exerting a preventive influence against so-called malarious diseases. It is a safe tonic for children. Dose for an adult, from one to two drachms in a little water. For children according to table of proportions at p. 6.

NURSES, DUTIES OF.—The nurse must remember that *she is not* to diagnose the case, but to repeat all symptoms to the doctor, and leave him to draw his own conclusions. If a nurse wishes to serve a doctor, she must, in his absence, use her five senses to detect anything that can add to his knowledge of the case. There are no such things as 'trifles' in nursing. Nothing is beneath notice, and the more minute the observations the better. Among the prominent duties of the nurse are, to see to the cleanliness of the patient, to make provisions for his food, to note the quality, the time at which it is taken, and the quantity; to note the temperature as directed; to see that the excretions are preserved or measured as directed, or otherwise to notice their appearance; to note the periods of sleep, the expressions used by the patient, and any change in his appearance or demeanour.

NURSING OF HELPLESS PATIENTS.—The patient's strength should be saved; he should not be permitted to excite himself or to exert himself unnecessarily, and he should never be waked to take medicine. When patients are weak or have been a long time in bed, there is a tendency to faint when they are raised into an erect posture. Therefore such patients should be removed from the horizontal position as little as possible. When *washing* patients the points to be secured are not to tire and not to chill. Washing should be done after food, and part of the person should be washed at one time. When *beds or clothing require changing,* a time should be chosen when the patient is least exhausted, as half an hour after food.

A patient's bed may be changed by bringing another bed alongside, and sliding the patient from one to the other, or lifting him in a sheet. The new bed should be placed by the side of the old one, but sufficiently distant to allow a space between the two for attendants to move freely. Then, the patient being carried feet foremost over the foot of the old bed, so as to clear it, he should be carried head foremost over the foot of the new bed, the attendants walking along the sides of the bed, and lowering the patient steadily into the proper place. Or, if there is space, the bed-heads may be placed end to end, and the patient may be lifted out of the first and over it into the second.

Changing the Sheets of Helpless Patients.—Roll up, lengthways, half of the dirty sheet, and push the roll under the side of the patient. Then roll up one half of the clean sheet, and spread the other half over the side of the bed from which the dirty sheet has been removed, and, tucking it under the mattress, place the roll alongside the roll of the dirty sheet. Then gently raise the patient, and turn him over the rolls of sheets, or draw the rolls under him. Then take away the dirty sheet and unfold the clean one. When the patient can be raised, it may be convenient to roll the sheets from the head towards the foot of the bed. The patient should be raised into a sitting posture, the dirty sheet should be rolled, and the clean one spread down to the buttocks. Then the patient should lie down, and, the legs and buttocks being raised, the dirty sheet may be drawn away, and the clean one brought down.

Changing the Clothes of Helpless Patients.—This should be done without uncovering or raising the person. The dress should be taken from over each arm, and then drawn out from under the body. The arms should be placed in the sleeves of the clean garment, the body of which should be placed over the patient's head, and drawn down without lifting the shoulders. A 'divided dress' has been invented which is very convenient.

Position of Helpless Patients in Bed.—Every sick-bed should be provided with a rope, and transverse handle hanging above it, by which the patient will often be able to slightly raise himself, and so materially assist his nurses. Or a substitute for the rope and handle is a long towel fastened to the foot of the bed. When pillows are used to raise a patient in bed, they should not be piled one on top of the other under the patient's head, as this has only the effect of raising the head and pressing the chin forward on the chest, a position irksome to the patient, and which obstructs the breathing. The pillows should be placed under the patient's back as well as his head, commencing at the small of the back, and rising gradually to where a pillow is placed for the head. When the upper part of the body is raised, there is a tendency for the patient to slip downwards. A foot-board with a pillow for the feet to rest against will prevent this, but often the patient cannot bear his feet against the board. Under such circumstances a pad, or an air or water cushion, either horseshoe-shaped or circular, with a hole in the centre, may be put under the buttocks of the patient, and tied by two tapes to the head or sides of the bed, and thus a fixed obstruction will be opposed to the buttocks slipping down.

Feeding Helpless Patients.—When necessary to give food, drink, or medicine to a patient, the head, and, if possible, the upper part of the body, should be raised. For fluids, a feeding-cup should be employed. Where this is not provided, a spoon, a glass, or a mug may be used. When the latter are used they should be only half-filled. If too full, the fluid is sure to be spilt.

The Bed-pan for Helpless Patients.—The bed-pan should be used with great care, and with as little disturbance as possible to the patient, especially when injury necessitates its use. There are two kinds of bed-pans—the circular and the slipper. When the circular bed-pan is used, the patient will have to be lifted by two or three attendants, and the pan slipped under him. With the slipper bed-pan the patient should be raised at one side, and the thin end introduced under the buttocks.

Quiet in the Sick-Room.—None but the attendants required should be admitted. A patient is often unwilling to talk, and excitement always does harm. Asking unnecessary even if sympathising questions, whispering, walking on tiptoe, rustling garments, or creaking shoes, and all unnecessary noise, both inside and outside the house, should be avoided.

Temperature of the Sick-Room.—In a temperate climate, unless in some particular forms of disease, the temperature of the sick-room should range between 65° and 70° Fahr. But in India it will frequently be much higher, and the use of punkahs, or even of tatties, although often undesirable, cannot always be dispensed with. Whatever the temperature may be, every care should be given to maintain it *equable*, especially when dealing with affections of the chest. During the spring and autumnal seasons in the more northerly parts of India, there is a great difference of temperature between the night and day, particularly apparent in the early morning; when extraordinary care should be taken to prevent a patient being chilled. At page 676 chill is mentioned as a fertile source of disease in India, and the liability to take cold in a hot climate is insisted upon. As such is the case with persons in health, the sick must be doubly susceptible.

Ventilation of the Sick-Room.—The amount of air required for breathing; the impurities in air; the disease germs which arise from the sick; and the necessity of ventilation to remove or destroy these germs, are detailed at pp. 694, 732. In Indian bungalows the entrance of fresh air into the apartment and the exit of foul air from the room are only to be obtained through the doors and windows, and in many parts of the country at some seasons of the year the hot winds forbid opening doors and windows during the day. Much, however, may be done by the arrangement of doors and windows in different parts of the house, so that fresh air from *outside* the house may enter the chamber; and for this nearly all houses require different arrangements. The purity of a sick-room may be judged of by noticing whether there is any perceptible odour on entering the room. A better test is placing a wide-mouthed bottle in the room for some hours, and then pouring a little clear lime-water (Recipe 25) into it, and shaking it. If the air is impure, the fluid will become more or less milky in appearance.

VISITING THE SICK-ROOM.—Visitors should be guided by the medical attendant as regards time of interview and subjects mentioned. They should not make a noise, nor speak in whispers, nor walk about on tiptoe. They should avoid talking about the patient and asking questions. If there is any breeze, visitors should remain on the side of the bed to which the air approaches. The mouth should be kept closed, as the penalty of breathing with the mouth open may be infection, which is much less likely to occur through the nose (*vide* p. 671).

APPENDIX

PRESCRIPTIONS

THE prescriptions to be made up from the small medicine case to accompany this volume, or from articles procurable in the bazaars, are placed *first* under the following headings, and are separated by a double line from the prescriptions to be procured from chemists. For the peculiar action of these medicines *vide* page 8. The *first* prescriptions are those referred to in the *large* type of the preceding chapters; the *others*, to be procured from chemists, and are those referred to in the *small* type.

Aperients and Purgatives

The above terms sufficiently denote the action of these kinds of medicines. But many have influence on different internal organs, and are therefore of use under different conditions.

1. Take of	Podophyllum resin . . .	grain, one sixth.
„	Compound Rhubarb Pill . .	grains, two and a half.
„	Extract of Hyoscyamus . .	grain, one and a quarter.

Mix well, and make into one pill. To be coated tasteless.

The pill may be taken at night, and, if not acting sufficiently, Recipe 2, or citrate of magnesia (*vide* p. 15), or some mineral water, or a Seidlitz powder, may be taken in the morning. Ordinarily one of the pills will be sufficient, although some will require two, or even three.

This pill is carried ready-made in the medicine case designed to accompany the volume. It should be supplied in a tasteless capsule which quickly dissolves in the stomach. It is as good a pill for general use as can be devised. It is therefore referred to in the foregoing chapters for maladies for which nothing could be better suited. But it is sometimes recommended (as indeed are various other prescriptions) as a substitute for medicine which could not be included in the medicine chest, or procured except from a chemist's. *But no pill yet devised will suit all* *people at all times.* If, therefore, anyone consulting this book possesses a recipe which experience has shown acts satisfactorily, such recipe may be used when this prescription is recommended. Otherwise, Recipe No. 1 not answering, Recipe 7 may be procured for ordinary use, and Recipes 9, 10, 13, 14, for occasional use.

2. Take of Sulphate of Soda . . . drachms, six.
   „ Tincture of Ginger . . . minims, twenty.
   „ Water, distilled . . . ounces, two.

Mix well, and make a draught. An aperient, which may be taken alone, or used in the morning to assist the action of pills taken overnight. If a quicker action is required, the draughts may be taken three or four hours after the pills. The quantity of sulphate of soda may be increased by one or two drachms if the above prescription is not sufficiently powerful; or if too strong, the amount may be diminished.

3. Take of Sulphate of Soda . . . drachms, six.
   „ Quinine . . . . . grains, twenty.
   „ Sulphate of Iron (the *Hera-Kusees* of the bazaars) . . } grains, fifteen.
   „ Water, distilled . . . ounces eight.

Mix well, and make a mixture. Dose—two table-spoonfuls every four hours. A tonic and aperient. Useful in affections of the spleen, and for amenorrhœa; also for thread-worms.

4. Take of Sulphate of Soda . . . drachms, six.
   „ Dilute Sulphuric Acid . . drachm, one.
   „ Infusion of Roseleaves . . ounces, eight.

Mix well, and make a mixture. Dose—two table-spoonfuls every four hours. A cooling aperient with astringent action. Useful in miscarriage, menorrhagia, epistaxis, and in other cases where loss of blood occurs.

5. Take of Sulphate of Magnesia . . drachms, six.
   „ Tincture of Digitalis . . . minims, eight.
   „ Camphor Mixture . . . ounces, two.

Mix well, and make a draught. An aperient and sedative. Useful in asthmatic attacks with constipation.

6. Take of Bicarbonate of Magnesia . . grains, ten.
   „ Bicarbonate of Soda . . . grains, eight.
   „ Compound Senna Mixture . . ounce, one.

Mix well, and make a draught. An antacid and aperient. Useful in dy spepsia and liver affections.

7. Take of Euonymin . . . . . grains, twelve.
„ Extract of Hyoscyamus . . grains, eighteen.
„ Extract of Gentian . . . grains, eighteen.
„ Extract of Belladonna . . grains, three.

Mix well, and make into twelve pills. Dose—one, two, or three occasionally. A good vegetable aperient for liver.

8. Take of Blue Pill . . . . . grains, five.
„ Calomel . . . . . . grains, five.

Mix well, and make into two pills. A strong purgative; for use only as prescribed in preceding chapters.

9. Take of Blue Pill . . . . . grains, five.
„ Compound Extract of Colocynth grains, five.

Mix well, and make into two pills. A moderate purgative; for occasional use.

10. Take of Compound Extract of Colocynth grains, five.
„ Compound Rhubarb Pill . . grains, five.

Mix well, and make into two pills. A mild purgative; for occasional use.

11. Take of Calomel . . . . . grains, five.
„ Compound Jalap Powder . drachm, one.

Mix well, and make a powder. A strong purgative, producing watery stools. Used in dropsical affections.

12. Take of Podophyllum resin . . . grain, one and a half.
„ Compound Extract of Colocynth grains, thirty.
„ Ipecacuanha Powder . . grains, four.

Mix well, with a little gum, and divide into twelve pills. Dose—one twice a day. In liver affections, and for constipation.

13. Take of Extract of Aloes (Glacial) . grains, fifteen.
„ Powdered prepared Castile Soap grains, fifteen.
„ Extract of Glycyrrhiza . . grains, fifteen.
„ Ipecacuanha Powder . . grains, two.

Mix well, and make into twelve pills. One or two for a dose. A mild aperient, and a good dinner pill, taken a quarter of an hour after dinner.

14. Take of Pill Aloes and Myrrh . . grains, three.
„ Blue Pill . . . . . grain, one.
„ Extract of Taraxacum . . grains, two.
„ Extract of Stramonium . . grain, one half.

Mix well, and make into two pills. Useful in asthma,

15. Take of Sulphate of Iron . . . scruple, one.
,, Extract of Aloes (Glacial) . grains, fifteen.
,, Powdered Rhubarb . . . scruple, one.

Mix well, and make twelve pills. Two for a dose. A good aperient for weakly constipated persons, and for delayed monthly courses.

16. Take of Powdered Rhubarb . . . ounce, one.
,, Powdered Ginger . . . ounce, one half.
,, Carbonate of Magnesia . . ounces, three.

Mix well in a mortar. This is known as 'Gregory's Powder.' Dose—half a tea-spoonful to a tea-spoonful, in a little peppermint water. For indigestion and acidity of the stomach. It may be used for children from two to three years old in ten- or twelve-grain doses, when a mild purgative is required. It may be given at night, and be followed by a tea-spoonful of castor-oil in the morning.

Alteratives

Alteratives are medicines given to alter the condition of the blood, or the secretions of the kidneys, liver, and bowels.

17. Take of Compound Ipecacuanha Powder (*Dover's Powder*) . . } grains, ten.
,, Quinine . . . . . grains, three.
,, Ipecacuanha Powder . . grain, one.

Mix well, and make a powder. To be taken at bed-time. For dysentery, diarrhœa, and liver affections. It may be necessary to omit the ipecacuanha powder if it causes nausea or sickness.

18. Take of Compound Ipecacuanha Powder (*Dover's Powder*) . . } grains, two.
,, Quinine . . . . . grain, one.

Mix well, and make a powder. Dose—one night and morning for a child two years old. For a child one year old, half the quantity. For a child six months old, one quarter. For infantile diarrhœa with fever.

19. Take of Bromide of Potassium . . drachm, one.
,, Water, distilled . . . ounces, six.

Make a mixture. Dose—two table-spoonfuls three times a day. For nervous affections. (*Vide* note to Recipe 21.)

20. Take of Bromide of Potassium . . drachm, half.
,, Spirits of Nitrous Ether . . drachm, half.
,, White Sugar . . . . drachm, one.
,, Water, distilled . . . ounce, one and a half.

Mix well, and make a mixture. Dose—a tea-spoonful every second hour for a child from one to two years old. Two tea-spoonfuls after two years old. For nervous affections and convulsions of children.

21. Take of Iodide of Potassium . . drachm, one.
,, Water, distilled . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For syphilitic diseases, and various other morbid deposits.

Note.—Iodide and bromide of potassium as in Recipes 19, 20, and 21, after being taken for some time (days in some persons, weeks in others), may produce symptoms of cold in the head, sore-throat, or an eruption of pimples on the body. When this occurs the medicine should be stopped.

22. Take of Bicarbonate of Magnesia . . grains, fifteen.
,, Oil of Aniseed . . . drops, two.
,, Water, distilled . . . ounce, one and a half.

Make a mixture. Dose—one tea-spoonful occasionally for an infant from six months to one year old, with flatulence or 'wind on the stomach.' At less than six months old, half a tea-spoonful. Useful also for the sickness of pregnancy, when the whole may be taken.

23. Take of Calomel . . . . . grains, two.
,, Extract of Opium . . . grain, one quarter.

Mix well, and make into a pill. Dose—one every three or four hours. Used when the specific action of mercury on the system is required.

24. Take of Blue Pill . . . . grains, two.
,, Extract of Opium . . . grain, quarter.
,, Ipecacuanha Powder . . grain, quarter.

Mix well, and make a pill. Dose—one every three or four hours. In dysentery or bad diarrhœa.

Calomel and blue pill contained in the two last recipes are preparations of mercury, and it should be a rule, before prescribing any preparation of mercury, to inquire if there be any peculiarity of constitution permitting very small doses of mercury to affect the system; for it occasionally happens, owing to some constitutional idiosyncrasy, that even one dose of calomel or blue pill will produce salivation, and to such persons no preparation of mercury can be safely given. If ever calomel is given to children, it should be held in mind that it produces in children unnatural-looking stools having a greenish slimy appearance, and care must be taken that more mercurials are not administered with the view of correcting the condition they induce.

25. *Lime-water.*—Place one quart of pure cold water in a glazed earthen vessel, and add half an ounce of quicklime. Cover, let it stand for three hours, and pour off the clear liquid for use. The bottle in which it is kept should be provided with a stopper, as access of air spoils lime-water. For the same reason it should be made fresh every second or third day. Dose—from one to three ounces, several times daily, with a child's food. Useful in teething, diarrhœa, indigestion, cholera, dysentery.

26. Take of Powdered Rhubarb . .	scruple, one.
„ Sulphate of Soda . . .	scruple, one.
„ Aromatic Spirits of Ammonia	drachm, one half.
„ Peppermint Oil . . .	drop, one.
„ Water, distilled . . .	ounces, two.

Make a draught. For acidity, and in the sickness of pregnancy.

27. Take of Solution of Potash . . .	drachm, one.
„ Tincture of Hyoscyamus . .	drachms, two.
„ Tincture of Cinchona . .	drachms, two.
„ Infusion of Buchu . . .	ounces, six.

Make a mixture. Dose—two table-spoonfuls three times a day. For chronic affections of the bladder.

28. Take of Bicarbonate of Soda . .	drachm, one.
„ Tincture of Hyoscyamus . .	drachms, two.
„ Decoction of Pareira . .	ounces, six.

Make a mixture. Dose—two table-spoonfuls three times a day. For chronic affections of the bladder.

29. Take of Salicylic Acid . . .	grains, forty.
„ Hydrochlorate of Morphia .	grain, one.

Mix well, and make into eight pills. One every four hours. For acute rheumatism.

30. Take of Bicarbonate of Soda . .	drachms, two.
„ Colchicum Wine . . .	drachms, two.
„ Spirits of Nitrous Ether . .	drachms, two.
„ Water, distilled . . .	ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For gout or rheumatism.

31. Take of Benzoic Acid . . .	drachm, one.
„ Carbonate of Ammonia . .	drachm, one.
„ Water, distilled . . .	ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For chronic cystitis, urinary disorders, and rheumatism.

32. Take of Bicarbonate of Soda . . drachms, two.
„ Tincture of Rhubarb . . ounce, half.
„ Tincture of Ginger . . . drachm, one.
„ Spirits of Chloroform . . drachm, one.
„ Water, distilled . . . ounces, six.

Make a mixture. Dose—two table-spoonfuls three times a day. Useful in jaundice.

33. Take of Extract of Taraxacum . . drachms, two.
„ Dilute Muriatic Acid . . drachm, one.
„ Infusion of Gentian . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. Shake the bottle before using. Useful in jaundice and for liver affections.

34. Take of Dilute Nitric Acid . . . drachm, one.
„ Dilute Hydrochloric Acid[1] . drachm, one.
„ Tincture of Ginger . . . drachm, one.
„ Water, distilled . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. In affections of the liver and dyspepsia. Also as a tonic, after dysentery and fevers. After taking this medicine the mouth should be well washed. [1] Hydrochloric acid is also called *muriatic* acid.

35. Take of Bicarbonate of Potash . . drachm, one and a half.
„ Water, distilled . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For fever and certain affections of the urine. Also sometimes useful as a lotion for external use in skin diseases.

36. *Effervescing Draughts.*—Dissolve twenty grains of Bicarbonate of Potash in two ounces of water, and add fourteen grains of Citric Acid when about to be taken.

Or, dissolve seventeen grains of Bicarbonate of Soda in two ounces of water, and add ten grains of Citric Acid. For acidity of the stomach.

Or, dissolve two drachms of Bicarbonate of Soda in eight ounces of water, and place in a bottle. Dissolve one drachm of Tartaric Acid in four ounces of water, and place in another bottle. Dose—two table-spoonfuls of the Soda Mixture with one table-spoonful of the Acid Mixture. Useful in fever, and in the sickness of pregnancy.

Effervescing Mixture with Chloroform.—Add to the Soda Mixture given in the last para. twenty minims of Chloroform. *Shake well before using.* For sickness and indigestion of pregnancy, also for sea-sickness.

37. Take of Bicarbonate of Potash . . drachm, one.
„ Nitrate of Potash . . . drachm, half.

Take of	Tincture of Ginger . . .	drachm, one.
„	Water, distilled . . .	ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For indigestion or rheumatism, attended with scanty, high-coloured urine.

Antispasmodics and Sedatives

Antispasmodics are stimulating medicines usually combined with sedative or soothing agents.

38. Take of	Strong Tincture of Ginger .	drachm, one.
„	Aromatic Spirits of Ammonia	drachm, one.
„	Spirits of Nitrous Ether . .	drachm, one.
„	Brandy	ounce, one.

Mix. Dose—one tea-spoonful in a glass of water hourly, or every two hours. For a child six months old, three or four drops; one year old six or seven drops; two years old, ten or twelve drops, in a little water. For diarrhœa and cholera. To be kept in a well-stoppered bottle.

39. Take of	Chloroform	drachm, one.
„	Aromatic Spirits of Ammonia	drachm, one.
„	Chlorodyne	drachms, two.
„	Brandy	ounce, one.

Mix. Dose—one tea-spoonful in water every two, three, or four hours. For diarrhœa and cholera. This and Recipe 38 should be taken in as much water as will dilute the compound, so that it may not be unpleasantly strong to swallow. Shake the mixture before using.

40. Take of	Prepared Chalk	drachm, one.
„	Aromatic Spirits of Ammonia	drachms, two.
„	Tincture of Opium	minims, forty.
„	Camphor Mixture	ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For dyspepsia and diarrhœa.

41. Take of	Extract of Conium	grains, three.
„	Extract of Indian Hemp. .	grain, one quarter.
„	Camphor.	grain, one.

Make a pill. Dose—one three times a day. For asthma and spasmodic bronchitis.

Astringents

Astringents are medicines which, acting on different parts of the system, diminish the secretions of various organs. They also when applied locally, contract the mouths of small bleeding blood-vessels, and prevent the continuance of loss of blood.

42. Take of	Powdered Alum	drachm, one.
„	Water, distilled	ounces, eight.

Make a mixture. Dose—two table-spoonfuls every four hours. For miscarriage, menorrhagia, chronic dysentery. Also used as an external application for ulcers &c.

43. Take of	Dilute Sulphuric Acid	drachms, two.
„	Tincture of Ginger	drachm, one.
„	Water, distilled	ounces, eight.

Make a mixture. Dose—two table-spoonfuls every four hours. For miscarriage, or bleeding from the lungs, also for dyspepsia. After taking this medicine the mouth should be well washed out.

44. Take of	Acetate of Lead	grains, three.
„	Tincture of Opium	drops, five.
„	Water, distilled	ounce, one and a half.

Make a draught. To be taken every three or four hours. For bleeding from the lungs.

45. Take of	Dilute Sulphuric Acid	minims, twenty-five.
„	Tincture of Opium	drops, eight.
„	Water, distilled	ounce, one.

Make a draught. To be taken three times a day. For bleeding from the lungs, or for bleeding from the stomach. Useful also in diarrhœa and cholera. The dose for a child six months old is half a tea-spoonful; at a year old one tea-spoonful. A tea-spoonful contains nearly one drop of laudanum (or tincture of opium); and one small drop of laudanum for each year of a child's age is the ordinary dose. Any preparation containing opium must be given with great caution to children, on account of their susceptibility to the drug. The dose should not be repeated oftener than every four hours.

46. Take of	Gallic Acid	grains, five.
„	Water, distilled	ounces, two.

Make a draught. To be taken three times a day. For bleeding from the lungs or stomach, or in scurvy, diarrhœa, and dysentery.

47. Take of	Acetate of Lead	grains, three.
„	Extract of Opium	grain, quarter.

Mix well, and make a pill. One to be taken three times a day. For bleeding or hæmorrhage. Also in diarrhœa and dysentery.

48. Take of	Compound Chalk Powder with Opium	grains, five.
,,	Bicarbonate of Soda	grain, one.
,,	Powdered Alum	grain, one.

Make a powder. To be taken every night, or, in bad cases, every night and morning. For infantile diarrhœa and dysentery. Forty grains of compound chalk powder with opium (*Pulvis Cretæ Aromaticus* [*vel compositus*] *cum Opio*) contain one grain of opium. Therefore five grains of the compound chalk powder contain one-eighth of a grain of opium. The powder may be given to a child of one and a half to two years old. Half the powder at one year old; a quarter at six months.

49. Take of	Dilute Sulphuric Acid	minims, twenty.
,,	Tincture of Catechu	minims, forty.
,,	Syrup of Ginger	drachms, two.
,,	Water, distilled	drachms, ten.

Make a mixture. Dose—half a tea-spoonful for a child six months old; one tea-spoonful for a child one year old; two tea-spoonfuls for a child eighteen months old. For diarrhœa, and after dysentery.

Diuretics and Diaphoretics

Diuretics are medicines which, acting on the kidneys and urinary passages, increase the quantity of urine. Many of the same medicines also act on the skin, increasing perspiration, and are therefore termed diaphoretics.

50. Take of	Nitrate of Potash	drachm, one.
,,	Spirits of Nitrous Ether	drachms, three.
,,	Water, distilled	ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For fever and rheumatism, and to increase flow of urine.

51. Take of	Spirits of Nitrous Ether	drachm, one.
,,	Aromatic Spirits of Ammonia	drachm, half.
,,	Ipecacuanha Wine	minims, twenty.
,,	White Sugar	drachm, one.
,,	Water, distilled	ounce, one and a half.

Make a mixture. Dose—half a tea-spoonful every third hour for a child six months old; a tea-spoonful for a child one year old; two tea-spoonfuls for a child two years old. For fever in children when the skin is dry. If the stomach is irritable, the ipecacuanha may be omitted.

52. Take of	Nitrate of Potash	scruples, two.
,,	Spirits of Nitrous Ether	drachms, two.
,,	Wine of Colchicum	drachms, two.
,,	Water, distilled	ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For rheumatism.

53. Take of	Nitrate of Potash	scruples, two.
,,	Spirits of Nitrous Ether	drachms, two.
,,	Tincture of Cantharides	drachms, two.
,,	Water, distilled	ounces, eight.

Make a mixture. Dose, two table-spoonfuls every three hours. In cholera, when no urine is secreted.

Emetics

Emetics cause the stomach to contract on its contents, and to expel them through the gullet and mouth. The emetics in common use are mustard, ipecacuanha, tartar emetic, and sulphate of zinc. *Ipecacuanha* is the best of all emetics, especially the wine for children. For the proper doses *vide* p. 15.

54. Take of	Mustard Flour	table-spoonful, one.
,,	Common Salt	tea-spoonful, one.
,,	Warm Water	ounces, ten to twelve.

Mix, and let the patient drink it all. This emetic should act within five or eight minutes. For children a tea-spoonful of mustard and a quarter of a tea-spoonful of salt in half a tumbler of warm water. It is desirable to promote the action of emetics by copious draughts of warm water, which, filling the stomach, also diminish the disagreeable sensations accompanying vomiting when the stomach is empty.

Expectorants

Expectorants are medicines which, acting on the air-passages leading to the lungs, and also, in some degree, on the general system, facilitate the passage of fluids secreted in the lungs and in the tubes leading to the lungs, in cough, catarrh, bronchitis, and asthma.

55. Take of	Aromatic Spirits of Ammonia	drachms, two.
,,	Spirits of Nitrous Ether	drachms, four.
,,	Tincture of Ginger	drachm, one.
,,	Water, distilled	ounces, five and a half.

Make a mixture. Dose—two table-spoonfuls every two or three hours. For asthmatic attacks and chronic bronchitis.

56. Take of Camphorated Tincture of Opium (*Paregoric*) . . . . } drachms, three.
„ Aromatic Spirits of Ammonia . drachms, two.
„ Water, distilled . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls every two or three hours. For asthmatic attacks and chronic bronchitis.

57. Take of Camphorated Tincture of Opium (*Paregoric*) . . . . } drachms, three.
„ Ipecacuanha Wine . . . drachms, one.
„ Spirits of Nitrous Ether . . drachms, three.
„ Water, distilled . . . ounces, seven.

Make a mixture. Dose—two table-spoonfuls every three or four hours. For catarrh, bronchial and lung affections. Useful in smaller doses for children with cough, bronchitis, inflammation of the lungs, and croup. The dose for a child one year old is one teaspoonful, increasing half a tea-spoonful for every year of age.

58. Take of Camphor . . . . grain, one.
„ Powdered Ipecacuanha . . grains, three.

Mix well with a little gum, and make into a pill. May be taken every two hours for asthma.

59. Take of Tartar Emetic. . . . grain, one.
„ Camphorated Tincture of Opium (*Paregoric*) . . . . } drachms, two.
„ Water, distilled and boiling . ounces, twelve.

Make a mixture and allow it to cool. Dose—two table-spoonfuls every two or three hours. For bronchitis, pleurisy, laryngitis, and pneumonia.

60. Take of Camphorated Tincture of Opium (*Paregoric*) . . . . } drachms, three.
„ Ipecacuanha Wine . . . drachms, two.
„ Tincture of Scilla . . . drachms, one.
„ Bicarbonate of Soda . . scruples, two.
„ Water, distilled . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls every three or four hours. For bronchial affections, especially when there are also dyspeptic symptoms or acidity. Useful for children in smaller doses, for cough, bronchitis, or croup. The dose for a child one year old is one tea-spoonful; increasing half a tea-spoonful for every year of age.

61. Take of Carbonate of Magnesia . . . grains, twenty-five.
„ Peppermint Oil . . . drops, two.
„ Water, distilled . . . ounce, one.

Make a mixture. Dose—a tea-spoonful three or four times a day. In hooping-cough, for a child one or two years old. Before using, the bottle should be well shaken. Also useful for the sickness of pregnancy, when the whole may be taken at once as a draught.

62. Take of Sulphate of Zinc . . . grains, two.
„ Camphorated Tincture of Opium (*Paregoric*) . . . } minims, sixty.
„ Water, distilled . . . ounce, one and a half.

Make a mixture. Dose—a tea-spoonful three times a day. For a child from one to two years old, for hooping-cough.

63. Take of Extract of Conium . . . grains, three.
„ Water, distilled . . . ounce, one and a half.

Make a mixture. Dose—a tea-spoonful three times a day. For a child from one to two years old with hooping-cough. Shake the bottle before using.

Opiates

Opiates are medicines which relieve pain and induce sleep. Of these the principal are opium, morphia, chloral. In large doses they are poisons, and must be administered with caution.

64. Take of Chloral . . . . . grains, twenty.
„ Water, distilled . . . ounce, one and a half.

Make a draught. (*Vide Chloral*, p. 10.)

65. Take of Hydrochlorate of Morphia . grain, one.
„ Rectified Spirits of Wine . . drops, ten.
„ Water, distilled . . . ounce, one.

Make a draught. To be taken when a strong opiate is required, as in obstruction of the bowels, and in tetanus.

Tonics

Tonics impart 'tone' or strength to the system, and are useful during convalescence from exhausting maladies, and in most debilitated conditions. Tonics act without stimulating the system, and are thus different from 'stimulants.' One variety of tonics—namely, preparations of iron—owes its virtues to its power of supplying a deficient element of the blood (*vide* p. 24).

66. Take of Quinine . . . . . . grains, twenty-four.
„ Sherry Wine . . . . . ounces, two.
„ Water, distilled . . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day.

67. Take of Quinine . . . . . . grains, twenty-four.
„ Lemon Juice (fresh) . . . drachms, two.
„ Water, distilled . . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day.

68. Take of Isinglass . . . . . . drachms, two.
„ Sugar, white . . . . . drachms, two.
„ Brandy . . . . . . half a wine-glass, or
„ Sherry . . . . . . one glass.
„ Nutmeg . . . . . . a pinch.
„ Boiling Water . . . . ounces, four.

Make a draught. A good stomachic tonic in diarrhœa.

69. Take of Quinine . . . . . . grains, twenty.
„ Dilute Sulphuric Acid . . drachm, one.
„ Tincture of Ginger . . . . drachm, half.
„ Water, distilled . . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls every three or four hours.

70. Take of Citrate of Iron and Quinine . scruples, two.
„ Water, distilled . . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls every three or four hours. Wash the mouth after taking the medicine. For a child one year old, two tea-spoonfuls; two years old, a dessert-spoonful. It should be recollected that any iron medicine colours the stools black.

71. Take of Tincture of Iron (*Steel Wine*) . drachms, two.
„ Water, distilled . . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day. For anæmia and debility. Wash the mouth after taking the medicine. *Neutral solution of peroxide of iron* (known as liquid dialysed iron) may be substituted for those objecting to the taste of steel wine. Or the solution, being almost tasteless, may be taken in eight- or ten-drop doses on a lump of sugar. *Carbonate of Iron* is a good remedy for those objecting to the taste of the tincture. It may be taken in five- to ten-grain doses, in water; or as a powder mixed with sugar, or alone; or, being almost tasteless, it may be sprinkled on the food. Iron lozenges may be procured from the chemists.

72. Take of Sulphate of Iron . . . grains, twelve.
„ Dilute Sulphuric Acid . . drachm, one.
„ Water, distilled . . . ounces, six.

Make a mixture. Dose—two table-spoonfuls three times a day. For anæmia and debility.

73. Take of Sulphate of Iron . . . grains, nine.
„ Sulphate of Quinine . . grains, twelve.
„ Dilute Sulphuric Acid . . drachm, one.
„ Sulphate of Soda . . . ounce, one.
„ Sugar, white . . . . drachms, two.
„ Water, distilled . . . ounces, twelve.

Make a mixture. Dose—two table-spoonfuls two or three times a day. For painful menstruation with constipation. As a tonic aperient, in affections of the liver or spleen.

74. Take of Syrup of the Iodide of Iron . ounce, one.

Dose—thirty drops three times a day in a wine-glassful of water.

75. Take of Arsenical Solution . . . minims, forty.
„ Water, distilled . . . ounces, eight.

Make a mixture. Dose—two table-spoonfuls three times a day after meals. Arsenical solution is also called *Liquor Arsenitis Potassæ*. As a tonic; also used for the cure of ague, and in skin disease.

After arsenic has been taken for some time (varying with different people from days to weeks), it produces certain effects. These are colicky pains in the bowels, diarrhœa, watering, itching, and irritation about the eyes, the whites becoming 'blood-shot,' and the eyelids feeling stiff. These effects show that the system has been brought under the influence of the medicine. In order to avoid pain in the bowels and to prevent the arsenic passing away with diarrhœa, arsenic should be taken a quarter of an hour after meals.

76. Take of Sulphate of Quinine . . grains, twelve.
„ Sulphate of Cinchonidine . grains, twelve.
„ Arsenious Acid . . . grain, one quarter.
„ Carbolic Acid . . . . grain, one and a quarter.
„ Camphor . . . . . grain, one and a quarter.
„ Powdered Capsicum . . grains, five.

Mix well with a little gum arabic, and make into twelve pills. One night and morning, or every three or four hours. For use as a tonic, and preventive of fever in malarious districts.

Hot Applications

77. *Bran Poultice.*—Make a linen or flannel bag of the size requisite and fill loosely with bran. Pour boiling water on till thoroughly moistened. Put it into a coarse towel and absorb excess of moisture. Then place it on the part, and cover with a dry towel.

78. *Bread Poultice.*—Put half a pint of scalding hot water into a basin. Add as much crumb of bread as the water will cover. Let it steep five minutes. Then drain off the water and spread the moistened bread on a piece of linen, and apply. In India, *atta* or flour must often be substituted, bread not being always available. If *atta* is used it will be necessary to stir it, to mix it well with the water.

79. *Linseed Meal Poultice* is made in a similar manner by scalding finely powdered linseed meal.

Powdered Charcoal is also used for poultices when an application to a gangrenous wound is required. It should be made of equal parts of linseed meal or bread and powdered charcoal.

When applying a poultice, cover the surface with a little butter or oil, which will prevent the poultice sticking to the skin when removed. Poultices should never be allowed to remain on after they have cooled, as they become clammy, unpleasant, and injurious.

80. *Fomentation.*—This is managed by some pieces of flannel of the required size, and containing four or five folds, soaked in water so hot as to be grateful to the patient. The hand is not a fair guide to the heat necessary; neither is the thermometer, as some persons bear without flinching heat to the skin which would be painful to others. Beneath the part to be fomented should be placed a waterproof sheet or oil-cloth. Then the flannel should be wrung nearly dry (by twisting it in a towel), applied to the part, and covered with a thick, warm towel. Another fold of flannel should be in the water in readiness, and the flannels should be changed before they feel cool to the patient. This should be effected quickly, so that the patient may not take cold, and care should be taken to dry the parts after the fomentation. Sometimes, instead of poultices or fomentations, it will be more convenient to use spongiopiline, which is composed of felt with an impervious covering. Or 'Iceland Moss poultice,' which only requires steeping in hot water.

81. *Poppy Water for fomentation.*—Steep half a dozen bruised poppy-heads and the contained seeds in as many pints of boiling water, and, after half an hour, strain the infusion. It is employed instead of plain water for painful affections, and may be used to make poultices.

82. *Dry Fomentations.*—This may be effected by flannel bags filled with camomile flowers, hops, bran, or even sand. The bag thus filled should be heated and then applied to the part, another being substituted when it becomes cold.

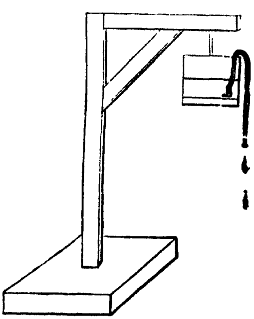
Cooling Applications

Hot applications are most useful to hasten a 'gathering,' but in the commencement of any local inflammation it will often be proper to use cooling applications, and thus endeavour to check the 'gathering.' As it may be sometimes difficult to decide whether the use of hot or cold applications will be best, the sensations of the patient should be consulted, which are generally a safe guide. Thus, if shivering or pain follow the application of cold, it should be cautiously changed for *warm* applications, *gradually* made hotter. The application of cold may be effected by the following means:—

1. *Evaporating Lotions.* (*Vide* Recipes 83, 84.)—A piece of linen, *not doubled,* should be dipped in the liquid and laid on the part affected, but no covering should be permitted over this. To secure evaporation and the resulting cold, exposure to the air is required. The piece of linen should be frequently freshly wetted, or the lotion may be dropped upon it from a sponge. In the absence of a lotion, iced water may be used. Or a lotion may be made by mixing two ounces of spirits of wine and two ounces of vinegar in a pint of cold water.

2. *Ice in a Bladder or India-rubber Bag.*—Ice roughly pounded, or shaved with a cucumber grater, placed in a bag, will produce intense cold. Or, if ice is available in small quantities, it may be mixed with an equal bulk of salt. *Ice Poultices* are made by placing lumps of ice on a thick layer of linseed meal. Sprinkle more meal lightly over and cover with another cloth. Fold in the edges to prevent escape of the meal, and apply the thick side. The exclusion of air prevents quick melting of the ice, and the thick layer of meal prevents a high degree of cold.

3. *Irrigation.*—Expose the part, beneath which india-rubber cloth or oil-cloth should be placed. Then a vessel containing cold water should be suspended on the bedpost, or from a hook in the wall, or from a stand as here figured, so that the receptacle may hang directly over the part to be 'irrigated.' Continuous dripping of the water may be accomplished by hanging over the edge of the vessel a thin strip of lint previously well soaked. Capillary attraction will cause the fluid to drop more or less rapidly, according to the size of the strip of lint. The exact point on which the dripping occurs should be varied from time to time by altering the position of the hanging vessel.


IRRIGATION STAND

83. Take of Nitrate of Potash . . . ounce, half.
„ Hydrochlorate of Ammonia . ounce, half.
„ Common Salt . . . . ounce, half.
„ Water . . . . . ounces, twelve.

Make a lotion. Either this or Recipe 84 may be used when cooling lotions are required. The materials may be procured in Indian bazaars. *Vide* pp. 21, 26. If greater cold is required, equal parts of the ingredients may be mixed roughly in a very small quantity of water, then placed in an india-rubber bag or bladder, and applied to the part. This forms a good substitute for ice.

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84. Take of Acetate of Lead . . . drachm, one.
 „ Rectified Spirits of Wine . ounce, one.
 „ Water, distilled . . . ounces, twelve.

Make a lotion. To be applied as mentioned under 'Evaporating Lotions,' p. 723.

SOOTHING APPLICATIONS

85. *Water Dressing.*—This consists of a double fold of lint or linen soaked in water and applied to the part. Over this a covering of oil-silk, gutta-percha tissue, or bladder should be laid. Warm or cold water may be used, and the dressing should be changed three times a day. It is often advisable to use carbolic acid lotion (No. 119) instead of water.

86. *Simple Ointment.*—Mutton fat, two parts; olive oil, one part; yellow beeswax, half a part. Melt in a saucepan, and stir while cooling. This forms a healing ointment, which may be medicated in various ways by other agents (*vide* Recipes 95, 96). If practicable, *lanolin* should be used instead of mutton fat. Lanolin is made from wool oil, is absorbed readily by the skin, and does not become rancid.

87. *Carron Oil.*—Equal parts of linseed oil and lime-water (*vide* Recipe 25) should be taken together. For burns and scalds. If no linseed oil, use olive or salad oil.

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88. Take of Calomel . . . . . . grains, thirty.
 „ Lime-water (*vide* Recipe 25) . ounces, ten.

Mix well, and make a lotion. 'Black Wash,' so called from the dark colour the mixture assumes, is chiefly used for venereal sores.

89. Take of Tincture of Opium . . . drachm, one.
 „ Tincture of Aconite . . drachm, one.
 „ Chloroform . . . . drachm, one.
 „ Soap Liniment . . . ounce, one and a half.

Mix for a liniment, and mark POISON. This liniment may be rubbed on the skin with a piece of sponge or lint for neuralgic pains.

90. Take of Tincture of Opium . . . drachm, one.
 „ Tincture of Aconite . . drachm, one.
 „ Chloroform . . . . drachm, one.

Mix for a liniment, and mark POISON. This liniment may be rubbed on the skin with a piece of sponge or lint for neuralgic pains. It is much stronger than Recipe 89. It should not be used when any injury of the skin exists, or for the mouth; or for children.

N.B.—*Solidified liniments* are made by chemists. They may be sent by post, and they possess the advantage of not running away from the hand when used like fluids.

91. Fill a small phial two-thirds full with powdered camphor, and fill up with rectified spirits of wine or sulphuric ether. With this solution the part affected by neuralgia should be lightly rubbed by means of a sponge or lint fixed to a piece of stick. A minute suffices to produce almost entire loss of sensation, but this effect does not last long.

Stimulating Applications.—Ointments

92. Take of	Flour of Sulphur	ounce, one.
,,	Nitrate of Potash	drachm, half.
,,	Soap, or Glycerine	drachm, one.
,,	Mutton Fat	ounces, four.

Mix thoroughly after melting the fat over a fire. For itch.

93. Take of	Tincture of Opium	drachms, two.
,,	Carbolic Acid	grains, twenty.
,,	Mutton Fat	ounce, one.
,,	Olive Oil	ounce, one.

Melt over the fire, and stir while cooling. A good stimulating ointment for ulcers.

94. Take of	Red Iodide of Mercury	grains, sixteen.
,,	Mutton Fat	ounce, half.
,,	Olive Oil	ounce, half.

Mix the fat and oil by melting over a fire, and then rub the iodide of mercury thoroughly into the fat and oil in a mortar. For enlarged spleen, 'Derbyshire neck,' and enlarged glands generally.

95. Take of	Powdered Gall Nuts	grains, eighty.
,,	Extract of Opium	grains, thirty.
,,	Simple Ointment (Recipe 86)	ounce, one.

Mix thoroughly in a mortar. A good application for piles.

96. Take of	Acetate of Lead	grains, thirty.
,,	Simple Ointment (Recipe 86)	ounce, one.

Mix thoroughly in a mortar. A good ointment for scorbutic ulcers.

Lotions

97. Take of Powdered Alum	. . .	grains, twenty.
,, Water, distilled	. . .	ounces, eight.

Mix well, and make a lotion. Useful for eye and ear affections, for ulcers and skin diseases.

98. Take of Sulphate of Zinc	. . .	grains, eight.
,, Water, distilled	. . .	ounces, eight.

Mix well, and make a lotion. For eye and ear affections.

99. Take of Bicarbonate of Soda	. .	drachm, one.
,, Water, distilled	. . .	ounces, eight.

Mix well, and make a lotion. For eczema and other skin diseases.

Stimulating and Astringent Gargles

100. Take of Alum	. . . . .	drachm, one.
,, Water, distilled	. . .	ounces, eight.

Mix, and make a gargle. For sore-throat, ulcerated mouth, and scurvy. Also as an injection.

101. Take of Tincture of Ginger (*strong*)	..	drachm, one.
,, Water, distilled	. . .	ounces, eight.

Mix well, and make a gargle. For relaxed throat.

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102. Take of Gallic Acid	. . . .	scruple, one.
,, Brandy	. . . .	drachms, four.
,, Water, distilled	. . .	ounces, six.

Mix, and make a gargle. For salivation, ulcerated mouth, and scurvy.

103. Take of Sulphate of Zinc	. . .	grains, thirty.
,, Water, distilled	. . .	ounces, eight.

Mix well, and make a gargle. This and the three preceding gargles are useful in salivation, ulcerated mouth, and relaxed and sore throats.

Injections or Enemas

Previous to giving an injection the bed and clothing should be well protected. Then the tube of the injection syringe should be warmed and oiled, and the instrument should be filled so that air may not be pumped in. 'Lynch's safety enema syringe' is to be recommended, being light, portable, suitable for travelling, and by which air cannot be pumped in. The patient should lie on the left side, with the knees drawn up, and the passage should be opened by the finger and thumb placed on each side of it. The tube should be *gently* introduced, in the direction of the bowel, which is *towards the left hip bone*. The instrument should be worked slowly, and not too forcibly. Two drachms may be injected if the patient is an infant; from one to five years, one to three ounces; from ten to fifteen, four to six ounces; above that age, eight to twelve ounces. For children, an india-rubber bottle furnished with a gum elastic pipe screwing on to the mouth is the best kind of instrument, as fluid can scarcely be injected too forcibly from it. If an injection syringe is not available, a substitute may be improvised by tying a piece of tobacco pipe, or other tube, into a bladder containing the injection. The contents must then be squeezed out of the bladder through the tube.

Injection of the Female Privates.—A female syringe should be employed, and when using the syringe the patient should lie with the hips raised on a pillow, in which position the injection flows over all the affected parts, and she should remain in such position for at least five minutes. It is also *essential* that the parts should be *first* washed out with tepid water. A cane couch and utensil beneath are required.

Injection of the Male Privates.—A glass syringe three inches long with a smooth round nozzle half an inch long, should be used. The patient, having passed water, puts the nozzle into the orifice and holds the head of the penis with the left thumb and fingers. The piston is then pressed down with the right forefinger, while the syringe is held with the thumb and other fingers. The nozzle is then withdrawn, the patient still nipping the penis to prevent escape of the injection. After two minutes on relaxing the hold of the penis the injection is forcibly discharged.

104. Take of Starch or Soap . . .	drachms, two.
,, Water, warm . . .	ounces, ten.

Mix well, and make an injection.

105. Take of Asafœtida	drachm, one.
,, Soap	drachm, one.
,, Castor Oil	ounce, one.
,, Water, warm . . .	ounces, eight.

Mix well. A stimulating injection.

106. Take of Castor Oil	ounce, half.
,, Spirits of Turpentine . .	ounce, half.
,, Croton Oil	drops, four.
,, Soap	grains, thirty.
,, Water, warm . . .	ounces, eight.

Mix well. A purgative injection. For apoplexy.

107. Take of Sulphate of Zinc	. . .	grains, twenty.
„ Tincture of Opium	. .	minims, thirty.
„ Water, warm	. . .	ounces, eight.

Mix well. Useful for 'whites' and womb diseases.

Nutrient Enema.—A good nutrient enema may be made with two eggs, four ounces of beef tea, four ounces of port wine or two of brandy, beaten up in a pint of water, thickened with arrowroot, at temperature of 100° Fahr.

Digested enemas are useful when the patient cannot take food. Eight ounces of beef tea, the yolk of an egg, and a tea-spoonful of raw arrowroot should be mixed and warmed in a covered jar to 100° Fahr. Then fifteen grains of pepsin and ten drops of strong hydrochloric acid should be added separately. The whole should stand, at the same temperature, for one hour. Then, while the mixture is stirred, small quantities of bicarbonate of soda should be added so long as it occasions effervescence. This imitates the process of digestion, and the material is injected into the bowel in a state in which it may be easily absorbed.

Previous to giving a *nutrient* or *digested* enema, if a natural motion has not been lately passed, the gut should be washed out by an injection of warm water. The quantity of nutrient or digested enema given should not exceed four or five ounces. Neither should injections of the kind be given more frequently than every four hours, as the gut soon becomes indolent and does not absorb. After injecting, a towel should be placed against the orifice for some minutes to prevent escape of the enema.

IRRITATING, RUBEFACIENT, OR BLISTERING APPLICATIONS

108. *Turpentine Stupe.*—Saturate a piece of lint or a piece of flannel with spirits of turpentine. Place this on the painful part and cover with oiled silk or a dry cloth. Retain it on the part for an hour, or until it is too painful. It produces redness of the skin, but does not blister.

109. *Mustard Poultice.*—Mix flour of mustard with lukewarm water into a thick paste, and spread thickly over a piece of linen of the size required. A piece of muslin should be placed between the mustard and the skin to prevent the mustard adhering to the skin, and in delicate people to prevent too great action of the mustard. Then apply it on the part for twenty minutes, or less if very painful. On removal the skin should be sponged with warm water and cotton wool applied. *For children* the mustard should be diluted with half flour, it should be guarded by muslin, and it should be removed in eight minutes. A good substitute is 'Mustard Paper.' One leaf immersed in water half a minute and applied to the skin will have the same effect as a poultice, and save the patient from the disagreeable smell and acrid vapour arising from a poultice. When used for children it should be guarded by muslin.

110. *Blisters.*—Cantharides plaster is spread thinly on a piece of sticking-plaster, leaving a margin which, when the blister is applied to the skin, adheres, and maintains the whole in position. The blister begins to smart in about two hours, and may be taken off in six or eight hours. But the time necessary to produce a blister depends on the sensibility of the person's skin. When the blister is taken off, all the raised blebs should be snipped at their most bulging parts with sharp scissors, and the water allowed to drain out, but none of the raised skin should be removed. Then the part should be dressed with Recipe 86, or with salad oil spread on linen or lint. In six hours this should be taken off, when other blebs will have formed. These must be snipped and the water drained out. Then the place should be dressed twice daily with simple ointment. If, after blisters, boils form near the part, they should be fomented and poulticed. There is also a *blistering tissue* made, but it does not keep well in India. No kind of blister should be applied to children except under medical advice.

111. *Iodine Paint*, called 'Liniment of Iodine,' is sometimes used instead of mustard or blisters. It should be lightly applied with a feather or brush every day, or less frequently after the first three or four days, so as to maintain an irritation of, but not to blister, the skin. Iodine paint acts more energetically on some sensitive skins, and therefore must be used with caution. The ordinary effects are, after a second application, itching and smarting, which soon subsides. After several applications the upper layer of the skin becomes loose, and may be rubbed off. If too much paint is applied, blisters may form.

Applications for Injuries

112. *Starch Bandage.*—Make a very thick solution of starch, soak a bandage in it, and apply it to the part, winding fold after fold until four or five folds cover the limb. While applying the bandage smear it thickly with starch. Then let it dry, when it forms a firm support or shell. It should be applied with firmness, but not too tightly. It is useful as a support after the splints are removed from a fractured limb.

113. *Leather Plaster.*—This is adhesive plaster spread on leather. It is useful for fractures as a support after splints are taken away.

Baths

Judiciously used, warm baths are remedies of great utility, but improperly used they do injury. The effect of a hot bath is to relax the muscles, to diminish the force of the heart's action, and to produce faintness. In weakness of the heart this danger is exaggerated. It is, therefore, necessary to watch a person placed in a warm bath, and while in the bath the reclining position should be assumed, which renders fainting less likely. The time which a person should remain in a warm bath must be regulated by the effect. Faintness requires removal; the person should lie down, and be dried in that position.

The temperature for baths is, cold, 60° to 75°; tepid, 85° to 92°; warm, 92° to 98°; hot, 98° to 115°. But the skin of infants will suffer from a degree of heat innocuous to an adult. Infants have been scalded to death in too hot baths. The temperature for children should not exceed 96° to 98° Fahr.

The complaints for which warm baths are most useful in adults are those accompanied by great and spasmodic pain, as gravel, rupture, stoppage in the bowels, and rheumatism. In children warm baths are chiefly required in convulsions, croup, pain in the bowels, restlessness from teething, flatulence.

When necessary to put the *feet of insensible patients* in a hot bath, this may be accomplished by drawing the person over the foot of the bed until the knees bend and the feet hang down.

A method of applying heat when a hot bath is not advisable is wrapping the patient in a blanket wrung out of hot water, and covering with dry blankets, in which the patient may remain twenty minutes, and must then be dried with warm towels.

Modified Turkish baths are often beneficial to tropical invalids, who, without organic disease, suffer from prolonged residence in the East. The patient should leave the hot chamber as soon as perspiration occurs, and should take a tepid douche, instead of the plunge into the cold bath. The mistake usually made is staying too long in the hot room.

A Medicated Bath is one in which some substance, to act as a medicine through the pores of the skin, has been mixed with the water. Substances thus used are salts, acids, soda, sulphur, &c.

114. *Nitro-muriatic Acid Bath.*—

Take of Muriatic Acid . . .	three parts.
„ Nitric Acid . . .	two parts.

Mix the acids slowly, then add slowly five parts of water. Wait till the heat produced by the mixture of the ingredients subsides, and bottle. One ounce of this solution should be added to each gallon of water, and the vessel for the bath should be wood or earthenware. The patient should remain in the bath fifteen minutes, the temperature being maintained at 98° by the gradual addition of hot water. On coming out of the bath the body should be rubbed with coarse towels. The Acid Bath is used in chronic liver and spleen affections. For children, half strength. When using strong acids care must be taken, as they burn anything they come in contact with. Muriatic is also called *hydrochloric* acid.

115. *Dry-Cupping.*—This means the application of the cupping-glasses, without the following use of the scarificator. Several glasses may be applied, which causes a rise of blood to the surface. If cupping-glasses are not at hand, dry-cupping may be accomplished by tumblers, which should be first exhausted of air by the introduction inside of a little cotton wool tied on a stick and saturated with spirits of wine or brandy, and then lighted. Care must be taken that the glass is not sufficiently heated to burn the skin. To take the glass off, the finger nail should be insinuated between the edge of the glass and the skin, when the glass will become loose. After dry-cupping no application is required; the parts will recover their natural appearance in a few hours. If it is desired to maintain the irritation caused by dry-cupping, hot fomentations should be used.

116. *Massage.*—Massage is methodical shampooing, and consists of rubbing, stroking, and kneading, principally in the direction of the veins, or from below upwards. It stimulates the skin and superficial vessels, promoting the flow of blood and lymph and the absorption of effete matter, thus exciting appetite to supply the place of removed material. It also increases the muscular strength and promotes sleep. In these ways it in some degree proves a substitute for exercise. There is nothing mysterious in massage, which is efficiently performed by many Indians. Heart affections, disease of blood-vessels, albuminuria, gastric ulcer, consumption, disease of joints, contra-indicate the employment of massage. Systematic massage, combined with strict isolation of the patient and feeding, is known as the 'Weir-Mitchell treatment,' and often much benefits hysterical, nervous, and debilitated persons.

117. *Leeches—how to apply them.*—The leech has three teeth, and makes a triangular wound. The Indian leech, being smaller than the European, does not take so much blood. Leeches should be kept in a cool place, in a jar of water with mud at the bottom, the mouth of the vessel being covered with muslin. The water should be changed every two or three days. There is often trouble in getting leeches to fix. The part to which they are to be applied should be cleansed with a cool moist cloth, so as to leave it damp. If they do not bite readily, the part may be moistened with a little sugar and water, or milk. If this does not answer, the skin may be slightly scratched with a sharp needle till the blood comes. Sometimes rubbing a refractory leech in a dry towel, or placing it for a moment in warm water, will cause it to bite. To

apply leeches in one circumscribed spot, put them all in a wineglass, which is to be turned down over the part. If required over a large surface, they must be put on singly; they should be held lightly by the tail, wrapped in a piece of wet cloth, so that they may not be inconvenienced by the heat of the hand. If the leech does not fix soon, it is better to return it to the water for a time, trying another in the meantime. More leeches than the number to be applied should be obtained, as often some will not bite. It is advisable, if possible, particularly with children, to apply leeches over some bone, against which pressure may be exerted to stop the bleeding, if necessary. A rule with regard to children is to employ small leeches. Two little leeches may be used instead of one large one, the bites of the former rarely bleeding so much after their removal. When applied, they should not be disturbed or torn off, as the teeth may be left in the wound. They should be covered with a light cloth until, having filled, they will fall off in about three-quarters of an hour. Then the leech-bites should be fomented with hot water, if it is wished to encourage the flow of blood, otherwise they should be covered with dry lint. A little salt should be sprinkled on the leeches after they drop off, which causes them to disgorge the blood, otherwise they probably die. They should then be returned to clear water, which should be frequently changed.

Leech-bites will generally stop bleeding without interference; if not, the measures noted at p. 512 should be adopted.

Disinfection

The impurities in air may be suspended, or gaseous matter. The universal diffusion of suspended material is proved by the atoms which become visible in a ray of sunlight. These are atoms of the local soil; spores, germs, pollen, decaying débris from the vegetable world, decaying tissue, cells, germs of animalcula and of disease, particles of carbon, fibres of hair, cotton, wool, and other fabrics from various sources. Noxious gases arise from sewers, from decaying animal and vegetable matter, and from the respiration and skins of animals, and all such gases are charged with inconceivably minute particles of decaying matter, and with living germs, either animal or vegetable, or of disease. There are also present in air vital bodies, known as *vibrios* and *bacteria*, which, brought into contact with dead organic matter, increase hourly by myriads; this being in fact the process of putrefaction.

The simplest form of *contagion* is when a disease is communicated by the conveyance of a palpable, minute poisonous matter from the sick to the healthy, either directly or through the medium of clothing, food, animals, &c. But the poisonous matter of many diseases may be transmitted through the atmosphere by the agency of invisible *germs* generated by the sick, or from the discharges of the sick ; or even, as there is reason to presume, spontaneously—or certainly localised—under various unsanitary conditions and favouring atmospheric influences. The appearance of vegetable growths or of insects in unexpected places often creates surprise ; but the germs must have been wafted to such places through the atmosphere. The unexpected appearance of disease is explainable in a similar manner. Disease germs are most abundant where sick people are congregated. Germs may be breathed into the lungs, or be taken with food or drink, or be absorbed by a sore. They may multiply, and grow with rapidity within the body ; they poison the blood, and they excite disease similar to that from which they originate. All persons are not alike, or always in the same degree susceptible, to contagion by contact, or to infection by germs. A weakened, fatigued, or chilled person will become affected more easily than a robust vigorous man ; the intemperate sooner than the temperate ; the hungry and poverty-stricken before the well-fed, well-clothed, and well-housed. Similarly, all germs (as is the case with seeds) are not prolific. The great majority are destroyed by the oxidising influence of the atmosphere before they find a suitable ground for their development. Disease germs may or may not be associated with bad smells.

Disinfection means not only the removal of bad smells, but the more important operation of rendering innocuous all germs, or decomposing or diseased matter from which germs may arise. Two classes of agents are in use. One class are simply *deodorants*, and only act by overpowering one odour by the substitution of another, and do little good. They may be pleasant as deodorisers, and therefore not to be altogether condemned, but they fail as disinfectants. Under the head *deodorants* are the fumes from burning brown paper, tar fumes, vinegar, acetic acid, ammonia, roasted coffee, pastilles. Agents can only be termed *disinfectants* when they destroy, or at least render harmless, noxious emanations. Under this head may be classed extreme dry heat, charcoal, quicklime, carbolic acid, sulphurous acid, nitrous acid, Condy's fluid, nitrate of lead, sulphate of iron, chloralum, &c. But there are some agents which act both as *deodorants* and as *disinfectants*, the principal of which are Condy's fluid, carbolic acid, chlorine gas, chloride of aluminium, nitrate of lead, and izal.

Deodorants and disinfectants should never be permitted to take the place of ventilation and cleanliness. If dirt and filth are not removed, and if fresh air is not admitted, neither disinfectants nor deodorants will do good. They simply hide the dirt, and conceal the want of pure air, instead of destroying the evil arising from it. The poison of all infectious diseases may be *best* diluted and destroyed by fresh air.

The method of using some of the principal disinfecting agents is now given.

118. *Condy's Fluid.*—Is a dilution of strong solution of *permanganate of potassium.* May be placed in saucers, or cloths soaked in it may be hung up in apartments where there are contagious maladies. Furniture, clothing, utensils, the hands of the attendants and of the sick, may be washed in one part of Condy's fluid to fifty of water. As Condy's fluid is odourless it is preferred by many to carbolic acid preparations, but it is not so powerful, and its use must be limited by the fact of its leaving a brown stain on linen. It should not be used at the same time as carbolic acid, as they are chemically opposed. Messrs. Burroughs & Wellcome prepare compressed tabloids of permanganate which may be used as a *disinfectant* for foul discharges in the sick-room. Three tabloids, 2 grains each, dissolved in an ounce of water is the proper strength to use for this purpose. These pellets are useful for travellers, who find themselves occupying rooms requiring both ventilation and disinfection.

119. *Carbolic Acid.*—In its *pure* state it is a white crystalline solid, which burns everything it comes into contact with. The *commercial* acid is a thin, tarry fluid, possessing a strong odour and poisonous properties. The *powder* is made by treating a certain quantity of sawdust with a certain proportion of the acid. The *pure* acid is used for surgical purposes, the *lotion* most generally applicable for ordinary sores, boils, abscesses, and ulcers being ten grains of acid (or drops if the acid has liquefied) to one ounce of water; and it is recommended that this lotion be used, if available, instead of plain water when water dressing No. 85 is requird. For foul ulcers, from ten to thirty grains to an ounce of water; for sore throat with fœtid breath, or for a mouth-wash, two grains

to one ounce; if used with a spray apparatus, twenty grains to the ounce; for inhalation, fifteen grains in a pint of hot water; as an injection for the male or female privates, one grain to an ounce; as an ointment for ulcers or skin diseases, five grains to an ounce of simple ointment. *Carbolic oil* is often useful, and should consist of twenty grains or drops of acid, to one ounce of salad or olive oil. When the *commercial* acid is diluted by fifty parts of water, it may be used for washing furniture, clothing, utensils, hands of attendants and of the sick, the heads of children, in skin affections, and as a wash for the mouth. In consequence of the poisonous properties of carbolic acid, the disinfecting powder is safer as a domestic disinfectant. It may be employed for scrubbing floors or furniture; it may be put in water, in the proportion of half a pound to the gallon, to form a solution for steeping infected clothing in; and it may be placed in vessels used for receiving the discharges of the sick. It is also very useful for disinfecting urinals, water-closets, &c.

120. *Chlorine Gas* would be best if it were not, unless largely diluted, irritating to the eyes and lungs. It may be obtained in various ways. Chloride of lime (popularly bleaching-powder), moistened with water in a saucer, gives off small quantities. If a quicker effect is desired, a little *dilute sulphuric acid* may be added. Chlorine gas may also be obtained by adding a little *dilute muriatic acid*, gradually, to half a tumblerful of Condy's fluid. Both these methods are convenient, and sufficient for a sick-room. When required in larger quantities, as for the disinfection of a sick-room during the absence of the occupant, chlorine gas may be generated from the following combination: common salt, four ounces; binoxide of manganese, one ounce; sulphuric acid, one ounce; water, two ounces. Mix the salt and manganese roughly, and place in a basin; then add the sulphuric acid *gradually* to the water, and pour over the powder. If the basin is placed on a box of hot sand, the formation of gas will be more rapid.

121. *Disinfection of the Air of Rooms.*—Ventilation and cleanliness being accorded the first places, the following agents may be used as most conveniently procurable. Baskets containing charcoal, which has the property of absorbing sewage gases, especially sulphuretted hydrogen, may be hung in the room. Quicklime, which absorbs carbonic acid, may be used, placed in a saucer. Chlorine gas may be obtained and used as mentioned under No. 120. Carbolic acid, one ounce mixed with a pound of sand, may be placed in saucers about the room. Cloths damped in carbolic acid solution, or in Condy's fluid, may be hung about the room, unelss in cases where there may be an objection to a damp atmosphere. The isolation of the patient may be rendered more certain by suspending outside the door a sheet moistened with a solution of carbolic acid or Condy's fluid. One or more of the above means may be used (excepting carbolic acid at the same time as Condy's fluid, *vide* No. 118). Charcoal

in bags, chlorine gas, and carbolic acid solution or powder, are probably the most efficacious, and the most easily procurable.

122. *Disinfection of Clothing, Bedding, Carpets, Tents, &c.*—Any material used by patients with infectious diseases should, if it can be spared, be immediately burnt. Otherwise articles of the kind should be immersed in solution of Condy's fluid or of carbolic acid, whichever may be available; and of the strengths given under Nos. 118, 119. This should be accomplished *immediately*, the things not being allowed to lie by, even for a few hours. A large vessel containing the disinfecting fluid used should be kept near the sick-room, for the reception of all bed and body linen. After soaking for three hours the articles should be boiled for half an hour in clean water, afterwards thoroughly washed with soap, and then exposed for three days to the sun and air. If disinfectants are not available, the time of boiling, of washing, and of exposure to the air should be doubled, or fumigation with sulphur may be used (*vide* No. 129). Where it can be carried out, clothing, bedding, &c., are best disinfected by being exposed for one hour or more to a dry heat of from 240° to 250° Fahr. For this purpose it would be well if public ovens were provided. The hair or other material of mattresses should be 'teased out' before being treated by disinfectants, washing, or heat. Disinfecting powder should be sprinkled on any soiled spots which may not demand immediate removal of the article. The final washing of infected clothing should be effected separately, as diseases may be conveyed by clothes prepared in a laundry where infected clothing has been 'got up.'

123. *Disinfection of Utensils.*—Utensils used by the sick, such as cups, spoons, forks, plates, &c., should be *immediately* immersed in some disinfecting fluid, of the strength mentioned under Nos. 118, 119; Condy's fluid is preferable, as carbolic acid might leave an unpleasant taste.

124. *Disinfection of the Hands of Attendants.*—Two basins, one containing Condy's fluid or carbolic acid solution, and another containing plain water, should be kept ready, so that attendants may wash *first* in disinfecting fluid, and then with soap and water *immediately* on the hands being soiled by infectious discharges. The strength of the solution should be as mentioned under Nos. 118, 119. If blood or thick discharges have dried on the hands, they should be scrubbed with sand.

125. *Disinfection of the Body of the Sick.*—The sick person should use water, for washing purposes, in which either Condy's fluid or carbolic acid (*vide* Nos. 118, 119) has been placed. When strong enough, benefit may often result from the use of disinfecting baths similarly medicated.

126. *Disinfection of Discharges from the Sick.*—Discharges should be soaked up with rags which may be burnt; sponges or pocket-handkerchiefs should not be used. Discharges from the bowels, or vomit, or urine, or expectoration, should be received into vessels charged with dis-

infectants. For this purpose four or five ounces of carbolic acid powder or six or eight ounces of a solution of commercial carbolic acid in water (strength, four ounces to the gallon), or six or eight ounces of a solution of sulphate of iron (strength, a pound to the gallon)—and which will probably be most easily procurable—should be placed in the close-stool, previous to use, and a smaller quantity in cups used for expectoration. The disinfected mass should be removed as soon as possible, and buried three feet deep, at some distance from any tank, well, or water. Otherwise, if not totally disinfected, it may infect the water and those drinking it. If thrown on the ground the material dries, and the germs of disease may be wafted to different places (*vide* p. 733).

The only safe disposal of material of the kind, whether arising from disinfecting clothing or utensils, or hands, or discharges from the sick, is burial in the earth, the oxidising powers of which render it innocuous. For this reason two or three inches of loose earth should be put daily around and under the cots of native cholera patients, so that it may receive any falling discharge. Thin wide gutta-percha placed under the breech of the patient prevents the discharge soaking into the bed, and, if kept clean and frequently changed and disinfected, is a great additional safeguard.

127. *Disinfection of Animals.*—Dogs and cats should not be allowed in rooms tenanted by patients with infectious disease, as they may convey contagion. If such animals have been exposed to contagion, they should be well washed with carbolic acid solution.

128. *Disinfection of Water-closets, Privies, &c.*—Dry earth is the best agent for ordinary use in privies attached to Indian houses. A handful of common dry earth placed over human excrement will prevent bad smell, and the mass may be taken away and used as manure, or be buried. But when infectious disease is present, or where water-closets are connected with sewers, disinfectants should be used. Water-closets, privies, cesspools, and drains can be disinfected by copperas (sulphate of iron). For the disinfection of a cubic foot of filth, half a pound of copperas dissolved in a couple of quarts of soft water is sufficient. The addition by each individual using a privy or water-closet of two-thirds of an ounce of copperas to such privy, or one-third of a pint of the above solution to such water-closet, will keep it wholesome. Carbolic acid can be used after the addition of copperas till the place smells strongly of it. It may be diluted by being shaken up with twenty times its volume of water, and if poured from a watering-pot with rose-nozzle over the sides of a recently emptied privy or cesspool will do great good. Sawdust or sand strongly impregnated with carbolic acid may be used for this purpose. All water-closets and privies should, when epidemics of cholera or typhoid may be expected, be disinfected, whether they be offensive or not. It is well at such periods to avoid using any such conveniences which have

not been disinfected, especially if, as at hotels and railway stations, they may have been used by persons from infected localities. Manure-heaps or accumulations of filth, which it is inexpedient to disturb during epidemics, or which cannot be moved, should be covered, especially if to leeward of dwellings, with coarsely powdered charcoal to the depth of two or three inches, or with freshly burnt lime, or with fresh dry earth if charcoal or lime cannot be obtained.

To test the air of privies, lay a piece of turmeric paper between two pieces of glass, so that half the paper hangs down. If the air is not pure, the part of the paper exposed turns reddish-brown after a few minutes, while the non-exposed part remains yellow.

129. *Disinfection of Rooms after Removal of the Sick.*—The room should be disinfected by burning brimstone in it in the proportion of four ounces to every 100 cubic feet. The cubic space may be calculated by multiplying the height, length, and breadth together by feet. The brimstone should be placed on an iron plate, which should be suspended over a lamp or charcoal fire (the whole supported, for protection, over a tub of water). Or the brimstone may be set fire to by putting live coals upon it. This causes sulphurous acid gas to be given off, which is a strong disinfectant. Doors, chimneys, and windows must be shut whilst this is being done, and clothes or carpets belonging to the room should previously to further disinfection (*vide* No. 122) be spread out on ropes during the process. The room should be kept closed for four hours. No disinfection of the kind is thorough if a man can live in the room whilst it is going on. After disinfection, the furniture, flooring, and all woodwork should be washed with solution of Condy's fluid, or with carbolic acid solution of the strength mentioned under those heads. If the walls are papered, the paper should be well wetted with the disinfecting solution and removed. If the walls are colour-washed, the wash should be all scraped off. If the floorings are earthen, or broken chunam, they should be dug up. The doors and windows should be thrown open and kept open for two or three days.

130. *Disinfection of the Dead Body.*—When a patient dies from infectious disease, the body should be washed with solution of carbolic acid (one part of acid to fifteen of water) and placed in the coffin as soon as possible. The body should be surrounded and the coffin filled up with charcoal, and chlorine gas may be generated in the room.

ADDENDUM

DIETETIC PREPARATIONS FOR THE INVALID

Barley Water.—Wash two ounces of pearl barley well with cold water, and reject the washings. Then boil in a pint and a half of water for twenty minutes in a covered vessel, and strain. The liquid may be sweetened and flavoured with thinly cut lemon-peel, which may be introduced during the boiling.

Beef Tea.—Mince finely one pound of lean beef, place it in a preserve jar, and pour upon it one pint of cold water. Stir, and allow it to stand for about one hour. Then place the jar with its contents in a saucepan of water, let it simmer gently over the fire for an hour, and strain. The liquid which runs through the strainer contains a quantity of fine sediment, which is to be drunk with the liquid, after flavouring with salt at pleasure.

Beef tea prepared as above is very nutritive, and possesses an agreeable meaty flavour. Beef tea should not be subjected to prolonged or violent boiling, as it then becomes a soup or broth, from the most nutritious portion (the gelatine and albuminous material) being, during the boiling process, incorporated with the solid rejected residue. The liquid thus loses in flavour and nutritive power.

Beef Tea, Savoury.—Mince finely three pounds of lean beef, and add one onion, half-a-dozen cloves, one small carrot, a little celery seed or essence, a little thyme and parsley, half a teacupful of mushroom ketchup, three pints of water, and salt and pepper according to taste. Prepare as directed for beef tea.

Beef Extract.—Cut up a pound of the best beef into small pieces, and put them into a good-sized pickle-bottle with a wide mouth. This is corked loosely, and placed in a kettle of water and kept boiling for two hours. If the bottle be now removed, it will be found to contain a considerable quantity of fluid, which may be poured off, the beef also being subjected to slight pressure to make it yield more. In this fluid we have a highly concentrated article of nourishment, which may be given, after seasoning, either pure or diluted, according to the state of the stomach.

BREAD.—Obtaining good bread is very often a difficulty in India. Soda and baking powders, which contain an alkali, are objectionable, because they neutralise the gastric juice. So is, very often, the *mussallah* used by native bakers instead of yeast, which is not unfrequently sour. *To procure yeast or barm* is the difficulty in making good bread, which may be overcome, at least in the cooler weather, as follows: Put half a breakfast-cupful of good hops into a saucepan with two quarts of cold water, and boil slowly for some hours, until it is reduced to little more than one quart. Let this decoction get cool, then add half a breakfast-cupful of sugar, stir till the sugar is dissolved, then bottle and cork. Let the bottle stand in a cool place for three days, when yeast will be formed.

To make bread, take six pounds of flour, three table-spoonfuls of yeast, and one quart of lukewarm water. Put the yeast and water into the centre of the flour, mix, and cover with a cloth for five or six hours, till it rises. Then add as much tepid water as will make the whole into dough, also a dessert-spoonful of salt, and knead properly. Cover, and let the mass stand till it ferments, which is known by its cracking on the top. Then divide into loaves and bake. Double the proportions of articles named will make better bread.

To make unfermented bread.—Take flour, one pound; bicarbonate of soda, forty grains; powdered white sugar, one teaspoonful; muriatic acid, fifty drops; water, half-pint. Thoroughly mix the soda and the sugar with the flour in a large basin with a wooden spoon. Then add the acid to the water, and gradually add the mixture to the flour, sugar, and soda, stirring well all the time. Divide into two loaves, and immediately put them in a quick oven.

BREAD JELLY OR 'PAP.'—Steep stale bread in boiling water and pass through a fine sieve while hot. This may be flavoured with sugar or mixed with milk. It is suitable for children and invalids with weak stomachs.

BROTHS are made by boiling the materials chosen for two hours, and straining through a wide sieve. Pearl barley, rice, vermicelli, or semolina may be added. The bones of the meat may also be broken up, and used in the preparation of broth.

CHICKEN, VEAL, or MUTTON TEA may be prepared in the same manner as beef tea.

CHICKEN JELLY.—Cut up a chicken, and put the pieces into a jar; pour over it a tea-cupful of cold water, tie down closely with a piece of bladder, and boil the jar in a saucepan of water for six or eight hours. Strain the liquid, and when cold remove the fat. A nourishing jelly remains.

FLOUR AND MILK.—Fill a small basin with flour, tie a cloth over the mouth, and boil it slowly in a saucepan of water for eight or ten hours. The inside portion of the flour becomes incorporated into a hard mass. After removing the outer sodden part add one grated table-spoonful of the flour to a pint of milk, and boil. This preparation is often advisable in dysentery and diarrhœa.

IMPERIAL DRINK.—Take half an ounce of cream of tartar, the juice of one lemon, and two table-spoonfuls of sifted white sugar. Put the whole in a jar, and pour over them one quart of boiling water. Cover till cold. A useful drink in fevers.

LEMONADE.—Pare the rind from a lemon thinly, and cut the lemon into slices. Put the peel and sliced lemon into a jug, with one ounce of white sugar, and pour over them one pint of boiling water. Cover the lid closely, and let it stand till cold. Then strain and pour off the liquid.

LIEBIG'S RAW MEAT SOUP.—Take eight ounces of recently killed meat, and mince fine. Place the mince in twelve ounces of distilled or pure water, add four drops of strong muriatic acid (also called hydrochloric acid) and half a salt-spoonful of salt. Stir well, and allow it to stand one hour, then strain through a fine sieve or cloth. When all the fluid, which is of a red colour, has run through, add eight or ten ounces more water. It should be made fresh once daily and given cold. This preparation is often taken and retained when other foods are refused or vomited, as it presents a form of sustenance requiring very little aid from digestion. It is very useful in cholera, in fevers, and in the wasting diseases of children. A patient may be usually given as much as he will take.

Linseed Tea.—Place one ounce of bruised linseed and two drachms of bruised liquorice root into a jug, and add one pint of boiling water. Let it stand, lightly covered, for three hours near a fire. Strain the liquid, which may be flavoured as mentioned for barley-water. Useful as a drink in urinary affections.

Milk and Suet.—Boil one ounce of finely chopped suet with a quarter of a pint of water for ten minutes, and press through flannel. Add a drachm of bruised cinnamon, one ounce of sugar, and three-quarters of a pint of milk. Boil again for ten minutes and strain. A wine-glassful or more may be taken at a time. It is nutritive and fattening, and, if there is no diarrhœa, is useful in the atrophy or emaciation of children.

Oatmeal Gruel.—Mix thoroughly but gradually one table-spoonful of groats with two of cold water, and add one pint of boiling water, stirring all the while. Boil for ten minutes, continuing the stirring. Sweeten with sugar and add, if desired, a little sherry or brandy. Milk may be used instead of water. This is also a nourishing food, containing more nitrogenous matter than preparations of arrowroot.

Oatmeal Porridge.—Mix a large table-spoonful of oatmeal with two table-spoonfuls of cold water. Stir well, and pour into a pint of boiling water in a saucepan. Boil and stir well for ten minutes, and flavour with salt or sugar as preferred. Milk may be used instead of water. If the boiling is continued for half an hour, the porridge then turned out into a soup plate, and cold milk poured over it, it will become semi-solid. Oatmeal porridge is beneficial when constipation exists, but should not be used if there is tendency to diarrhœa. It is a nourishing food, but sometimes causes acidity or water-brash.

Panada.—Take the white part of the breast and wings of a boiled or roasted chicken, and pound in a mortar with an equal quantity of stale bread. Add the water in which the chicken has been boiled, or beef tea, until the whole forms a fluid paste; then boil for ten minutes, stirring all the time.

The under side of cold sirloin of roasted beef, or cold roasted leg of mutton, may be used instead of chicken.

Rice Water.—Well wash one ounce of rice with cold water. Then steep the rice for three hours in a quart of water kept at a tepid heat; afterwards boil slowly for one hour and strain. It may be sweetened and flavoured as barley water. A useful drink in dysentery and diarrhœa.

Tamarind Drink.—Take a quarter of a pint of tamarinds, and pour over them a quart of boiling water. Sweeten as required, and cover till cold. A useful drink in fevers.

Tamarind Whey.—Boil a pint of milk, and while it is boiling add two table-spoonfuls of tamarinds. Strain, and sweeten to taste. A cooling and slightly laxative drink.

White-wine Whey, or 'Posset.'—Boil half a pint of milk in a saucepan, and while it is boiling add a wine-glassful of sherry. Strain, and sweeten as agreeable. A useful drink in colds and mild febrile attacks.

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PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
LONDON