THE LAWS OF HEALTH

HUTCHISON

PHYSIOLOGY
HYGIENE
STIMULANTS
NARCOTICS

LAWS OF HEALTH

HUTCHIS

H. - Laws of Health
P. - Functions of body.
A. - Structure of body.

H. Villareal

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Physiology.
1 veins
2 ligaments
3 ...
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2 Orvicularo palpebre

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LAWS OF HEALTH.

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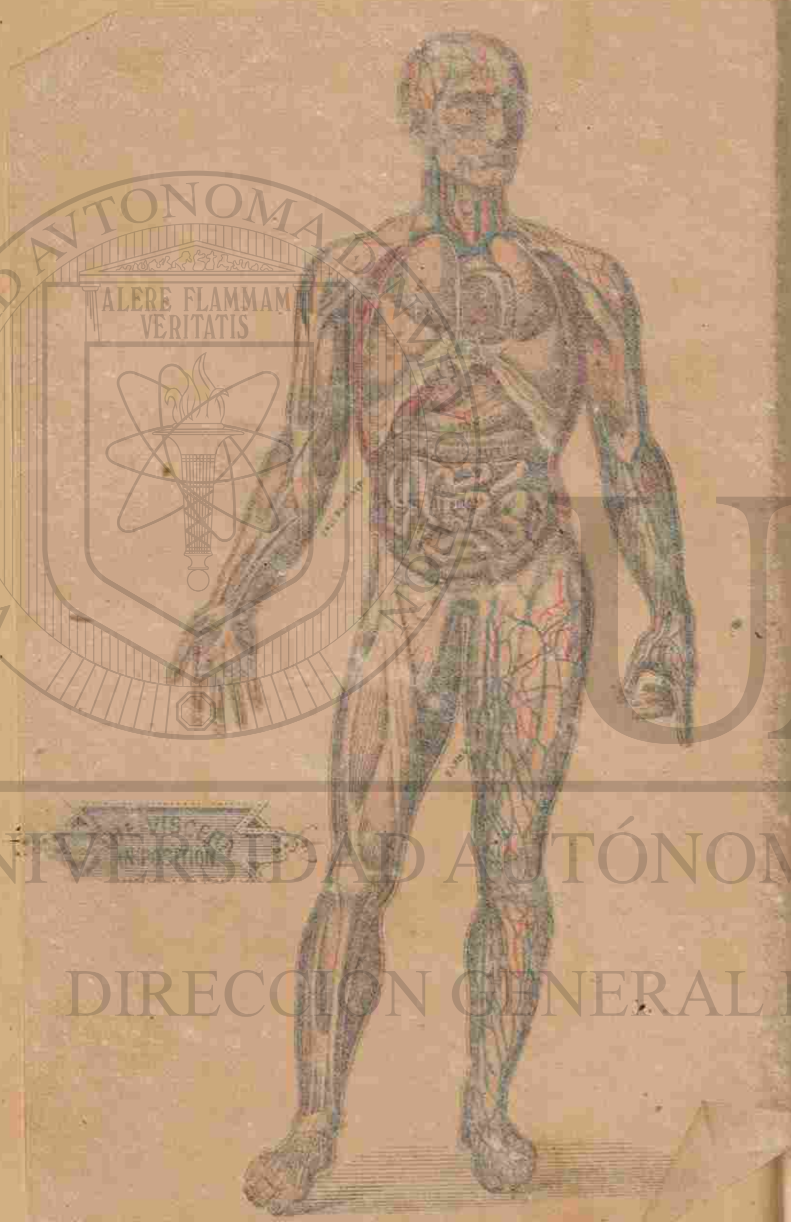

THE

LAWS OF HEALTH.

PHYSIOLOGY, HYGIENE.

STIMULANTS, NARCOTICS.

FOR

EDUCATIONAL INSTITUTIONS AND GENERAL READERS.

COPIOUSLY ILLUSTRATED.

BY

JOSEPH C. HUTCHISON, M.D., LL.D.,

AUTHOR OF A TREATISE ON PHYSIOLOGY AND HYGIENE; EX-PRESIDENT OF THE NEW YORK PATHOLOGICAL SOCIETY; EX-VICE-PRESIDENT OF THE NEW YORK ACADEMY OF MEDICINE; SURGEON TO THE BROOKLYN CITY HOSPITAL; LATE PRESIDENT OF THE MEDICAL SOCIETY OF THE STATE OF NEW YORK; ETC., ETC.

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1893.

A COMPLETE COURSE

IN

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FIRST LESSONS IN PHYSIOLOGY AND HYGIENE.

A Book for Elementary Grades. 160 Pages, 16mo, Cloth.

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Each book in the course complies with the laws requiring instruction in the physiological effects of stimulants and narcotics.

PREFACE.

THE object of this work is to present in clear and concise language the knowledge of to-day concerning the Laws of Health and the effects of Narcotics and Stimulants, as far as possible in a work so elementary. Enough of Anatomy and Physiology has been introduced to enable the pupil to study intelligently the laws by which health may be preserved and disease prevented. It is specially designed to meet the requirements of Grammar Schools, but is also adapted to those of a higher grade.

A feature of the work is the relation of Stimulants and Narcotics to the Laws of Health, a subject which is now receiving a large share of public attention. Correct instruction upon this subject will, it is believed, tend to diminish the use of Stimulants and Narcotics, and all the bad consequences which so frequently follow.

Great care has been taken to use familiar language as far as practicable, but scientific terms not in common use are sometimes necessarily introduced; their meaning may be learned by referring to the Pronouncing Glossary at the end of the volume.

The discussion of disputed points has been avoided because it would be manifestly inappropriate in a work of this character.

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THE FRAMEWORK OF THE BODY.

The Bones—Their Uses—Their Size and Shape—Their Structure and Composition—The Properties of Bone—The Skeleton—The Joints and Motion—The Spinal Column—The Repair of Bone—Changes in the Skeleton.

1. The Bones.—The human body is the house in which the soul of man dwells during life. When life ends and the soul takes its departure, its temporary home speedily falls to pieces; some parts of it sooner, some later. As in a mansion that has been allowed to go to decay, or has been wasted by fire, the frail portions perish, while the masonry, the walls and the stouter timbers remain, so in the untenanted body, its stronger, harder parts, the *bones*, outlast the softer ones,—those by means of which we feel, breathe and move.

2. The Uses of the Bones.—The bones supply the foundation, frame and rafters of the house in which we live. They determine and preserve the general outline and size of the body. They give rigidity to the limbs, so that movements are possible, and also serve as a protection to the more delicate and important parts.

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The more delicate the organ, the more completely does Nature shield it. For example: the brain, which is soft in texture, is enclosed on all sides by a spherical box of bone; the eye, though it must be near the surface of the body to command an extensive view, is sheltered from injury within a deep recess of bone; the lungs, requiring freedom of motion as well as protection, are surrounded by a mobile "chest" composed partly of bone and partly of muscle.

3. The Size and Shape of the Bones.—Nearly every scientific principle known in architecture was anticipated by the Divine hand which framed our bodies long before human science began to exist. The size and form of the bones vary greatly in different parts of the body. There are, however, but three general classes: the *long* bones, such as those of the limbs; the *short*, as in the wrist; and the *flat*, like the shoulder-blade. The long bones are commonly round and hollow at their middle portion, as greater degree of strength is furnished by the same amount of material, if it is in the form of a tube, than if it is a solid pillar of the same length.

4. The Structure of Bone.—Let us examine one of the long bones after it has been sawed through lengthwise (Fig. 1.)

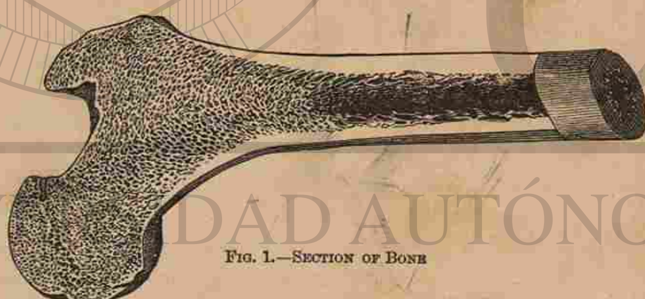
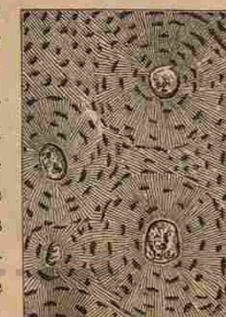


Fig. 1.—Section of Bone

We notice the hollow central cavity, containing an oily substance, called the *marrow*. We find that the outer surface is hard like ivory, and is pierced here and there with small openings for the admission of blood-vessels. The interior, especially at the ends, is comparatively light and porous, the slender fibres interlacing like miniature lattice-work. So that, although a

bone be as hard as stone externally, it is by no means as heavy. If a thin section of bone be examined under the microscope, we discover that it is pierced by numerous fine tubes (Fig. 2), about which layers of bone-substance are arranged. By means of these tubular passages the blood-vessels, which nourish the bones, run to and fro through their inner structure.

Fig. 2.



Structure of Bone Enlarged.

5. The Composition of Bone.—Bone is partly a mineral and partly an animal substance, united in the proportion of two parts of the former with one of the latter. Each of these substances may be separated from the other for examination. First, if we expose a bone to the action of fire, the animal matter, which is called *gelatine*, is driven off, or "burned out." We now find that although the shape of the bone remains the same, that which is left is quite brittle and will not sustain weight as before. Again, we may remove the mineral ingredient, which is a form of lime, by placing a second piece of bone in a dilute acid. The lime is thus dissolved away, leaving the shape the same. The bone is now no longer stiff and hard, but is flexible; and if a long and thin bone, a rib for example, has been made use of in the experiment, it may be tied in a knot without breaking. In early life the bones contain more of the animal substance; in old age, more of the mineral. Hence the bones of the young, although exposed to a great variety of accidents, do not break readily; and when broken unite rapidly. On the other hand, the bones of old persons are decidedly brittle, and when broken, do not always unite well and quickly.

6. Properties of the Bones.—From these facts, made known to us by chemistry and the microscope, we learn that the bones are not so simple and uninteresting as at first appears.

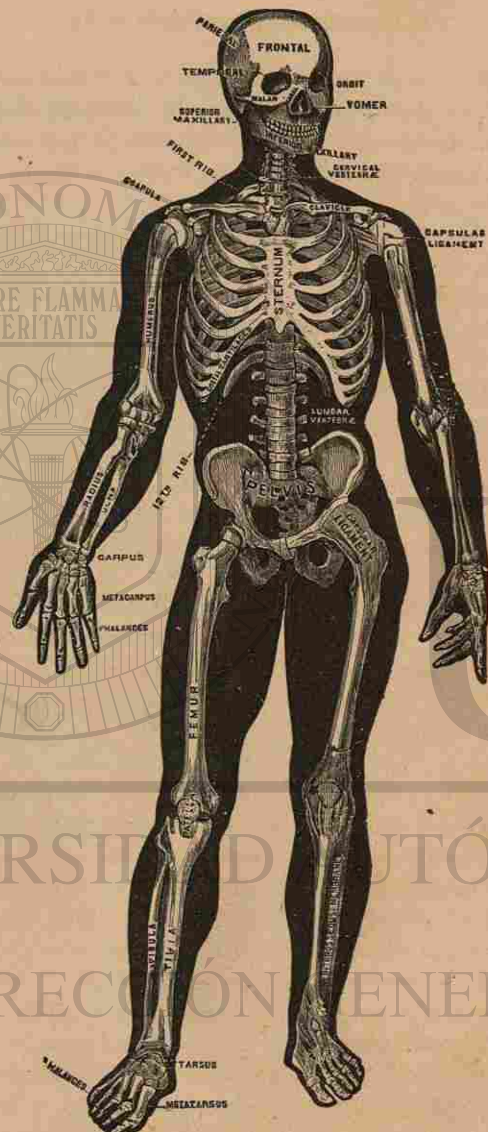


FIG. 3.—THE SKELETON.

but are adapted with wonderful care and skill to all the purposes they are designed to serve. They are strong, but not heavy; hard, but not brittle; somewhat elastic by reason of the gelatine, and yet solid and firm by reason of the lime. Their exposed portions are so made as to be dense and resisting, while the interior is more sponge-like and well furnished with blood-vessels which nourish and cause them to live.

7. The Skeleton.—The bones of the human body are about 200 in number, each of which is known to the anatomist by its appropriate name. A few of these names are marked upon the accompanying engraving (Fig. 3.) All these bones when united together in their natural relations form the *Skeleton*. The greater number of the bones are arranged in pairs, one of each kind on each side of the frame. The skeleton contains three important cavities.

The first of these surmounting the frame, is a box of bone, called the *skull;* below this, is a hooped case, or "chest;" and lower down is a bony basin, called the *pelvis*. The two latter compose the "trunk." The trunk and skull are maintained in their proper relations by the "spinal column." Branching from the trunk are two sets of limbs: the arms, which are attached to the chest by means of the "collar-bone" and "shoulder-blade;" and the legs, directly joined to the lower part of the trunk.

8. These three cavities are designed for the lodgment and protection of the more delicate and perishable parts of the system. Thus, the skull together with the bones of the face, shelter the brain and the organs of four senses—sight, hearing, smell, and taste. The chest contains the heart, lungs, and great blood-vessels, while the lower part of the trunk holds and shields a variety of organs, chiefly those concerned in nourishing the body.

9. The Joints.—The point of union of two or more bones forms a joint, or *articulation*, the connection being made in various ways according to the kind and amount of motion desired. The movable joints are connected by strong fibrous bands, called ligaments. These ligaments are of a silvery whiteness, and very unyielding; so much so, that the bone to which a ligament is attached may be broken, while the ligament itself remains uninjured. When this connecting material of the joints is strained or lacerated by an accident, a "sprain" is the consequence. An injury of this sort frequently is quite as serious as the breaking of a bone.

10. Motion in the Joints.—The ligaments then make the joints firm and strong. How are they rendered flexible and easy of motion? In the first place, the bones are made somewhat broad and flat at the ends, and are so formed that one will fit into the other In the next place, these fitted surfaces are

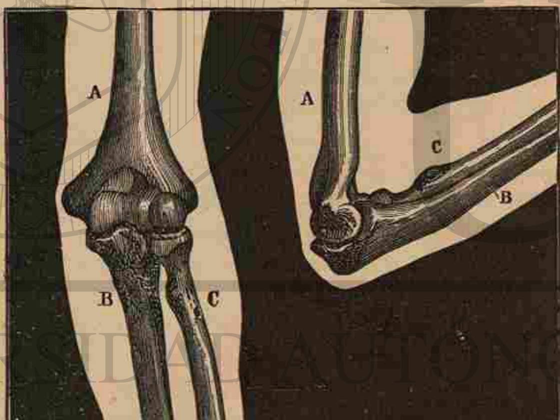


FIG. 4.—ELBOW JOINT. A, Bone of the arm; B, C, Bones of the fore-arm.

covered with a thin layer of "cartilage," an elastic and exceedingly smooth material, which not only enables them to move easily over each other, but also serves, like the springs of a carriage, to deaden the force of jolts and jars. A third provision for smooth motion is the introduction between the ends of

the bones of a thin *sac*, containing a fluid resembling the white of egg. This fluid serves the same end in the joints, as the oil that is used on the wheels of a carriage; it diminishes wear and noise and friction. But it is self-supplied, and flows only so fast as it is used up by the motions of the joint. (*Read note, end of chapter.*)

11. The Spinal Column.—The spinal column is commonly called the "back-bone," as if it were a single bone, whereas it really consists of a chain of 26 small bones, named *vertebræ.* It is channeled out for the reception of the spinal cord. (Fig. 5.)

FIG. 5.—THE SPINAL COLUMN.

12. The joints of the vertebræ are remarkable for the thick layers of cartilage which separate the adjacent surfaces of bone. The amount of motion between any two of these bones is not great; but these little movements, taken together, admit of very considerable flexibility in several directions. The abundant supply of these cartilages adds greatly to the elasticity of the frame. It is due, in part to this elastic material, and in part to the frequent curves of the spine, that the brain and other delicate organs are not more frequently injured by the shock of sudden falls or missteps. During the day, the constant pressure upon these joints, while the body is erect, diminishes the thickness of the cartilages; so that a person is not so tall in the evening as in the morning. The effects of this compression pass away when the body is in a reclining posture.

13. The Growth of Bone.—The bones, like all other parts of the body, are constantly undergoing change, worn out material being withdrawn to make room for a fresh supply. This change has been shown conclusively by experiment. If an animal be fed with madder—a red coloring matter—for a day or two the bones soon become tinged; then, if the madder be discontinued for a few days, the original color returns. If, however, this material be alternately given and withheld at short intervals, the bone will be marked by alternate rings of red and white. In a very young animal, all the bones become red in a single day; in old ones, a longer time is necessary. The process of waste and repair in the hard bones, therefore, is constantly taking place and with astonishing rapidity.

14. The Repair of Bone.—Nature's provision for uniting broken bones is very complete. At first, blood is poured out around the ends of the bone, as a result of the injury. This is gradually absorbed and gives place to a watery fluid, which, thickening from day to day, acquires at the end of two weeks the consistency of jelly. This continues to harden by the deposit of new bone-substance until, at the end of five or six weeks, the broken bone may be said to be united. It is, however, still fragile, and must be used carefully a few weeks longer, but months pass before the union can be said to be complete. When firmly united, the bone is very strong, and if another accident happens to it, it is quite as liable to break in some new place as at the point of union.

15. Changes in the Skeleton.—Man does not reach his full height until he is about twenty-five years old; and even after that age, the bones continue to increase in strength and hardness. Before that age, they are comparatively soft and flexible, by reason of the gelatin they contain. This is especially true in childhood; and it is fortunate that it is so, since that condition is much more favorable to the steady and rapid growth of the bones than if they contained more of the lime, as is the case in old age when there is no occasion for change in the size or shape of the skeleton. The skull, however, is said to increase slightly in size even in advanced life in those persons in whom the brain is continually employed in thought or study. However, this very flexibility of the bones, in early life, which favors their steady growth and prevents their breaking easily, is sometimes the source of serious deformity. A young child may be allowed to stand and walk too early, and as a consequence, the lower limbs become permanently bent inward, in the distortion called "knock-knees," or outward, as in "bow-legs." For the same reason, a bent position of the spinal column, permitted to exist habitually in childhood, may result in a life-long deformity.

16. The Erect Posture.—Youth is, in a great measure, the forming as well as the growing period of the frame. Bad habits of posture, early formed, become fixed in later life, and their results—as seen in contracted chests and round shoulders—are with difficulty remedied. Right habits, on the other hand, tend to produce an erectness of posture which is favorable, not alone to strength and health, but also to grace and ease. The following directions should be learned and practiced: hold the head erect with the chin somewhat near the neck; expand the chest in front; throw the shoulders back, keeping them of the same height on both sides; maintain the natural curves of the spine, as shown in the last figure. Man alone, of all the animals, has the power to stand and move in the erect posture.

NOTE.

How Joints may be Injured (p. 16, ¶ 10).—"All the joints are liable to dislocation—that is, being 'put out' of their place. Owing to the shallowness of the cavity at the shoulder, this joint is frequently dislocated; and this sometimes happens with the thigh, but not so often, as the cup in which the femur moves is much deeper. Joints which have been dislocated should at once be 'set;' but now that you have seen how liable you are to accident, I hope you will be careful not to indulge in too violent or rough exercise, by which you might not only dislocate the joints, and so in time weaken them, but might also break the bones, and perhaps become crippled for life. Many children have the habit of pulling their fingers so as to make them 'crack.' This is exceedingly wrong, for it is to a certain extent pulling the joints out of their sockets, and this may so loosen the parts as to cause permanent injury."—DAVIDSON'S "OUR BODIES."

Table of the Skeleton.

(See Fig. 3, Page 15.)

The Skeleton Contains 206 Bones.

I. THE HEAD (28 Bones).

1. THE SKULL (8 Bones).

- 1 Fron'tal (forehead).
- 1 Oc-cip'i-tal (back of head).
- 2 Pa-ri'e-tals (side of head).
- 2 Tem'po-rals (temples).
- 1 Sphe'noid ("wedge-shaped").
- 1 Eth'moid ("sieve-like," through which filaments of the olfactory nerve pass to the nose).

II. THE TRUNK (54 Bones).

1. THE SPINAL COLUMN (26 Bones).

- 7 Cer'vi-cal (or neck) ver'te-bræ.
- 12 Dor'sal (or back) vertebræ.
- 5 Lum'bar (or loin) vertebræ.
- Sa'crum (the "sacred" bone, becaused used in sacrifices).
- Coc'cyx (the "cuckoo" bone, because of its likeness to the bill of that bird).

III. THE LIMBS (124 Bones).

1. THE UPPER LIMBS (64 Bones).

- Clav'i-cle, or Collar-bone (from "*clavis*," a key).
- Scap'u-la, or Shoulder-blade.
- Hu'mer-us (arm).
- Ul'na (forearm), from the Greek word meaning "Elbow."
- Ra'di-us (forearm), from the Latin word meaning "Spoke."
- 8 Car'pals, or Wrist-bones.
- 5 Met-a-car'pals (in the palm), *meta* "beyond," and *carpus* "the wrist."
- 14 Pha-lan'ges (3 in each finger, 2 in the thumb).

TABLE OF THE SKELETON.—Continued.

THE HEAD.—Continued.

2. THE FACE (14 Bones).

- 2 Na'sal Bones (they form the "bridge" of the nose).
- 2 Ma'lar (or cheek) Bones.
- 2 Lach'ry-mals (from a Latin word meaning "tear"; small thin bones which form a part of the inner wall of the orbits).
- 2 Pal'ate Bones.
- 2 Tur'bin-ated ("cone-shaped," one on each side of the outer wall of the nasal cavities).
- 2 Upper and 1 Lower Max'il-la-ry (or jaw) Bones.
- 1 Vo'mer ("plough-share," a thin bone which separates the nostrils).

3. THE EAR (6 Bones).

- Mal'le-us, or "mallet."
- In'cus, or "anvil."
- Sta'pes, or "stirrup."

THE TRUNK.—Continued.

2. THE RIBS (24 Bones).

12 on each side; the upper seven are called "true" ribs, the five lower ones are "false," or "floating" ribs.

3. THE HY'OID.

A small "U-shaped" Bone in the upper part of the neck, and supports the base of the tongue.

4. THE STERNUM (Breast-Bone).

5. THE TWO HIP-BONES.

THE LIMBS.—Continued.

2. LOWER LIMBS (60 Bones).

- Fe'mur (thigh-bone).
- Pa-tel'la, or Knee-pan.
- Tib'i-a (leg-bone), a Latin word meaning "flute."
- Fib'u-la (leg-bone), a Latin word for "pin."
- 7 Tar'sals (forming the instep).
- 5 Met-a-tar'sals.
- 14 Phalanges (2 in the great toe, 3 in each of the others).

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NOTE.

Some Properties of Bone.—The power of bone to resist decay is remarkable. Fossil bones deposited in the ground long before the appearance of man upon the earth have been found by Cuvier exhibiting a considerable portion of cartilage. The jaw of the Cambridge mastodon contained over forty per cent. of animal matter—enough to make a good glue—and others about the same. From this we see that a nutritious soup might be made from the bones of animals that lived before the creation of man. The teeth resemble bone in their structure, but resist decay longer; they are brought up by deep-sea dredging, when all other parts of the animal have wasted away. The bones differ at different ages, and under different social conditions. In the disease called "rickets," quite common among the ill-fed children of the poor in Europe, but somewhat rare in America, there is an inadequate deposit of the mineral substance, rendering the bones so flexible that they may be bent almost like wax. In females and weak men the bones are light and thin, while in a powerful frame they are dense and heavy. Exercise is as necessary to the strength of bone as to the strength of muscle; if a limb be disused, from paralysis or long sickness, the bones lose in weight and strength as well as the soft parts. Bone is said to be twice as strong as oak, and, to crush a cubic inch of it, a pressure equal to 5,000 pounds is requisite.

CHAPTER II.

THE MUSCLES.

Movements of the Body—The Muscles—Flexion and Extension—The Tendons—Contraction—Physical Strength—Relative Strength of Animals—Physical Culture—Necessity for Exercise—Its Effects—Forms of Exercise—Excessive Exercise—Walking—Riding—Gymnastics—Open-air Exercise—Sleep—Recreation.

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2. The Muscles, or the Flesh.—The muscles, nearly four hundred in number, form the great bulk of the body external to the skeleton. They largely determine its weight and outline. They are nearly all designed to move the bones, but a few act

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3. The Tendons.—Tendons, or sinews, are the extremities of muscles, and are firmly fastened upon the bones. They are very strong, and of a silvery whiteness. They may be felt just beneath the skin, when the muscles are being used, as at the bend of the elbow or knee. The largest tendon of the body is that which is inserted into the heel, called the tendon of Achilles, after the hero of the Grecian poet, the fable relating that it was at this point that he received his death-wound, no other part of his body being vulnerable.

4. Structure of the Muscles.—The muscles are composed of a soft substance, of a deep red color, which closely resembles the lean meat of beef. Under the microscope, we observe that it is composed of layers and bundles of small fibres. And these are, in turn, made up of still finer fibres, called *fibrillæ* (Fig. 8). The fibres are beautifully marked by regular cross lines, or stripes, about ten thousand to an inch. These circular markings are always present in the voluntary muscles, and hence they are known as the "striped" muscles.

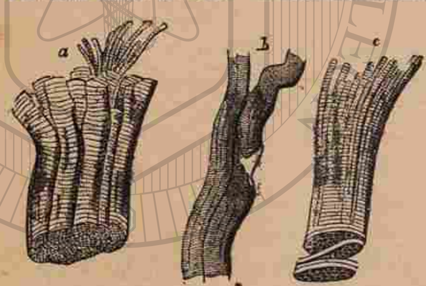

FIG. 6.—MUSCULAR TISSUE.
a, *b*, Striped muscular fibres; *c*, The same more highly magnified.

5. Voluntary and Involuntary Muscles.—The muscles are divided into two classes, the voluntary and the involuntary. In the first class are those which are used only when we wish or will to use them—as the muscles of the hand or arm. The second includes those which are not under the control of the mind. The heart is a muscle of the involuntary variety. We cannot change its action by an effort of the will. During profound sleep, when the will is entirely at rest, the heart continues to beat without cessation. The muscles concerned in breathing are partially under our control, but they are chiefly involuntary, and, therefore, continue to act while the mind is at rest or is fully occupied in work or play.

6. Muscular Contraction.—Whenever a muscle is caused to act it undergoes *contraction*, or a change of form by which its two ends are brought more nearly together. The raising of the arm, the bending of the finger and most of the ordinary movements of the limbs are effected by the will; but the will is not the only means of producing muscular action. Electricity, or a sharp blow over a muscle will also produce it.

7. Contraction is not the permanent state of a muscle. It cannot long remain contracted, but after a shorter or longer time, it wearies and is obliged to relax. After a short rest it can then again contract. For this reason, it is more fatiguing to stand for any great length of time in one position, than to be walking.

8. Relative Strength of Animals.—The amount of muscular power which different animals possess has been tested by experiment. It is found that man is able to drag a little less than his own weight. A draught-horse can exert a force equal to about two-thirds of his weight. The horse, therefore, though vastly heavier than man, is relatively not so powerful. Insects are remarkable for their power of carrying objects larger and heavier than themselves. Many of them can drag ten, and even twenty times their weight. Some of the beetles have been known to move bodies more than forty times their own weight.

9. Physical Strength.—The difference in strength, as seen in different individuals, is not due to any original difference in their muscles. Nature gives essentially the same kind and amount of muscles to every healthy person, and the power of one, or the weakness of another, arises, in great part, from the manner in which these organs are used or disused.

10. Importance and Effects of Exercise.—Action is the law of the living body. Every organ demands use to preserve it in full vigor, and to obtain from it its best services. Exercise consists in a well-regulated use of the voluntary muscles, but its effects are not limited to the parts used. Other organs are indirectly influenced by it. The heart beats more rapidly, the skin acts more freely, the brain is invigorated, and the appetite and power of digestion are increased.

11. The first effects of exercise, however, are upon the muscles themselves. If we examine a muscle thus improved by exercise, we find that its fibres have become larger and more closely blended together, that its color is of a darker red, and that the supply of blood-vessels has increased. Without exercise the muscle appears thin, flabby, and pale. On the other hand, excessive exercise, without sufficient relaxation, causes a similar condition. The muscle then becomes flabby and weak, because it is worn out more rapidly than nature builds it up.

12. Violent exercise is not beneficial, as strength is the result of a gradual growth. To gain the most beneficial results, the exercise should be at regular hours and during a regular period, the activity and the time varying with the strength of the individual and measured by it.

13. Different Modes of Exercise.—There are very few who have not the power to walk. There is required for it no expensive apparatus, nor does it demand a period of preliminary training. *Walking may be called the universal exercise.* With certain foreign nations, the English especially, it is a very popular exercise, and is practised habitually by almost every class of society. Running, leaping, and other more rapid and violent movements, are the forms of exercise that are most enjoyed in childhood. For the child, they are not too severe, but they may be so prolonged as to become injurious. Instances have been recorded where sudden death has resulted after violent playing, from overtaxing the heart: for example, we have the case of a young girl who, while skipping the rope, and

endeavoring to excel her playmates by jumping the greatest number of times, fell dead from rupture of the heart.

14. Carriage-riding is particularly well suited to invalids, and to persons advanced in life. Horseback exercise brings into use a greater number of muscles than any other one exercise, and with it there is an exhilaration of feeling which refreshes the mind at the same time. That form of exercise which interests and diverts the mind will yield the best results; and as many sets of muscles should be employed as possible, open-air exercise being the best. No in-door exercise, however excellent in itself, can fill the place of hearty and vigorous activity in the open air.

15. Excessive Exercise.—If neglect of exercise is injurious, so also is the excess of it. Violent exertions do harm; they often cause undue strain, and even lasting injury to some part of the body. For this reason the spirit of rivalry which leads to tests of endurance and feats of strength should be discouraged. Those trials of the muscles, especially, which are supposed to demand "training" should not be encouraged. Training, it is true, can produce a remarkable muscular development, so that nearly every muscle of the limbs is as large and corded as the arm of a blacksmith, but it is too often at the expense of some internal, vital organ. Large muscles are not a certain index of good health. It was well known by the ancients that athletes of their day were short-lived, notwithstanding the perfection of the physical training then employed. When a person overtasks the heart, or, in other words, "gets out of breath," he should regard it as a signal to take rest. It is well known that both horses and men, after having been brought into "condition" for competitive trials, soon lose the advantages of their training after the occasion for it has passed.

16. Rest.—We cannot always be active: after labor we must rest. We obtain this rest partly by suspending all exertion, as in sleep, and partly by change of employment. It is said that Alfred the Great recommended that each day should be divided in the following manner: "Eight hours for work, eight hours for recreation, and eight hours for sleep." This division of time is as good as any that could now be made, if it be borne in mind that, when the work is physical, the time of recreation should be devoted to the improvement of the mind; and when mental, we should then recreate by means of physical exercise.

17. During sleep, all voluntary activity ceases, the rapidity of the circulation and breathing diminishes, and the temperature of the body falls one or two degrees. In consequence, the body needs warmer coverings than during the hours of wakefulness. During sleep, the body seems wholly at rest, and the mind is also inactive, if we except those involuntary mental wanderings which we call dreams. Nevertheless it is not an idle period. Nutrition, or the nourishing of the body, now takes place. While the body is in action, the process of pulling down predominates; but in sleep, that of building up is more active. If sleep is insufficient, the effects are seen in the lassitude and weakness which follow.

18. All persons do not require the same amount of sleep, but most men need from seven to nine hours. Frederick the Great required only five hours of sleep daily, and Bonaparte could pass days with only a few hours of rest. But this long-continued absence of sleep is attended with danger. After loss of sleep for a long period, in some instances, stupor has come on so profoundly, that there has been no awaking.

19. There are instances related of sailors falling asleep on the gun-deck of their ships while in action. On the retreat from Moscow, the French soldiers would fall asleep on the march, and could only be aroused by the cry, "The Cossacks are coming!" Tortured persons are said to have slept upon the rack in the intervals of their torture. In early life, while engaged in a laborious country practice, the writer not infrequently slept soundly on horseback. These instances, and others, show the imperative demand which nature makes for rest in sleep.

TABLE OF THE PRINCIPAL MUSCLES.

The Head.

Oc-cip'i-to—fron-ta'lis, moves the scalp and eyebrows.
Or-bic-u-la'ris pal'pe-brae, closes the eye.
Le-va'tor pal'pe-brae, opens the eye.
The Recti muscles (4 in number), move the eye-ball.
Tem'po-ral, **Mas-se'ter**, } raise the lower jaw.

The Neck.

Pla-tys'ma My-oi'des, **Ster'no Mas'toid**, } move the head forwards.
Sca-le'ni muscles move the neck from side to side.

The Trunk.

Pec-to-ra'lis, moves the arm forwards.
La-tis'si-mus dor'si, moves the arm backwards.
Tra-pe'zi-us, **Ser-ra'tus mag'nus**, **Rhom-boi de'us** } move shoulder-blade.
In-ter-cos'tals, move the ribs in respiration.
External Oblique, **Internal Oblique**, } move the trunk forwards.
Erec'tor spi'næ, move the trunk backwards.

The Upper Limb.

Del'toid, raises the arm.
Te'res ma'jor, lowers the arm.
Sub-scap-u-la'ris, **Spi-na'tus**, } rotate the arm.
Bi'ceps, bends forearm.
Tri'ceps, straightens forearm.
Pro-na'tor, **Su-pi-na'tor**, } rotate forearm.
Flex'or car'pi ra-di-a'lis, **" " ul-na'ris**, **Exten'sor car-pi ra-di-a'lis**, **" " ul-na'ris** } move the hand.
More than 30 muscles take part in moving the fingers.

The Lower Limb.

Il-i'a-cus, **Pso'as mag'nus**, **Pec-tin-e'us**, **Ad-duc'tor**, } move the thigh forwards.
Glu-te'us, **Pyr-i-form'is**, } move the thigh backwards.
Sar-to'ri-us (from *Sar'tor*, a tailor), crosses one thigh over the other.
Rec'tus, **Vas'tus**, } move the leg forwards.
Bi'ceps, **Grac'i-lis**, } move the leg backwards.
Tib-i-a'lis, **Per-o-ne'us**, **Gas-troc-ne'mi-us**, **So-le'us**, } move the foot.
Twenty muscles take part in moving the toes.

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NOTE.

The Ill Effects of Over-exertion.—"It should be recollected that the action of the muscles has limits, as well as that of every other organ of the body. The muscles and the heart may be taxed too severely, and permanent derangements may be produced by overtaxing the human body. The ancient gymnasts among the Greeks are said to have become prematurely old, and the clowns (or acrobats) and athletes of our own days suffer from the severe strain put upon their muscular systems." The effects of boat-racing in England have been thus described by Mr. Skey, an eminent surgeon: "The men look utterly exhausted. Their white and sunken features and pallid lips show serious congestion of the heart and lungs, and the air of weakness and lassitude makes it a marvel how such great exertion should have been so nobly undergone. We have repeatedly seen the after ill-effects—spitting of blood, congested lungs, and weakness of the heart from over-distension." "Persons should neither walk, run, leap, or play at any game, to the extent of producing permanent or painful exhaustion. All exercise should be attended with pleasurable feelings; and when pain is produced by proper exercise, those who suffer should rather seek medical advice than persevere in exercise."—*Lankester's Manual of Health.*

CHAPTER III.

The Integument, or Skin.

The Skin—Its Structure—Its Changes or Growth—The Nails and Hair—The Complexion—The Sebaceous Glands—The Perspiratory Glands—Perspiration and its Uses—Importance of Bathing—Different kinds of Baths—Manner of Bathing—The Benefits of the Sun—Importance of Warm Clothing—Poisonous Cosmetics.

1. The Skin.—The skin is the outer covering of the body. The parts directly beneath it are very sensitive, and without its protection life would be an agony, as is shown whenever by accident the skin is broken or torn off, the bared surface being very tender and sensitive even to exposure to the air.

2. The Structure of the Skin.—When examined closely, the skin is found to be made up of two layers—the outer and the inner. The inner one is called the *cutis*, or true skin; the outer one is the *epidermis*, or scarf-skin. The latter is also known as the *cuticle*. These two layers are closely united, but they may be separated from each other. This separation takes place whenever, from a burn, or other cause, a blister is formed; a watery fluid is poured out between the two layers, and lifts the epidermis from the true skin.

3. The Scarf-Skin.—Of the two layers, the outer is the thinner one, and has the appearance of a whitish membrane. It is tough and elastic; it has no feeling and does not bleed when cut. On the palm of the hand, where the scarf-skin is especially thick, a needle may be run in and out of it without causing pain or drawing blood. If it be magnified, it will be found to be composed of numberless flat cells, or scales, arranged layer upon layer. Its thickness varies in different parts of the body. Where exposed to use, it is thick and horn-like, as may be seen on the soles of the feet, or on the palms of the hands of those who are accustomed to perform much manual labor.

4. The Cutis, or True Skin.—This layer lies beneath the scarf-skin. It is firm, elastic, very sensitive, and is freely supplied with blood-vessels. Hence a needle entering it not only produces pain, but draws blood. It is closely connected with the tissues below it, but may be separated by means of a sharp instrument. The surface of the cutis is not smooth, but is covered here and there with minute elevations, called *papillæ*. These are arranged in rows, or ridges, such as those which can be seen plainly in the palm and thumb; their number is about 80 to the square line (a line being one-twelfth of an inch). These *papillæ* contain blood-vessels and nerves, and are largely concerned in the sense of touch; hence they are abundant where the touch is most delicate, as at the ends of the fingers.

5. Changes in the Skin.—Like all other parts of the body, the scarf-skin is constantly being worn out; it dries, shrivels and falls from the body in the form of fine flakes, or scales. In the scalp, these scales form the "dandruff." As fast as it wears away, it is renewed from beneath. This seemingly simple process is very important, for by it a uniform thickness is secured to the covering of the body. If it were otherwise, this covering would grow thicker as it grew older, like the bark of a tree, until it became unwieldy; it would prevent perspiration also, and this, as we shall see, would be fatal to life. The growth of the true skin is provided for in the blood vessels which abound in it.

6. The Nails.—These are appendages of the skin. The nail grows from a fold of the cuticle at the root, and from the under surface. The rapidity of its growth can be ascertained by filing a slight groove on its surface, and noticing how the space be-

tween it and the root of the nail increases, in the course of a few weeks. When the nail is removed by any accident, it will be replaced by a new one, if the root be not injured. The practice of biting the nails should be avoided, not only because of the ugly shape which is produced, but because it impairs the sense of touch in the ends of the fingers. The nail serves as a protection to the end of the finger, and also enables us to grasp more firmly, and to pick up small objects.

7. The Hair.—The hair is produced in a similar manner, the skin forming depressions, or hair sacs, from the bottom of which they grow and are nourished (Fig. 7). The bulb, or root, from which the hair arises, is lodged in a small pouch, or depression in the skin. The shaft is the part which grows out beyond the level of the skin. Its growth is altogether in one direction, in length alone.

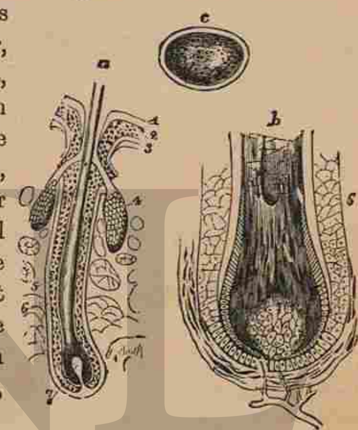

FIG. 7.—*a. b.* THE ROOT OF A HAIR. 1, 2, 3. The skin forming the hair sac. 4. Sebaceous glands. 5. The hair sac. *c.* TRANSVERSE SECTION OF A HAIR.

8. The outer part of the hair is quite firm, while its interior is softer, and supplies the nutriment by which it grows. The hair is a protection to the parts it covers. On the head, it shields the brain from extremes of heat and cold, and moderates the force of blows upon the scalp. On the body it is useful in affording a more extensive surface for carrying off the perspiration.

9. The Complexion.—In the deeper cells of the scarf-skin lies a pigment, or coloring matter, consisting of minute colored grains. On this pigment *complexion* depends; and its presence, in less or greater amount, occasions the difference of hue that exists between the light and the dark races of men, and between the blonde and brunette of the white races. Freckles are due to an irregular increase of coloring matter.

10. The Sebaceous Glands.—In all parts of the surface where the hairs grow are to be found the *sebaceous*, or oil-producing, glands. These glands are little rounded sacs, or pouches, usually connected with the hair-bulbs; and upon these bulbs they empty their product of oil, which acts as a natural dressing for the hair (4, Fig. 7). A portion of the sebaceous matter passes out upon the surface, and prevents the cuticle from becoming dry and hard. It also sheathes the skin from the irritation by the acrid properties of the perspiration. The glands situated upon the face and forehead, open directly upon the skin. In these, the sebaceous matter is liable to collect, and become too hard to flow off naturally. The mouths of these glands, around the nose and on the forehead of young people, frequently appear as small black points, which are incorrectly called "worms."

11. The Perspiratory Glands.—The chief product of the skin's action is the perspiration. For the formation of this, there are furnished countless numbers of little sweat-glands in the true skin. They consist of fine tubes which measure about one-tenth of an inch in length. In diameter, they are about one three-hundredth of an inch, and upon parts of the body there are not far from three thousand of these glands to the square inch. Their whole number in the body is, therefore, very great; and it is computed if they were all united, end to end, their combined measurement would exceed three miles.

12. The Sensible and Insensible Perspiration.—The pores of the skin are constantly exhaling a watery fluid; but, under ordinary circumstances, there is no moisture apparent upon the surface, for it passes off in the form of vapor as rapidly as it is formed. This is called insensible perspiration. Under the influence of heat or exercise, however, this fluid is formed more abundantly and appears on the surface in minute, colorless drops. It is then termed sensible perspiration. Water is

the chief part of this fluid. The average daily amount escaping from the body by perspiration in the adult, is not far from two pints, or more than nine grains each minute.

13. The Uses of the Perspiration.—Besides liberating from the blood this large amount of water, with the worn-out matter it contains, perspiration regulates the temperature of the body. As evaporation always diminishes temperature, so perspiration as it passes off in the form of fine vapor cools the surface. In hot weather this function is much more active, and the cooling influence increases in proportion.

14. The importance of perspiration is shown by the effects that often follow its temporary interruption, namely, headache, fever, and the other symptoms that accompany "taking cold." When its flow is stopped for a considerable time, the consequences are very serious. Experiments have been performed upon certain smaller animals, as rabbits, to ascertain the results of closing the pores of the skin. When they are covered by a coating of varnish impervious to water and gases, death ensues in from six to twelve hours; the attendant symptoms resembling those of suffocation.

15. The Importance of Bathing.—From these considerations, it is evident that health must greatly depend upon keeping the skin clean. "He who keeps the skin ruddy and soft, shuts many gates against disease." For as the watery portion of the perspiration evaporates, the solid matter is left behind. There, also, remain the scales of the dead scarf-skin and the excess of sebaceous matter. The healthful action of the skin requires that these impurities be removed by the frequent application of water.

16. In warm climates and during hot weather, bathing is especially necessary. For a person in good health, a daily cold bath is advisable. To this should be added occasionally a tepid bath, with soap, water alone not being sufficient to remove impurities of a greasy nature like the sebaceous matter.

17. There is a maxim by the chemist Liebig, to the effect that the civilization of a nation is high in proportion to the amount of soap that it consumes; and that it is low in proportion to its use of perfumes. In some degree, we may apply the same test to the refinement of an individual. The soap removes impurity; the perfume covers, while retaining it.

18. The different kinds of Baths.—All persons are not alike able to use the cold bath. When the health is vigorous, a prompt reaction and glow upon the surface will show that it is beneficial. Where this pleasurable feeling is not experienced, but rather a chill and sense of weakness follows, we are warned that the system will not endure cold bathing.

19. It should also be borne in mind, that the warm or hot bath cannot be continued so long, or repeated so frequently as the cold, on account of the weakening effect of unusual heat so applied to the body. For persons who are not in robust health, one warm bath each week is sufficient. Sea-bathing is even more invigorating than fresh-water bathing. Those who cannot endure the fresh water, are often benefited by the salt-water baths.

20. Time and Manner of Bathing.—A person in sound health may take a bath at almost any time, except directly after a full meal. The most appropriate time is about three hours after a meal, the noon-hour being probably the best. For the cold bath, taken rapidly, no time is better than immediately after rising. Those beginning the use of cold baths should first try them at 70° Fahr., and gradually use those of a lower temperature. From five to twenty minutes may be considered the proper limit of time to remain in a bath; but a sensation of chilliness is a signal to withdraw instantly, whether at home, or at the sea-side. Two sea-baths may be taken daily; one of any other kind is sufficient.

21. The body should be warm, rather than cold, when stepping into the bath; and after it, the skin should be thoroughly dried with a coarse towel. It is best to continue friction until there is a sensation of warmth or "glow" throughout the entire

surface. This reaction is the test of the good effects of the bath. If reaction is still incomplete, a short walk may be taken, especially in the sunshine.

22. Bathing among the Ancients.—The Romans and other nations of antiquity made great use of the vapor-bath as a means of preserving the health, but more particularly as a luxury. The Thermæ, as the baths of Rome were called, were of great extent, built very substantially, and ornamented at vast expense. They were practically free to all, the cost of a bath having been less than a cent. It is related that some persons bathed seven times a day. After the bath their bodies were anointed with perfumed oil. If the weather was fine, they passed directly from the Thermæ into the gymnasium and engaged in some gentle exercise previous to taking the midday meal. Swimming was a favorite exercise, and a knowledge of it was regarded as necessary to every educated man. Their common expression, when speaking of an ignorant person, was, "He can neither read nor swim."

23. The Sun-Bath.—Some also were accustomed daily to anoint themselves, and lie or walk in apartments arranged for the purpose, with naked bodies exposed to the direct rays of the sun. We may judge somewhat of the benefits of the sun, by observing the unnatural and undeveloped condition of plants and animals which are deprived of light. Plants become blanched and tender; the fish of subterranean lakes, where the light of day does not enter, are undersized, and have no eyes; men growing up in mines are sallow, pale, and deformed.

24. Clothing.—More harm arises from using too little clothing than too much, especially in a changeful climate like our own. Boerhaave says, "We should put off our winter clothing on midsummer's day, and put it on again the day after. Only fools and beggars suffer from the cold; the latter not being able to get sufficient clothes, the others not having the sense to wear them." The practice of exposing the limbs and necks of young children is quite hazardous. As the skin is constantly acting, by night as well as by day, it is conducive both to cleanliness and comfort to change the clothing entirely on retiring for the night. The day clothing should be aired during the night, and the bedding should be aired in the morning, for the same reason.

25. Poisonous Cosmetics.—The extensive use of *cosmetics* for the complexion is a fertile source of disease. The majority of these preparations contain certain poisonous mineral substances, chiefly lead. The skin rapidly absorbs the fine particles of lead, and the system experiences the same evil effects that are observed among the operatives in lead-works and painters, namely, "painters' colic," and paralysis of the hands, called "wrist-drop."

26. Certain hair-dyes also contain lead, together with other noxious and filthy ingredients. These do not work as great harm as the cosmetics, since they are purposely kept away from the skin, but they rob the hair of its vitality. Eye-washes, too, are made from solutions of lead, and many an eye has been ruined by their use. They deposit a white metallic scale on the surface of the eye, which when in front, permanently blurs the sight.

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CHAPTER IV.

FOOD AND DRINK.

The Necessity for Food—Waste and Repair—Hunger and Thirst—Amount of Food—Renovation of the Body—The Sources of Food—Its Classification—Water and its Purity—Salt—The Necessity of a Regulated Diet—Milk—Meats—Fish—The Vegetables—The Fruits—Coffee and Tea.

1. The Necessity for Food.—Activity is everywhere followed by waste. During life, our bodies are ceaselessly active, undergoing a constant round of changes in nearly all their parts. Thus the wear is constant. The particles that are worn out are thenceforth useless, and must be removed from the body. Their loss must be made good by constantly renewed supplies of strength-giving particles. Hence the daily recurring demand for food and drink. In health, therefore, while the body is always wasting, it is constantly renewed, and does not greatly change from day to day either in size, form, or weight.

2. Hunger and Thirst.—When the system is deprived of its supply of solid food during a longer time than usual, nature gives warning by the sensation of hunger, to repair the losses that have taken place. The feeling of thirst, in like manner, is evidence that the system is suffering from the want of water. The length of time that man can exist without food or drink is estimated to be about seven days. If water alone be supplied, life will last some days longer; there being cases recorded where men have lived twenty days and over, without taking any solid food.

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CHAPTER IV.

FOOD AND DRINK.

The Necessity for Food—Waste and Repair—Hunger and Thirst—Amount of Food—Renovation of the Body—The Sources of Food—Its Classification—Water and its Purity—Salt—The Necessity of a Regulated Diet—Milk—Meats—Fish—The Vegetables—The Fruits—Coffee and Tea.

1. The Necessity for Food.—Activity is everywhere followed by waste. During life, our bodies are ceaselessly active, undergoing a constant round of changes in nearly all their parts. Thus the wear is constant. The particles that are worn out are thenceforth useless, and must be removed from the body. Their loss must be made good by constantly renewed supplies of strength-giving particles. Hence the daily recurring demand for food and drink. In health, therefore, while the body is always wasting, it is constantly renewed, and does not greatly change from day to day either in size, form, or weight.

2. Hunger and Thirst.—When the system is deprived of its supply of solid food during a longer time than usual, nature gives warning by the sensation of hunger, to repair the losses that have taken place. The feeling of thirst, in like manner, is evidence that the system is suffering from the want of water. The length of time that man can exist without food or drink is estimated to be about seven days. If water alone be supplied, life will last some days longer; there being cases recorded where men have lived twenty days and over, without taking any solid food.

3. Quantity of Food.—The quantity of food required varies greatly, according to the individual and his mode of life. The young, and those who lead active lives, or who live in the open air, require more food than the old, the inactive, or the sedentary. Those who live in cold regions require more than the inhabitants of hot climates.

4. The average daily quantity of food and drink for a healthy man of active habits is estimated at six pounds. This amount may be divided in the following proportions: the mineral kingdom furnishes three and one-half pounds, including water and salt; the vegetable kingdom, one and one-half pounds, including bread, vegetables, and fruits; the animal kingdom, one pound, comprising meat, eggs, butter, and the like. This amount is about equal to one twenty-fourth part of the weight of the body of an adult,—namely, one hundred and forty pounds.

5. Renovation of the Body.—But these pounds of food are not all real nutriment. A considerable portion of that which we eat is innutritious, and though useful in various ways, is not destined to repair the losses of the system. An opinion prevails that the body is renewed throughout once in seven years; how correct this may be it is not easy to decide. Some parts change more or less completely several times during the day. The muscles, and other parts in frequent use, change often during a year; the bones not so often, and the enamel of the teeth never changes after being once formed.

6. The Source of Food.—The term *food* includes all those substances, whether liquid or solid, which are necessary for the nourishment of the body. The original source of all food is the earth, which the poet has fitly styled the "Mother of all living." But the salts of the earth and gases of the air are not all directly suited to the wants of man; for the most part, they must be made into forms more closely resembling the tissues of his own body. These higher forms are prepared through the medium of the plants and lower animals.

7. Moreover some of the forms of vegetable and animal life are unfit, in their crude state, for man's use, but must pass through one or more refining processes. Thus clover, and hay and husks of corn, become, through the agency of the bee and the cattle, honey, milk and meat. The insect world furnishes food for the fowl, and thus indirectly supplies our own tables.

8. Inorganic Substances.—The substances we use as food are classified as *organic* and *inorganic*. By organic substances are meant those derived from living forms, such as vegetables and animals. Inorganic substances are those simpler forms which belong to the mineral kingdom. The former alone are commonly spoken of as food, but the latter enter very largely into the constitution of the body, and must therefore be present in our food. With the exception of two articles, water and common salt, these substances enter the system only when blended with organic substances.

9. Water.—Water, from a physiological point of view, is the most important of all the articles of food. It is everywhere found in the body, even in the bones and the teeth. It is estimated that two-thirds of the body is water. The teeth, the densest of the solids in the human system, contain ten per cent. of water. The muscles, tendons, and ligaments are more than half water; for it is found that they lose more than half their weight when dried with moderate heat. But it is in the *fluids* of the body that water is found most abundantly.

10. Man can remain a longer time without solid food than without water. He may be deprived of the former for ten or twelve hours without great suffering, but deprivation of water for the same length of time will produce both suffering and weakness. Water constitutes the great bulk of all our drinks, and is also a large constituent of the meats, vegetables, and fruits which come upon the table.

11. Pure Water.—It is important that the water we drink and use in the preparation of food should be pure. It should be clear and colorless, with little or no taste or smell, and free from any great amount of foreign ingredients. Chemically pure water does not occur in nature; it is obtained only by the condensation of steam, carefully conducted, and is not as agreeable for drinking purposes as the water furnished by springs and streams. Rain-water is the purest occurring in nature; but even this contains certain impurities, especially the portion which falls in the early part of a shower; for in its descent from the clouds, the particles floating in the air are caught by the falling drops. Water from springs and wells always contains more or less foreign matter of mineral origin. This imparts to the drink its pleasant taste—the sparkle, or "life," coming from the gases absorbed by the water during its passage under ground.

12. Action of Water upon Lead.—The danger of using water that has been in contact with certain metals is well known. Lead is probably the most poisonous of these substances in common use. When pure water and an untarnished surface of lead come in contact, the water gradually corrodes the metal, and soon holds an appreciable quantity of it in solution. When this takes place the water becomes highly injurious.

13. In cities, lead pipes are commonly used to convey water through the houses; lead being also used in the construction of roofs, cisterns, and vessels for keeping water and other liquids. After the articles of lead have been in use several months, the danger of lead-poisoning diminishes. An insoluble coating of the sulphate of lead forms upon the exposed surface, thus protecting it from further corrosion. It is, however, a wise precaution, at all times to reject the water or other fluid that has been in contact with leaden vessels over night, or for a number of hours. Allow the water in pipes to run freely before using.

14. Common Salt.—Salt, as an article of food, is obtained chiefly from the mineral kingdom; although plants contain it in small quantities, and it is also found in the tissues of nearly all animals used as food. Even the water we drink sometimes

has traces of it. In the human body, it is an ingredient of all the solids and fluids. The importance of salt is shown by the value placed upon it in countries where it is rare. On the gold coast of Africa, a handful of it will buy one or two slaves; next to gold it is their most valuable commodity. Its necessity to animal life is also seen in the great appetite for it among domestic animals, and by the periodical resort of herds of wild beasts to the "salt-licks" or springs.

15. Experiments upon domestic animals show that the withdrawal of salt from their food, not only makes their hides rough and causes the hair to fall out, but also interferes with the proper digestion of food. If it be withheld persistently, they become unable to appropriate nourishment, and die of starvation.

16. Organic Substances.—The organic food-substances are derived from the vegetable and animal kingdoms. They comprise all those articles which are commonly spoken of as "food," and are essential to sustain the body in life and strength. They are divided into three groups: (1) the *Albuminoids*, or flesh-producers; among these are albumen, or white of eggs; caseine from cheese; gluten from wheat; also the lean part of meat; (2) the *Fats* or *Oils*, or the great heat-producers. Among these are butter, lard, olive and other vegetable oils. In cold climates, the fat of animals is the chief "staff of life," but where vegetation is scanty and innutritious, the waters even of the frozen regions teem with forms of animal life rich in fat. The Esquimau consumes daily from ten to fifteen pounds of meat or blubber, a large proportion of which is fat. The Laplander will drink train-oil, and regards tallow-candles as a great delicacy. In hot climates, on the other hand, a vegetable fat is supplied by the olive and the palm. (3) The *Sugars*, like the last group, are producers of heat. They are, with the exception of the sugar of milk and honey, chiefly the products of vegetable life; among the principal sources are the sugar-cane, maple and beet-root. Moreover, the sweet-tasting fruits, such as grapes, pears, peaches and cherries are rich in grape-sugar. In this group *starch* is placed, for the reason that it must be changed into sugar by digestion, before it can take part in building up the body.

17. The bread stuffs, wheat, corn, and rye flours, are more than one-half starch. Rice, which is the "staff of life" to one-third of the human family, contains eighty per cent. Unripe fruits have much starch in them, which renders them indigestible when eaten uncooked; for the granules of raw starch are but slightly acted upon within the body. But under the potent chemistry of the sun's ray, this crude material is converted into sugar. Thus are the fruits prepared by the careful hand of Nature, so that when ripe they may be freely used without further preparation.

FIG. 8.—GRANULES OF STARCH MAGNIFIED.

18. Necessity of a Regulated Diet.—These three organic food-groups are each essential to life. Neither of them can be used to the exclusion of the others without endangering health and life. An animal can be starved to death on an unlimited allowance of white of egg, or butter, or pure sugar, which represent the three classes. But if these are given together, or are changed at short intervals, the animals live and thrive.

19. Milk.—Milk is the earliest nutriment of the human race, and from the arrangement of its constituents, may be regarded as the model food, no other single article being capable of sustaining life so long. Cow's milk holds casein, one of the albuminoids, about five parts in one hundred; a fatty principle, when separated, known as butter, about four parts; sugar of milk, four parts; water and salts, eighty-seven parts. The casein and fatty substance are far more digestible in milk, than after

they have been separated from it in the form of cheese and butter.

20. The Egg.—The egg contains about two-thirds water, the rest being pure albumen and fat. The fat is in the yolk, and gives it its yellow color. Eggs contain none of the sugar-principles, and should be eaten with bread or vegetables that contain them. Soft-boiled eggs are more wholesome than those which are hard-boiled or fried, as the latter require longer time to digest.

21. Meats.—The meats, so called, are derived from the muscular parts of various animals. They are most important articles of food for adults, inasmuch as they are richly stored with albuminoid substances, and contain more or less fat. Such food is very nourishing and easily digested if eaten when fresh, —veal and pork being exceptions. The flesh of young animals is more tender and, in general, more digestible than that of older ones. All meat is more tough immediately after the killing of the animal, but improves by being kept a certain length of time.

22. Cold is one means of preserving meat from decay. In the markets of northern Russia, the frozen carcases of animals stand exposed for sale in the winter air for a considerable time, and are sawn in pieces, like sticks of wood, as the purchases are made; such meat, when thawed, being entirely fit for food. Beef and pork are preserved by salting down in brine, and in this condition may be carried on long voyages or kept for future use. Salted meat is not as nutritious as fresh, since the brine absorbs its rich juices and hardens its fibres.

23. Cooking.—The preparation of food by the agency of fire is of almost universal practice, even among the rudest nations. The object of cooking is to render food more easy of digestion by softening it, to develop its flavor, and to raise its temperature more nearly to that of the body. A few articles of flesh-food are eaten uncooked in civilized lands, the oyster being an instance. Raw meat is occasionally eaten by invalids with weak digestive powers, and by men training for athletic contests.

24. In boiling meat, the water in which it is placed tends to dissolve its nutrient juices. In fact, the cooking may be so conducted as to rob the meat of its nourishment, its tenderness, and even of its flavor. The proper method, in order to preserve these qualities, is to place the meat in boiling water, which, after a few minutes, should be reduced in temperature. In this way the intense heat, at first, hardens the exterior layers and imprisons the delicate juices; after that, moderate heat best softens it throughout. When soup is to be made, an opposite course should be pursued; for then the object is to extract the juices and reject the fibre. Meat, for such purpose, should be cut in small pieces and put into cold water, which should then be gradually raised to boiling heat.

25. Roasting is probably the best method of cooking meat, especially "joints" or large pieces, as by this process the meat is cooked in its own juices. Roasting should begin with intense heat, and be continued at a moderate temperature, in order to prevent the drying out of the nutritious juices, as by this process an outer coating or crust of coagulated albumen is formed. During this process the meat loses one-fourth of its weight, but the loss is almost wholly water, evaporated by the heat. Too intense or prolonged heat will dry the meat, or burn it. Frying is the worst possible method, as the heated fat, by penetrating the meat, or other article placed in it, dries and hardens it, and thus renders it indigestible.

26. Trichina.—It should be remembered that ham, sausages, and other forms of pork, should never be eaten in a raw or imperfectly cooked condition. The muscle of the pig is often infested by a minute animal parasite, or worm, called *trichina spiralis*. This worm may be introduced alive, in pork food, into the human body, where it multiplies with great rapidity, and gives rise to a painful and serious disease. The disease has been prevalent in Germany, and cases of it occur from time to time in this country. Other varieties of parasites, not less than seven in number, may be introduced by means of animal food. The true means of destroying them all is thorough cooking.

27. Fish.—The part of fish that is eaten is the muscle, just as in the case of the meats and poultry. It closely resembles flesh in its composition, but is more watery. Some varieties are very easy of digestion, such as salmon, trout, and cod; others are quite indigestible, especially lobsters, clams, and shell-fish generally.

28. Vegetable Food.—The list of vegetable articles of diet is a very long one, including the grains from which our breadstuffs are made, the vegetables from the garden, and the fruits. All the products of the vegetable kingdom are not alike useful. Some are positively hurtful; indeed, the most virulent poisons, as strychnia and prussic acid, are obtained from certain vegetables. Again, of such articles as have been found good for food, some are more nourishing than others: some require very little preparation for use, while others are hard and indigestible. Great care must therefore be exercised, and many experiments made, before we can arrive at a complete knowledge in reference to these articles of diet. Tea, coffee, and other substances from which drinks are made, are of vegetable origin.

29. Bread.—Bread made from wheat-flour has been in use for many hundreds of years, and on this account, as well as because of its highly nourishing properties, has been aptly called "the staff of life." We never become tired of good bread as an article of daily food.

The white kinds of flour contain more starch and less gluten than the darker, and are therefore less nutritious. The hard-grain wheat yields the best flour. In grinding wheat, the chaff or bran is separated by a process called "bolting." Unbolted flour is used for making brown or Graham bread.

30. The form of bread most easily digested is that which has been "leavened," or rendered porous by the use of yeast, or by some similar method. Unleavened bread requires much more mastication, or chewing. Hot bread is unwholesome, because it is not firm enough to be thoroughly masticated, but is converted into a pasty, heavy mass that is not easily digested.

31. Wheaten bread contains nearly every principle requisite for sustaining life, except fat. This is commonly added in other articles of diet, especially in butter,—"bread and butter," consequently, forming an almost perfect article of food. The following experiment is recorded: "A dog eating *ad libitum* of white bread, made of pure wheat, and freely supplied with water, did not live beyond fifty days. He died at the end of that time with all the signs of gradual exhaustion." Death took place, not because there was anything hurtful in the bread, but because of the absence of one or more of the food-principles.

32. The Potato.—The common or Irish potato is the vegetable most extensively used in this country and Great Britain. Among the poorer classes in Ireland it is the main article of food. While it is not so rich in nutritious substances as many others, it has some very useful qualities. It keeps well from season to season, and men do not weary of its continuous use. It is three-fourths water, the remainder being chiefly starch. It is rich in potash and other salts, and is believed to have been highly valuable in warding off the attacks of scurvy which recurred in Europe every spring and winter previous to its introduction.

33. Fruits.—These are produced, in this country, in great abundance, and are remarkable alike for their variety and delicious flavor; consequently they are consumed in large quantities, especially during the warmer months. The moderate use of ripe fruits, in their season, is beneficial, because they offer a pleasant substitute for the more concentrated diet that is used in cold weather. Unripe fruits contain starch, which, during the process of ripening, is converted into sugar. Such fruits are indigestible and should be avoided; cooking, however, in part removes the objections to them.

34. Coffee.—This is an important addition to diet, and if moderately used is beneficial to persons of adult age. As commonly employed, it consists of an infusion in boiling water of the roasted and ground berry. With most persons its action is that of a gentle stimulant, without any injurious reaction.

35. Another property of coffee is, that it retards the waste of the tissues, and consequently permits the performance of excessive labor upon an economical and inadequate diet. This has been tested among the miners of Belgium. Their allowance of solid food was below that found necessary in prisons and elsewhere; but, with the addition of about four pints of coffee daily, they were enabled to undergo severe labor without reducing their muscular strength. The caravans which traverse the deserts are supported by coffee during long journeys and lengthened privation of food. Among armies it is indispensable in supplementing their imperfect rations, and in relieving the sense of fatigue after great exposure and long marches. When taken with meals, coffee is also thought to promote digestion.

36. Tea.—The effects of tea are very similar to those of coffee, and are due to a peculiar principle called *theine*. This principle is probably the same as that found in coffee, *caffeine*, since the chemical composition of both is the same. Tea, as a beverage, is made from the dried leaves of the plant by the addition of hot water; if the tea is boiled, the oil which gives it its agreeable flavor is driven off with the steam.

37. Chocolate is made from the seeds of the cocoa-tree, a native of tropical America. Its effects resemble somewhat those of tea and coffee, but it is very rich in nutriment. Linnæus, the botanist, was so fond of this beverage, that he gave to the cocoa-tree the name, *Theobroma*—"the Food of the Gods."

38. Alcohol.—The word alcohol is of doubtful origin. It is commonly supposed to be derived from the Arabic language, several words in that tongue resembling it in sound, but none of them or any other in the language have a meaning corresponding with that of the English term.

39. History.—Alcohol was distilled from rice many centuries before that seed was known in Europe. We hear of it in Bagdad about the year 900. It was known to the Moors of Spain, through whom the knowledge of its production spread into Western Europe. The first description of alcohol was given by a western writer about 1280, who wrote of a "burning or ardent water" that resulted from the distillation of wine. It may also have been known to the Romans, for Pliny, in the first century, wrote of a strong kind of wine that was inflammable—a quality that strongly suggests the knowledge of a product of distillation.

40. The Alcohols.—There are at least twelve members of the alcohol family, the oldest of which is common alcohol. This last is the only one that need be referred to here. *Common Alcohol* is sometimes known as spirit of wine, also as vinic alcohol. It is commonly obtained by the distillation of grains or of wine. The ardent spirits of commerce (brandy, whiskey, gin and rum) contain about one half water, the other half alcohol. Alcohol is also found in all the wines and malt liquors (beer, ale, and porter) in varying proportions. The juices of ripe, sweet fruits will, at seventy degrees of Fahrenheit, begin spontaneously to "work" or ferment; also wheat and other starch-grains, when sprouting, will have their starch changed into sugar, and this, in like manner, will undergo fermentation: alcohol being one of the results of this action in both cases.

41. Properties of Alcohol.—Alcohol is a clear, colorless, volatile and inflammable liquid of penetrating odor and burning taste. It is lighter than water. As it cannot be frozen, it is used in thermometers for taking low or exceedingly cold temperatures. It is also used in spirit levels. It burns with a pale, bluish flame, without smoke, and with intense heat; hence its use in the spirit-lamp.

42. Is Alcohol Food?—A chemical analysis clearly indicates that, while it is more or less allied to the sugars, the effect of alcohol within the human system is in all respects very unlike

that of the sugars. The latter are nourishing, while the former tends to impair nutrition. It was on the mistaken theory that alcohol had sustaining power, that for two hundred years the armies and navies of certain countries were supplied with rations of rum or some other alcoholic drink, under the name of "grog." During recent years, a systematic inquiry has been made to discover whether the grog-ration was really serviceable or the reverse. Tests have been tried upon considerable bodies of men, under military discipline, by withdrawing that ration; comparisons have been made at home and abroad, in hot climates and in cold, in active service and at rest. The results of these observations have without exception been favorable to the non-use of spirits. The proportion of ill health, the number of sick days, and the incapacity for work have invariably been greater among the men to whom the spirit-ration has been issued, the quality of food and other circumstances being made as nearly equal as possible.* Hence the conclusion that not only is alcohol not a food, but is injurious in itself, and a detriment to the food taken.†

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* **Alcohol in the Army.**—Dr. F. H. Hamilton writes concerning the use of spirits by the Army of the Potomac in the late war. One gill of whiskey was, for a time, given daily to each soldier, on the ground that the hardship and exposure of the soldiers demanded it. He condemned the experiment and expressed the hope that "no such experiment will ever be repeated in the armies of the United States. My conviction is fixed, by the experience and observation of a lifetime, that the regular, routine employment of alcoholic stimulants, by a man in health, is never, under any circumstances, useful. I make no exception in favor of cold, or heat, or rain, nor indeed in favor of old drinkers, when we consider them as soldiers."

† **Beer and Wine.**—Beer and wine are drank chiefly for pleasure or from habit, and therefore might be got rid of without any disadvantage; whilst at the same time they are costly, and cause an enormous waste of money amongst the working classes. The cost of two pints of ale daily, viz., 3*s.* 6*d.* a week, would well clothe a whole family. * * * *

They do not give strength for work, but on the other hand often make people dull, heavy, stupid, and unfit for work. The most severe and continued work can be performed without them, and there are now some millions of people in this country who never taste them. Happy will be the day when they are not drank by any, but particularly by the working man, who finds it difficult to maintain his family. Then will there be less quarrelling, poverty, and crime, and more food, clothing, and education.

About 120 millions of money are spent yearly in these substances, and therefore we may well ask whether so large a sum is wisely spent. If we allow that there are 1,000

43. Does Alcohol Relieve Thirst?—One of the most striking properties of alcohol is its affinity for water. When swallowed, therefore, its tendency is to deprive the body of water and to create thirst rather than to relieve it. It may then be stated that alcoholic drinks which appear to quench thirst do so by means of the water that, in greater or less quantities, dilutes the alcohol they contain. Water, the peerless beverage of nature, does its work better in proportion as it remains free from alcohol. To maintain normal action, the delicate organs of the body require a uniform supply of water. When alcohol is introduced, it draws the water to itself, and leaves the organs without their share of proper moisture; hence, after death from alcoholism, we find them affected in different degrees, being drier and harder than is natural.

44. Does Alcohol Enable its Consumers to Resist Extreme Cold?—If this could be proved to be a fact, some of its boasted usefulness would receive support. In extremely cold climates, the inhabitants are enabled to live comfortably by consuming vast quantities of animal food alone, especially if it is abundantly oily. Will alcohol act in a similar way or assist in maintaining heat? Experience and observation say no.

45. Before the thermometer was applied to the testing of the body's temperature, it was commonly supposed, by reason of the sensations of warmth, that alcohol increased bodily heat. When, however, this new test was applied, it became apparent that those sensations were deceptive, and that there had been an actual fall in temperature as the result of imbibing alcohol. The surface of the stomach is irritated by this powerful agent, causing the nerves of sensation to convey to the brain the impression that something has entered the stomach which is producing warmth. This is a delusive impression, as we know, by pouring a few drops of alcohol on the skin, that the

millions of people in the whole world, and that a 4 lb loaf of bread could be purchased everywhere for 6*d.*, that sum would feed the whole world with $\frac{3}{8}$ lb. of bread daily for one month..—*Dr. E. Smith. in "English Magazine."*

tendency is to cool the surface whenever evaporation can take place.

46. The sensation of warmth of the face and surface of the body is also deceptive. The flushing of the face, common to hard drinkers, does not indicate that they have a superabundance of animal heat, the temperature of their bodies being below normal. The true cause of the flush is a paralysis of one set of nerves governing the natural action of the hair-like vessels that course just below the skin. Nature has provided these infinitely fine vessels with minute controlling nerves, whose duty it is to regulate the flow of blood in exposed positions. Alcohol paralyzes this control; the blood flows at random, and the terminal vessels are over-charged with blood. Hence the high color which is so remarkable in habitual drinkers that it amounts to a disfigurement, is Nature's signal of distress, showing that the circulation is deranged and the blood is unduly brought into contact with the lower temperature of the outer air. Alcohol, therefore, is not a producer of heat, but a promoter of cold, and must be dangerous to any persons taking it when they are exposed to low temperatures.

47. The testimony of those who have had experience in contact with the realms of snow and ice is unanimous against the cold-resisting property of alcohols. It is recorded of the men who served in Napoleon's campaign in Russia, under great exposure to cold, that death was hastened by the use of alcohol. The evidence of the Monks of St. Bernard is similar. Numerous Arctic explorers testify that not only is the temporary indulgence liable to result in most serious consequences, but that strong, able-bodied men in the habit of using alcoholic drinks, are entirely unfitted to resist the cold to which they must be exposed. The natives and travelers alike rely upon fresh animal food, especially fatty food, and avoid alcohol as a danger to life.*

* "Alcohol is not the warming cordial and invigorating stimulant that it is reputed to be, but there is a world-full of preconceived opinions in its favor that must be met and

Dr. Rae's Statement.—The Arctic explorer, Dr. Rae, states that he found entire avoidance of alcohol necessary, in the far North. The moment a man had swallowed a drink of spirits, it was certain that his day's work was nearly at an end. "It was absolutely necessary that the rule of total abstinence should be rigidly enforced, if we would accomplish our day's task. Any use of liquor, as a beverage, when we had work on hand, in that terrific cold, was out of the question."

48. Alcohol Destructive to Life.—Instead of being a promoter of life, as the early alchemists who produced it hoped it would be, alcohol is hostile to life; it is a poison. Plant life is speedily destroyed when brought into close contact with it. The lower animals are poisoned by it. When applied directly to small insects and reptiles, death commonly occurs in a few seconds or minutes. It is hurtful to the larger animals, and the more intelligent of them appear to resent its use instinctively. This is seen when dogs have been forced to take brandy in small doses for some time. Instead of learning to like it, they gradually show a greater and greater dislike to it.*

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overcome before the true view can make its way. But the truth must prevail at last. Its true place is not along with the displays of wealth and luxury upon our sideboards, but in the medicine-chest along with hasheesh, henbane, opium, stramonium, and so-forth, labeled as a POISON!"—*Dr. A. F. Kinne.*

* "There is no such thing as a temperate use of spirits. In any quantity they are an enemy to the human constitution. Their influence upon the physical organs is unfavorable to health. They produce weakness, not strength; sickness, not health; death, not life."—*Dr. Alden.*

Adulteration in Liquors.—It is not enough that alcoholic drinks are dangerous when purely made, but there is an added danger growing out of the almost universal practice of the manufacturers of these drinks to tamper with them and adulterate them with other harmful materials. Not many months ago the city government of Paris caused a testing of all the wines that were brought into the market during a month; there were 1,518 samples of French wine examined and only 65 found absolutely free from injurious addition: that is, less than 5 per cent. was really pure.—*N. Y. Scientific Times.*

A Mixed Diet affords the best Results.—"The mixed diet to which the inclination of a man in temperate climates seems unusually to lead him, when circumstances allow that inclination to develop itself freely, appears to be fully conformable to the construction of his dental and digestive apparatus, as well as to his instinctive cravings. And whilst on the one hand it may be freely conceded to the advocates of 'vegetarianism,' that a well-selected vegetable diet is capable of producing, in the greatest number of individuals, the highest *physical* development of which they are capable, it may, on the other hand, be affirmed with equal certainty, that the substitu-

(*For further matter on Alcohol see p. 72.*)

tion of a moderate proportion of animal flesh is in no way injurious; but, so far as our evidence at present extends, this seems rather to favor the highest *mental* development. And we can scarcely avoid the conclusion that the Creator, by conferring on man a remarkable range of choice, intended to qualify him for subsisting on those articles of diet, whether animal or vegetable, which he finds most suitable to his tastes and wants."—*W. B. Carpenter on the Principles of Physiology.*

Bread.—"The health and power of a nation, as of an army, depend greatly on its food. The quality of bread in any nation, community, or family is a pretty good measure of its civilization. No one can entirely dispense with it. Good or bad, in some form it must be had. So it is, and has been from the earliest records of the race, and so it will doubtless continue. Leavened or fermented bread is as old as the time of Moses, and its value has been fully tested. Whatever be the precise action of the leaven, it transforms the grain by partial decomposition of its original elements, and leaves as its resultant what all men in all ages have approved. Is the art of making good, honest, leavened, Bible bread lost in Massachusetts, as some of our friends declare? Baker's bread is almost universally adulterated. Bread hastily made in families is mixed in a variety of ways, with a variety of chemicals, and is generally imperfectly cooked. Very often the elements of wheat and fat which the body demands (a wise and witty clergyman of the last generation used to say, 'bread is the staff of life, but bread and butter is a gold-headed cane') are furnished in underdone pastry, made from flour and hog's lard. Any family can have good bread who will take the pains. It involves not more than ordinary skill and judgment. It 'is to be found on the continent of Europe on all the great lines of travel, and is as common among the people in France and Germany as it is rare with us.' The materials for an honest, wholesome loaf are simple and not expensive. The value of time and labor required for kneading the dough are the only difficulties, and these we would not undervalue; they are in many families very serious, and not easily overcome."—*Derby on the Food of Massachusetts*

QUESTIONS FOR TOPICAL REVIEW.

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CHAPTER V.

DIGESTION.

The Principal Processes of Nutrition—The General Plan of Digestion—Mastication—The Teeth—Preservation of the Teeth—The Action of the Saliva—The Stomach and the Gastric Juice—The Movements of the Stomach—Gastric Digestion—The Intestines—The Bile and Pancreatic Juice—Intestinal Digestion—Absorption by means of Blood-vessels and Lacteals—The Lymphatic or Absorbent System—The Lymph—Conditions which affect Digestion—The Quality, Quantity, and Temperature of the Food—The Influence of Exercise and Sleep.

1. Nutrition.—The great design of food is to give *nutriment* or nourishment to the body. But this is not accomplished directly, as the food must first pass through certain preparatory changes, as follows: (1), *Digestion*, by which the food is reduced to a soluble condition; (2), *Absorption*, by which, when digested, it is taken up by the blood; (3), *Circulation*, which carries the enriched blood to the various parts of the system; and (4), *Assimilation*, by which each tissue selects from the blood the materials necessary for its support. By these four steps the sustaining power of food is gradually brought into exercise, and the vital machinery kept in working order.

2. General Plan of Digestion.—The great change which food undergoes in digestion is essentially a refining process, reducing articles of diet, which are at first more or less solid, crude, and coarse, to a liquid condition, suitable for absorption into the blood. The entire process of digestion takes place in

QUESTIONS FOR TOPICAL REVIEW.

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3. The stomach and intestines are situated in the abdomen (Fig. 9, C, and Fig. 15), and occupy about two-thirds of its space. The action to which the food is subjected in these organs is of two kinds—mechanical and chemical. By the former it is softened, agitated, and carried onward from one point to another; by the latter it is changed in form through the solvent power of the various digestive fluids.

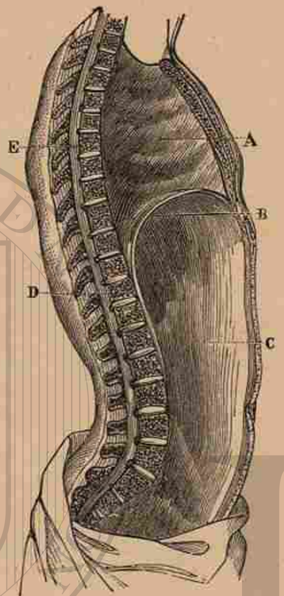

FIG. 9. — SECTION OF THE TRUNK SHOWING THE CAVITIES OF THE CHEST AND ABDOMEN.
A, Cavity of Chest; B, Diaphragm; C, Abdomen; D, E, Spinal Column.

4. Mastication. —As soon as solid food is taken into the mouth, it undergoes mastication, or chewing. It is caught between the opposite surfaces of the teeth, and by them is cut and crushed into very small fragments. In the movements of chewing, the lower jaw plays the chief part; the upper jaw, having almost no motion, acts simply as a point of resistance, to meet the action of the former. These movements of the lower jaw are of three sorts: an up-and-down or cutting, a lateral or grinding, and a to-and-fro, or gnawing motion.

5. The teeth are composed of a bone-like material, and are held in place by roots running deeply into the jaw. The exposed portion, or "crown," is protected by a thin layer of

enamel (Fig. 10, *a*), the hardest substance in the body, which, like flint, is capable of striking fire with steel. In the interior of each tooth is a cavity containing blood-vessels and a nerve, which enter it through a minute opening at the point of the root (Fig. 12).

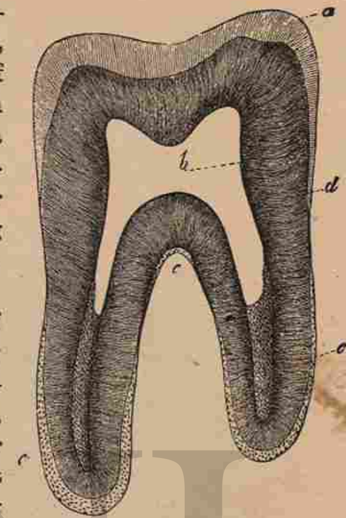

FIG. 10.—A MAGNIFIED SECTION OF A TOOTH.
a, Enamel; *b*, Cavity; *c c*, Roots; *d*, Body of the Tooth.

6. There are two sets of teeth: first, those belonging to the earlier years of childhood called the milk teeth, which are twenty in number and small. At six or eight years of age, when the jaw expands, and when the growing body requires a more powerful and numerous set, the roots of the milk teeth are absorbed, and the latter are "shed," or fall out, one after another (Fig. 11), to make room for the permanent set.

7. There are thirty-two teeth in the permanent set, an equal number in each jaw. Each half-jaw has eight teeth, similarly shaped and arranged in the same order. The front teeth are small, sharp, and chisel-edged, and are well adapted for cutting purposes; hence their name incisors. The canines stand next, one on each side of the jaw; these receive their name from their resemblance to the long, pointed tusks of the dog (Fig. 12).

8. The bicuspids, next in order, are larger and have a broader crown than the former; while behind them are the molars, the largest and most powerful of the entire set. These large back teeth, or "grinders," present a broad, rough surface, suitable for holding and crushing the food.

9. It is interesting, at this point, to notice the different forms of teeth in different animals, and observe how admirably their teeth are suited to the respective kinds of food upon which they subsist. In the *carnivora*, or flesh feeders, the teeth are sharp and pointed, enabling them both to seize their prey, and tear it in pieces; while the *herbivora*, or vegetable-feeders,

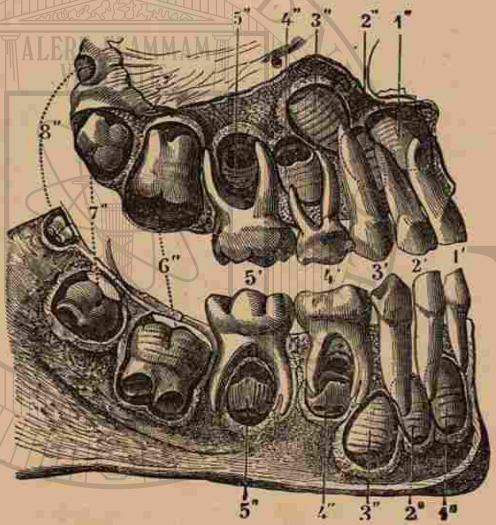

FIG. 11.—SECTION OF THE JAW.
1' 2' 3' 4' 5', The Milk Teeth; 1" to 8", The Germs of the Permanent Set.

have broad, blunt teeth, with rough crowns, suitable for grind ing the tough grasses and grains upon which they feed. Human teeth partake of both forms; some of them are sharp, and others are blunt; they are therefore well adapted for the mastication of both flesh and vegetables. Hence we infer that, although man may live exclusively upon either vegetable or animal food, he should, when possible, choose a diet made up of both varieties.

10. Preservation of the Teeth.—In order that the teeth

shall remain in a sound and serviceable condition, some care is of course requisite. In the first place, they require frequent cleansing; for every time we take food, some particles of it re-

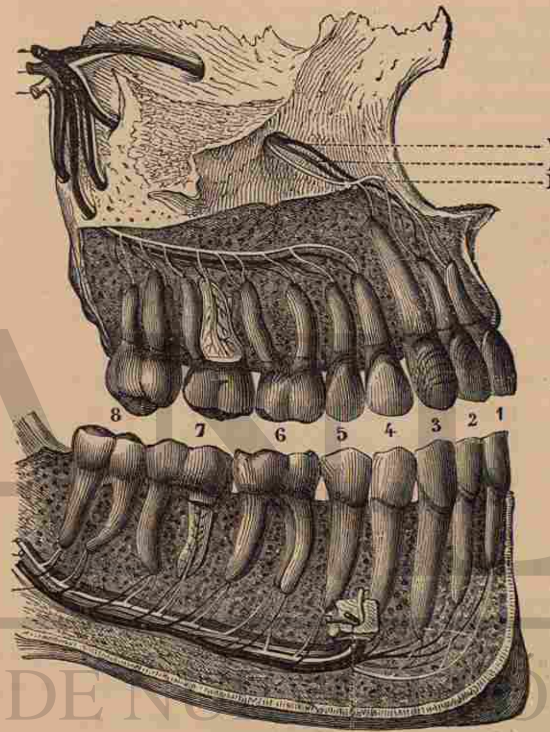

FIG. 12.—SECTION OF THE JAWS—RIGHT SIDE.
V, A, N, Veins, Arteries, and Nerves of the Teeth. The root of one tooth in each jaw is cut vertically to show the cavity and the blood-vessels, etc., within it; 1 to 8, Permanent Teeth.

main in the mouth; and these, on account of the heat and moisture present, soon begin to putrefy. This not only renders the breath very offensive, but promotes decay of the teeth.

11. The saliva, or moisture of the mouth, undergoes a putrefactive change, and becomes the fertile soil in which a certain minute fungus has its growth. This fluid, too, if allowed to dry in the mouth, collects upon the teeth in the form of an unsightly, yellow substance, called "tartar." To prevent this formation, and to remove other offensive substances, the teeth should be frequently cleaned with water, applied by means of a soft tooth-brush.

12. It should be borne in mind that the enamel, Nature's protection for the teeth, when once destroyed is never formed anew; and the body of the tooth thus exposed, is liable to rapid decay. On this account, certain articles are to be guarded against; such as sharply acid substances that corrode the enamel, and hard substances that break or scratch it—as gritty tooth powders, metal tooth-picks, and the shells of hard nuts. Sudden alternations from heat to cold, when eating or drinking, also tend to crack the enamel.

13. The Action of the Saliva.—While the morsel of food is cut and ground by the teeth, it is at the same time intimately mixed with the saliva, or fluids of the mouth. This constitutes the second step of digestion, and is called "insalivation." The saliva, the first of the digestive solvents, is a colorless, watery, and frothy fluid. It is secreted (*i. e.* separated from the blood) partly by the mucous membrane which lines the mouth; but chiefly by the salivary glands, of which there are three pairs situated near the mouth.

Fig. 13.—Structure of a Salivary Gland.

14. These glands consist of clusters of very small pouches, around which a delicate network of blood-vessels is arranged: they empty into the mouth by means of little tubes

or ducts. The flow from these glands is generally sufficient to maintain a soft and moist condition of the tongue and mouth; but when they are excited by the presence and taste of food, they pour forth the saliva more freely. In the horse and other animals, that feed upon dry and coarse fodder, and require an abundant supply of saliva, we find large salivary glands, as well as powerful muscles of mastication.

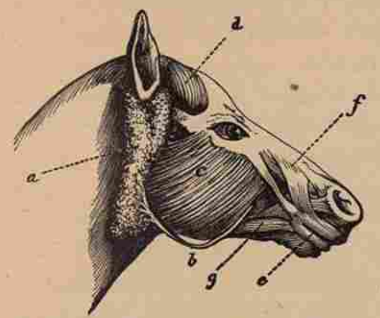

Fig. 14.—The Head of a Horse, showing the large salivary gland (*a*), its duct (*b*), the muscles of mastication (*c*, *d*, *e*, *f*, and *g*).

15. The mingling of the saliva with the food seems a simple process, but it is one that plays an important part in digestion. In the first place, it facilitates the motions of mastication by moistening the food and lubricating the various organs of the mouth. Secondly, it prepares the way for other digestive acts: by the action of the teeth, the saliva is forced into the solid food, softens the harder substances, and assists in converting the whole morsel into a semi-solid, pulpy mass, that can be easily swallowed, and readily mixed with other digestive fluids. The saliva also, by dissolving certain substances, as sugar and salt, develops the peculiar taste of each; whereas, if the tongue be dry and coated, they are tasteless. Hence, if substances are insoluble, they are devoid of taste.

16. Finally, the saliva has the property of acting chemically upon the food. As we have before stated (Chap. IV.), starch, in order to become nutriment, must first be changed to grape sugar. This change is, in part, effected by the saliva, and takes place almost instantly, whenever it comes in contact with cooked starch. This is due to an organic ingredient of the saliva called *ptyalin.*

17. Importance of Mastication and Insalivation.—Each of these processes complements the other, and by their joint action, they prepare the food in the best possible manner for further digestive changes. The study of these preliminary functions will appear the more important, when we reflect that they are the only ones which we can regulate by the will. For, as soon as the act of swallowing begins, the food not only passes out of sight, but beyond control; and the subsequent acts of digestion are consequently involuntary and unconsciously performed.

18. It is generally known that rapid eating interferes with digestion. How does this occur? In the first place, the flow of the saliva is insufficient to moisten the solid parts of the food, so that they remain too hard and dry to be easily swallowed. This leads to the free and frequent use of water or some other beverage, at meals, to "wash down" the food,—a most pernicious practice. For these fluids, not only cannot take the place of the natural digestive juices, but, on the contrary, dilute and weaken them.

19. Secondly, the saliva being largely the medium of the sense of taste, the natural flavors of the food are not developed, and consequently it appears comparatively insipid. Hence the desire for highly-seasoned food, and pungent sauces, that both deprave the taste and over excite the digestive organs. Rapid eating also permits the entrance of injurious substances which may escape detection by the taste, and be unconsciously received into the system. In some instances, the most acrid and poisonous substances have frequently been swallowed "by mistake," before the sense of taste could act, and demand their rejection.

20. Thirdly, the food, being imperfectly broken up by the teeth, is hurried onward to the stomach, to be by it more thoroughly divided. But the stomach is not at all adapted to perform the task thus imposed upon it. Hence persons who habitually eat too rapidly, frequently fall victims to dyspepsia. Rapid eating also conduces to overeating. The food is introduced so rapidly, that the system has not time to recognize that its real wants are met, and hence the appetite continues,

after more nutriment has been swallowed than the system requires, or can healthfully appropriate.

21. The Stomach.—As soon as each separate portion of food is masticated and insalivated it is swallowed; that is, it is caused to move downward to the stomach, through a narrow muscular tube about nine inches in length, called the *œsophagus*, or gullet (Fig. 16). The stomach is the only large expansion of the digestive canal, and is a most important organ of digestion. It is a hollow, pear-shaped pouch, having a capacity of three pints, in the adult.

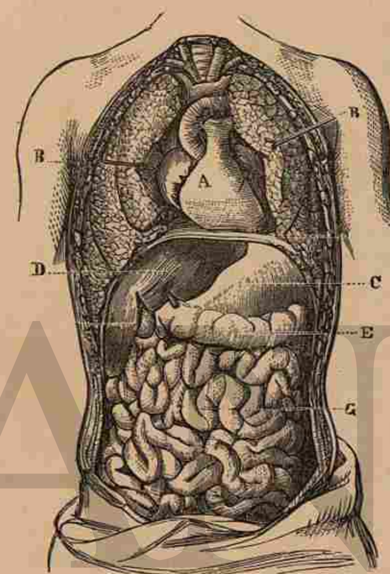

FIG. 15.—SECTION OF CHEST AND ABDOMEN.
A, Heart. B, The Lungs. C, Stomach. D, The Liver. E, Large Intestine. G, Small Intestine.

22. The stomach has two openings; that by which food enters, being situated near the heart, is called the *cardiac*, or heart orifice; the other is the *pylorus*, or "gate-keeper," which guards the entrance to the intestines, and, under ordinary circumstances, permits only such matters to pass it as have first been properly acted upon in the stomach. Coins, buttons, and the like are, however, readily allowed to pass, because they can be of no use if retained. The soft and yielding texture of the stomach indicates that it is not designed to crush and break-up solid articles of food.

23. The Gastric Juice.—We have seen how the presence of food in the mouth excites the salivary glands, causing the saliva quickly to flow. In the same manner, when food reaches the stomach, its inner lining, the mucous membrane, is at once excited to activity. At first its surface, which while the

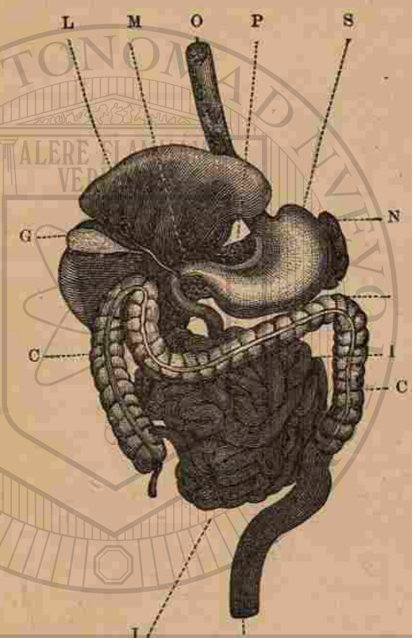

FIG. 16.—THE ORGANS OF DIGESTION.

O, Œsophagus. S, Stomach. L, Liver. M, Pylorus. I, Small Intestines. C, Large Intestines. P, Pancreas. N, Spleen. G, Gall-bladder.

stomach is empty presents a pale pink hue, turns to a bright red color, for the minute blood-vessels which course through it, are filled with blood. Presently a clear, colorless, and acid fluid flows out, drop by drop, from millions of little tubes, until finally the inner surface is moistened in every part, and the fluid begins to mingle with the food. This fluid is termed the gastric juice.

24. The gastric juice dissolves certain articles of food, especially those belonging to the albuminoid class. This solvent power is due to its peculiar ingredient, *pepsin*. The quantity of gastric juice secreted daily is very large, probably not less than three or four pints at each meal. Though this fluid is used in the digestion of the food, it is not lost; since it is soon re-absorbed by the stomach, together with those parts of the food which it has digested and holds in solution.

25. **Movements of the Stomach**.—The inner coating of the stomach is the mucous membrane, which, as we have seen, furnishes the gastric juice. Next to this coating lies another, called the muscular coat, composed of muscular fibres, some of which run circularly, and others in a longitudinal direction. These expand to accommodate the food as it is introduced, and contract as it passes out. In addition, these fibres are in continual motion while food remains in the stomach, and they act in such a manner that the contents are gently turned round from side to side, or from one end of it to the other.

26. By these incessant movements of the stomach, the gastric juice comes in contact with all parts of the food. We are, however, not conscious that these movements take place, nor have we the power to control them. When such portions of the food as are sufficiently digested approach the pylorus, it expands to allow them to pass out, and it closes again to confine the residue for further preparation.

27. The knowledge of these and other interesting and instructive facts has been obtained by actual observation; the workings of the stomach of a living human being have been laid open to view and examined—the result of a remarkable accident. Alexis St. Martin, a Canadian *voyageur*, received a gun-shot wound which laid open his stomach, and which, in healing, left a permanent orifice nearly an inch in diameter. Through this opening the observer could watch the progress of digestion, and experiment with different articles of food.

28. **Gastric Digestion**.—What portions of the food are digested in the stomach? It was formerly thought that all the great changes of digestion were wrought here, but later investigation has taught us better. We now know that the first change in digestion takes place in the mouth, in the partial conversion of starch into sugar. We also know that, of the three organic food principles (considered in Chapter IV.) two—the fats and the sugars—are but slightly affected by the stomach; but that its action is confined to that third and very important class, from which the flesh is formed, the albuminoids. A few articles need no preparation before entering the system, as water, salt, and fruit-sugar. These are rapidly taken up by the blood-vessels of the stomach, which everywhere underlie its mucous membrane in an intricate and most delicate network. In this way the work of absorption begins.

29. The albuminoid substances are speedily attacked and digested by the gastric juice. From whatever source they are derived, vegetable or animal, they are all transformed into the same digestive product called *albuminose*. This is very soluble in water, and is *in part* absorbed by the blood-vessels of the stomach. After a longer or shorter time, varying from one to five hours, according to the individual and the quantity and quality of his food, the stomach will be found empty. Not only the *unabsorbed* digested food, but also those substances which the stomach could not digest, have passed little by little through the pylorus, to undergo further action in the intestines. At the time of its exit the digested food is of a pulpy consistence, and dark color, and is then known as the *chyme*.

30. The Intestines.—The intestines are continuous with the stomach, and consist of a fleshy tube, or canal, twenty-five feet in length. The small intestine, whose diameter is about one inch and a half, is twenty feet long and very winding. The large intestine is much wider than the former, and five feet long (Fig. 23). In the small intestines, the work of digestion is completed, the large intestine receiving from them the indigestible residue of the food, and in time expelling it from the body.

31. Intestinal Digestion.—As soon as the food passes the pylorus and begins to accumulate in the upper part of the intestines, it excites the flow of a new digestive fluid, which enters through a small tube, about three inches below the stomach. It is formed by the union of two distinct fluids—the *bile* and the *pancreatic* juice. The bile is secreted by the liver, the largest gland of the body, and is constantly formed, but it flows most rapidly during digestion. During the intervals of digestion it is stored in the *gall-bladder*, a small membranous bag attached to the under side of the liver. This fluid is of a greenish-yellow color, having a peculiar smell, and a very bitter taste.

32. The pancreatic juice is the product of a gland called the *pancreas*, situated behind the stomach. This fluid is colorless, viscid, and without odor. By the joint action of these fluids, the fatty parts of the food are made ready for absorption. There results from this action a white and milky fluid, termed the *chyle*, which holds in solution the digestible portions of the food, and is spread over the extensive absorbent surface of the small intestines.

33. The mucous membrane of the intestines, also, produces a digestive fluid by means of numerous minute glands; this is called the intestinal juice. From experiments on the lower animals, it has been ascertained that this fluid exerts a solvent influence over each of the three organic food principles, and in this way completes the action of the fluids previously mentioned, viz.,—of the saliva in converting starch into sugar, of the gastric juice in digesting the albuminoids, and of the pancreatic juice and bile in emulsifying the fats.

34. Absorption.—With the elaboration of the chyle, the work of digestion is completed; but it has not yet become a part of the blood, by means of which it is to reach the different parts of the body. The process by which the liquefied food passes out of the alimentary canal into the blood is called absorption. This is accomplished in two ways; first, by the *blood-vessels.* We have seen how the inner membrane of the stomach is underlaid by a tracery of minute and numerous vessels, and how some portions of the food are by them absorbed. The supply of blood-vessels to the intestines is even greater; particularly to the small intestines, where the work of absorption is mostly carried on.

35. The absorbing surface of the small intestines, if considered as a plane surface, amounts to not less than half a square yard. Besides, the mucous membrane is formed in folds with an immense number of thread-like prolongations, called *villi,* which indefinitely multiply its absorbing capacity. These villi, give the surface the appearance and smoothness of velvet; and during digestion, they dip into the canal, and, by means of their blood-vessels, absorb its fluid contents, just as the *spongioles* which terminate the rootlets of plants, imbibe moisture from the surrounding soil.

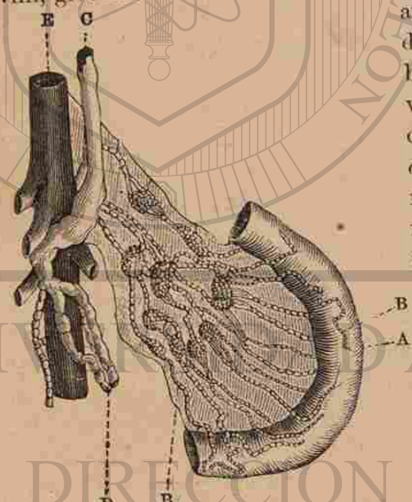

Fig. 17.—The Lacteals.
A, Small Intestine. B, Lacteals.
C, Thoracic Duct. D, Absorbents.
E, Blood-vessel.

36. Secondly, absorption is also effected by the *lacteals,* a set of vessels peculiar to the small intestines. These have their beginnings in the little villi just mentioned, side by side with the blood-vessels. These two sets of absorbents run in different courses, but their destination is the same, which is the right side of the heart. The lacteals receive their name from

their milky-white appearance. After a meal containing a portion of fat, they are distended with chyle, which they are specially adapted to receive. The lacteals all unite to form one tube, the *thoracic duct,* which passes upward through the *thorax,* or chest, and empties into a large vein, situated just beneath the left collar-bone.

37. Circumstances affecting Digestion.—What length of time is required for the digestion of food? From observations made, in the case of St. Martin, the Canadian already referred to, it has been ascertained that, at the end of two hours after a meal, the stomach is ordinarily empty. How much time is needed to complete the digestion of food, within the small intestines, is not certain; but, from what we have learned respecting their methods of action, it must be evident that it largely depends upon the amount of starch and fat which the food contains.

38. In addition to the preparation which the food undergoes in cooking, which we have already considered, many circumstances affect the duration of digestion; such as the quality, quantity, and temperature of the food; the condition of the mind and body; sleep, exercise, and habit. Fresh food, except new bread and the flesh of animals recently slain, is more rapidly digested than that which is stale; and animal food more rapidly than that from the vegetable kingdom.

39. A wine glassful of ice-water causes the temperature of the stomach to fall thirty degrees; and it requires a half-hour before it will recover its natural warmth. A variety of articles, if not too large in amount, is more easily disposed of than a meal made of a single article; although a single indigestible article may retard the digestion of a meal that without it would be easily digested.

40. Strong emotion, whether of excitement or depression, checks digestion, as do also a bad temper, anxiety, business cares, and bodily fatigue. The majority of these conditions make the mouth dry, that is, they restrain the flow of the saliva;

and without doubt they render the stomach dry also, by preventing the flow of the gastric juice. And, as a general rule, we may decide, from a parched and coated tongue, that the condition of the stomach is not very dissimilar, and that it is unfit for the performance of digestive labor. This is one of the points which the physician bears in mind when he examines the tongue of his patient.

41. The practice of eating at short intervals, or "between meals," as it is called, has its disadvantage, as well as rapid eating and over-eating, since it robs the stomach of its needed period of entire rest, and thus overtasks its power. With the exception of infants and the sick, no persons require food more frequently than once in four hours. Severe exercise either directly before or directly after eating retards digestion; a period of repose is most favorable to the proper action of the stomach. The natural inclination to rest after a hearty meal may be indulged, but it should not be carried to the extent of sleeping; since in that state the stomach, as well as the brain and the muscles, seeks release from labor.

42. **Effect of Alcohol upon Digestion.**—"The irritating effects of alcohol upon the lining of the stomach are first seen in deranged digestive action, in loss of appetite, and at a later stage, in changes in the stomach's structure, principally by a thickening of the walls of that organ."

Alcohol and Digestion.—The effects of alcohol upon digestion vary greatly according to the quantity imbibed; it may act as a temporary check, or in large doses it may completely arrest the digestive act; vomiting is frequently induced, the stomach thus freeing itself from the hurtful intruder. The habitual use of spirits often gives rise to a most distressing form of dyspepsia.

Dyspepsia due to Alcohol.—"Many cases of dyspepsia are due to alcohol solely and wholly, and no reliance whatever can be placed upon the word, statement or the assertion under oath of a drunkard; for 'a drunkard is a liar.' And this holds good of both sexes, all ages, everywhere and ever."—*Dr. J. M. Fothergill.*

Effect upon the Appetite.—At a Peace Congress held at Frankfort, Germany, the inn-keepers found it necessary to increase the price of board of the strangers attending the congress, the majority of whom were teetotalers, for the reason that their appetites required an amount of solid food in excess of that usually consumed by their own nationality, who are habitual drinkers of beer containing appreciable amounts of alcohol.

"Dr. Beaumont was able to observe the condition of the stomach of Alexis St. Martin (see paragraph 27, page 67) after alcoholic excesses. He states that the surface of the organ was overcharged with blood, at times drops of blood exuding from it; and that its secretions became thick, unnatural, and slightly tinged with blood. It is a fact beyond dispute that other organs concerned in the act of digestion, particularly the liver, become diseased by the habitual use of spirituous liquors."

"By direct contact, alcohol acts upon the stomach and leads to a destruction of its secreting tubules. Nothing with such certainty impairs the appetite and the digestive power as the continued use of strong alcoholic liquids. From the stomach it is absorbed, and with its distribution through the system it interferes with nutrition and leads to a diseased state of the liver, kidneys, and other organs."—*Pavy.*

Cordials, Bitters, etc.—In health, alcohol no wise plays a friendly part in regard to digestion. And it is just here that a mistake is made by many persons who have been deluded into the use of what are termed 'cordials'; these are very strong alcoholic liquors, and they are supposed by those who use them to be especially appropriate at the end of a hearty meal. Absinthe, the pet poison of the Parisian, is one of these falsely-named 'cordial' substances. These cordials are never less welcome than after a substantial meal." So many misleading names have been given to beverages (Cordials, Bitters, etc.) that many persons have used them without knowing the evil consequences which follow. It is made clear by recent proofs that the so-called cordials are the most rapidly poisonous of all the spirituous beverages.

The Digestibility of Solid Foods.—The accompanying table shows some of the results obtained from the experiments of Dr. Beaumont upon the stomach of Alexis St. Martin. It will surprise many to find that vegetable foods—they are placed in the latter part of the table—require, as a rule, as much time for digestion as animal food.

Food.	Mode of Cooking.	Time required for digestion. h. m.	Food.	Mode of Cooking.	Time required for digestion. h. m.
Pork	roasted	5 15	Salmon Trout	boiled	1 30
Cartilage	boiled	4 15	Eggs (whipped)	raw	1 30
Ducks	roasted	4 0	Tripe (soused)	boiled	1 0
Fowls	do.	4 0	Pig's Feet (soused)	do.	1 0
Do.	boiled	4 0	Cabbage	boiled	4 0
Beef	fried	4 0	Beetroot	do.	3 45
Eggs	do.	3 30	Turnips	do.	3 30
Do.	hard boiled	3 30	Potatoes	do.	3 30
Cheese		3 30	Wheaten Bread	baked	3 30
Oysters	stewed	3 30	Carrot	boiled	3 15
Mutton	roasted	3 15	Indian Corn Bread	baked	3 15
Do.	boiled	3 0	Do. Cake	do.	3 0
Beef	roasted	3 0	Apple-dumpling	boiled	3 0
Do.	boiled	2 45	Potatoes	baked	2 33
Chicken	fricasseed	2 45	Do.	roasted	2 30
Lamb	broiled	2 30	Parsnips	boiled	2 30
Pig (suckling)	roasted	2 30	Sponge Cake	baked	2 30
Goose	do.	2 30	Beans	boiled	2 30
Gelatin	boiled	2 30	Apples (sour)	raw	2 0
Turkey	do.	2 25	Barley	boiled	2 0
Eggs	roasted	2 15	Tapioca	do.	2 0
Cod Fish (cured, dry)	boiled	2 0	Sago	do.	1 45
Ox Liver	broiled	2 0	Apples (sweet)	raw	1 30
Venison Steak	do.	1 30	Rice	boiled	1 0

(*For further matter on Alcohol see p. 87.*)

QUESTIONS FOR TOPICAL REVIEW.

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CHAPTER VI.

THE CIRCULATION.

The Blood—Its Plasma and Corpuscles—Coagulation of the Blood—The Uses of the Blood—Transfusion—Change of Color—The Organs of the Circulation—The Heart, Arteries, and Veins—The Cavities and Valves of the Heart—Its Vital Energy—Passage of the Blood through the Heart—The Frequency and Activity of its Movements—The Pulse—The Spygmograph—The Capillary Blood-vessels—The Rate of the Circulation—Assimilation—Injuries to the Blood-vessels.

1. The Blood.—Every living organism of the higher sort, whether animal or vegetable, requires for the maintenance of life and activity, a circulatory fluid, by which nutriment is distributed to all its parts. In plants, this fluid is the sap; in insects, it is a watery and colorless blood; in reptiles and fishes, it is red but cold blood; while in the nobler animals and man, it is the red and warm blood.

2. The blood is the most important, as it is the most abundant, fluid of the body; and upon its presence, under certain definite conditions, life depends. With the exception of a few tissues, such as the hair, the nails, and the *cornea* of the eye, blood everywhere pervades the body, as may be proven by puncturing any part with a needle. The total quantity of blood in the body is estimated at about one-eighth of its weight, or eighteen pounds.

3. The color of the blood, in man and the higher animals, as is well known, is red; but it varies from a bright scarlet to a

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3. The color of the blood, in man and the higher animals, as is well known, is red; but it varies from a bright scarlet to a dark purple, according to the part whence it is taken. "Blood is thicker than water," as the adage truly states, and has a glutinous quality. It has a faint odor, resembling that peculiar to the animal from which it is taken.

4. When examined under the microscope, the blood no longer appears a simple fluid, and its color is no longer red. It is then seen to be made up of two distinct parts: first, a clear, colorless fluid, called the *plasma;* and secondly, of a multitude of minute solid bodies, or corpuscles, that float in the watery plasma. The plasma, or nutritive liquid, is composed of water richly charged with materials derived from the food, viz., albumen, which gives it smoothness and swift motion; fibrin; certain fats; traces of sugar; and various salts.

5. The Blood Corpuscles.—In man, these remarkable "little bodies,"—for that is the meaning of the word *corpuscles* —are of a yellow color, but by their vast numbers impart a red hue to the blood. They are very small, and if piled one above another, it would take at least 14,000 of them to stand an inch high.

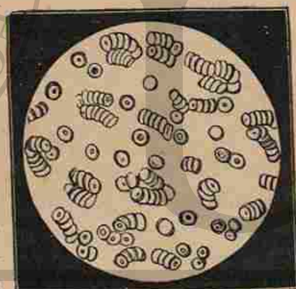

FIG. 18.—THE BLOOD CORPUSCLES HIGHLY MAGNIFIED.

6. The corpuscles, just described, are known as the *red* blood-corpuscles. Beside these, and floating along in the same plasma, are the white corpuscles. These are fewer in number, but larger and globular in form. They are colorless, and their motion is less rapid than that of the other variety. The total number of both varieties of these little bodies in the blood is enormous. It is calculated that in a cubic inch of that fluid there are eighty-three millions, and at least five hundred times that number in the whole body.

7. Coagulation.—The blood, in its natural condition in the body, remains perfectly fluid; but, within a few minutes after

its removal from its proper vessels, a change takes place. It begins to coagulate, or assume a semi-solid consistence. If allowed to stand, after several hours it separates into two distinct parts, one of them the coagulum, or clot, which is heavy and sinks; and the other, a clear, straw-colored liquid, called serum, which covers the clot.

8. In this law of coagulation of the blood is our safeguard against death by hemorrhage, or loss of blood. If coagulation were impossible, the slightest injury in drawing blood would prove fatal. Whereas now, in ordinary small wounds, bleeding ceases, because the blood, as it coagulates, stops the mouths of the injured blood-vessels. When the larger vessels are cut or torn, it is commonly sufficient to close them by a temporary pressure; for in a few minutes the clot will form and seal them up. In still more serious cases, where the blood-vessel is of large size, the surgeon is obliged to tie a "ligature" about it, thereby preventing the force of the blood-current from washing away the clots, which, forming within and around the vessel, close it effectually.

9. The Uses of the Blood.—The blood is the great provider and purifier of the body. It both carries new materials to all the tissues, and removes the worn out particles of matter. This is effected by the plasma. It both conveys oxygen and removes carbonic acid. This is done through the corpuscles.

10. Change of Color.—The blood undergoes a variety of changes in its journey through the system. As it visits the different organs it both gives out and takes up materials. In one place it is enriched, in another it is impoverished. By reason of these alterations in its composition, the blood also changes its color. In one part of the body it is bright red, or arterial; in another it is dark blue, or venous. In the former case it is pure and fit for the support of the tissues; in the latter, it is impure and charged with worn-out materials. (The details of the change from dark to bright will be given in the chapter on Respiration.)

11. Circulation.—The blood is in constant motion during life. From the heart, as a centre, a current is always setting towards the different organs; and from these organs a current is constantly returning to the heart. In this way a ceaseless circular movement is kept up, which is called the Circulation of the Blood. This stream of the vital fluid is confined to certain fixed channels, the blood-vessels. Those branching from the heart are the arteries; those converging to it are the veins. The true course of the blood was unknown before the beginning of the seventeenth century. In 1619 it was discovered by the illustrious William Harvey. Like many other great discoverers, he suffered persecution and loss, but unlike some of them, he was so fortunate as to conquer and survive opposition. He lived long enough to see his discovery universally accepted, and himself honored as a benefactor of mankind.

12. The Heart.—The heart is the central engine of the circulation. In this wonderful little organ, hardly larger than a man's fist, resides that sleepless force by which, during the whole of life, the current of the blood is kept in motion. It is placed in the middle and front part of the chest, inclining to the left side. The heart-beat may be felt and heard between the fifth and

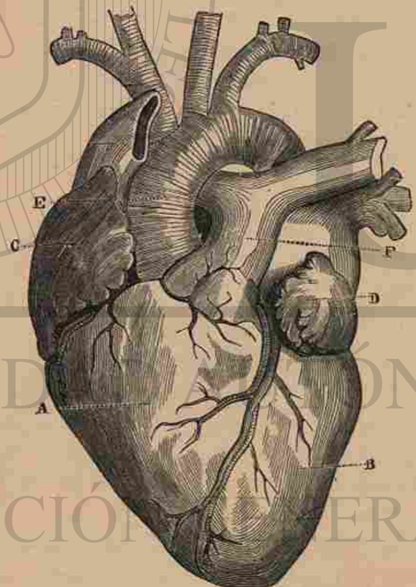

FIG. 19.—THE HEART AND LARGE VESSELS.
A, Right Ventricle. D, Left Auricle.
B, Left " E, Aorta.
C, Right Auricle. F, Pulmonary Artery

sixth ribs, near the breast-bone. The shape of the heart is conical, with the point downward and in front. The base, which is upward, is attached so as to hold it securely in its place, while the point is freely movable. To avoid friction, the heart is enclosed between two layers of serous membrane, which forms a kind of sac. This membrane is as smooth as satin, and itself secretes a fluid in sufficient quantities to keep it at all times well lubricated. The lining membrane of the heart, likewise, is extremely delicate and smooth.

13. The Cavities of the Heart.—The heart is hollow, and so partitioned as to contain four chambers or cavities; two at the base, known as the *auricles*, from a fancied resemblance to the ear of a dog, and two at the apex or point, called *ventricles*. An auricle and a ventricle on the same side, communicate with each other, but there is no opening from side to side. The right side always carries the dark or venous blood, and the left always circulates the bright or arterial blood.

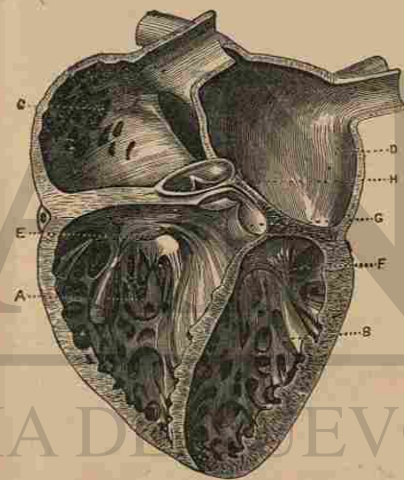

FIG. 20.—SECTION OF THE HEART.
A, Right Ventricle. E, F, Inlets to the Ventricles.
B, Left " G, Pulmonary Artery.
C, Right Auricle. H. Aorta.
D, Left Auricle.

14. If we examine the heart, we at once notice that though its various chambers have about the same capacity, the walls of the ventricles are thicker and stronger than those of the auricles. This is a wise provision, for it is by the powerful action of the former that the blood is forced to the most remote regions of the body. The auricles, on the contrary, need much less power, for they simply discharge their contents into the cavities of the heart near at hand and below them—into the ventricles.

15. Action of the Heart.—The substance of the heart is of a deep red color, and its fibres resemble those of the voluntary muscles by which we move our limbs. But the heart's movements are entirely involuntary. The advantage of this is evident; for if it depended upon us to will each movement, our entire attention would be thus engaged, and we would find no time for study, pleasure, or even sleep. The action of the heart consists in alternate contractions and expansions. During contraction the walls come forcibly together, and thus drive out the blood. Then they expand and receive a renewed supply. These movements are called *systole* and *diastole*. The latter may be called the heart's period of repose; and although it lasts only during two-fifths of a heart-beat, or about a third of a second, yet during the day it amounts to more than nine hours of total rest.

16. A remarkable property of the tissue of the heart is its intense vitality. For while it is more constantly active than any other organ of the body, it is the last to part with its vital energy. This is especially interesting in view of the fact that after life is apparently extinguished, as from drowning, or poisoning by chloroform, there yet lingers a spark of vitality in the heart, which, by continued effort, may be fanned into a flame so as to revivify the whole body.

17. Passage of the Blood through the Heart.—Let us now trace the course of the blood through the several cavities of the heart. In the first place, the venous blood, rendered dark and impure by contact with the changing tissues of the body, returns to the right heart by the veins. It enters and fills the right auricle during its expansion; the auricle then contracts and fills the right ventricle. Almost instantly, the ventricle contracts forcibly and hurries the blood along the great artery of the lungs, to be purified in those organs. Secondly, having completed the circuit of the lungs, the pure and bright arterial blood enters the left auricle. This now contracts and fills the left ventricle, which cavity, in its turn, contracts and sends the blood forth on its journey again through the system. This general direction from right to left is the uniform course of heart-currents.

18. The mechanism which compels this regularity is as simple as it is beautiful. Each ventricle has two openings, an inlet and an outlet, each of which is guarded by strong curtains, or valves. These valves open freely to admit the blood entering from the right, but close inflexibly against its return. Thus, when the auricle contracts, the inlet valve opens; but as soon as the ventricle begins to contract, it closes promptly. The contents are then, so to speak, cornered, and have but one avenue of escape, that through the outlet valve into the arteries beyond. As soon as the ventricle begins to expand again, this valve shuts tightly and obstructs the passage. The closing of these valves occasions the two heart-sounds, which we hear at the front of the chest.

19. Frequency of the Heart's Action.—The alternation of contraction and expansion constitutes the heart-beats. These follow each other not only with great regularity, but with great rapidity. The average number in an adult man is about seventy-two in a minute. Heat, exercise, and food increase its action; cold, fasting, and sleep diminish it. Posture, too, has a curious influence; for if while sitting, the beats of the heart number seventy-one, standing erect will increase them to eighty-one, and lying down will lower them to sixty-six.

20. The modifying influence of mental emotions is very powerful. Sudden excitement of feeling will cause the heart to palpitate, or throb violently. Depressing emotions sometimes temporarily interrupt its movements, and the person faints in consequence. Extremes of joy, grief, or fear, have occasionally suspended the heart's action entirely, and thus caused death.

21. Again, if we estimate the amount of blood expelled by each contraction of the ventricle at four ounces, then the weight of the blood moved during one minute will amount to eighteen pounds; and in the course of a lifetime, over one hundred and fifty thousand tons. These large figures indicate, in some measure, the immense labor necessary to carry on the interior and vital operations of our bodies.

22. The Arteries.—The tube-like canals which carry the blood away from the heart are the arteries. Their walls are made of tough, fibrous materials, so that they sustain the mighty impulse of the heart, and are not ruptured. In common with the heart, the arteries have a delicately smooth lining membrane. They are also elastic, and thus re-enforce the action of the heart: they always remain open when cut across, and after death are always found emptied of blood.

23. The early anatomists observed this condition, and supposing that the same condition existed during life, came to the conclusion that these tubes were designed to act as air-vessels, hence the name artery, from Greek words which signify "containing air." This circumstance affords us an illustration of the mistaken notions of the ancients in reference to the internal operations of the body. Cicero speaks of the arteries as "conveying the breath to all parts of the body."

24. The arterial system springs from the heart by a single trunk, like a minute and hollow tree, with numberless branches. As these branches leave the heart they divide and subdivide, continually growing smaller and smaller, until they can no longer be traced with the naked eye. If, then, we continue the examination by the aid of a microscope, we see these small branches sending off still smaller ones, until all the organs of the body are penetrated by arteries.

25. The Pulse.—With each contraction of the left side of the heart, the impulse causes a wave-like motion to traverse the entire arterial system. If the arteries were exposed to view, we might see successive waves speeding from the heart to the

smallest of the branches, in about one-sixth part of a second. The general course of the arteries is as far as possible from the surface. This arrangement is certainly wise, as it renders them less liable to injury, the wounding of an artery being especially dangerous. It also protects the arteries from external and unequal pressure, by which the force of the heart would be counteracted and wasted. Accordingly, we generally find these vessels hugging close to the bones, or hiding behind the muscles and within the cavities of the body.

26. In a few situations, however, the arteries lie near the surface; and if we apply the finger to any of these parts, we will distinctly feel a throbbing motion taking place in harmony with the heart-beat. This is part of the wave-motion just mentioned, and is known as "the pulse." All are familiar with the pulse at the wrist; but the pulse is not peculiar to that position, for it may be felt in the neck, at the temple, and elsewhere, especially near the joints.

27. Since the heart-beat makes the pulse, whatever affects the former affects the latter also. Accordingly, the pulse is a good index of the state of the health, so far as the health depends upon the action of the heart. It informs the physician of the condition of the circulation in four particulars: its rate, regularity, force, and fullness; and nearly every disease modifies in some respect the condition of the pulse.

28. The Veins.—The vessels by which the blood returns to the heart are the veins. At first they are extremely small; but uniting together as they advance, they constantly increase in size, reminding us of the way in which the fine rootlets of the plant join together to form the large roots, or of the rills and rivulets that flow together to form the large streams and rivers. In structure, the veins resemble the arteries, but their walls are much less elastic. They are more numerous, and communicate with each other freely in their course, by means of interlacing branches.

29. But the chief point of the distinction is in the presence of the valves in the veins. These are little folds of membrane, disposed in such a way, that they open only to receive blood flowing toward the heart, and close against a current in the opposite direction. Their position in the veins on the back of the hand may be readily observed, if we first obstruct the return of blood by a cord tied around the forearm or wrist. In a few minutes the veins will appear swollen, and upon them will be seen certain prominences, about an inch apart. These latter indicate the location of the valves, or, rather, they show that the vessels in front of the valves are distended by the blood, which cannot force a passage back through them.

FIG. 21.—THE VALVES OF THE VEINS.

30. This simple experiment proves that the true direction of the venous blood is toward the heart. That the color of the blood is dark, will be evident, if we compare the hand thus bound by a cord with the hand not so bound. It also proves that the veins lie near the surface, while the arteries are beneath the muscles, well protected from pressure; and that free communication exists from one vein to another. If now we test the temperature of the constricted member by means of a thermometer, we will find that it is colder than natural, although the amount of blood is larger than usual. From this fact we infer, that whatever impedes the venous circulation tends to diminish vitality; and hence, articles of clothing or constrained postures, that confine the body or limbs, and hinder the circulation of the blood, are to be avoided as injurious to the health.

31. The Capillaries.—A third set of vessels completes the list of the organs of the circulation, namely, the *capillary* vessels, so called (from the Latin word *capillaris*, hair-like), because of their extreme fineness. They are, however, smaller than any hair, having a diameter of about $\frac{1}{3000}$ of an inch, and can be observed only by the use of the microscope. These vessels are

the connecting link between the last of the arteries and the first of the veins. The existence of these vessels was unknown to Harvey, and was the one step wanting to complete his great discovery. The capillaries were not discovered until 1661, a short time after the invention of the microscope.

32. The circulation of the blood, as seen under the microscope, in the transparent web of a frog's foot, is a beautiful sight, possessing more than ordinary interest from the fact that something very similar is taking place in our own bodies on a much grander scale. It is like opening a secret page in the history of our own frames. We there see distinctly the three classes of vessels with their moving contents; first, the artery, with its torrent of blood rushing down from the heart, secondly, the vein, with its slow, steady stream flowing in the opposite direction; and between them lies the network of capillaries so fine

FIG. 22.—WEB OF A FROG'S FOOT, slightly magnified.

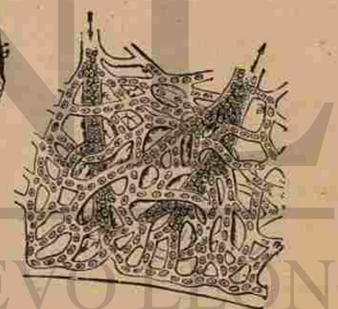

FIG. 23.—MARGIN OF FROG'S WEB, magnified 30 diameters.

that the corpuscles can pass through only "in single file." The current of the capillaries has an uncertain or swaying motion, hurrying first in one direction, then hesitating, and then turning back in the opposite direction, and sometimes the capillaries contract so as to be entirely empty. Certain of the tissues are destitute of capillaries; such are cartilage, hair, and a few others on the exterior of the body. In all other structures, networks of these vessels are spread out in countless numbers; so abundant is the supply, that it is almost impossible to puncture any part with the point of a needle without lacerating tens, or even hundreds of them.

33. The capillaries are elastic, and may so expand as to produce an effect visible to the naked eye. Let a grain of sand lodge in the eye and irritate it, and in a short time the white of the eye will be "blood-shot." This appearance is due to an increase in the size of these vessels.

34. Rapidity of the Circulation.—That the blood moves with great rapidity is evident from the almost instant effects of certain poisons, as prussic acid, which act through the blood. Experiments upon the horse, dog, and other inferior animals, have been made to measure its velocity. If a substance, which is capable of a distinct chemical reaction (as *potassium ferrocyanide*, or *barium nitrate*), be introduced into a vein on one side of a horse, and blood be taken from a distant vein on the other side, its presence may be detected at the end of thirty or thirty-two seconds. In man, the blood moves with greater speed, and the circuit is completed in twenty-four seconds.

35. What length of time is required for all the blood of the body to make a complete round of the circulation? This question cannot be answered with absolute accuracy. But we find that, under ordinary circumstances, all the blood makes one complete rotation every two minutes; passing successively through the heart, the capillaries of the lungs, the arteries, the capillaries of the extremities, and through the veins.

36. Assimilation.—The crowning act of the circulation, the furnishing of supplies to the different parts of the body, is effected by means of the capillaries. The organs have been wasted by use; the blood has been enriched by the products of digestion. Here, within the meshes of the capillary network, the needy tissues and the needed nutriment are brought together. By some mysterious chemistry, each tissue selects and withdraws from the blood the materials it requires, and converts them into a substance like itself. This conversion of lifeless food into living tissue is called assimilation. The process probably takes place at all times, but the period especially favorable for it is during sleep. Then the circulation is slower and more regular, and most of the functions are at rest. The body is then like some trusty ship, which after a long voyage is "hauled up for repairs."

37. Injuries to the Blood-vessels.—It is important that every one should be able to discriminate between an artery and a vein, in the case of a wound, and if we remember the physiology of the circulation it will be impossible to make a mistake. For, as we have already seen, hemorrhage from an artery is much more dangerous than that from a vein. The latter tends to cease spontaneously after a short time. The arterial blood flows away from the heart with considerable force, in jets; its color, bright scarlet. The venous blood flows toward the heart from that side of the wound furthest from the heart; its stream being continuous and sluggish; its color dark. In an injury to an artery, pressure should be made between the heart and the wound; while in the case of a vein that persistently bleeds, it should be made upon the vessel beyond its point of injury.

38. Effects of Alcohol upon the Heart.—The first symptoms after a moderate dose of alcohol is an increase of the heart's action, a flushing of the face, a sensation of warmth within, a general glow without, and some other appearances of increased vitality. The action has been that of a spur or goad. It has caused strength to be expended instead of increasing it, and, in fact, costs the system whatever amount of force is necessary to expel it; so that there is a loss of strength, and not a gain.

39. The late Dr. Parkes made a careful study of the amount of strain put upon the heart by alcohol. He found that it increased both the number and force of the heart's pulsations. The period of rest between the beats is reduced, and, consequently, the heart's nutrition must be interfered with. He estimates, in one set of experiments, that the extra work of the heart, induced by alcohol, was equivalent to the lifting of 15.8 tons one foot daily; and during two days, 24 tons in excess of the regular work.

40. Alcohol as a Fat Producer.—Alcohol is said to diminish waste and to make those "fleshy" who use it. This may well be the case in those—and the proportion is not small—who are rendered sluggish and sleepy by it. The fat which they acquire is the fat of inaction. If we may judge of the true influence of alcohol by experiments on the lower animals, that are compelled to take it pure, we will not grant it any fattening power.

41. There is a certain "fatty degeneration" in man—the result of alcohol-drinking—that is very disastrous, namely a deposit of fat in the muscles of the body. This is destructive or weakening to muscular power, and when it evinces itself in the heart it creates a change that is to be dreaded as sapping the strength of the one particular organ that should be strong in drinkers. It attacks them at a vital spot.

42. The blood also undergoes a fatty change which greatly impairs its work of nourishing the body.

The Blood.—"You feel quite sure that blood is red, do you not? Well, it is no more red than the water of a stream would be if you were to fill it with little red fishes. Suppose the fishes to be very, very small, as small as a grain of sand, and closely crowded together through the whole depth of the stream, the water would look red, would it not? And this is the way in which the blood looks red: only observe one thing; a grain of sand is a mountain in comparison with the little red bodies that float in the blood, which we have likened to little fishes. If I were to tell you they measured about the 3200th part of an inch in diameter, you would not be much the wiser; but if I tell you that in a single drop of blood, such as might hang on the point of a needle, there are a million of these bodies, you will perceive that they are both very minute and very numerous. Not that any one has ever counted them, as you may suppose, but this is as close an estimate as can be made in view of what is known of their minute size."—*Macé's History of a Mouthful of Bread.*

(For further matter on Alcohol and Narcotics see p. 120.)

TABLE OF THE PRINCIPAL ARTERIES.

(SEE FIGURE OPPOSITE PAGE 75.)

The Head.

- **Internal Ca-rot'id,** and **Ver'te-bral,** supply the brain.
- **Oph-thal'mic,** supplies the eye.
- **External Ca-rot'id** gives off.........
  - **Lin'gual,** supplies the tongue.
  - **Fa'ci-al,** supplies the lower part of the face.
  - **Tem'po-ral,** supplies the upper part of the head and face

The Trunk.

The A-or'ta, arising from the heart, is the main arterial trunk.
Cor'o-na-ry, supplies the walls of the heart.
Bron'chi-al, supplies the lungs.
In-ter-cos'tals, supply the walls of the chest.
Gas'tric, supplies the stomach.
He-pat'ic, supplies the liver.
Splen'ic, supplies the spleen.
Re'nal, supplies the kidney.
Mes-en-ter'ics, supply the bowels.
Spi'nal, supplies the spinal cord.

The Upper Limb.

Branches of the Ax-il-la'ry, supply the shoulder.
" " **Bra'chi-al,** supply the arm.
" " **Ra'di-al,** and " " **Ul'nar,** supply the forearm and fingers.

The Lower Limb.

Branches of the Fem'o-ral, supply the hip and thigh.
" " **Pop-li-te'al,** " " **Tib'i-al,** and " " **Per-o-ne'al,** supply the leg and foot.

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CHAPTER VII.

RESPIRATION.

The Object of Respiration—The Lungs—The Air-Passages—The Movements of Respiration—Expiration and Inspiration—The Frequency of Respiration—Capacity of the Lungs—The Air we breathe—Changes in the Air from Respiration—Changes in the Blood—Interchange of Gases in the Lungs—Comparison between Arterial and Venous Blood—Respiratory Labor—Impurities of the Air—Dust—Carbonic Acid—Effects of Impure Air—Nature's Provision for Purifying the Air—Ventilation.

1. The Object of Respiration.—In one set of capillaries, or hair-like vessels, the blood is impoverished in order that it may support the different members and organs of the body. In another capillary system the blood is refreshed and again made fit to sustain life. The former belongs to the greater or *systemic* circulation; the latter to the lesser or *pulmonary*, the lungs, in which organs it is situated. The blood sent from the right side of the heart to the lungs is venous, dark, impure, and of a nature hurtful to the tissues. But when the blood returns from the lungs to the left side of the heart, it has become arterial, bright, pure, and no longer injurious. This marvelous purifying change is effected by means of the very familiar act of respiration, or breathing.

2. The Lungs.—The lungs are the special organs of respiration. There are two of them, one on each side of the chest, which cavity they, with the heart, almost wholly fill. The lung-substance is soft, elastic, and sponge-like. Under pressure

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2. The Lungs.—The lungs are the special organs of respiration. There are two of them, one on each side of the chest, which cavity they, with the heart, almost wholly fill. The lung-substance is soft, elastic, and sponge-like. Under pressure of the finger, it crackles, and when thrown into water it floats; these properties are due to the presence of air in the minute air-cells of the lungs. To facilitate the movements necessary to these organs, each of them is provided with a double covering

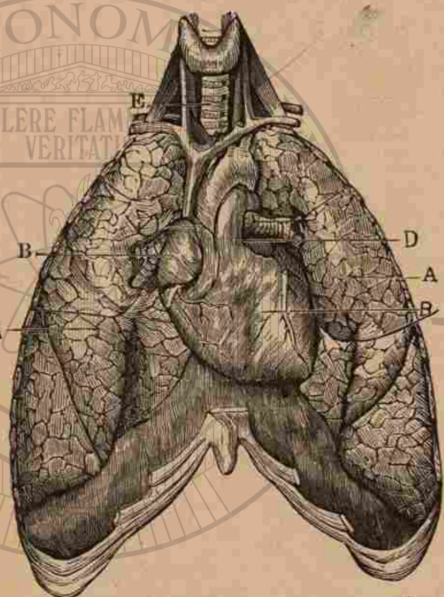

Fig. 24.—Organs of the Chest.

A, Lungs. D, Pulmonary Artery.
B, Heart. E, Trachea.

of an exceedingly smooth and delicate membrane, called the *pleura*. One layer of the pleura is attached to the walls of the chest, and the other to the lungs; and they glide one upon the other, with utmost freedom. Like the membrane which envelops the heart, the pleura secretes its own lubricating fluid, in quantities sufficient to keep it always moist.

3. The Air-Passages.—The lungs communicate with the external air by means of certain air-tubes, the longest of which, the *trachea*, or windpipe, runs along the front of the neck

(Figs. 24, E, and 25). Within the chest this tube divides into two branches, one entering each lung; these in turn give rise to numerous branches, or bronchial tubes, as they are called, which gradually diminish in size until they are about one-twenty-fifth of an inch in diameter. Each of these terminates in a cluster

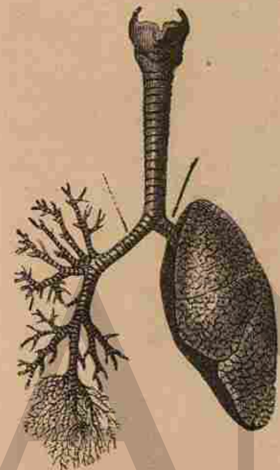

Fig. 25.—Larynx, Trachea, and Bronchial Tubes.

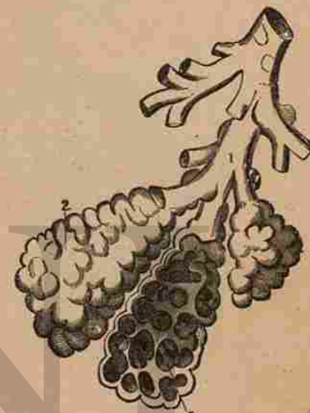

Fig. 26.—Diagram and Section of the Air-cells.

of little pouches, or "air-cells," having very thin walls, and covered with a capillary network, the most intricate in the body (Fig. 25).

4. These tubes are somewhat flexible, sufficiently so to bend when the parts move in which they are situated; but they are greatly strengthened by bands or rings of cartilage which keep the passages always open; otherwise there would be a constantly-recurring tendency to collapse after every breath. The lung-substance essentially consists of these bronchial tubes and terminal air-cells, with the blood-vessels ramifying about them (Fig. 26). At the top of the trachea is the larynx, a sort of box of cartilage, across which are stretched the vocal cords.

Here the voice is produced chiefly by the passage of the respired air over these cords, causing them to vibrate.

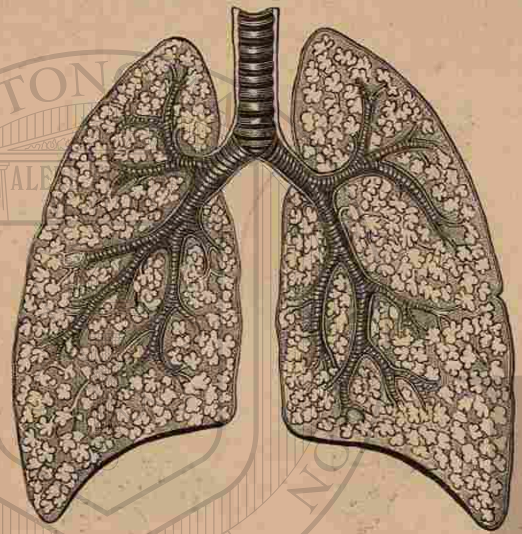

FIG. 27.—SECTION OF THE LUNGS.

5. Over the opening of the larynx is found the *epiglottis*, which fits like the lid of a box at the entrance to the lungs, and closes during the act of swallowing, so that food and drink shall pass backward to the œsophagus, or gullet (Fig. 27). Occasionally it does not close in time, and some substance intrudes within the larynx, when we at once discover, by a choking sensation, that "something has gone the wrong way," and, by coughing, we attempt to expel the unwelcome intruder. The air-passages are lined through nearly their whole extent with mucous membrane, which keeps them in a constantly moist condition.

6. The Movements of Respiration.—The act of breathing has two parts—(1), *inspiration*, or drawing air into the lungs, and (2), *expiration*, or forcing it out again. In inspiration, the chest extends in its length, breadth, and height. The motion

outwards and upwards can be observed every time we draw a full breath, and is caused by a lifting of the ribs. But the motion downwards is not so apparent, as it is caused by a muscle

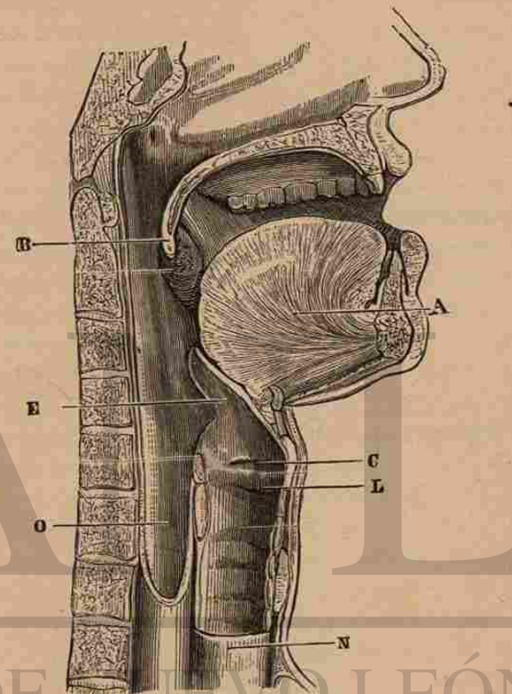

FIG. 28.—SECTION OF MOUTH AND THROAT.

A, The Tongue. B, The Uvula. C, Vocal Cord. E, Epiglottis. L, Larynx. N, Trachea. O, Œsophagus.

within the body called the *diaphragm*. This is the thin partition which separates the chest from the abdomen, rising like a dome within the chest (Fig. 9). With every inspiration, the diaphragm contracts, and in so doing, approaches more nearly a level surface, and thus enlarges the capacity of the chest. Laughing, sobbing, hiccoughing, and sneezing are caused by the spasmodic or sudden contraction of the diaphragm. The special power of this muscle is important in securing endurance, or "long wind," as it is commonly expressed; which may be obtained mainly by practice. It is possessed in a marked degree by the mountaineer, the oarsman, and the trained singer. As the walls of the chest extend, the lungs expand, and the air rushes in to fill them. This constitutes an inspiration. The habit of taking frequent and deep inspirations, in the erect position, with the shoulders thrown back, tends greatly to increase the capacity and power of the organs of respiration.

7. Expiration is a less powerful act than inspiration. The diaphragm relaxes and ascends in the form of a dome; the ribs descend and contract the chest; while the lungs themselves, being elastic, assist to drive out the air. The latter passes out through the same channels by which it entered. At the end of each expiration there is a pause, or period of repose, lasting about as long as the period of action.

8. Frequency of Respiration.—It is usually estimated that we breathe once during every four beats of the heart, or about eighteen times in a minute. When the action of the heart is hurried, a larger amount of blood is sent to the lungs, and, as the consequence, they must act more rapidly. Occasionally, the heart beats so very forcibly that the lungs cannot keep pace with it, and then we experience a peculiar sense of distress from the want of air. This takes place when we run until we are "out of breath."

9. Although, as a general rule, the work of respiration goes on unconsciously and without exertion on our part, it is nevertheless under the control of the will. We can increase or diminish the frequency of its acts at pleasure, and we can "hold the breath," or arrest it altogether for a short time. From twenty to thirty seconds is ordinarily the longest period in which the breath can be held; but if we first expel all the impure air from the lungs, by taking several very deep inspirations, the time may be extended to one and a half or even two

minutes. This should be remembered, and acted upon, before passing through a burning building, or any place where the air is very foul.

10. The air is not a simple element, as the ancients supposed, but is formed by the mingling of two gases, known to the chemist as oxygen and nitrogen, in the proportion of one part of the former to four parts of the latter. These gases are very unlike, being almost opposite in their properties: nitrogen is weak, inert, and cannot support life; while oxygen is powerful, and incessantly active; and is the essential element which gives to the atmosphere its power to support life and combustion. The discovery of this fact was made in 1778 by the French chemist, Lavoisier.

11. Changes in the Air from Respiration.—Air that has been once breathed is no longer fit for respiration. An animal confined within it will sooner or later die; so, too, a lighted candle placed in it will be at once extinguished. If we collect a quantity of expired air and analyze it, we shall find that its composition is not the same as that of the inspired air. When the air entered the lungs it was rich in oxygen; now it contains twenty-five per cent. less of that gas. Its volume, however, remains nearly the same; its loss being replaced by another and very different gas, which the lungs exhale, called *carbonic acid*, or, as the chemist terms it, *carbon dioxide*.

12. The expired air has also gained moisture. This is noticed when we breathe upon a mirror, or the window-pane, the surface being tarnished by the condensation of the watery vapor given off by the lungs. In cold weather, this causes the fine cloud which is seen issuing from the nostrils or mouth with each expiration, and contributes in forming the feathery crystals of ice which decorate our window-panes on a winter's morning.

13. Changes in the Blood from Respiration.—The most striking change which the blood undergoes by its passage through the lungs, is the change of color from a dark blue to bright red. That this change is dependent upon respiration has been fully proved by experiment. If the trachea, or windpipe, of a living animal be so compressed as to exclude the air from the lungs, the blood in the arteries will gradually grow darker, until its color is the same as that of the venous blood. When the pressure is removed the blood speedily resumes its bright hue. Again, if an animal breathe an atmosphere containing more oxygen than atmospheric air, the color changes from scarlet to vermilion, and becomes even brighter than arterial blood. This change of color is not of itself a very important matter, but it indicates a most important change of composition.

14. The air, as we have seen, by respiration loses oxygen and gains carbonic acid: the blood, on the contrary, gains oxygen and loses carbonic acid. Oxygen is the food of the blood corpuscles; while the articles we eat and drink go more directly to the plasma of the blood. The air, then, it is plain, supplies one kind of food, while our articles of diet supply another. But there is this difference, our lung food is needed constantly, while ordinary food is taken at distinct intervals. Again, as the demand of the system for food is expressed by the sensation of hunger, so the demand for air is marked by a painful sensation called suffocation.

15. Interchange of Gases in the Lungs.—But the air and the blood do not come in contact—they are separated by the walls of the air-cells and of the blood-vessels,—how then do the two gases, oxygen and carbonic acid, exchange places? Moist animal membranes have a property which enables them to transmit gases through their substance, although they are impervious to liquids. This may be beautifully shown by suspending a bladder containing dark venous blood in a jar of oxygen. At the end of a few hours the oxygen will have diminished, the blood will be scarlet in color, and carbonic acid will be found in the jar.

16. If this interchange takes place outside of the body, it must take place much more perfectly within it, where the circumstances are of the most favorable character. The walls of

the vessels and the air-cells are thin and moist, and the currents of air and blood are in constant motion. Both parts of this process of exchange are equally important. Without oxygen life ceases; if carbonic acid is not thrown off, it acts like a poison, producing unconsciousness, convulsions, and even death.

17. Difference between Arterial and Venous Blood.—The following table presents the essential points of difference in the appearance and composition of the blood, before and after its passage through the lungs:

	Venous Blood.	Arterial Blood.
Color,	Dark blue,	Scarlet.
Oxygen,	8 per cent.,	18 per cent.
Carbonic Acid,	15 to 20 per cent.	6 per cent. or less.
Water,	More,	Less.

The temperature of the blood varies considerably; but the arterial stream is generally warmer than the venous. The blood imparts heat to the air while passing through the lungs, and consequently the contents of the right side of the heart have a higher temperature than the contents of the left side.*

18. Amount of Respiratory Labor.—During ordinary calm respiration, we breathe eighteen times in a minute; and twenty cubic inches of air pass in and out of the lungs with every breath. From this we calculate that the quantity of air which hourly traverses the lungs is about thirteen cubic feet, or seventy-eight gallons; and daily, not less than three hundred cubic feet, an amount nearly equal to the contents of sixty barrels.

19. Impurities of the Air.—The oxygen in the atmosphere is of such prime importance, and its proportion is so nicely adjusted to the wants of man, that any gas or volatile substance which supplants it must be regarded as a hurtful impurity. All gases, however, are not alike injurious. Some, if inhaled, are necessarily fatal; *arseniuretted hydrogen* being one of these, a single bubble of which destroyed the life of its discoverer, Gehlen. Others are not directly dangerous, but because they

* "Bernard has succeeded in establishing the following facts with regard to the temperature (of the blood) in various parts of the circulatory system in dogs and sheep: 1. The blood is warmer in the right than in the left cavities of the heart. 2. It is warmer in the arteries than in the veins, with a few exceptions."—*Physiology of Man, Flint.*

take the place of oxygen, and exclude it from the lungs, they do harm. To this latter class belongs carbonic acid.

20. Most of the actively poisonous gases have a pungent or offensive odor; and, as may be inferred, almost all bad smells indicate the presence of substances unfit for respiration. Accordingly, as we cannot see or taste these impurities, the sense of smell is our principal safeguard against them. In this we recognize the forethought which has stationed this sense, like a sentinel, at the entrance of the air-passages, to give us warning of approaching harm. Take, as an example, the ordinary illuminating gas of cities, from which so many accidents happen. How many more deaths would occur from it by suffocation and explosion, if we were not made aware of leakage by means of its disagreeable odor.

21. "Man's greatest enemy is his own breath," it is said; but chiefly because of the organic matter it contains. Organic matter exists in increased measure in the expired breath of sick persons, and impart to it, at times, a putrid odor. This is especially true in diseases which, like typhus and scarlet fever, are referable to a blood poison. In such cases the breath is one of the means by which nature seeks to expel the offending material from the system. Hence, those who visit or nurse fever-sick persons should obey the oft-repeated direction, "not to take the breath of the sick." At such times, if ever, fresh air is demanded, and not for the sick alone, but also for those who take care of them.

22. Dust in the Air.—In a lecture on this subject by Professor Tyndall, he remarks that, "by breathing through a cotton wool respirator, the noxious air of the sick room is restored to practical purity. The air thus filtered, attendants may breathe unharmed. In all probability, the protection of the lungs will be the protection of the whole system. For it is exceedingly probable that the germs which lodge in the air-passages are those which sow epidemic disease in the body. If this be so, then disease can certainly be warded off by filters of cotton wool.

23. Carbonic Acid in the Air.—This gas exists naturally in the air in small quantities. In the open air, men seldom suffer from carbonic acid, for, as we shall see presently, nature provides for its rapid distribution, and even turns it to good use. But its ill effects are painfully evident in the abodes of men, in which it is liable to collect as the waste product of respiration and of that combustion which is necessary for lighting and warming our homes. A man exhales one-half cubic foot of carbonic acid per hour; a single gas-burner liberates five cubic feet in the same time, and therefore spoils as much air as ten men. A fire burning in a grate or stove emits some impure gases, and at the same time abstracts from the air as much oxygen as twelve men would consume in the same period, thus increasing the relative amount of carbonic acid in the air. From furnaces, as ordinarily constructed, this and other gases are constantly leaking and poisoning the air of tightly-closed apartments.

24. Effects of Impure Air.—Carbonic acid, in its pure form, is irrespirable, causing rapid death by suffocation. Air containing forty parts per thousand of this gas (the composition of the expired breath) extinguishes a lighted candle, and is fatal to birds; when containing one hundred parts, it no longer yields oxygen to man and other warm-blooded animals; and is of course speedily fatal to them. In smaller quantities, this gas causes headache, labored respiration, palpitation, unconsciousness, and convulsions.

25. Another unmistakable result of living in and breathing foul air is found in certain diseases of the lungs, especially consumption. For many years the barracks of the British army were constructed without any regard to ventilation; and during those years a large number of men died of consumption. At last the government began to improve the condition of the buildings, giving larger space and air-supply; and as a consequence, the mortality from that disease has diminished more than one-third.

26. The lower animals confined in the impure atmosphere of stables and menageries suffer from the same diseases as man. Those brought from a tropical climate, and requiring to be closely housed, generally die of consumption. In the Zoological gardens of Paris, this disease affected nearly all monkeys, until care was taken to introduce fresh air by ventilation; and then it almost wholly disappeared.

27. Nature's Provision for Purifying the Air.—We have seen that carbonic acid is heavier than air, and is poisonous. Why, then, does it not sink upon and overwhelm mankind with a silent, unseen wave of death? Among the gases there is a force more potent than gravity, which forever prevents such a tragedy. It is known as the diffusive power of gases. It acts according to a definite law, and with irresistible force, compelling gases, when in contact, to mingle until they are thoroughly diffused. The added influence of the winds is useful, by insuring more rapid changes in the air; air in motion being perfectly wholesome. The rains also wash the air.

28. We have seen that the whole animal creation is constantly taking oxygen from the air, and as constantly adding to it vast volumes of a gas hurtful to all kinds of animals, even in small quantities. How, then, does the air retain unchanged its life-giving properties? The uniformly pure state of the air is secured by means of the vegetable creation. Carbonic acid is the food of the plants, and oxygen is its waste product. The leaves are its lungs, and under the stimulus of sunlight a vegetable respiration is set in motion, the effects of which are just the reverse of that of animals. Thus nature purifies the air, and at the same time builds up two beautiful and useful worlds—the life of each growing out of the decay of the other.

29. Ventilation.—Since the external atmosphere, as provided by nature, is always pure, and since the air in our dwellings and other buildings is almost always impure, it becomes imperative that there should be a free communication from the one to the other. This we aim to accomplish by ventilation. As our houses are

ordinarily constructed, the theory of ventilation, "to make the internal as pure as the external air," is seldom carried out. Doors, windows, and flues, the natural means of replenishing the air, are too often closed against the precious element. Special means, or special attention, must therefore be used to secure even a fair supply of fresh air. This is still more true of those places of public resort, where large numbers of persons crowd together.

30. If there are two openings in a room, one as a vent for foul air and the other an inlet for atmospheric air, and if the openings be large, in proportion to the number of air consumers, the principal object will be attained. Thus, a door and window, each opening into the outer air, will ordinarily ventilate a small apartment; or a window alone will answer, if it be open both above and below, and the open space at each end be not less than one inch for each occupant of the room, when the window is about a yard wide. The direction of the current is generally from below upward, since the foul, heated air tends to rise. Its rate need not be rapid; a "draught," or perceptible current, is never necessary to good ventilation. The temperature of the air admitted may be warm or cold. It is thought by many that if the air is cold, it is pure; but this is an error, since cold air will receive and retain the same impurities as warm air.

31. Shall we open our bedrooms to the night air? Florence Nightingale says, in effect, that night air is the only air that we can then breathe. "The choice is between pure air without and impure air within. Most people prefer the latter,—an unaccountable choice. An open window, most nights in the year, can hurt no one. In great cities, night air is the best and purest to be had in twenty-four hours. I could better understand, in towns, shutting the windows during the day than during the night."

32. Animal Heat.—The temperature of the human body is about 100° Fahr., and remains about the same through winter and summer, in the tropics as well as in the frozen regions of the north. It may change temporarily within the range of about twelve degrees; but any considerable, or long-continued elevation or diminution of the bodily heat is certain to result disastrously.

33. The regulation of the temperature of the body is effected by means of perspiration, and by its evaporation. So long as the skin acts freely and the air freely absorbs the moisture, the heat of the body does not increase, for whenever evaporation takes place, it is attended with the abstraction of heat—that is, the part becomes relatively colder. This may be tested by moistening some part of the surface with cologne, ether, or other volatile liquid, and then causing it to evaporate rapidly by fanning. The principle that evaporation produces cold has been ingeniously and practically employed, in the manufacture of ice, by means of freezing machines.

QUESTIONS FOR TOPICAL REVIEW.

Anita.

CHAPTER VIII.

The Nervous System.

Animal and Vegetative Functions—Sensation, Motion, and Volition — The Structure of the Nervous System — The White and Gray Substances—The Brain—Its Convolutions—The Cerebellum—The Spinal Cord and its System of Nerves—The Anterior and Posterior Roots—The Sympathetic System of Nerves—The Properties of Nervous Tissue—Excitability of Nervous Tissues—The Functions of the Spinal Nerves and Cord—The Direction of the Fibres of the Cord—Reflex Activity, and its Uses—The Functions of the Medulla Oblongata and the Cranial Ganglia—The Reflex Action of the Brain.

1. Animal Functions.—The vital processes which we have been considering, in the three previous chapters, of digestion, circulation, and respiration—belong to the class of functions known as *vegetative* functions. That is, they are common to vegetables as well as animals. The plant has its circulatory fluid and channels, by which the nutriment is distributed to all its parts. It has, also, a curious apparatus in its foliage, by which it abstracts from the air those gaseous elements so necessary to its support; and thus it accomplishes vegetable respiration.

2. The animal, in addition to these vegetative functions, has another set of powers, by the use of which he becomes conscious of a world external to himself, and brings himself into active relations with it. These functions, among which are sensation, motion, and volition, not only distinguish the animal from the

plant, but, in proportion to their development, elevate one creature above another; and it is by virtue of his pre-eminent endowment, in these respects, that man holds his position at the head of the animal creation.

3. Among animals whose structure is very simple, the hydra or fresh-water polyp, being an example, no special organs are empowered to perform separate functions; but every part is endowed alike, so that if the animal be cut into pieces, each portion has all the properties of the entire original; and, if the circumstances be favorable, each of the pieces will soon become a complete hydra. As we approach man, in the scale of beings, we find that the organs multiply, and the functions become more complete. The function of motion, the instruments of which—the muscles and bones—have been considered in former chapters, and all the other animal functions of man, depend upon the set of organs known as the nervous system.

4. The Nervous System.—The nervous tissue is composed of a soft, pulpy substance, which, early in life, is almost fluid, but which gradually hardens with the growth of the body. When examined under the microscope, it is found to be composed of two distinct elements:—(1) the white substance, composing the larger proportion of the nervous organs of the body, which is formed of delicate filaments, about $\frac{1}{6000}$ of an inch in diameter, termed the nerve-fibres; and (2) the gray substance, composed of grayish-red, or ashen-colored cells, of various sizes.

5. The gray, cellular substance constitutes the larger portion of those important masses, which bear the name of *nervous centres* and *ganglia* (from *ganglion*, a knot), in which all the nerve-fibres unite. These white nerve-fibres are found combined together in long and dense cords, called *nerves* (from *neuron*, a cord), which serve to connect the nervous centres with each other, and to place them in communication with all the other parts of the body which have sensibility or power of motion. That part of the nervous system which is concerned in the animal functions, comprises the brain, the spinal cord,

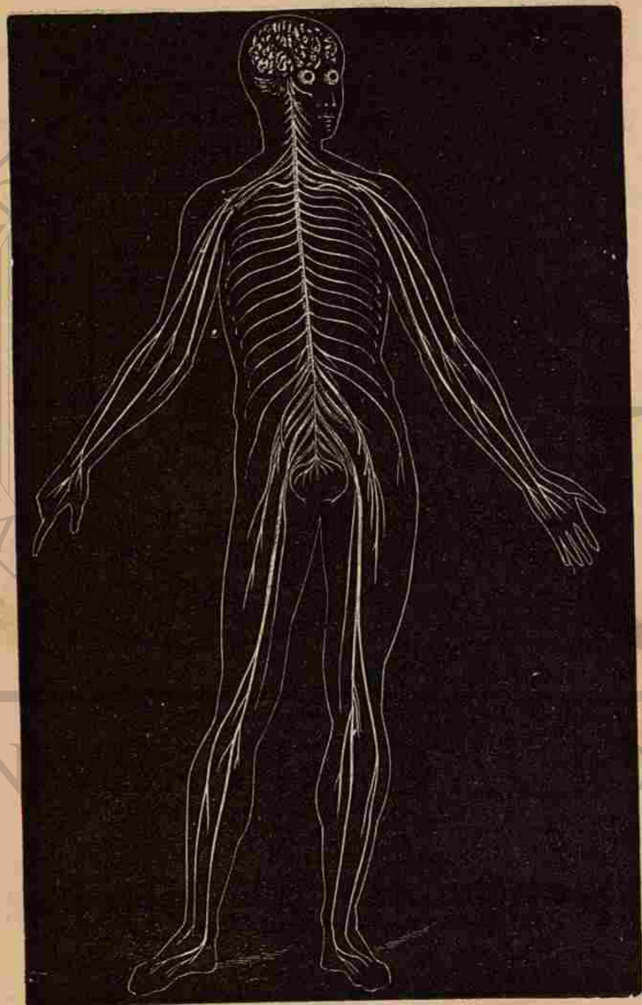

FIG. 29.—THE CEREBRO-SPINAL SYSTEM.

and the nerves which are derived therefrom; these, together, are called the *cerebro-spinal* system (Fig. 29); while that other set of organs, which presides over, and regulates the vegetative functions, is called the sympathetic system of nerves.

6. The Brain.—The brain is the great volume of nervous tissue that is lodged within the skull. It is the largest and most complex of the nervous centres, its weight in the adult being about fifty ounces, or one-fortieth of that of the whole body. The shape of the brain is oval, or egg-shaped, with one extremity larger than the other. The brain consists chiefly of two parts: the *cerebrum*, or brain proper, and the *cerebellum*, or "little brain." In addition to these, there are several smaller organs at the base, among which is the commencement or expansion of the spinal cord, termed the *medulla oblongata*, or oblong marrow.

7. The tissue of the brain is soft and easily altered in shape by pressure; it therefore requires to be placed in a well-protected position, such as is afforded by the skull, or *cranium*, which is strong without being cumbrous. In the course of an ordinary lifetime, this bony box sustains many blows, with little inconvenience; while, if they fell directly upon the brain, they would at once, and completely, disorganize that structure. Within the skull, the brain is enveloped by three membranes, which at once protect it from friction, and furnish it with a supply of nutrient vessels. The supply of blood sent to the brain is very liberal, amounting to one-fifth of all that the entire body possesses. The brain of man is heavier than that of any other animal, except the elephant and whale.

8. The Cerebrum.—The brain proper, or *cerebrum*, is the largest of the intracranial organs, and occupies the entire upper and front portion of the skull. It is almost completely bisected by a fissure, or cleft, running through it lengthwise, into two equal parts called *hemispheres*. The exterior of these hemispheres is gray in color, consisting chiefly of nerve-cells, arranged so as to form a layer of gray matter one-fifth of an inch in thickness, and is abundantly supplied with blood-vessels. The interior of the brain, however, is composed almost wholly of white substance, or nerve-fibres.

9. The surface of the cerebrum is divided by a considerable number of winding and irregular furrows, about an inch deep, as shown in Fig. 30. Into these furrows the gray matter of

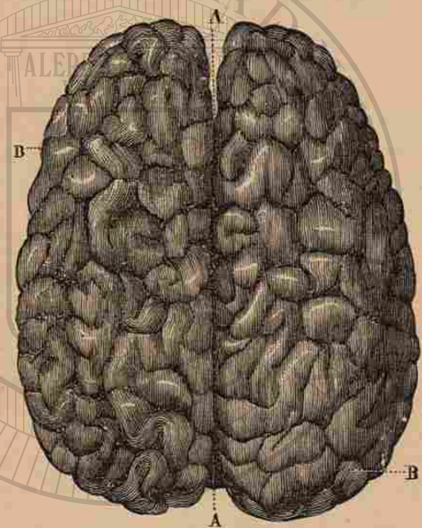

FIG. 30.—UPPER SURFACE OF THE CEREBRUM.
A, Longitudinal Fissure.
B, The Hemispheres.

the surface is extended, and, in this manner, its quantity is vastly increased. When it is stated that the gray matter is the true source of nervous power, it becomes evident that this arrangement has an important bearing on the mental capacity of the individual. And it is noticed that in children, before the mind is brought into vigorous use, these markings or furrows on the surface are comparatively shallow and indistinct; the same fact is true of the brain in the less civilized races of mankind and in the lower animals. It is also noticeable that, among

animals, those are the most capable of being educated which have the best development of the cerebrum.

10. The Cerebellum.—The "little brain" is placed beneath the posterior part of the cerebrum, and, like the latter, is divided into hemispheres. Like it, also, the surface of the cerebellum is composed of gray matter, and its interior is chiefly white matter. It is subdivided by many parallel ridges, which, sending down gray matter deeply into the white, central portion, gives the latter a somewhat branched appearance. This peculiar appearance has been called the *arbor vitæ*, or the "tree of life," from the fact that when a section of the organ is made, it bears some resemblance to the trunk and branches of a tree (Fig. 31, F).

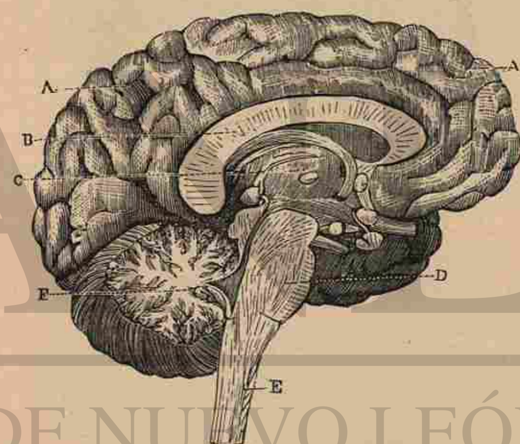

FIG. 31.—VERTICAL SECTION OF THE BRAIN.

A, Left Hemisphere of Cerebrum.
B, Corpus Callosum.
C, Optic Thalamus.
D, The Pons Varolii.
E, Upper Extremity of the Spinal Cord.
F, The Arbor Vitæ.

In size, this cerebellum, or "little brain," is less than one-eighth of the cerebrum.

11. From the under surface of the cerebrum, and from the front margin of the cerebellum, fibres collect together to form the *medulla oblongata* (Fig. 32, M *a*), which, on issuing from the skull, enters the spinal column, and then becomes known as the spinal cord. From the base of the brain and from the

FIG. 32.—THE BASE OF THE BRAIN.
The numbers refer to the pairs of nerves.

sides of the medulla originate, also, the *cranial nerves*, of which there are twelve pairs. These nerves are round cords of glistening white appearance, and, like the arteries, generally lie remote from the surface of the body, and are well protected from injury.

12. The Spinal Cord.—The spinal cord, or "marrow," is a cylindrical mass of soft nervous tissue, which occupies a chamber, or tunnel, fashioned for it in the spinal column (Fig. 33). It is composed of the same substances as the brain; but the arrangement is exactly reversed, the white matter encompassing or surrounding the gray matter instead of being encompassed by it. The amount of the white substance is also greatly in excess of the other material. A vertical fissure partly separates the

cord into two lateral halves, and each half is composed of two separate bundles of fibres, which are named the anterior and posterior columns.

13. These columns have entirely different uses, and each of them unites with a different portion of the nerves which have their origin in the spinal cord. The importance of this part of the nervous system is apparent from the extreme care taken to protect it from external injury. For, while a very slight disturbance of its structure suffices to disarm it of its power, yet so staunch is its bony enclosure, that only by very severe injuries is it put in peril.

14. The Spinal Nerves.—The spinal nerves, thirty-one pairs in number, spring from each side of the cord by two roots, an anterior and a posterior root. The posterior root is distinguished by possessing a ganglion of gray matter, and by a somewhat larger size. The successive points of departure, or the off-shooting of these nerves, occur at short and nearly regular intervals along the course of the spinal cord. Soon after leaving these points, the anterior and posterior roots unite to form the trunk of a nerve, which is distributed, by means of branches, to the various

FIG. 33.
A, Cerebrum.
B, Cerebellum.
D, D, Spinal Cord.

organs of that part of the body which this nerve is designed to serve. The spinal nerves supply chiefly the muscles of the trunk and limbs and the external surface of the body.

15. The tissue composing the nerves is entirely of the white variety, or, in other words, the nerve-fibres; the same as we have observed forming a part of the brain. But the nerves, instead of being soft and pulpy, as in the case of the brain, are dense in structure, being hardened and strengthened by means of a fibrous tissue which surrounds each of these delicate fibres, and binds them together in glistening, silvery bundles. Delicate and minutely fine as are these nerve-fibres, with their extremities often only a hair's breadth distant from each other, the impression which any one of them communicates is perfectly distinct, and is referred to the exact point whence it came. This may be illustrated in a simple manner, thus: if two fingers be pressed closely together, and the point of a pin be carried lightly across from one to the other, the eyes may be closed, and yet we can easily note the precise instant when the pin passes from one finger to the other.

16. The Sympathetic System.—The *sympathetic system* of nerves remains to be described. It consists of a double chain of ganglia, situated on each side of the spinal column, and extending through the cavities of the trunk, and along the neck into the head. From these, numerous small nerves are derived, which connect the ganglia together, send out branches to the cranial and spinal nerves, and form networks in the vicinity of the stomach and other large organs. Branches also ascend into the head, and supply the muscles of the eye and ear, and other organs of sense.

17. The Properties of Nervous Tissue.—We have seen that in all parts of this system, there are only two forms of nervous tissue; namely, the gray substance and the white substance, so called from their difference of color as seen by the naked eye; or the nerve-cell, and the nerve-fibre, so called from their microscopic appearance. Now these two tissues are not commonly mingled together, but either form separate organs, or distinct parts of the same organs. This leads us to the conclusion that their respective uses are distinct. And this proves to be the simple fact; wherever we find the gray substance, we must look upon it as performing an active part in the system, that is, it originates nervous impulses; the white matter, on the contrary, is a passive agent, and serves merely as a conductor of nervous influences. Accordingly, the nervous centres, composed so largely of the gray cells, are the great centres of power, and the white fibres are simply the instruments by which the former communicate with the near and distant regions of the body under their control.

18. The Functions of the Nerves.—The nerves are the instruments of the two grand functions of the nervous system, Sensation and Motion. If a nerve that has been exposed be divided, and the inner end, or that still in connection with the nerve-centres, be irritated, sensation is produced, but no movement takes place. But if the outer end, or that still connected with the limb, be irritated, then no pain is felt, but muscular contractions are produced. Thus we prove that there are two distinct sets of fibres in the nerves; one of which, the *sensory* fibres, conduct toward the brain, and another, the *motor* fibres, conduct to the muscles. The former may be said to begin in the skin and other organs, and end in the brain; while the latter begin in the nervous centres and end in the muscles.

19. We have already spoken of the two roots of the spinal nerves, called, from their points of origin in the spinal cord, the anterior and posterior roots. These have been separately cut and irritated in the living animal, and it has been found that the posterior root contains only sensory fibres, while the anterior root has only motor fibres. So that the nerves of a limb may be injured in such a way that it will retain power of motion and yet lose sensation; or the reverse condition, feeling without motion, may exist. Between these two sorts of fibres no difference of structure can be found; and where they have joined to form a nerve it is impossible to distinguish one sort from the other. The rate of motion of a message, to or from the brain along a nerve, has been measured by experiment upon the lower animals, and estimated in the case of man at about two hundred feet per second. As compared with that of electricity, this is a very slow rate, but, in respect to the size of the human body, it is practically instantaneous.

20. The Functions of the Spinal Cord.—As the anterior and posterior roots of the spinal nerves have separate functions, so the anterior and posterior columns of the cord are distinct in function. The former are concerned in the production of motion, the latter in sensation.

21. When the spinal cord of an animal has been cut, in experiment, it may be irritated in a manner similar to that alluded to when considering the nerves. If, then, the upper cut surface be excited, it is found that pain, referable to the parts below the cut, is produced; but when the lower cut surface is irritated, no feeling is manifested. So we conclude that in respect to sensation, the spinal cord is not its true centre, but that it is merely a conductor, and is therefore the great sensory nerve of the body. When the lower surface of the cut is irritated, the muscles of the parts below the section are violently contracted. Hence, we conclude that, in respect to the movements ordered by the will, the spinal cord is not their source; but that it acts only as a conductor, and is, accordingly, the great motor nerve of the body.

22. Direction of the Fibres of the Cord.—If one lateral half of the spinal cord be cut or injured, a very singular fact is observed. All voluntary power over the muscles of the corresponding half of the body is lost, but the sensibility of that side remains undiminished. This result shows that the motor fibres of the cord pursue a direct course, while its sensory fibres are bent from their course. The direction of the anterior or motor columns of the cord is downward from the brain. In the cord itself, the course of the motor fibres is for the most part a

direct one; but in the medulla oblongata, or upper extremity of the cord, and therefore early in their career, these fibres cross from side to side in a mass.

23. From this double interlacing of fibres results a cross action between the original and terminal extremity of all nerve-fibres which pass through the medulla; namely, those of all the spinal nerves. Consequently, if the right hand be hurt, the left side of the brain feels the pain; and if the left foot move, it is the right hemisphere which dictates its movement.

24. The Reflex Action of the Cord.—We have already considered the cord as the great motor and sensory nerve of the body, but it has another and extremely important use. By virtue of the gray matter, which occupies its central portion, it plays the part of an independent nerve centre. The spinal cord not only conducts some impressions to the brain, but it also arrests others; and, as it is expressed, "reflects" them into movements by its own power. This mode of nervous activity is denominated the *Reflex Action* of the cord. A familiar example of this power of the cord is found in the violent movements which agitate a fowl after its head has been cut off. The cold-blooded animals also exhibit reflex movements in an astonishing degree. A decapitated centipede will run rapidly forward, and will seemingly strive to overturn, or else climb over obstacles placed in its way.

25. The Uses of the Reflex Action.—The reflex activity of the cord is exhibited in the healthy body in many ways, but since it is never accompanied with sensation, we do not readily recognize it in our own bodies. Reflex movements are best studied in the cases of other persons, when the conditions enable us to distinguish between acts that are consciously, and those that are unconsciously performed. For example, if the foot of a person sound asleep be tickled or pinched, it will be quickly withdrawn from the irritation. Again, when a substance like melted sealing-wax, or a heated coin, falls upon the hand, the limb is snatched away at once, even before the feeling of pain has been recognized by the brain. When jolted in a rapidly moving car, we involuntarily step forward or backward, so as to preserve the centre of gravity of the body.

26. Another variety of reflex motions takes place in certain involuntary muscles, and over these the cord exercises supreme control. They are principally those movements which aid the performance of digestion and nutrition, the valve-action of the pylorus, and other movements of the stomach and intestines. In these movements the mind shares no part. And it is well that this is so; for since the mind is largely occupied with affairs external to the body, it acts irregularly, becomes fatigued, and needs frequent rest. The spinal cord, on the contrary, is well fitted for the form of work on which depends the growth and support of the body, as it acts uniformly, and with a machine-like regularity.

27. The objects of the reflex activity of the cord are threefold. In the first place, it acts as the protector of man, in his unconscious moments. It is his unseen guardian, always ready to act, never growing weary, and never requiring sleep. In the second place, it is the regulator of numerous involuntary motions, that are necessary to the nutrition of the body. And, thirdly, it acts as a substitute and regulates involuntary movements in the muscles usually under the influence of the will. It thus takes the place of the higher faculties in performing habitual acts, and permits them to extend their operations more and more beyond the body and its material wants.

28. The Functions of the Medulla Oblongata.—The prolongation of the spinal cord, within the skull, has been previously spoken of as the medulla oblongata. It resembles the cord, in being composed of both white and gray matter, and in conducting sensory and motor influences. A portion of the medulla presides over the important function of respiration, and from it arises the *pneumogastric* nerve, so called because its branches serve both the lungs and stomach. The feelings of hunger, thirst, and the desire for air are aroused by means of this nerve.

29. The Function of the Cerebellum.—The function of the cerebellum, or "little brain," is the directing of the movements of the voluntary muscles. When this organ is the seat of disease or injury, it is usually observed that the person is unable to execute orderly and regular acts, but moves in a confused manner as if in a state of intoxication. Like the larger brain, or cerebrum, it appears to be devoid of feeling; but it takes no part in the operations of the mind.

30. The Function of the Cerebrum.—The cerebrum, or brain proper, is the seat of the mind; or, speaking more exactly, it is the material instrument by which the mind acts; and, as it occupies the highest position in the body, so it fulfills the loftiest uses. All the other organs are subordinate to it: the senses are its messengers, which bring it information from the outer world, and the organs of motion are its servants, which execute its commands.

31. There have been a few, but only a few, men of distinguished ability whose brains have been comparatively small in size; the rule being that great men possess large brains. The relative weight of the brain of man, as compared with the weight of the body, does not, in all instances, exceed that of the inferior animals; the canary and other singing-birds have a greater relative amount of nervous matter than man; but man surpasses all other creatures in the size of the hemispheres of the cerebrum, and in the amount of gray substance which they contain.

32. Impressions conveyed to the hemispheres from the external world arouse the mental operations called thought, emotion, and the will. All these mental acts, and many others, are developed through the action of the brain; not that the brain and the mind are the same, or that the brain secretes memory, imagination, or the ideas of truth and justice, as the stomach secretes the gastric juice. But rather, as the nerve of the eye, stimulated by the subtile waves of light, occasions the notion of color, so the brain, called into action by the mysterious influences of the immaterial soul, gives rise to all the intellectual, emotional, and voluntary activities of mankind.

33. Effects of Alcohol upon the Brain.—The brain under the influence of small and occasional doses of alcohol shows no serious changes other than an increased supply of blood to the head. Very serious changes, however, result from the habitual use of alcohol; the brain becomes harder and tougher than is natural and its cell elements show a wasting away, its substance appears shrunken, and an undue amount of watery fluid fills the cavities in the brain, in order to make up the diminished bulk. The blood-vessels of the brain are sometimes found to be in a weakened condition and from this various diseased conditions may follow.

34. Effects of Alcohol on the Mind.—Alcohol produces an artificial insanity, in which, according to the quantity taken, the various types of mental diseases are distinctly manifest. The perceptions are bewildered, there is sleeplessness, loss of memory, delusion, clouded reasoning power and benumbed moral sense following in the train of alcohol drinking. There is also a monomania caused by the prolonged use of alcohol, a craving for drink that knows no bounds, and but rarely a cure; this is dipsomania, or thirst madness.

Trembling due to Alcohol.—"Another condition is trembling, due to alcohol. The hands are shaky, or unsteady, even when at rest, or if the hand is held out it is seen to vibrate slightly, or in more advanced condition, 'shakes like an aspen leaf.' I have seen this in a spirit-drinker, a barber, as almost the only symptom; he worked night and day, in shaving, and to 'steady his hand,' partook repeatedly of spirits—at first to relieve fatigue and then, because he saw that if he discontinued, his hand was too shaky to use the razor. Complete abstinence from alcohol and strong coffee, quite removed his tremblings and his desire for spirits."—*Dr. W. S. Greenfield.*

Alcohol a Poison of the Intellect.—"In the normal state of a man's mind all the faculties, the imagination, the judgment, the memory, the association of ideas, are regulated by another superior faculty, viz., the attention. The attention of the will, is the man himself; it is the *ego* which, being in the full possession of the resources of which it disposes, takes them where it will, when it will, to do whatever it pleases. Now in drunkenness, even at the very beginning, the will and the attention have disappeared. Nothing is left but the imagination and the memory, which, left to themselves without regulation and without guides, produce the most irrational results."
– *Charles Richet.*

"Alcohol in small doses super-excites certain intellectual faculties—the imagination, the memory and the association of ideas, but it paralyzes others, especially the will, the reflection and judgment. Yet, with a stronger dose all trace of intelligence disappears. When old Sly is stretched on the ground insensible from drink and snoring in the mud, he excites compassion and disgust:

O monstrous beast! how like a swine he lies!
Grim death, how foul and loathsome is thine image."

Charles Richet, in Revue des Deux Mondes.

Drunkenness and Insanity.—"The connection between drunkenness and crime, and between drunkenness and poverty is close and unvarying in its effect upon society. The remarkable increase of insanity in recent years may in part be traced to the use of intoxicating beverages. It has been asserted that at least seven-tenths of all the crime and poverty and calamity to the people of the United States spring from the abuse of liquors."—*Dr J. E. Reeves.*

35. The Impairment of the Will.—The direst result of the taking of alcohol is seen in the loss of self-control. "The worst estate of man is that wherein he loses the knowledge and government of himself." It is in the formation of the drinking habit that alcohol too often works the absolute ruin of its devotee, in both body and mind. It is apt to be a continuous habit, having for its sequel the dethronement of the will. It may be stated, as the rule, that after forty years of age, a man who has formed this habit is unequal by his own strength of will to abandon it. Many men of fine intellectual capacity and amiable qualities have become intemperate, and have so continued, as long as their efforts to get free again have not been supplemented by outside and enforced restraint. It is for such as these that inebriate asylums have been built. Other hard drinkers drift into violence and crime, and finally find a curative restraint within prison walls. The benumbing effects of drinking habits upon the moral being of man is universally known. "All delicacy, courtesy and self-respect are gone; the sense of justice and of right is faint or quite extinct; there is no vice into which the victim of drunkenness does not easily slide, and no crime from which he can be expected to refrain. Between this condition and insanity there is but a single step," and death, in a worldly sense a deliverance, in spite of many an effort to rally, "terminates the miserable scene; one by one lights have been removed from the banquet of folly, and the last is now extinguished."*

36. An illustration of the disadvantage of drunkenness to the moral tone of a community may be drawn from the results of the labors of Father Mathew, about forty years ago, as a temperance reformer. In the five years, 1838–1842, the consumption of whiskey in Ireland fell 50 per cent., the crimes of violence falling from 64,520 to 47,027, and executions from 59 in the first year to 1 in the last year.

Alcohol and Crime.—Thirty years of judicial experience have taught me that of the crimes which judges are called upon to try, and upon which sentences of the law are pronounced, more than eight-tenths of them involving any degree of violence in their character are directly traceable to the liquor shops. How often have I had young men look up at me when I asked them what they had to say why the sentence of the law should not be pronounced, declare, "I should never have done this crime if it were not for drink. Rum was my ruin; rum and not my hand struck the blow, that killed the man for whose death I am tried; rum has caused me to beat my wife and injure my helpless child or to do the act which now confines me to a prison."—*Judge Noah Davis.*

37. The Poisonous Effects of Alcohol.—Alcohol is, in the main, a narcotic poison in its effects upon human beings; although the visible results vary immensely according to the quantity taken. If a sufficient quantity be taken to cause any visible result, a condition, known as stimulation, is observed.†

* **The Effects of Mild Stimulation.**—"Words of caution to young men concerning the injurious effects of tobacco, as well as indulgence in wine or the pleasures of the table, elicit, in ninety-nine out of one hundred cases, the reply, 'It does not hurt me.' Does not hurt you! Wait and see. In years to come, when you ought to be in your prime, you will be a poor, nervous, irritable, nerve-dried creature. Your hands will tremble, your head will ache, your sleep be fitful and disturbed, your digestion impaired; in short, the unnatural and transient pleasure at one end of your life will be more than counterbalanced by the discomfort and misery at the other. It is a truth of the greatest moment, which ought to be so impressed upon the mind as to be always rising up within it, that *transgressions of the laws of health, not punished at one end of life, are sure to be at the other.*"—*J. R. Black on the Ten Laws of Health.*

† "Suppose, for instance, you measure your muscular strength with a 'health lift' or dynamometer (by which muscular exertion can be accurately measured), and then take some of the drink, in the strength-inspiring power of which you have most confidence, and when you are most exhilarated by it and feel as if you could shoulder a large fragment of Mount Olympus measure your strength again. The drink has fooled you, that is all. You *felt* that you were stronger than natural; you *find* that the narcotic has been true to its paralyzing nature and that you are weaker. Then, after a

If an extremely large dose be taken, a state of stupor follows, and death has been known to result in some cases. Between these two extremes there may be a variety of manifestations. As a stimulant, it appears to many to have a kindly action, to cause a glow and sense of warmth, to increase muscular activity, and to make the mind and organs of speech more nimble. Alcohol is not the only narcotic poison that exercises this influence, which is not kindly, but is, in fact, the first indication of a paralysis of a portion of the nervous system.*

Most of the habitual takers of alcohol freely admit that they are injured by it in one way or another, and still they continue in their indulgence. In such cases, the mental balance is already lost: for a person to covet that which he knows to be hurtful to him, is manifestly not the sign of a sound mind.

38. Tobacco and its Effects.—Tobacco, familiarly known as "the weed," is an annual plant said to be a native of America. It grows to the height of several feet, with leaves of a pale green color. These leaves, when dried, are made into cigars, chewing tobacco, and snuff, which are extensively used throughout the civilized world.

39. Tobacco as a Poison.—Tobacco is a poison to the

time, when the drug has spent itself and reaction (so called) comes on, and you feel weak and prostrated, measure your strength once more. Fooled again; the stuff has fooled you twice. When you felt yourself strong you were weak, and now when you feel yourself weak you find yourself stronger—your natural strength is returning, and what you have called reaction is in reality recovery from the weakening effects of the narcotic."—*Dr. A. F. Kinne.*

* "Here is a company of 'jolly good fellows' all standing on their feet, their faces red and radiant, and all swinging their arms and talking at once. These men have been taking alcohol, and, surely, you will say, it has stimulated them. But if you will attend for a moment to what they are saying, you will see that there is no true brain-stimulation about it. We shall be reminded rather of what Addison says of the difference between the mind of the wise man and that of the fool: "There are infinite, numberless extravagancies, and a succession of vanities which pass through both. The great difference is that the first knows how to pick and cull his thoughts for conversation, by suppressing some and communicating others; whereas the other lets them all indifferently fly out in words? The case with these revelers is precisely this. The poison which they have taken has paralyzed their conservative faculties, and the talking propensity is running on without anything to hold it in check and regulate it."—*Dr. A. F. Kinne.*

young, and is far more hurtful to the adult than is generally supposed. It may be stated as a rule that there are few persons using it habitually who do not suffer injury from it. The injury is mainly caused by what is known as "nicotine," one of the narcotic poisons, and particularly prominent in tobacco. Some of the effects of its limited use are nausea, vomiting, vertigo, and weakness; and its prolonged use, by those who are sensitive to it, often results in convulsions and other like symptoms, together with an irritability and weakened condition of the heart known to physicians as the "tobacco-heart."

40. Effects on the Young.—Of the pernicious influence of the use of tobacco upon the young, the testimony of the Naval and Military Academies of the country is very decided. It has at times been allowed in both institutions, but at present it is forbidden, on the ground that its use is attended with serious damage to health. It is stated that its prohibition at the Naval Academy in 1881 was received with unanimous approval by the officers in charge and with "great joy by many of the cadets." Tremor of the muscles, caused by smoking, was very noticeable in the drawings that form so important a part of the cadets' work. A teacher of drawing, of fourteen years experience, has said that he can always tell from the character of the lines in the drawings whether or not the pupils used tobacco.* Its avoidance has resulted in the reduced number of minor ailments that swelled the sick-list in years when its use was unrestricted.

Athletes and other persons who engage in running matches and the like, are commonly not allowed to use either alcohol or tobacco while they are "in training"; as such use interferes with the fullest development of muscular strength.

* Prof. Mantegazza, of Florence, Italy, a distinguished sanitarian and physician, testifies that "Tobacco is never necessary; it is always hurtful to boys and young men, to weak people and those disposed to consumption. * * * * All good citizens should try to put a stop to the general invasion of tobacco, which threatens to involve the whole of Europe in a dense cloud of smoke, which poisons even those who do not smoke."

41. Cigarette-Smoking.—This form of taking tobacco is injurious in two particulars that do not apply to the other forms. The smoker of cigarettes, either voluntarily or involuntarily, takes into his lungs a very large amount of smoke, and with it, that hurtful element, carbonic oxide. Again, there is an excessive amount of adulteration of the tobacco in cigarettes; and one substance, opium, is largely so used and is extremely injurious.

42. Snuff-Taking.—In addition to the hurtful effects of tobacco generally, snuff-taking is notoriously injurious to the senses of smell and taste, and to the voice.

"The end of all science is to secure long life and good health to the individual and the race, and it ought to be a part of the rational creed of every good man and woman to abjure the use of tobacco and keep others from falling into the vice."—*Dr. C. R. Drysdale.*

"Of tobacco, Franklin said that he could not think it had ever done much good in the world, since he never knew a person who used it habitually who would recommend another to do the same."

"Tobacco is certainly not a food for man, nor has it much value as a medicine. The tobacco-worm is the only animal known to thrive upon it."—*F. H. Hamilton.*

An illustration of the depressing influence of tobacco is given by Dr. Jacob Bigelow, who states that soldiers, when wishing to shirk duty and get on the sick-list, sometimes succeed in bringing on the symptoms of alarming illness by wearing a piece of tobacco under each arm-pit. The skin absorbs sufficient of the poison to affect the general system to a marked degree.

43. Narcotics.—The term narcotic is applied to different substances derived chiefly from the vegetable kingdom, which have the wonderful property of quieting pain and causing sleep. Next in importance to alcohol—which belongs to the narcotics—are opium (and its preparations), chloral hydrate, hasheesh and chloroform.

44. Opium.—Opium is the thickened juice of the poppy-plant of India, and is commonly regarded as the most important of the narcotics. Its active principle is morphine, which gives the soothing property to laudanum, paregoric, and Dover's powders. It is also used in nostrums to put infants to sleep: but unwisely used often brings on a sleep that knows no waking.

45. Effects of Opium. — Opium is particularly injurious to the young, even small doses sometimes producing alarming symptoms. Upon adults the external effects are not as noticeable as are those of alcohol, but the mind is more deeply stirred and the flow of ideas more copious.

46. Danger from Opiates.—The use of opium for relieving pain has been known for hundreds of years. The enchanting sense of relief to suffering wrought by opiates leads to the morphine habit, commonly called opium-eating. It will be seen, therefore, why such great care is exercised by physicians in administering opiates, lest their patients afterward fall into the habit of taking them without medical advice.

"The opium eater loses none of his moral sensibilities or aspirations ; he wishes and longs as earnestly as ever to realize what he believes possible and feels to be exacted by duty ; but his intellectual apprehensions of what is possible infinitely outruns its power not of execution only but even the power to attempt. He lies under the weight of incubus and nightmare ; he lies in sight of all that he would fain perform, just as a man forcibly confined to his bed by the mortal languor of a relaxing disease, who is compelled to witness injury and outrage offered to some object of his tenderest love ; he curses the spells which chain him down from motion ; he would lay down his life if he might but get up and walk ; but he is powerless as an infant and cannot even attempt to rise."—*De Quincey's Confessions of an Opium Eater.*

47. Physiological Effects of Opium.—The frequent use of opium disturbs and weakens the stomach as well as the other digestive organs ; hence we invariably find the opium-eater to be a lean, yellow, sallow personage. His muscular and mental powers are impaired, and his will is terribly enfeebled. This dreadful habit can be broken only with unspeakable suffering to its victim.

48. Chloral Hydrate. — Chloral hydrate, commonly called chloral, is produced from alcohol, but its power as a sedative was not generally known until within the past twenty years. It also is a destroyer of appetite as well as of digestion, unless prescribed in proper doses, and the unfortunates once given over to it find themselves unable to sleep without its continued use. It should never be taken except under the direction of a physician.

49. Hasheesh.—Hasheesh, the juice of Indian hemp, is said to be used by millions of the inhabitants of Asia. It is not much known in the western countries. In the East the excitement caused by its use takes the form of furious madness, leading its victim to commit acts of violence and murder. Hence the term "hasheeshers" in our language has come to be synonymous with assassins.

"As everybody knows, the intoxication caused by alcoholic liquors, by hasheesh, by opium, after a first period of excitement, brings about a notable impairment of the will. The individual is more or less conscious of this : other persons see it more clearly. Soon—especially under the influence of alcohol—the weakening of the will becomes excessive. The extravagances, violences and crimes committed in this state are innumerable."—*Dr. T. Ribot.*

50. Chloroform.—Chloroform, another product from alcohol, is used by inhalation when surgical operations are to be performed. As it is very powerful and subtle in its action, the unskilful use of it is dangerous in the extreme. The habit of taking chloroform by those who are great physical sufferers, or whose constitutions have been wrecked by the use of other narcotics, should be discouraged. It too often happens that the career of such is short, for the drug may easily be taken in excess and so cause death.

51. Sleep Produced by Narcotics.—Opium and the opiates have the power of quieting the activity of the brain, and of compelling sleep. This may be a blessed action if skilfully applied by the physician, but not so applied it is the source of infinite peril. The sleep so caused differs from natural, restful slumber, especially in the fact that the after effects are commonly depressing and disturbing to the brain to the extent of being harder to bear than the wakefulness on account of which the drugs are taken.

Very young persons are especially subject to injury by sleep-producing medicines ; and many are the deaths that have been caused among infants by the giving of "soothing syrups," "cordials" and "anodynes" that are so freely made and sold for the purpose of compelling sleep.

52. Results of the Use of Narcotics.—The use of any of these narcotics, without proper medical advice, is their abuse. In this way they become powerful for harm. They are no longer remedies, but poisons. Self-prescribed, they have a thousand times been the instrument of unintentional suicide.

The Narcotics and Digestion.—The habitual use of opium and other narcotic drugs is unfriendly to digestion, leading to nausea and a distaste for wholesome food. The vigor of the organs of digestion is impaired.

The disturbing effects of tobacco, in producing nausea and vomiting, is well known; and is almost the invariable experience of all beginners in the use of that substance, loss of appetite is a very frequent result of the habitual use of it.

The Emotions Influence the Bodily Health.—"The exciting emotions which are pleasurable, such as joy and hope, are of a kind that seldom tend to a dangerous excess, and may be regarded as exercising generally an eminently healthful influence upon the body. Hilarity is a great refresher and strengthener of life. Laughter is a wholesome exercise, which, beginning at the lungs, diaphragm, and connected muscles, is continued to the whole body, 'shaking the sides,' and causing that jelly-like vibration of the frame of which we are so agreeably conscious when under its influence. The heart beats more briskly, but with a safe regularity of action, and sends the blood to the smallest and most distant vessel. The face glows with warmth and color, the eye brightens, and the temperature of the whole body is moderately raised. With the universal pleasurable sensation there comes a disposition of every organ to healthy action. When hilarity and its ordinary expression of laughter become habitual, the insensible perspiration of the skin is increased, the breathing quickened, the lungs and chest expanded, the appetite and digestion strengthened, and nutrition consequently increased. The old proverb, 'Laugh and grow fat,' states a scientific truth. The influence of laughter upon the body is recognized by Shakspere, in his description of the 'spare Cassius'—'Seldom he smiles.' 'To be free-minded and cheerfully disposed at hours of meat, and sleep, and exercise, is one of the best precepts of long-lasting.' Such is the testimony of Lord Bacon to the favorable influence of the pleasurable emotions upon the body. The depressing emotions, such as fear, anxiety, and grief, are always fatal to health, and frequent causes of death. There is an Eastern apologue which describes a stranger on the road meeting the Plague coming out of Bagdad. 'You have been committing great havoc there,' said the traveler, pointing to the city. 'Not so great!' replied the Plague. 'I only killed one-third of those who died; the other two thirds killed themselves with fright.'"—*The Book of Health.*

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CHAPTER IX.

THE SPECIAL SENSES.

The Production of Sensations—Variety of Sensations—General Sensibility—Pain and Its Function—Special Sensation, Touch, Taste, Smell, Sight, and Hearing—The Hand, the Organ of Touch—The Sense of Touch—Delicacy of Touch—Sensation of Temperature and Weight—The Tongue the Organ of Taste—The Nerves of Taste—The Sense of Taste and its Relations with the other Senses—The Influence of Education on the Taste—The Nasal Cavities, or the Organs of Smell—The Olfactory Nerve—The Uses of the Sense of Smell—The Sense of Sight—Light—The Optic Nerve—The Eyeball and its Coverings—The Function of the Iris—The Sclerotic, Choroid, and Retina—The Tears and their Function—The Movements of the Eyeball—The Function of Accommodation—The Sense of Hearing—Function of Accommodation—The Sense of Hearing and Sound—The Ear, or the Organ of Hearing—The External, Middle, and Internal Ear.

1. Production of Sensations.—We have already seen that the true centre of sensation is some organ within the skull, probably among the gray masses at the base of the brain; but the mind never perceives impressions at that point, but, on the contrary, always refers them to the external organs of sensation. Hence it is convenient to say, that those outer parts possess the property of sensibility. For instance, we say that we hear with the ear, taste with the tongue, and feel with the fingers. That

this is not the exact truth is proven by the fact, that whenever the nerve connecting one of these organs with the brain is severed, it at once loses its capacity for sensation.

2. Consciousness, another faculty of the brain, is necessary to complete a sensation. During sleep, and in other unconscious states, the usual impressions are presented to the ear, the nose, and the skin, but they fail to excite sensations, because the nerve-centres are inactive. In profound insensibility, from chloroform or ether, a limb may be removed without occasioning the least feeling.

3. Variety of Sensations.—All animals have some degree of sensibility. It is of course feeble and indistinct in the lower forms of life, but increases in power and variety as we ascend the scale. In the earth-worm, the nervous system is very simple, the sensibility being moderate and alike in all parts: hence, if its body be cut into two pieces, each piece will have the same degree of feeling as before. As we approach man, however, the sensations multiply and become more acute; the organs are more complex, and special parts are endowed with special gifts. These special organs cannot be separated from the rest of the body without the loss of the functions they are designed to exercise.

4. The lowest form of sensation, that of simple contact, is possessed by the lowest of the animal creation. The highest forms are those by which we are enabled to know the properties of external objects, such as shape, size, sound and color. Sensations are modified by use. They become more acute and powerful by moderate exercise; or, they are dulled by undue excitement. The former is shown by the acute hearing of the Indian, by the sharp sight of the sailor, and by the delicate touch of the blind. The latter is exemplified by the impaired hearing of the boiler-maker, and the depraved taste of him who uses pungent condiments with his food. Again, impressions habitually presented may not be consciously felt; as is the case with the rumbling of carriages in a neighboring street, or the regular ticking of a clock. All sensations become less acute with the advance of age, especially hearing and vision.

5. General Sensibility.—There is a property possessed by nearly all parts of the human body which we call general sensibility. The brain is wholly insensitive, and may be cut or pinched without pain. The same is true of the nails, hair, the scarf-skin or external covering of the body, and a few other structures. In these parts no nerves are found. On the other hand, the sensibility of the true skin, and of mucous membranes, as of the eye and nose, is exquisite, these organs having a large supply of sensory nerve-fibres. The bones and tendons have less of these fibres, and are only moderately sensitive.

6. The sensibility of any part of the body, then, depends upon the number of nerves present; and, as a rule, the nervous supply is proportional to the importance of the part, and to its liability to injury. When, therefore, a surgical operation is performed, the most painful part of it is the incision through the skin; the muscles, cartilage, and bone being comparatively without sensation. Hence, if we could benumb the surface, certain of the lesser operations might be undergone without great inconvenience. This is, in fact, very successfully accomplished by means of the cold produced by throwing a spray of ether, or of some other rapidly evaporating liquid, upon the part to be cut.

7. Tickling is a modification of general sensibility. At first, it excites a pleasurable sensation, but this soon passes into pain. It is only present in those parts where the sense of touch is feeble. But all impressions are not received from without: there are, also, certain internal sensations, as they are called, which depend upon the condition of the internal organs, such as appetite, hunger, thirst, dizziness when looking down from some lofty position, drowsiness, fatigue, and other feelings of comfort or discomfort. General sensibility, whether of the internal or external organs of the body, chiefly depends upon the sensory fibres of the spinal nerve. The face, however, is

supplied by the sensory cranial nerves. The sympathetic system has a low grade of feeling in health; but disease in the parts served by it arouses an intense degree of pain.

8. The Sensation of Pain.—What then is *pain?* Is it identical with ordinary sensibility? There seems to be some necessary connection between the two feelings, for they take place through the same channels, and they are alike intense in the same situations. But sensibility habitually contributes to our sources of pleasure, the very opposite of pain; hence, these feelings cannot be identical.

9. Pain must, therefore, be a modification of the general sensibility which follows an excessive degree of excitement of the nerves; there being a natural limit to the amount of stimulation which they will sustain. So long as this limit is observed, the part excited may be said to be simply sensitive; but when it is exceeded, the impression becomes painful. This difference between sensibility and pain is well shown by the effects of sunlight upon the eye. The indirect illumination of the sun arouses only the former feeling, and is indispensable to our comfort and existence; while the direct ray received into the eye occasions great pain.

10. The Uses of Pain.—The dread of pain is a valuable monitor to the body. It puts us on our guard in the presence of danger; teaches moderation in the use of our powers; indicates the approach of disease; and calls attention to it when present. The word disease, in fact, according to its original use, had reference simply to the pain, or want of ease, which commonly attends disordered health. When we observe the serious mishaps which occur when sensibility and pain are absent, we cannot fail to appreciate its value. For example, a paralytic in taking a foot-bath, forgets to test its temperature, and putting his limbs into water while it is too hot, is severely scalded without knowing it.

11. Pain is, indeed, a present evil, but its relations with the future prove its mission merciful. Considered in the light of results, pain has a use above that of pleasure; for while the immoderate pursuit of the latter leads to harm, the tendency of pain is to restrict the hurtful courses of life, and in this manner to protect the body.

12. As to painful sensation among the inferior animals, the plan of Nature seems to be, that the higher the intelligence of the creature, and the more complete its power of defence, the more acute is its sensibility. We infer, therefore, that animals low in the scale of existence, and helpless, are not very liable to suffer pain.

13. **Special Sensation.**—The sensations of simple contact and pain are felt by nearly all parts of the system, whether external or internal, and are the necessary consequence of the general sensibility. Besides these feelings, man is endowed with certain special sensations, which are positive and distinct in character, and which he can call into exercise at will, and employ in the pursuit of knowledge.

14. These distinct and active faculties are termed the special senses, and are five in number, viz., Touch, Taste, Smell, Sight, and Hearing. For the exercise of these senses, special organs are furnished, such as the hand, the tongue, the nose, the eye, and the ear. The manner in which the nerves of special sense terminate varies in the case of each organ, so that each is adapted to one set of sensations alone, and is incapable of perceiving any other. Thus the nerve of hearing is excited by the waves of sound, and not by those of light, while the reverse is true of the nerve of sight.

15. By some writers six senses are accorded to man; the additional one being either the sense of temperature, for as we shall presently see this is not the same as touch; or, according to others, the muscular sense by which we are enabled to estimate the weights of bodies. The latter also differs in some respects from the sense of touch.

16. **Organs of Touch.**—The sense of touch is possessed by nearly all portions of the general surface of the body, but it

finds its highest development in the hands. The human hand is properly regarded as the model organ of touch. The minute structure of the skin fits it admirably for this form of sensation: the cuticle, or scarf-skin, is fine and flexible, while the cutis, or true skin, contains multitudes of nerve-filaments, arranged in rows of *papillæ*, or cone-like projections, about one-hundredth of an inch in length. It is estimated that there are 20,000 of these papillæ in a square inch of the palmar surface of the hand. Now, although the nerves of the cutis are the instruments by which impressions are received and transmitted to the brain, yet the cuticle is essential to the sensation of touch. This is shown by the fact that whenever the true skin is laid bare, as by a burn or blister, the only feeling it experiences from contact is one of pain, not that of touch.

17. The office of the cuticle is thus made evident: it is to shield the nerve filaments from direct contact with external objects. At the tips of the fingers, where touch is most delicate, the skin rests upon a cushion of elastic material, and receives firmness and permanence of shape by means of the nail placed upon the less sensitive side. Besides these favorable conditions, the form of the arm is such, and its motions are so easy and varied, that we are able to apply the test of touch in a great number of directions. The slender, tapering fingers, with their pliant joints, together with the thumb, enable the hand to grasp a great variety of objects; so that great as are the delicacy and grace of the hand, it is not wanting in the elements of power.

18. **The Sense of Touch.**—Touch is the simplest of the senses. It is that which the child first calls into exercise, and it is that which is in the most constant use throughout life. We are brought by the touch into the most intimate relations with external objects, and by it we learn the greater number, if not the most important, of the properties of these objects; such as size, figure, solidity, motion, and smoothness or roughness of surface.

19. The sense of touch assists the other senses, especially that of sight, giving foundation and reality to their perceptions. Without it, the impressions received by the eye would be as vague and unreal as the figures that float through our dreams. A boy who had been blind from birth, at the age of twelve years received sight by means of a surgical operation: at first, he was unable to distinguish between a globe and a circular card, of the same color, before he had touched them. After that, he at once recognized the difference in their form. He knew the peculiarities of a dog and a cat by feeling, but not by sight, until one day, happening to take up the cat, he recognized the connection of the two sorts of impressions, those of touch and sight; and then, putting the cat down, he said: "So puss, I shall know you next time."

20. Of all the senses, touch is considered the least liable to error; yet, if that part of the skin by which the sense is exercised is removed from its customary position, a false impression may be created in the mind. This is well illustrated by an experiment, which dates from the time of Aristotle. If we cross

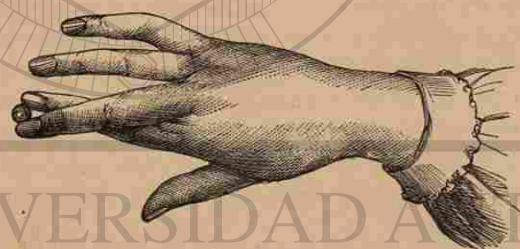

FIG. 34

the middle finger behind the fore-finger, and then roll a marble, or some small object, upon the tips of the fingers (see Fig. 34), the impression will be that two marbles are felt. If the fingers, thus transposed, be applied to the end of the tongue, two tongues will be felt.

21. The Delicacy of Touch.—Although the hand is the

proper organ of this sense, yet it is exercised by various parts of the body, their degree of sensibility being proportional to the number of papillæ they contain. The varying degrees of tactile delicacy of the different parts of the surface have been measured, in an ingenious manner, by means of a pair of compasses, tipped with small pieces of cork. The two points of the compasses are touched at the same moment to the skin, the eyes being closed, and it is found that, in sensitive parts, the distance between the points may be quite slight, and yet each be plainly felt; while, in less sensitive parts, the points of the compasses are felt as a single point, although they are separated one or two inches.

22. At the tips of the fingers, the distance between the points being one-twentieth of an inch, a double impression is felt. The distance must be twice as great, for the palm; four times as great, for the lips; and, on the forehead, it must be twenty times greater. At the middle of the back, where the touch is least acute, the points must be separated more than two inches before they can be separately felt. Therefore, the sense of touch in the fingers is said to be fifty times more delicate than upon the posterior surface of the body.

23. Exquisite delicacy of touch is attained by practice. This is shown in many of the lighter and more graceful employments of daily life. Without it, the skill of the painter, sculptor, and musician would be rude indeed. By training, also, the physician acquires the *tactus eruditus*, or discriminating touch; but among the blind, delicacy of touch is most remarkable, and it here finds its highest value; for its possession, in a measure, compensates the loss of sight by enabling them to read, by means of raised letters, to work with certain tools, and even to play upon musical instruments. A person born without sight, and without hearing or voice, may, by the education of the touch, be rescued from apparent imbecility, and be taught not only to read and write, but even to perform household and other useful labors.

24. Sensations of Temperature and Weight.—Each of these sensations has been described by the physiologists as a special sense, and they are rival candidates, so to speak, for the position and title of the sixth sense. In the sensation of temperature, or the thermal sense, touch bears a part, but the two feelings appear to be distinct. In proof of this, we observe, firstly, that they are not alike intense in the same situations; as, for example, the skin of the face and elbow, where the sense of touch is feeble, is very sensitive to impressions of heat and cold. Secondly, the ability to recognize temperature may be lost by paralysis, while the sensibility of touch remains unaffected. When the skin comes in contact with a very hot substance, the sensation felt is that of pain, not of touch. In like manner, a very cold substance causes pain, not the feeling of cold. So that a red-hot iron, and solid carbonic acid (the temperature of which is 108° below zero), feel alike; and each, if pressed slightly, will produce a blister.

25. The *muscular sense*, by some considered distinct from touch, gives rise to the sensations of weight, and other forms of external resistance. That this feeling exists, is shown by the following simple experiment. If the hand be placed flat upon a table, and a somewhat heavy weight be put into it, touch alone is exercised and a feeling of pressure results; but if the hand be raised, a certain amount of muscular effort must be put forth, and thus the sensation of weight is recognized. Through the muscular sense, precision of effort is rendered possible; for by it we learn to adjust the force exerted to the weight of the object to be lifted, moved, or carried. Without it, all our movements would necessarily become ill-regulated and spasmodic.

26. The Organ of Taste.—The *tongue* is the special organ of the sense of taste; but the back part of the mouth also possesses this faculty. The tongue is a muscular organ, the muscles composing it being so numerous and interwoven as to give it the freedom and variety of motion which it possesses.

It can curve itself upward or downward; it can extend or contract itself; and, with its point, can sweep the cavity of the mouth, in all directions, in the search for scattered particles of food.

27. The upper surface of the tongue is peculiar, being marked by the presence of innumerable *papillæ*, some of which are of microscopic size, resembling those that abound in the fingers, and in other parts of the body that have the sense of touch. Others are much larger, and give to the tongue its roughness of feeling and appearance. Through the medium of these papillæ, the tongue receives impressions of touch and temperature, as well as taste; indeed, its extremity is fully as delicate, in respect to tactile sensations, as the tips of the fingers themselves. It can recognize the two points of the compasses when separated not more than one-twenty-fourth of an inch; the back of it is much less sensitive to touch, while at the same time it is more highly sensitive to impressions of taste.

28. Each lateral half of the tongue resembles the other in structure, and each receives the same number of nerves—three. One of these regulates motion, the other two are nerves of special sense. One of the latter supplies the front half of the tongue, and is called the *gustatory* nerve. This is a branch of the great cranial nerve, called the "fifth pair," which ramifies in all parts of the face. The back of the tongue is endowed with the power of taste through a nerve known as the *glosso-pharyngeal*, because it is distributed both to the tongue and throat. This difference in the nervous supply of the tongue becomes significant, when we learn, as we shall presently, that each part of it perceives a different class of flavors.

29. The Sense of Taste.—Taste is the special sense by means of which we discover the savors, or flavoring properties of the substances, which come in contact with the tongue. Mere contact with the surface of the tongue, however, is not sufficient, but contact with the extremities of the nerves of taste within the papillæ is required. In order that the substance to be tasted may penetrate the cells covering the nerves, it must be either liquid in form, or readily soluble in the watery secretion of the mouth, the saliva. The tongue must be moist also. If the substance be insoluble, as glass or sand, or the tongue dry, the sense of taste is not awakened. In sickness, when the tongue is heavily coated, the taste is very defective, or, as is frequently expressed, "nothing tastes aright."

30. All portions of the tongue are not alike endowed with the sense of taste, that function being limited to the posterior third, and to the margin and tip of this organ. The soft palate, also, possesses the sense of taste; hence, an article that has an agreeable flavor may very properly be spoken of as palatable, as is often done. All parts of the tongue do not perceive equally well the same flavors. Thus, the front extremity and margin, which is the portion supplied by the "fifth pair" of nerves, perceives more acutely sweet and sour tastes; but the base of the tongue, supplied by the *glosso-pharyngeal* nerve, is especially sensitive to salt and bitter substances. The nerve of the front part of the tongue, as before stated, is in active sympathy with those of the face, while the relations of the other nerve are chiefly with the throat and stomach; so that when an intensely sour taste is perceived, the countenance is involuntarily distorted, and is said to wear an acid expression. On the other hand, a very bitter taste affects certain internal organs, and occasions a sensation of nausea, or sickness of the stomach.

31. Relations of Taste with other Senses.—Taste is not a simple sense. Certain other sensations, as those of touch, temperature, smell, and pain, are blended and confused with it; and certain so-called tastes are really sensations of another kind. Thus an astringent taste, like that of alum, is more properly an astringent feeling, and results from an impression made upon the nerves of touch, that ramify in the tongue.

32. Taste is largely dependent upon the sense of smell. A considerable number of substances, like vanilla, coffee, and gar-

lic, which appear to possess a strong and distinct flavor, have in reality a powerful odor, but only a feeble taste. When the sense of smell is interfered with by holding the nose, it becomes difficult to distinguish between substances of this class. The same effect is frequently observed when smell is blunted during an ordinary cold in the head. Sight, also, contributes to taste. With the eyes closed, food appears comparatively insipid; and a person smoking tobacco in the dark is unable to determine by the taste whether his cigar is lighted or not. Accordingly, it is not a bad plan to close the nose and shut the eyes when about to swallow some disagreeable medicine.

33. Influence of Education on the Taste.—The chief use of the sense of taste appears to be to act as a guide in the selection of proper food. Hence its organs are properly placed at the entrance of the digestive canal. As a general rule, those articles which gratify the taste are wholesome; while the opposite is true of those which impress it disagreeably. This statement is more exact in reference to the early years of life than to later years, when, by reason of mischievous habits, the sense of taste has become dulled or perverted. The desires of a child are simple; he is fully satisfied with plain and wholesome articles of diet, and must usually "learn to like" those which have a strongly marked flavor. Accordingly, it is far easier at this age to encourage the preference for plain food, and thus establish healthful habits, than later in life to uproot habits of indulgence in stimulating substances, after their ill effects begin to manifest themselves.

34. The tastes of men present the most singular diversities, partly the result of necessity and partly of habit or education. The Esquimaux like the rank smell of whale oil, which is a kind of food admirably suited to the requirements of their icy climate; and travelers who go from our climate to theirs are not slow to develop a liking for the same articles that the natives themselves enjoy. The sense of taste is rendered very acute by education, as is shown in an especial manner by those who become professional "tasters" of tea and wine.

35. The Sense of Smell—the Nasal Cavities.—The sense of smell is located in the delicate mucous membrane which lines the interior of the nose. That prominent feature of the face, the nose, which is merely the front boundary of the true nasal organ, is composed partly of bone and partly of cartilage. The upper part of it is united with the skull by means of a few small bones; to which circumstance is due its permanence of shape. The lower portion, or tip of the nose, contains several thin pieces of cartilage, which render it flexible and better able to resist the effects of blows and pressure. Behind the nose we find quite a spacious chamber, separated from the mouth by the hard palate, forming the "roof of the mouth," and also by the soft palate (see Fig. 35); and divided into two cavities by a central partition running from before backward.

36. These nasal cavities, constituting the true beginning of the air-passages, extend from the nose backward to the upper opening of the throat, and rise as high as the junction of the nose with the forehead. The inner wall of each cavity is straight and smooth; but from the outer wall there jut into each cavity three small scroll-like bones. The structure of these bones is very light, and hence they have been called the "spongy" bones of the nose. In this manner, while the extent of surface is greatly increased by the formation of these winding passages, the cavities are rendered extremely narrow; so much so, in fact, that a moderate swelling of the mucous membrane which lines them, as from a cold, is sufficient to obstruct the passage of air through them.

37. The Nerve of Smell.—The internal surface of the nasal passages is covered by a delicate and sensitive mucous membrane. Its surface is quite extensive, following, as it does, all the inequalities produced by the curved spongy bones of the nose. The upper portion of it alone is the seat of smell, since that part alone receives branches from the "first pair" of cranial

nerves, or the olfactory nerve, which is the special nerve of smell (see Fig. 32). In Fig. 35 is shown the distribution of this nerve, in the form of an intricate network upon the two upper spongy bones. The nerve itself (1) does not issue from the skull, but rests upon a thin bone which separates it from the cavity of the nose; and the branches which proceed from it pass through this bone by means of numerous small openings. The engraving represents the outer surface of the right nasal cavity; the three wave-like inequalities, upon which the nervous network is spread out, are due to the spongy bones. The left cavity is supplied in the same manner.

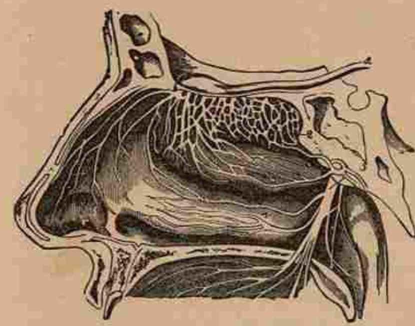

Fig. 35.—Section of the Right Nasal Cavity.

38. The nerves which ramify over the lower part of the membrane, and which endow it with sensibility to touch and pain, are branches of the "fifth pair" of nerves. An irritation applied to the parts where this nerve is distributed occasions sneezing, that is, a spasmodic contraction of the diaphragm; the object of which is the expulsion of the irritating cause. The manner in which the olfactory nerve-fibres terminate is peculiar. Unlike the extremities of other nerves, which are covered in by a greater or less thickness of tissue, these come directly to the surface of the mucous membrane, and thus come into very close contact with the odorous particles that are carried along by the respired air.

39. The Uses of the Sense of Smell.—Smell is the special sense which enables us to appreciate odors. Touch, as we have seen, is largely concerned with solid bodies; and taste, with fluids, or with solids in solution. Smell, on the other hand, is designed to afford us information in reference to substances in a volatile or gaseous form. Invisible particles come from odorous bodies, and are brought by the respired air in contact with the terminal filaments of the olfactory nerve, upon which an agreeable or disagreeable impression is produced. The fineness of the particles that constitute odors is often so extreme, that they elude all attempts to measure or weigh them. A piece of musk, for instance, may be kept for several years, constantly emitting perfume, without any appreciable loss of weight. In other cases, a loss of substance is perceptible, such as the essential oils, which enter into the composition of the ordinary perfumes.

40. Smell, like taste, aids us in the choice of proper food, leading us to reject such articles as have a rank or putrid odor, and which are, as a rule, unfit to be eaten. The highest usefulness of this sense, however, consists in the protection it affords to the organs of respiration. Stationed at the gateways of the air-passages, it examines the current of air as it enters, and warns us of the presence of noxious gases, and of other and generally invisible enemies to health. Not all dangerous vapors are offensive, but almost all offensive vapors are unfit to be breathed. A number of small stiff hairs grow from the margin of the nostrils to prevent the entrance of dust and other atmospheric impurities, which would be alike injurious to the olfactory mucous membrane and to the lungs. The benevolent design of the Maker of our bodies may be observed in all parts of their mechanism; but, probably, in none is it more clearly displayed than in connection with the sense of smell.

41. The Sense of Sight.—Sight, or Vision, is the special sense by means of which we appreciate the color, form, size, distance, and other physical properties of the objects of external nature. Primarily, this sense furnishes us with information concerning the different shades of color and the different degrees of brightness: these are the simple sensations of sight, such as the yellowness and glitter of a gold coin. In addition to these, there are composite visual sensations, produced by the joint action of the other senses and by the use of the memory and judgment; such as, in the case of the coin, its roundness, solidity, size, its distance and direction from us. So that many of our sensations, commonly considered as due to sight, are in reality the results of intellectual processes which take place instantaneously and unconsciously.

42. Light.—The Optic Nerve.—Unlike the senses previously considered—touch, taste, and smell—sight does not bring us into immediate contact with the bodies that are examined; but, by it, we perceive the existence and qualities of objects that are at a greater or less distance from us. In the case of the stars, the distance is incalculable, while the book we read is removed but a few inches. Light is the agent which gives to this sense its wide range. The nature of this mysterious force is not known, and it is not here to be discussed; since its study belongs more properly to the province of natural philosophy.

43. It is sufficient, in this connection, to state that the theory of light now generally accepted, and which best explains the facts of optics, is that known as the undulatory theory. This theory supposes that there exists an intangible, elastic medium, which fills all space, and penetrates all transparent substances, and which is thrown into exceedingly rapid undulations or waves, by the sun and every other luminous body, the undulations moving not less than 186,000 miles in a second.

44. These waves are thought to produce in the eye the sensation of light, in the same manner as the sonorous vibrations of the air produce in the ear the sensation of sound. That part of the eye which is sensitive to these waves is the expansion of the *optic nerve*. It is sensitive to no other impression than that of light, and it is the only nerve which is acted upon by this agent. The optic nerve, also called the "second pair" of cranial nerves, is the means of communication between the eye and the brain.

45. The Organ of Sight.—The Eye.—The proximity of the eye to the brain, and the important part it performs in giving expression to the emotions, have given it the name of "the window of the soul." The exceeding beauty of its external parts, and the high value of its function, have long made this organ the subject of enthusiastic study. It is chiefly within the last twenty years, however, that this study has been successful and fruitful of practical results. Several ingenious instruments have been invented for the examination of the eye in health and disease, and new operations have been devised for the relief of blindness and of impaired vision. As a result, it is now a well-marked fact that, in civilized lands, the number of those who suffer from loss of sight is proportionally much less than in countries where science is less known and cultivated.

46. The most obvious fact in respect to the apparatus of sight is that there are two eyes, which may either act together as one, and be fixed upon one object, or one eye may be used independently of the other. In consequence of this arrangement the loss of one eye does not necessitate blindness, and, in fact, it not infrequently happens that the sight of one eye may be long impaired or lost before the fact is discovered. We next notice that it is placed at the most elevated part of the body, in front, and near the brain. It also commands a wide range of view, being itself moved with great rapidity, and being further aided by the free motion of the head and neck. The organ of vision consists essentially of two parts: the optical instrument itself—the eyeball—and its enveloping parts, or the case in which the instrument is kept free from harm. The latter, which are external, and which we shall first consider, are chiefly the *Orbits*, the *Eyelids*, and the apparatus for the *Tears*.

47. The Orbits.—The eyeball, which is a delicate organ, is well defended against external injury within the orbits or bony sockets of the head. These are deep conical hollows, bounded in part by the bones of the skull, and in part by those of the nose and cheek. The orbit juts out beyond the most exposed portion of the eyeball, as may be seen by laying a book over the eye, when it will be found that no part of the eyeball, un-

less it be very prominent, will be touched by the book; so that the only direction in which an injury is liable to be received is immediately in front of the eye. The overhanging brow is itself covered by a layer of thick skin, studded with short, stout hairs, which are so bent as to prevent the perspiration from running into the eye and obscuring vision. Through a hole in the bottom of the orbit, the nerve of sight passes outward from the brain. The orbit also contains a considerable amount of a fatty tissue, upon which, as upon an elastic cushion, the eye rests.

48. The Eyelids.—The eyelids are two movable curtains, or folds, which, when shut, cover the front part of the orbit, and hide the eye from view. The upper lid is the larger, has a curved margin, and moves freely, while the lower lid is comparatively short and straight, and has but a slight degree of motion (Fig. 36). Skin covers the exterior of the lids, while a fine mucous membrane lines their inner surface, and is likewise spread out over the entire front of the eyeball. This membrane, which is called the *Conjunctiva*, is highly sensitive, and thus plays an important part in protecting the eye against the lodgment of sand, ashes, chaff, and other foreign particles that are blown about in the air. This sensitive membrane will not endure the presence of these particles. If any find access, it causes a constant winking, a flow of tears, and other signs of irritation, until it is removed.

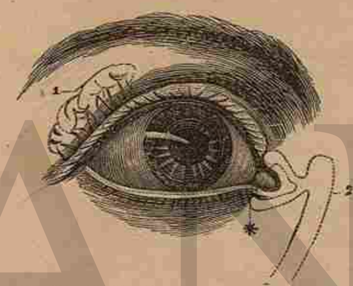

FIG. 36.—FRONT VIEW OF THE RIGHT EYE. (Natural Size.)

1. The Lachrymal, or tear gland, lying beneath the upper eyelid.

2. The Nasal Duct is shown by the dotted line. The * marks the orifice in the lower lid.

The central black spot is the *pupil*; surrounding it is the *iris*; and the triangular white spaces are the visible portion of the *sclerotic*.

49. The long, silky eyelashes, which garnish the edges of the lids, act like a sieve to prevent the entry of dust and the like; and together with the lids, they regulate the amount of light which is permitted to enter the eye, so that it is shielded from a sudden flood or glare of light. The little points seen in the figure just within the line of the lashes, especially on the lower lid, represent the mouths of numerous little sebaceous glands (Fig. 37, D, D), such as are always found in the neigh-

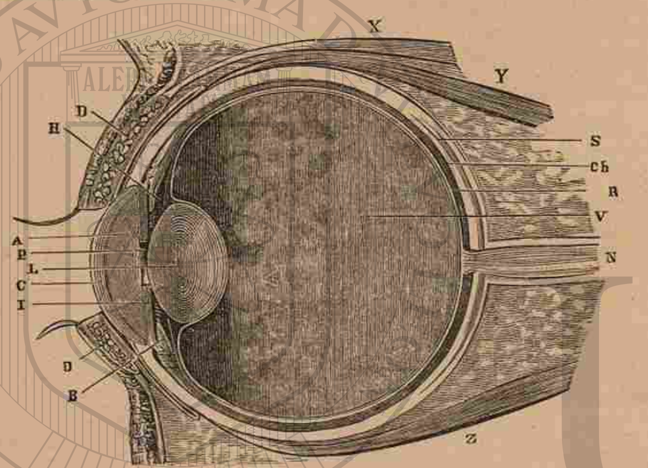

Fig. 37.—Vertical Section of the Eye. (Enlarged.)

C, The Cornea.
A, The Aqueous Humor.
I, The Iris.
P, The Pupil.
L, The Crystalline Lens.
H, The Ligament of the Lens.
B, The Ciliary Process.
V, The Cavity containing the Vitreous Humor.
S, The Sclerotic.
Ch, The Choroid.
R, The Retina.
N, The Optic Nerve.
DD, The Eyelids.
X, The Levator Muscle of the Upper Lid.
Y, The Upper Straight Muscle of the Eye.
Z, The Lower Straight Muscle.

borhood of hairs. These glands supply a thick, oily material which greases the edges of the lids and prevents their adhering together, and likewise prevents the overflow of the tears upon the cheek.

50. The Lachrymal Fluid, or the Tears.—Just within the outer part of the bony arch of the brow, where the bone may be felt to be sharper than in other positions, is lodged a little organ called the lachrymal gland, the situation of which is indicated in

Fig. 36, 1. This is the gland whence flows the watery secretion, commonly called the *tears*, which is designed to perform an exceedingly important duty in lubricating the lids, and in keeping the exposed surface of the eyeball moist and transparent. For, without this or some similar liquid, the front of the eye would speedily become dry and lustreless, like that of a fish which has been removed from the water: the simple exposure of the eye to the air would then suffice to destroy vision.

51. Secretion of the Tears.—This secretion of the tears takes place at all times, during the night as well as the day; but it is seldom noticed, unless a person is under the influence of some strong mental emotion, when it is poured forth in excess, so as to overflow the lids. Strong light or a rapid breeze will, among many other causes, excite the flow of the tears. That portion of this secretion not used in moistening the eye is carried off into the nose by a canal, called the *nasal duct*, situated near the inner angle of the eye. This duct, shown in Fig. 36, 2, is connected with each lid by delicate tubes, which are indicated by dotted lines in the figure; the asterisk marks the little opening in the lower lid, by which the tears enter the nasal duct. By gently turning the inner part of that lid downward, and looking in a mirror, this small "lachrymal point" may be seen in your own eye. In old people, these points become turned outwards, and do not conduct the tears to the nasal cavity, so causing an overflow of tears upon the face.

52. Thus we observe that the gland which forms the tears is placed at the outer part of the eye, while their means of exit is at the inner angle of the eye; which fact renders it necessary for this watery fluid to pass over the surface of the eyeball before it can escape. This arrangement cannot be accidental, but evinces design, for it thus secures the perfect lubrication of the surface of the eye, and cleanses it from the smaller particles of dust which may enter it, in spite of the vigilance of the lids and lashes. The act of winking, which is generally unconsciously performed, and which takes place six or more times in a minute, assists this passage of the tears across the eye, and is especially frequent when the secretion is most abundant.

53. The Eyeball.—The remarkable optical instrument called the eyeball, or the globe of the eye, upon which sight depends, is, as the name indicates, spherical in shape. It is not a perfect sphere, since the front part projects somewhat beyond the rest, and at the posterior part the optic nerve (Fig. 37, N) is united to it, resembling the junction of the stem with a fruit. In its long diameter, that is, from side to side, it measures a little more than an inch; in other directions it is rather less than an inch. In structure, the ball of the eye is firm, and may be felt by pressing the fingers over the closed lids.

54. The eyeball is composed chiefly of three internal, transparent media, called *humors;* and three investing coats, or *tunics*. The former are the *aqueous humor*, Fig. 37, A, the *crystalline lens* L, and the *vitreous humor* V. Of these the lens alone is solid. The three coats of the eyeball are called the *sclerotic* S, the *choroid* Ch, and the *retina* R. This arrangement exists in respect to five-sixths of the globe of the eye, but in the anterior one-sixth, these coats are replaced by the *cornea* C, which is thin and transparent, so that the rays of light pass freely through it, as through a clear window-pane.

55. The Cornea in shape is circular and prominent, resembling a miniature watch-glass, about $\frac{1}{25}$ of an inch thick. In structure, it resembles horn (as the name signifies), or the nail of the finger, and is destitute of blood-vessels. The *Sclerotic* (from *scleros*, hard) is composed of dense, white fibrous tissue, and gives to the eyeball its firmness of figure and its white color; in front, it constitutes the part commonly called "the white of the eye."

56. The Choroid is the second or middle coat of the eyeball, and lies closely attached to the inner surface of the sclerotic. Unlike the latter coat, its structure is soft and tender, it is dark in color, and possesses a great abundance of blood-vessels. Its dark color is due to a layer of dark brown or chocolate-colored cells spread out over its inner surface. This dark layer serves

to absorb the rays of light after they have traversed the transparent structures in front of it; if the rays were reflected from side to side within the eye, instead of being thus absorbed, confused vision would result from the multitude of images which would be impressed upon the optic nerve.

57. The Iris.—Continuous with the choroid, in the front part of the globe of the eye, is a thin, circular curtain, which occasions the brown, blue, or gray color of the eye in different individuals. On account of the varieties of its color, this membrane has received the name *Iris*, which is the Greek word for "rainbow" (See Fig. 37, I). A front view of it is shown in Fig. 36. The iris is pierced in its centre by a round opening, called the *pupil* (P), which is constantly varying in size. In olden times it was spoken of as the "apple of the eye." The hinder surface of the iris has a layer of dark coloring matter resembling that of the choroid. The iris is a muscular organ, and contains two distinct sets of fibres; one of which is circular, while the other radiates outward from the pupil. The action of these sets of fibres regulates the size of the pupil; for when the circular set acts, the pupil contracts, and when the other set acts, the opening expands. Their action is involuntary, and depends on the reflex system of nerves, which causes the contraction of the pupil when a strong light falls upon the eye, and its expansion when the illumination is feeble.

58. The iris, accordingly, serves a very useful purpose in regulating the admission of light to the eye. It, however, does not act instantaneously; and hence, when we pass quickly from a dark room into the bright sunlight, the vision is at first confused by the glare of light, but as soon as the pupil contracts, the ability to see becomes perfect. On the other hand, when we enter a dark apartment, such as a cellar, for a short time we can see nothing clearly; but as soon as the pupil expands and admits more light, we are enabled to distinguish the surrounding objects. Animals of the cat species, and others which prowl around after nightfall, are enabled to see in the dark by having the iris very dilatable. The size of the pupil affects the lustre of the eye. When it is large, as it usually is during youth, the eye appears clear and brilliant; while in old age the pupil is small and the eye is dull.

59. The Retina constitutes the third and inner coat of the globe of the eye. This, the important part of the eye that is sensitive to light, is a kind of nervous membrane, formed by the expansion of the optic nerve. Its texture is soft, smooth, and very thin; it is translucent and of a grayish-white color. It is sensitive to light alone; and if any form of mechanical irritation be applied to it, the sensations of touch and pain are not experienced, but flashes of fire, sparks, and other luminous appearances are perceived. Too intense light occasions a feeling of pain, but it is of a peculiar kind, and is termed "dazzling."

60. Impressions made upon the retina are not at once lost, but remain a measurable length of time, and then gradually fade away. Thus, a bright light or color, gazed at intently, cannot be immediately dismissed from sight by closing or turning away the eyes. A stick lighted at one end, if whirled around rapidly in the dark, presents the appearance of an unbroken luminous ring; and the spokes of a rapidly revolving carriage-wheel seem to be merged into a plane surface. If an object move too rapidly to produce this sort of lasting impression, it is invisible, as in the case of a cannon-ball passing through the air in front of us.

61. If a card, painted with two primary colors—as red and yellow—be made to rotate swiftly, the eye perceives neither of them distinctly; but the card appears painted with their secondary color—orange. The average duration of retinal images is estimated at one-eighth of a second; and it is because they thus endure, that the act of winking, which takes place so frequently, but so quickly, is not noticed and does not interrupt the vision. The retina is easily fatigued or deprived of its sensibility. After looking steadfastly at a bright light, or at a

white object on a black ground, a dark spot, corresponding in shape to the bright object, presents itself in whatever direction we look. This spot passes away as the retina resumes its activity. In some persons the retina is incapable of distinguishing different colors, when they are said to be affected with "color-blindness." Thus, red and green may appear alike, and then a cherry-tree, full of ripe fruit, will seem of the same color in every part. Railroad accidents have occurred because the engineer of the train, who was color-blind, has mistaken the color of a signal.

62. The Crystalline Lens.—Across the front of the eye, just behind the iris, is situated the *Crystalline lens*, enclosed within its own capsule. It is supported in its place partly by a delicate circular ligament, and partly by the pressure of adjacent structures. It is colorless and perfectly transparent, and has a firm but elastic texture. In shape it is double-convex, and may be rudely compared to a small lemon-drop. It is only one-fourth of an inch thick.

63. When this little body becomes opaque, and no longer affords free passage to the rays of light, as often happens with the advance of age, an affection termed "cataract" is produced. Between the crystalline lens and the cornea is a small space which contains the *aqueous humor* (See Fig. 37, A). This humor consists of five or six drops of a clear, colorless liquid very much like water, as its name implies. That part of the globe of the eye lying behind the lens is occupied by the *vitreous humor*, so called from its fancied resemblance to melted glass (Fig. 37, V). This humor is a transparent, jelly-like mass, enclosed within an exceedingly thin membrane, and constitutes fully two-thirds of the bulk of the eyeball.

64. The Uses of the Crystalline Lens.—A convex lens has the property of converging the rays of light which pass through it; and the point at which it causes them to meet is termed its focus. If a lens of this description, such as a magnifying or burning-glass, be held in front of an open window, in such a position as to allow its focus to fall upon a piece of paper, it will be found to depict upon the paper a miniature image of the scene outside of the window. It will be further noticed that the image is inverted, or upside down, and that the paper at the place upon which the image is thrown is much brighter than any other part. All the transparent structures of the eye, but especially the crystalline lens, operate upon the

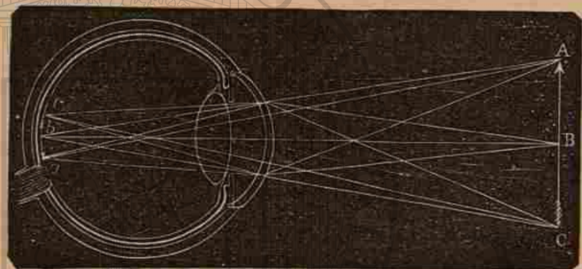

FIG. 38.—THE RETINAL IMAGE

retina, as the convex lens acts upon the paper; that is, they paint upon the retina a bright inverted miniature of the objects that appear in front of the eye (Fig. 38).

65. The form and structure of the crystalline lens endow it with a remarkable degree of refractive power, and enable it to converge all the rays of light that enter it through the pupil, to a focus exactly at the surface of the retina. When this lens is removed from the eye, as is frequently done for the cure of cataract, it is found that the rays of light then have their focus three-eighths of an inch behind the retina; that the image is four times larger than in the healthy eye, that it is less brilliant, and that its outline is very indistinct. From this we learn that one of the uses of the crystalline lens is to make the retinal image bright and sharply defined, at the same time that it reduces its size. Indeed, the small size of the image is a great advantage, as it enables the limited surface of the retina to receive, at a glance, impressions from a considerable field of vision.

66. As the image upon the retina is inverted, how does the mind perceive the object in its true, erect position? Many explanations have been advanced, but the simplest and most satisfactory appears to be found in the fact that the retina observes no difference, so to speak, between the right and left or the upper and lower positions of objects. Consequently, our knowledge of the relative location of external objects must be obtained from some other source than the retina. The probable source of this knowledge is the habitual comparison of those objects with the position of our own bodies: thus, to see an elevated object, we know we must raise the head and eyes; and to see one at our right hand, we must turn the head and eyes to the right.

67. **Long-sight or Hyperopia, and Short-sight or Myopia.** The eye is not in all cases perfectly formed. For example, persons may from birth have the cornea too prominent or too flat, or the lens may be too thick or too thin. In either of these conditions sight will be more or less defective from the first,

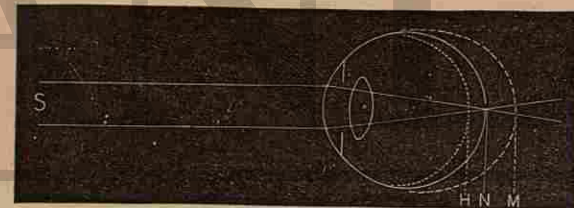

FIG. 39.—THE DIFFERENT SHAPES OF THE GLOBE OF THE EYE.
N, The Natural Eye. M, The Short-sighted Eye.
H, The Long-sighted Eye. S, Parallel Rays from the Sun

and the defect will not tend to disappear as life advances. The most common imperfection, however, is in the shape of the globe; which may be short (Fig. 39, H), as compared with the natural eye, N, or it may be too long, M.

68. When the globe is short, only objects that are at a distance can be clearly seen, and the condition of the vision is known as "long-sight," or hyperopia. It will be observed, by reference to Fig. 39, that the focus of the rays of light would fall behind the retina of this eye. When the globe is too long, only objects that are very near to the eye can be clearly seen; and the condition resulting from this defect is termed "short-sight," or myopia. The focus of the rays of light is, in this case, formed in the interior of the eye in front of the retina.

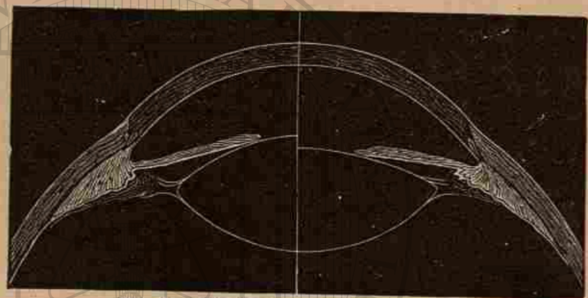

FIG. 40.—THE FUNCTION OF ACCOMMODATION.

The right half of the diagram shows the eye at rest. The left half shows the lens accommodated for near vision.

69. The Function of Accommodation.—If, after looking through an opera-glass at a very distant object, it is desired to view another nearer at hand, it will be found impossible to obtain a clear vision of the second object unless the adjustment of the instrument is altered; which is effected by means of the screw. If an object, like the end of a pencil, be held near the eye, in a line with another object at the other side of the room, or out of the window, and the eye be fixed first upon one and then upon the other, it will be found that when the pencil is clearly seen, the further object is indistinct; and when the latter is seen clearly, the pencil appears indistinct; and that it is impossible to see both clearly at the same time. Accordingly, the eye must have the capacity of adjusting itself to distances, which is in some manner comparable to the action of the screw of the opera-glass.

70. This, which has been called the function of accommodation, is one of the most admirable of all the powers of the eye, and is exercised by the crystalline lens. It consists essentially in a change in the curvature of the front surface of the lens, partly through its own elasticity, and partly through the action of the ciliary muscle. When the eye is at rest, that is, when accommodated for a distant object, the lens is flatter and its curvature diminished (see Fig. 40); but when strongly accommodated for near vision the lens becomes thicker, its curvature increases, and the image on the retina is made more sharp and distinct. Since a strong light is not required in viewing near objects, the pupil contracts, as is shown in the left-hand half of the diagram.

71. Old-sight, or Presbyopia.—But this marvellously beautiful mechanism becomes worn with use; or, more strictly speaking, the lens, like other structures of the body, becomes harder with the approach of old age. The material composing the lens becomes less elastic, the power to increase its curvature is gradually lost, and, as a consequence, the person is obliged to hold the book further away when reading, and to seek a stronger light. In a word, the function of accommodation begins to fail, and is about the first evidence that marks the decline of life. By looking at the last preceding diagram, and remembering that the increased curvature of the lens cannot take place, it will be at once understood why old-sight is benefited in near vision by the convex lens, such as the spectacles of old people contain. It acts as a substitute for the deficiency of the crystalline lens.

72. The Sense of Hearing.—Sound.—Hearing is the special sense by means of which we are made acquainted with *sound.* What is sound? It is an impression made upon the organs of hearing, by the vibrations of elastic bodies. This impression is commonly propagated by means of the air, which is thrown into delicate undulations, in all directions from the vibrating substance. When a stone is thrown into smooth water, a wave of circular form is set in motion, from the point where the stone struck, which, as it advances, constantly increases in size and diminishes in force.

73. Somewhat resembling this, is the undulation, or sound-wave, which is imparted by a sonorous vibration to the surrounding atmosphere. The rate of motion of this spherical wave of air is about 1050 feet per second, or one mile in five seconds. In water, sound travels four times as fast as in air, and still more rapidly through solid bodies; along an iron rod, its velocity is equal to two miles per second.

74. The earth, likewise, is a good conductor of sound. It is said that the Indian of our western prairies can, by listening at the surface of the ground, hear the advance of a troop of cavalry, while they are still out of sight, and can even discriminate between their tread and that of a herd of buffaloes. Solid substances also convey sounds with greater power than air. If the ear be pressed against one end of a long beam, the scratching of a pin at the other extremity may be distinctly heard, which will not be at all audible when the ear is removed from the beam. Although air is not the best medium for conveying sound, it is necessary for its production. Sound cannot be produced in a vacuum, as is shown by ringing a bell in the exhausted receiver of an air-pump, for it is then entirely inaudible. But let the air be readmitted gradually, then the tones become more and more distinct, and when the receiver is again full of air, they will be as clear as usual.

75. All sonorous bodies do not vibrate with the same degree of rapidity, and upon this fact depends the *pitch* of the sounds that they respectively produce. The more frequent the number of vibrations within a given time, the higher will be the pitch; and the fewer their number, the lower or graver will it be. Now, the rate of the successive vibrations of different notes has been measured, and it has thus been found that if they are less than sixteen in a second, no sound is audible; while if they exceed 60,000 per second the sound is very faint, and is painful to the ear. The extreme limit of the capacity of the human

ear may be considered as included between these points; but the sounds which we ordinarily hear are embraced between 100 and 3,000 vibrations per second.

76. The *ear*, which is the proper organ of hearing, is the most complicated of all the structures that are employed in the reception of external impressions. The parts of which it is composed are numerous, and some of them are extremely small and delicate. Nearly all these parts are located in an irregularly shaped cavity hollowed out in the temporal, or "temple," bone

FIG. 41.—THE EAR AND ITS DIFFERENT PARTS.
A, Diagram of the Ear.
a, *b*, External Ear. *d*, Middle Ear.
c, Membrane tympani. *e*, Internal Ear.
B to B‴, Bones of the Middle Ear (magnified).
C, The Labyrinths, or Internal Ear (highly magnified).

of each side of the head. That part of the bone in which the auditory cavity is placed has the densest structure of all bones of the body, and has therefore been called the "petrous," or rocky part of the temporal bone. In studying the ear, it is necessary to consider it as divided into three portions, which are called, from their relative positions, the *external* ear, the *middle* ear, and the *internal* ear. (In the diagram, Fig. 41, A, the first is not shaded, the second is lightly shaded, and the last has a dark background.)

77. The External Ear.—The external portion of the organ of hearing, designated in Fig. 41, A, includes, first, that outer part (*a*), which is commonly spoken of as "the ear," but which in fact is only the portal of that organ; and, secondly, the *auditory canal* (*b*). The former consists of a flat flexible piece of cartilage, projecting slightly from the side of the head, attached to it by ligaments, and supplied with a few weak muscles. Its surface is uneven, and curiously curved, and from its resemblance to a shell, it has been called the *concha*. It probably serves to collect sounds, and to give them an inward direction; although its removal is said not to impair the acuteness of hearing more than a few days.

78. The *auditory canal* Fig. 41, A, *b*), which is continuous with the outer opening of the ear, is a passage, an inch and a quarter in length, its inner extremity being bounded by a closely-fitting, circular membrane. This canal is of oval form, is directed forward and inward, and is slightly curved; so that the inner end is ordinarily concealed from view. The pouch of the skin which lines this passage is smooth and thin, especially at the lower end, where it covers the membrane just mentioned.

79. As in the case of the nostrils, a number of small, stiff hairs garnish the margin of the auditory canal, and guard it, to some extent, against the entrance of insects and other foreign objects. The skin, too, covering its outer half, is furnished with a belt of little glands which secrete a yellow, bitter substance, called "ear-wax," which is especially obnoxious to small insects. As the outer layer of this wax-like material loses its useful properties, it becomes dry, and falls out of the ear in the form of minute, thin scales, a fresh supply being furnished from the little glands beneath. In its form, the auditory canal resembles the tube of an ear-trumpet, and serves to convey the waves of sound to the middle portion of the ear.

80. The Middle Ear, or Tympanum.—The middle ear is a small cavity, or chamber, of irregular shape, about one-fourth

of an inch across from side to side, and half an inch long (see Fig, 41, A, *d*). From the peculiar arrangement of its various parts it has very properly been called the *tympanum*, or the "drum of the ear." The middle ear, like the external canal, contains air.

81. The circular membrane, already mentioned as closing the auditory canal, is the partition which separates the middle from the external ear, and is called the *membrana tympani* (*c*), and may be considered as the outer head of the drum of the ear. It is sometimes itself spoken of as the "drum," but this is incorrect; since a drum is not a membrane, but is the hollow space across which the membrane is stretched. This membranous drum-head is very tense and elastic, and so thin as to be almost transparent; its margin is fastened into a circular groove in the adjacent bone. Each wave of sound that touches this delicate membrane causes it to vibrate, and it, in turn, excites movements in the parts beyond.

82. Within the tympanum is arranged a chain of remarkable "little bones," or *ossicles*. They are chiefly three in number, and from their peculiar shapes bear the following names: *malleus*, or the mallet; *incus*, or the anvil; and *stapes*, or the stirrup. A fourth, the smallest bone in the body, in early life intervenes between the incus and stapes, but at a later period it becomes a part of the incus. It is called the *orbicular* bone. Small as are these ossicles—and they, together, weigh only a few grains—they have their little muscles, cartilages, and blood-vessels, as perfectly arranged as the larger bones of the body. One end of the chain of ossicles, the mallet, is attached to the membrane of the tympanum, or outer drum-head, while the other end, the stirrup, is firmly joined by its foot-piece to a membrane in the opposite side of the cavity. The chain, accordingly, hangs suspended across the drum between the two membranes; and when the outer one vibrates under the influence of the sound-wave, the chain swings inward and transmits the vibration to the entrance of the inner ear.

83. The musical instrument, the drum, is not complete if the air within be perfectly confined; we therefore find in all instruments of this kind a small opening in the side, through which air may pass freely. The tympanum, or drum of the ear, in like manner has an opening by means of which it communicates freely with the external air. This opening is a narrow canal, about an inch and a half long, called the *Eustachian tube*, after the name of its discoverer, Eustachius.

84. The course of this passage is indicated in Fig. 42, I,

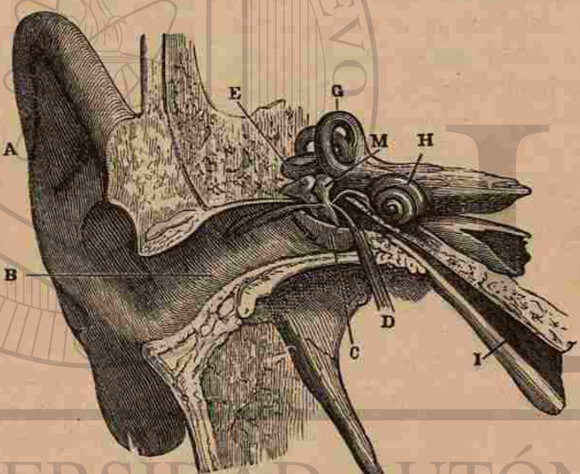

FIG. 42.—SECTION OF THE RIGHT EAR.

A, The Concha.
B, Auditory Canal.
C, Membrane of the Drum, (the lower half.)
D, A small muscle.
E, Incus, or Anvil.
M, Malleus, or Mallet.
I, Eustachian Tube.
G, Semicircular Canals
H, Cochlea, or snail's shell.

directed downward and inward: its other extremity opens into the upper part of the throat. The passage itself is ordinarily closed, but whenever the act of swallowing or gaping takes place, the orifice in the throat is stretched open, and the air of the cavity of the tympanum may then be renewed.

85. The Eustachian tube serves, also, as an escape-pipe for the fluids which form within the middle ear; and hence, when its lining membrane becomes thickened, in consequence of a cold, or sore throat, and the passage is thus more or less choked up, the fluids are unable to escape as usual, and therefore accumulate within the ear. When this takes place, the vibrations of the membrane are interfered with; the sounds heard appear muffled and indistinct; and a temporary difficulty of hearing, which is known as "throat-deafness," is the result. This result resembles the effect produced by interrupting the vibrations of a sonorous body, such as all are familiar with; if the finger be placed upon a piano-string or bell when it is struck, the proper sound is no longer fully and clearly emitted. But the primary use of this tube is to afford a free communication between the middle ear and the external atmosphere, and thus secure an equal pressure upon both sides of the membrane of the drum of the ear, however the density of the atmosphere may vary. If from undue tension of the membrane, pain is experienced in the ears, when ascending into a rare atmosphere, as in a balloon, or descending into a dense one, as in a diving-bell, it may be relieved by repeating the act of swallowing, from time to time, in order that the inner and outer pressure may thus be promptly equalized.

86. The Internal Ear, or Labyrinth.—The most essential part of the organ of hearing is the distribution of the *auditory nerve*. This is found within the cavity of the internal ear, which, from its exceedingly winding shape, has been termed the *labyrinth* (see Fig. 42, C). This cavity is hollowed out in dense bone, and consists of three parts; the *vestibule* (*a*), or ante-chamber, which is connected with the other two; the *cochlea* (*b*), or snail's shell; and the three *semicircular canals* (*c*). The manner in which the nerve of hearing is distributed is remarkable, and is peculiar to this nerve. In the vestibule and the canals its fibres are spread out over the inner surface, not of the bony cavity but of a membranous bag, which conforms to and partially fills that cavity; and which floats in it, being both filled and surrounded with a clear, limpid fluid.

87. A singular addition to the mechanism of hearing is observed within this membranous bag of the labyrinth. This consists of two small oval ear-stones, and a quantity of fine powder of a calcareous nature, which is called "ear-sand." When examined under the microscope, these sandy particles are seen to lie scattered upon and among the delicate filaments of the auditory nerve; and it is probable, that, as the tremulous sound-wave traverses the fluid of the vestibule, the sand rises and falls upon the nerve filaments, and thus intensifies the sonorous impression.

88. In the cochlea, or snail's shell, which contains the fluid, but no membrane, the nerve branches upon a spiral shelf. As many as three thousand nerve fibres of different lengths have been counted therein; these, it has been thought, form the grand, yet minutely small key-board, upon which strike all the musical tones that are destined to be conveyed to the brain. The vestibule, it is also supposed, takes notice of noise as distinguished from musical sounds; while the office of the semicircular canals is, in part at least, to prevent internal echoes, or reverberations.

89. The vestibule communicates with the chain of bones of the middle ear by means of a small opening, called the "oval window," or *fenestra ovalis*. Across this window is stretched the membrane, which has already been alluded to as being joined to the stirrup-bone of the middle ear. Through this window, then, the sound-wave, which traverses the external and middle ear, arrives at last at the labyrinth. The limpid fluid which the latter contains, and which bathes the terminal fibres of the nerve of hearing, is thus agitated, the nerve-fibres are excited, and a sonorous impression is conducted to the brain, or, as we say, a sound is heard.

90. Protection of the Sense of Hearing.—From what has been seen of the complicated parts which compose the organ of

hearing, it is evident that while many of them possess an exquisite delicacy of structure, Nature has well and amply provided for their protection. We have observed the concealed situation of the most important parts of the mechanism of the ear, the length of its cavity, its partitions, the hardness of its walls, and its communication with the atmosphere; all these provisions rendering unnecessary any supervision or care on our part in reference to the interior of the ear. But in respect to its external parts, which are under our control and within the reach of harm, it is otherwise. We may both observe the dangers which threaten them, and learn the means necessary to protect them.

91. One source of danger to the hearing consists in lowering the temperature of the ear, especially by the introduction of cold water into the auditory canal. Every one is familiar with the unpleasant sensation of distension and the confusion of sounds which accompany the filling of the ear with water when bathing: the weight of the water within it really distends the membrane, and the cold chills the adjacent sensitive parts. It is not surprising, therefore, that the frequent introduction of cold water and its continued presence in the ear enfeeble the sense of hearing. Care should be taken to remove water from the ear after bathing, by holding the head on one side, and, at the same time, slightly expanding the outer orifice, so that the fluid may run out. For a like reason, the hair about the ears should not be allowed to remain wet, but should be thoroughly dried as soon as possible.

92. Caution.—It may be stated as a general rule, to which there are but few exceptions, that no cold liquid should ever be allowed to enter the ear. When a wash or injection is rendered necessary, it should always be warmed before use. The introduction of cold air is likewise hurtful, especially when it pours through a crevice directly into the ear, as it may often do through the broken or partially closed window of a car. The avoidance of this evil gives rise to another almost as great; namely, the introduction of cotton or other soft substances into the ear to prevent it from "catching cold." This kind of protection tends to make the part unnaturally susceptible to changes of temperature, and its security seems to demand the continued presence of the "warm" covering. As a consequence of its presence, sounds are not naturally conveyed, and the sensitiveness of the nerve of hearing is gradually impaired.

93. The chief source of injury, however, to the ear is from the introduction of solid substances into the auditory canal, with the design of removing insects or other foreign objects that have found their way into the ear; or with the design of scraping out the ear-wax. For displacing a foreign object, it is usually sufficient to syringe the ear gently with warm water, the head being so held that the fluid easily escapes. If a live insect has gained entrance to the ear, it may first be suffocated by pouring a little oil upon it, and afterward removed by syringeing the ear as just mentioned.

94. The removal of ear-wax is generally unnecessary; for, as we have before seen, Nature provides that the excess of it shall become dry, and then spontaneously fall out in the form of fine scales. The danger from the introduction of solid implements into the outer ear is chiefly found in the fact that the membrane which lies at the bottom of it is very fragile, and that any injury of it is liable to be permanent, and to impair permanently the hearing of the injured ear.

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CHAPTER X.

THE VOICE.

Voice and Speech—The Larynx, or the Organ of the Voice—The Vocal Cords—The Laryngoscope—The Production of the Voice—The Use of the Tongue—The different Varieties of Voice—The Change of Voice—Its Compass—Purity of Tone—Ventriloquy.

1. Voice and Speech.—In common with the majority of the nobler animals, man possesses the power of uttering sounds, which are employed as a means of communication and expression. In man, these sounds constitute the voice; in the animals, they are designated as the cry. The song of the bird is a modification of its cry, which is rendered possible from the fact that its respiratory function is remarkably active. The sounds of the animals are generally, but not always, produced by means of their breathing organs. Among the insects, they are sometimes produced by the extremely rapid vibrations of the wings in the act of flight, as in the case of the mosquito; or they are produced by the rubbing together of hard portions of the external covering of the body, as in the cricket.

2. But man alone possesses the faculty of speech, or the power to use articulate sounds in the expression of ideas, and in the communication of mind with mind. Speech is thus an evidence of the superior endowment of man, and involves the culture of the intellect. An idiot, while he may have complete vocal organs and full power of uttering sounds or cries, is entirely incapable of speech; and, as a rule, the excellence of

the language of any people will be found to be proportional to their development of brain. Man, however, is not the only being that has the power to form articulate sounds, for the parrot and the raven may also be taught to speak by rote; but man alone attaches meaning to the words and phrases he employs.

3. Relation of Speech to Hearing.—Speech is intimately related to the sense of hearing. A child born deaf is, of necessity, dumb also; not because the organs of speech are imperfect, for he can utter cries and may be taught to speak, and even to converse in a rude and harsh kind of language; but because he can form no accurate notion of sound. And a person, whose hearing is not delicate, or as it is commonly expressed, who "has no ear for music," cannot sing correctly. A person who has impaired hearing commonly talks in an unnaturally loud and monotonous voice. These examples show the necessary relation of intelligence and the sense of hearing with that form of articulate voice, which is termed speech.

4. The Organ of the Voice.—The essential organ of the voice is the Larynx. This has been alluded to in its relation to the function of respiration; and, in the chapter on that subject, are figured the front view of that organ (Fig. 25), and its connection with the trachea, tongue, and other neighboring parts (Fig. 28). It is situated at the upper part of the neck, at the top of the trachea, or tube by which air passes into and out of the lungs. The framework of the larynx is composed of four cartilages, which render it at once very strong and sufficiently flexible to enable it to move according to the requirements of the voice.

5. The names of the cartilages are (1) the *thyroid*, which is a broad thin plate, bent in the middle and placed in the central line of the front part of the neck, where it is known as the *pomum Adami*, or Adam's apple (Fig. 43, B), and where it may be felt moving up and down with each act of swallowing; (2) the *cricoid*, which is shaped like a seal ring, with the broad part placed posteriorly (Fig. 43, E). At the top of the cricoid cartilage are situated the two small *arytenoid* cartilages, the right one of which is shown in Fig. 43, C. These latter little organs are much more movable than the other two, and are very important in the production of the voice. They have a true ball and socket joint, and several small muscles which contract and relax with as perfect regularity and accuracy as any of the larger muscles of the body.

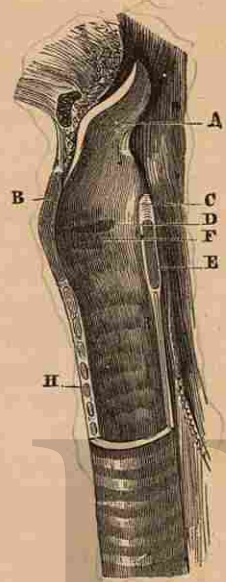

Fig. 43.
Section of the Larynx and Trachea.
A, The Epiglottis.
B, The Thyroid Cartilage.
C, Arytenoid Cartilage.
D, Ventricle of the Larynx.
E, Cricoid Cartilage.
F, Right Vocal Cord.
H, The Trachea.

6. The interior of the larynx is lined with a very sensitive mucous membrane, which is much more closely adherent to the parts beneath than is usually the case with membranes of this description. The epiglottis (A), consisting of a single leaf-shaped piece of cartilage, is attached to the front part of the larynx. It is elastic, easily moved, and fits accurately over the entrance to the air-passages below it. Its office is to guard these delicate passages and the lungs against the intrusion of food and other foreign articles, when the act of swallowing takes place. It also assists in modifying the voice.

7. The Vocal Cords.—Within the larynx, and stretched across it, from the thyroid cartilage in front to the arytenoid cartilages behind, are placed the two sets of folds, called the vocal cords. The upper of these, one on each side, are the false cords, which are comparatively fixed and inflexible. These are not at all essential to the formation of vocal sounds, for they have been injured, in those lower animals whose larynx resembles that of man, without materially affecting their charac-

teristic cries. Below these, one on each side, are the vocal cords (Fig. 43, F). They are composed of a highly elastic, though strong tissue, and are covered with a thin, tightly-fitting layer of mucous membrane. Their edges are smooth and sharply-defined, and when they meet, as they do in the formation of sounds, they exactly match each other.

8. If one or both of these cords are injured or become diseased, voice and speech are weakened; or when the mucous membrane covering them becomes thickened, in consequence of a cold, the vocal sounds are rendered husky and indistinct. When an opening is made in the throat below the cords, as not infrequently occurs in consequence of an attempt to commit suicide, voice is impossible except when the opening is closed by external pressure.

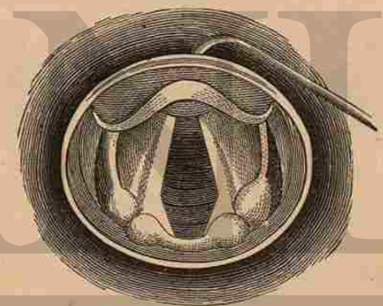

Fig. 44.—A View of the Vocal Cords by Means of the Laryngoscope.

9. The interval or space between the true cords of the voice is constantly varying, not only when their vocal function is in exercise, but also during the act of respiration. Every time the lungs are inflated, the space increases to make wide the entrance for the air; and diminishes slightly during expiration. So that these little cords move gently to and fro in rhythm with the expansion and contraction of the chest in breathing. These movements and others may be seen to take place, if a small mirror attached to a long handle be placed back into the upper part of the throat; the handle near the mirror must be bent at an angle of 45°, so that we may look "around the corner," so to speak, behind the tongue. The position which the mirror must assume will be understood by reference to Fig. 28. A view of what may be seen under favorable circumstances, during tranquil inspiration is represented in Fig. 44. The vocal cords are there shown as narrow, white bands, on each side of the central opening, and since the image is inverted, the epiglottis appears uppermost. The rings partly seen through the opening belong to the trachea. This little mirror is the essential part of an instrument, which is called the laryngoscope, and, simple as it may seem, it is accounted one of the most valuable of the recently invented appliances of the medical art.

FIG. 45.—THE DIFFERENT POSITIONS OF THE VOCAL CORDS.
A, The position during inspiration. B, In the formation of low notes. C, In the formation of high notes.

10. The Production of the Voice.—During ordinary tranquil breathing no sound is produced in the larynx, true vocal tones being formed only during forcible expiration, when, by an effort of the will, the cords are brought close together, and are stretched so as to be very tense. The space between them is then reduced to a narrow slit, at times not more than $\frac{1}{100}$ of an inch in width; and the column of expired air being forced through it causes the cords to vibrate rapidly, like the strings of a musical instrument. Thus the voice is produced in its many varieties of tone and pitch; its intensity, or loudness, depending chiefly upon the power exerted in expelling the air from the lungs. When the note is high, the space is diminished both in length and width; but when it is low, the space

is wider and longer (Fig. 45, B, C), and the number of vibrations is fewer within the same period of time.

11. The personal quality of the voice, or that which enables us to recognize a person by his speech, is mainly due to the peculiar shape of the throat, nose, and mouth, and the resonance of the air contained within those cavities. The walls of the chest and the trachea take part in the resonance of the voice, the air within them vibrating at the same time with the parts above them. This may be tested by touching the throat or breast-bone, when a strong vocal effort is made. The teeth and the lips also are important, as is shown by the unnatural tones emitted by a person who has lost the former, or by one who is affected with the deformity known as "hare-lip." The tongue is useful, but not indispensable to speech; the case of a woman is reported, from whom nearly the whole tongue had been torn out, but who could, nevertheless, speak distinctly and even sing.

12. The Varieties of voice are said to be four in number; two, the bass and tenor, belonging to the male sex; and two, the contralto or alto, and soprano, peculiar to the female. The baritone voice is the name given to a variety intervening between the bass and tenor. In man, the voice is strong and deep; in woman, soft and high. In infancy and early youth, the voice is the same in both sexes, being of the soprano variety: that of boys is both clear and loud, and being susceptible of considerable training, is highly prized in the choral services of the church and cathedral. At about fourteen years of age the voice changes, as it is termed; that is, it becomes hoarse and unsteady by reason of the rapid growth of the larynx. In the case of the girl, the change is not very marked, except that the voice becomes stronger and has a wider compass; but in the boy, the larynx nearly doubles its size in a single year, the vocal cords grow thicker, longer, and coarser, and the voice becomes masculine in character. During the progress of this change, the use of the voice in singing is injudicious.

13. The ordinary range of each of the four varieties of the voice is about two octaves; but this is exceeeded in the case of several celebrated vocalists. Madame Parepa Rosa has a compass of three full octaves. When the vocal organs have been subjected to careful training, and are brought under complete control of the will, the tension of the cords become exact, and their vibrations become exceedingly precise and true. Under these circumstances the voice is said to possess "purity" of tone, and can be heard at a great distance, and above a multitude of other sounds. The power of a pure voice to make itself heard was recently exemplified in a striking manner: at a musical festival held in an audience-room of extraordinary size, and amid an orchestra of a thousand instruments and a chorus of twelve thousand voices, the artist named above also sang; yet such was the purity and strength of her voice that its notes could be clearly heard rising above the vast waves of sound produced by the full accompaniment of chorus and orchestra.

14. Ventriloquism is a peculiar modification of natural speech, which consists in so managing the voice that words and sounds appear to issue, not from the person, but from some distant place, as from the chimney, cellar, or the interior of a chest. The ventriloquist not only seems to "throw his voice," as it is said, or simulates the sound as it usually appears at a distance with but little motion of the lips and face, but he imitates the voices of an infant and of a feeble old man, of a drunken man disputing with an exasperated wife, the broken language of a foreigner, the cry of an animal in distress, demonstrating that the performer must be proficient in the art of mimicry. Ventriloquism was known to the ancient Romans and Greeks; and it is thought that the mysterious responses that were said to issue from the sacred trees and shrines of the oracles at Dodona and Delphi, were really uttered by priests who had the power of producing this form of speech.

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APPENDIX.

Poisons and their Antidotes.

ACCIDENTS from poisoning are of such frequent occurrence, that every one should be able to administer the more common antidotes, until the *services of a physician can be obtained.* As many poisons bear a close resemblance to articles in common use, no dangerous substance should be brought into the household without having the word *poison* plainly written or printed on the label; and any package, box, or vial, without a label, if the contents are not positively known, should be at once destroyed.

When a healthy person is taken severely and *suddenly* ill *soon after some substance has been swallowed*, we may suspect that he has been poisoned. In all cases where poison has been taken into the stomach, it should be quickly and thoroughly expelled by some active emetic, which can be speedily obtained. This may be accomplished by drinking a tumblerful of warm water, containing either a tablespoonful of powdered mustard or of common salt, or two teaspoonfuls of powdered alum in two tablespoonfuls of syrup. When vomiting has already taken place, it should be maintained by copious draughts of warm water or mucilaginous drinks, such as gum-water or flaxseed tea, and tickling the throat with the finger until there is reason to believe that all the poisonous substance has been driven from the stomach.

The following list embraces only the more common poisons, together with such antidotes as are usually at hand, to be used until the physician arrives.

Acids.—*Hydrochloric acid; muriatic acid* (spirits of salt); *nitric acid* (aqua fortis); *sulphuric acid* (oil of vitriol).

ANTIDOTE.—An antidote should be given at once to neutralize the acid. Strong soapsuds is an efficient remedy, and can always be obtained. It should be followed by copious draughts of warm water or flaxseed tea. Chalk, magnesia, soda or saleratus (with water) or lime-water, are the best remedies. When sulphuric acid has been taken, water should be given sparingly, because, when water unites with this acid, intense heat is produced.

Oxalic acid.

ANTIDOTE.—Oxalic acid resembles Epsom salts in appearance, and may easily be mistaken for it. The antidotes are magnesia, or chalk mixed with water.

Prussic Acid; *oil of bitter almonds; laurel water; cyanide of potassium* (used in electrotyping).

ANTIDOTE.—Cold douche to the spine. Chlorine water, or water of ammonia largely diluted, should be given, and the vapor arising from them inhaled.

Alkalies and their Salts.—AMMONIA (hartshorn), *liquor or water of ammonia.* POTASSA:—*caustic potash, strong lye, carbonate of potassa* (pearlash), *nitrate of potassa* (saltpetre).

ANTIDOTE.—Give the vegetable acids diluted, as weak vinegar, acetic, citric, or tartaric acids dissolved in water. Castor oil, linseed oil, and sweet oil may also be used; they form soaps when mixed with the free alkalies, which they thus render harmless. The poisonous effects of saltpetre must be counteracted by taking mucilaginous drinks freely, so as to produce vomiting.

Alcohol.—*Brandy, wine; all spirituous liquors.*

ANTIDOTE.—Give as an emetic ground mustard or tartar emetic. If the patient cannot swallow, introduce a stomach pump; pour cold water on the head.

Gases.—*Chlorine, carbonic acid gas, carbonic oxide, fumes of burning charcoal, sulphuretted hydrogen, illuminating or coal-gas.*

ANTIDOTE.—For poisoning by chlorine, inhale, cautiously, ammonia (hartshorn). For the other gases, cold water should be poured upon the head, and stimulants cautiously administered; artificial respiration. (See *Marshall Hall's Ready Method,* page 180.)

Metals.—*Antimony, tartar emetic, wine of antimony,* etc.

ANTIDOTE.—If vomiting has not occurred, it should be produced by tickling the throat with the finger or a feather, and the abundant use of warm water. Astringent infusions, such as common tea, oak bark, and solution of tannin, act as antidotes.

Arsenic.—*White arsenic, Fowler's solution, fly-powder, cobalt, Paris green,* etc.

ANTIDOTE.—Produce vomiting at once with a tablespoonful or two of powdered mustard in a glass of warm water, or with ipecac. The antidote is hydrated peroxide of iron. If Fowler's solution has been taken, lime-water must be given.

Copper.—*Acetate of copper* (verdigris), *sulphate of copper* (blue vitriol), food cooked in dirty *copper vessels,* or pickles made green by *copper.*

ANTIDOTE.—Milk or white of eggs, with mucilaginous drinks (flaxseed tea, etc.), should be freely given.

Iron.—*Sulphate of iron* (copperas), etc.

ANTIDOTE.—Carbonate of soda in some mucilaginous drink, or in water, is an excellent antidote.

Lead.—*Acetate of lead* (sugar of lead), *carbonate of lead* (white lead), water kept in *leaden pipes* or *vessels,* food cooked in *vessels* glazed with *lead.*

ANTIDOTE.—Induce vomiting with ground mustard or common salt in warm water. The antidote for soluble preparations of lead is Epsom salts; for the insoluble forms, sulphuric acid largely diluted.

Mercury.—*Bichloride of mercury* (corrosive sublimate), *ammoniated mercury* (white precipitate), *red oxide of mercury* (red precipitate), *red sulphuret of mercury* (vermilion).

ANTIDOTE.—The white of eggs, or wheat flour beaten up with water and milk, are the best antidotes.

Silver.—*Nitrate of silver* (lunar caustic).

ANTIDOTE.—Give a teaspoonful of common salt in a tumbler of water. It decomposes the salts of silver and destroys their activity.

Zinc.—*Sulphate of zinc,* etc. (white vitriol).

ANTIDOTE.—The vomiting may be relieved by copious draughts of warm water. The antidote is carbonate of soda administered in water.

Narcotic Poisons.—*Opium* (laudanum, paregoric, salts of morphia, Godfrey's cordial, Dalby's carminative, soothing syrup, cholera mixtures), *aconite, belladonna, hemlock, stramonium, digitalis, tobacco, hyosciamus, nux vomica, strychnine.*

ANTIDOTE.—Empty the stomach by the most active emetics, as mustard, alum, or sulphate of zinc. The patient should be kept in motion, and cold water dashed on the head and shoulders. Strong coffee must be given. The physician will use the stomach pump and electricity. In poisoning by nux vomica or strychnine, etc., chloroform or ether should be inhaled to quiet the spasms.

Irritant Vegetable Poisons.—*Croton oil, oil of savine, poke, oil of tansy,* etc.

ANTIDOTE.—If vomiting has taken place, it may be rendered easier by copious draughts of warm water. But if symptoms of insensibility have come on without vomiting, it ought to be immediately excited by ground mustard mixed with warm water, or some other active emetic, and after its operation an active purgative should be given. After expelling as much of the poison as possible, strong coffee or vinegar and water may be given with advantage.

Poisonous Fish.—*Conger eel, mussels, crabs,* etc.

ANTIDOTE.—Evacuate, as soon as possible, the contents of the stomach and bowels by emetics (ground mustard mixed with warm water or powdered alum), and castor oil, drinking freely at the same time of vinegar and water. Ether, with a few drops of laudanum mixed with sugar and water, may afterward be taken freely.

Poisonous Serpents.—ANTIDOTE.—A ligature or handkerchief should be applied moderately tight above the bite, and a cupping-glass over the wound. The patient should drink freely of alcoholic stimulants containing a small quantity of ammonia. The physician may inject ammonia into the veins.

Poisonous Insects.—*Stings of scorpion, hornet, wasp, bee,* etc.

ANTIDOTE.—A piece of rag moistened with a solution of carbolic acid may be kept on the affected part until the pain is relieved; and a few drops of carbolic acid may be given frequently in a little water. The sting may be removed by making strong pressure around it with the barrel of a small watch-key.

Drowning.

MARSHALL HALL'S "READY METHOD" of treatment in asphyxia from drowning, chloroform, coal-gas, etc.

1st. Treat the patient *instantly on the spot*, in the *open air*, freely exposing the face, neck, and chest to the breeze, except in severe weather.

2d. In order *to clear the throat*, place the patient gently on the face, with one wrist under the forehead, that all fluid, and the tongue itself, may fall forward, and leave the entrance into the windpipe free.

3d. *To excite respiration*, turn the patient slightly on his side, and apply some irritating or stimulating agent to the nostrils, as *veratrine, dilute ammonia*, etc.

4th. Make the face warm by brisk friction; then dash cold water upon it.

5th. If not successful, lose no time; but, *to imitate respiration*, place the patient on his face, and turn the body gently, but completely, *on the side, and a little beyond*; then again on the face, and so on, alternately. Repeat these movements deliberately and perseveringly, *fifteen times only* in a minute. (When the patient lies on the thorax, this cavity is *compressed* by the weight of the body, and *ex*piration takes place. When he is turned on the side, this pressure is removed, and *in*spiration occurs.)

6th. When the prone position is resumed, make a uniform and efficient pressure *along the spine*, removing the pressure immediately, before rotation on the side. (The pressure augments the *ex*piration; the rotation commences *in*spiration.) Continue these measures.

7th. Rub the limbs *upward*, with *firm pressure* and with *energy*. (The object being to aid the return of venous blood to the heart.)

8th. Substitute for the patient's wet clothing, if possible, such other covering as can be instantly procured, each bystander supplying a coat or cloak, etc. Meantime, and from time to time, *to excite inspiration*, let the surface of the body be *slapped* briskly with the hand.

9th. Rub the body briskly till it is dry and warm, then dash *cold* water upon it, and repeat the rubbing.

Avoid the immediate removal of the patient, as it involves a *dangerous loss of time*—also, the use of bellows, or any *forcing* instrument; also, the *warm bath*, and *all rough treatment*.

The Care of the Sick-room.

The sick-room should be bright and airy, and "Sweetness and light" its motto. Other things being equal, it is best on one of the upper floors:—in the case of some "catching" disease on the top floor. Let it be on the sunny side of the house. If for any reason the light of the sun is temporarily to be avoided—as when the eyes are sensitive or have been operated upon—let the light be shut out by a proper arrangement of blinds or curtains. The air-supply to be breathed by the sick person should be pure. Those who, in health, find themselves in an impure air can quit it; they are not compelled to suffer from it; but a sick person may be incapable of recognizing the bad quality of the air, as well as helpless to free himself from it.

To keep the air pure, the windows should be opened as often as three times a day, care being taken to protect the patient from being chilled, while the room is being aired.

Unless the physician shall direct differently, one window—that most remote from the bed—should be open an inch or more both day and night, and in all seasons. The extent to which the sash shall be lowered must be governed largely by the weather and the direction of the wind.

A fire, in an open fireplace, except in summer weather, will be a great help towards keeping the air pure. The upward current through a chimney flue, if unobstructed, is equal to or not far below 20,000 cubic feet per hour: an outlet sufficient for a room occupied by ten persons.

The inlet of air, however, must not be forgotten, otherwise the air of the room tends to become both impure and rare. As our houses are generally constructed, the inlet of air is best secured by a window-sash being lowered from the top.

Take special care that no stationary wash-basin or other sewer-connected convenience is improperly plumbed, and that sewer gas cannot by any possibility escape into the sick-room.

The swinging of doors to create a current is not an efficient means of ventilation, as it agitates the air of the room without purifying it, and often disturbs the patient.

A draught of air is to be avoided; it will seldom occur that the air of the room requires to be so speedily changed that the patient need be exposed to a draught; never, when care has been taken to provide continuous and gradual ventilation.

It should be borne in mind that cold air is not necessarily pure air, and that ventilation is not less needed in winter than in warm weather.

Sleep is a great necessity to the sick. If a well person slumbers in the day-time, it will interfere with his sound repose at night, but with the sick this is generally not the case. The more they sleep the more favorable are the chances for their recovery: so that it will be readily seen how important it is to avoid noise and jar in the sick-room, especially if the disease is acute.

Bear in mind that even slight noises, as the rustling of garments, the creaking of doors, whispering or noisy footfalls, may be sufficient to disturb a brain that is rendered sensitive by pain or wakefulness.

The clothing next the skin should be changed more frequently in sickness than in health. These changes must be quickly and deftly made, and with as little disturbance as possible.

Under some conditions of disease, the best welfare of the patient is accomplished by having two beds in the room instead of one.

The temperature of the room must be watched. To that end a thermometer should always be present, and easily approached. It is better not to have it directly in the view of the patient. The temperature should not be allowed to vary much from 65° F., unless the doctor otherwise directs.

Let the furniture be as plain and as free from upholstery as possible: not many pieces are required. Movable carpets or rugs are better than those that are permanently laid. Curtains about the windows are out of place in a sick-room: so are flowering plants and birds, as a general rule. Florence Nightingale, however, makes an exception in the case of chronic invalids, and consents to the comforting influence of a pet bird or two.

In regard to the admission of visitors and conversation, much will depend upon the strength of the patient and the kind of sickness: at

many times these are to be forbidden, as having a disquieting influence. When contagious disease is in the house, the sick-room must be avoided by all except those who have the care of the patient, and those having this care should avoid coming in contact with the other members of the household, especially the children.

Bear in mind that everything brought in contact with the sick is liable to endanger the health of the well.

No articles in use by the invalid should be removed or used by others until thoroughly disinfected: the dishes and spoons should be put in boiling water before being taken from the room. The room itself should be fumigated with sulphur when the person is removed from it.

Old pieces of muslin, etc., may be used instead of handkerchiefs to receive the poisonous discharges from the nose, mouth, and throat. These can be destroyed by fire, and thus prevent the danger of conveying the disease to others.

"Taking the breath" and kissing should be avoided by those in attendance upon the case.

The bottles of medicine and other reminders of illness should, as far as convenient, be withdrawn from the view of the sick.

Such as are to be kept always at hand, should be arranged in an orderly way upon a tidily-covered bed-side table. The sight of a siphon-bottle of aërated water is agreeable to most patients: that may be kept in the room, but the vessels containing milk, drinking-water, etc., should be kept elsewhere.

Disinfection.

Filth fosters or produces certain diseases; it should therefore be removed as soon as possible. When it is difficult to remove it, disinfectants come into play, as they have the power to rob it of some of its disease-making force. But let it be remembered that disinfection is not cure: it is not a substitute for cleanliness and pure air. The true cure is the removal of filth: and when our homes are concerned in some question of drainage where the filth is out of our sight, it may be necessary to consult and employ the plumber or some other artisan.

In times gone by, it was the custom to mask bad smells by burning pastiles, coffee, cascarilla, and the like. These are not now much used, for most persons have come to understand that the fumes thus created do not remove but simply overpower the evil odors.

Chemistry has advanced to such a point that various pungent chemical substances, formerly not well known, can be furnished at small cost, and these substances have the power in varying degrees, to check vile odors.

Carbolic acid, chloride of lime, and Labarraque's solution are among the best known of these, but there are also certain of the salts of iron and zinc and the permanganate of potash that may be used. Sulphur is much used for the fumigation of rooms that have been infected.

Another cheap disinfectant is a solution of chloride of lead. It is inodorous, effective, and the cost is small. Take half a drachm of the nitrate and dissolve it in a pint or more of boiling water. Dissolve two drachms of common salt in a pail or bucket of water: pour the two solutions together and allow the sediment to sink. A cloth dipped in this solution and hung up in a room will correct a bad odor promptly, or if the solution be thrown down a drain or upon foul-smelling refuse, it will have the same effect.

The room to be purified with sulphur should be made as tight as possible, so that no fumes can escape, either by window, door or chimney. Put three pounds of sulphur in an iron pot, which should not stand upon woodwork or carpet, lest they be burned, but in a large pan of ashes, or upon a layer of bricks; on this sulphur pour a table-spoonful of alcohol. This is then set on fire, and everybody immediately withdraws from the room. The room should remain closed ten hours, after which it should be thoroughly aired before it is occupied, for the fumes of the sulphur are irritating to the lungs.

The chemicals above mentioned should be known and labeled as poisons. Many persons have been injured, if not killed, by incautiously or ignorantly drinking those that are of a liquid form.

Heat is one of the best, if not the best disinfecting agent. Articles of bedding and furniture that cannot well be treated otherwise can be purified by a long exposure to a temperature of 240° F. In some cities, especially in England, furnaces are made for the reception of bulky articles that have become infected.

Fresh pure air is another powerful agent. If woven fabrics, clothiug and the like are for a long time aired out of doors, they cease to be infective; probably by the enormous dilution, if not destruction, of the elements of danger.

Certain diseases are "catching"; they have the power of spreading from one person to another, chiefly by the particles that pass off from the body of the patient. Among these diseases are small-pox, measles, scarlet fever, and diphtheria. The articles that are worn or used by the patient become "infected," and they should be disinfected before they are used by others. As a rule, of course, a doctor will be called in to attend to these diseases. When that is so, follow his directions as to disinfection as well as every other part of the treatment of the case. For substances that are not injured by being washed, a good and cheap disinfectant is sulphate of zinc ("white vitriol") and common salt dissolved in water, boiling-hot if possible: using eight table-spoonfuls of the zinc and four of salt to the gallon of water. This is useful for clothing, bed-linen, towels, handkerchiefs, etc. After these articles have lain for an hour or two in this solution, they should be allowed to stand in boiling water before being washed. Infected articles that are of little value should, of course, be destroyed by fire.

The United States Treasury Department has published the following formula for the disinfection of the rags coming from Egypt: "1. Boiling in water for two hours under a pressure of fifty pounds per square inch; 2. Boiling in water for four hours without pressure; or, 3. Subjection to the action of sulphur fumes for six hours, burning one and one-half to two pounds of roll brimstone in each 1,000 cubic feet of space, with the rags well scattered upon racks." Either of these three methods is accepted as sufficiently thorough to prevent the spreading of cholera by means of rags.

Emergencies.

"The readiness is all."—HAMLET.

The life of many a child has been saved by the fire-drill in schools, and great good has been done on shipboard by a drilling of the crews.

If in a building filled with smoke, get down on hands and knees and crawl to door or window.

In a cellar, well, or vat where carbonic acid can collect, the true posture is to stand erect. If a candle, on being lowered into a suspected place, is put out, you may know that there is danger to human life.

Burns and Scalds.—The secret of the best treatment of these injuries is to exclude the air from the wounded surfaces. When they are slight, and the skin is not destroyed but merely blistered, prevent the displacement of the skin as much as possible. Let the blisters be punctured, if necessary, to let out the liquid, and then keep the skin in place by cotton cloth or lint, wet with a solution of one teaspoonful of carbolic acid in a quart of water, or a strong solution of baking soda. The cloth should be kept wet constantly, but do not irritate the wound by taking off the dressing too often.

Extensive burns are much worse than deep burns. In the former case, the outlook is grave and the patient will probably require the best aid, both medical and surgical, of some physician.

Scars after Burns.—If a burn be on the face, neck, or near a joint, it is not well to hasten the healing process, on account of the contraction that always takes place as the scar is formed.

"**Fire** is a source of danger, and is very destructive to life at times. Spontaneous combustion of the human body when saturated with alcohol is a myth, though perhaps the alcoholized body does burn more readily than one free from inflammable fluid. When a lady is on fire, she should not, and ought not to be permitted to run; that fans the flames amazingly. She must be laid down, and rolled up in the nearest woollen article,—rug, coat, or blanket. Such wrapping up in a non-inflammable article is a most effective method of extinguishing the flames. Immersion in water is, unfortunately, rarely practicable."—*Fothergill.*

Illuminating Gas is dangerous in two ways. If it escapes into a tightly closed room in sufficient quantities, it causes the death of the inmates by suffocation, unless some one from without discovers the perilous situation. If not too late, remove the patient into fresh air, undo the clothing, dash cold water on the face and neck, and employ artificial respiration, as in drowning (see p. 180). Again: If it escapes freely into an apartment, it forms an explosive compound by mixing with the air. If then a light is unguardedly taken into the place, an explosion that may be destructive to life will result. Always thoroughly air any room that has the odor of escaping gas before a light is taken in.

Kerosene is the cause of even more "accidents" than gas. Too much care cannot be taken in its use. Buy only that which has been tested, but remember that not all that are marked as "safe" are truly so. If a responsible oil-man certifies that the oil will not "flash" under 140°, it may be regarded as safe if properly used. Lamps should be filled only in the daytime. Never attempt to fill a lamp that is lighted, and never put kerosene in the stove for the purpose of kindling a fire. Very small lamps are dangerous, as also is a lamp that has burned a long time, and has but very little oil in it.

Frost-bites.—Keep away from the fire and in a cool room. Rub the nose or other part that has been "bitten" with snow or ice-water until the blood is again warmed and circulating in the part. Chilblains should not be brought to the fire; if the skin is unbroken, it should be hardened by brushing it over with alcohol having tannin in it.

Cuts.—These, if severe, should be promptly attended by a physician, but every one should know how to treat small wounds. Learn the difference between the two kinds of bleeding, called "arterial" and "venous." Arterial is bright red and comes in jets (or with throbs corresponding to the pulse); venous is dark colored and flows continuously. In the former, press on that side of the wound nearer to the heart; in the latter, on the further side. Or, pressure may be made over the wound itself with the

fingers: this may stop the loss of blood from small arteries as well as from veins. Loss of blood from arteries is apt to be more rapid and dangerous than that from veins, and when the cut vessel is a large one, the skill of the surgeon will ordinarily be required in order to close the bleeding artery permanently and securely.

It is well, in every household, to have, in some handy and well-known place, some strips of old muslin and some lint, or oakum, a bandage or two and some adhesive plaster, a soft sponge, and needles and thread in a basket or box by themselves. In this way, valuable time may be saved in the staunching of blood, flowing in consequence of some accidental cut or other injury.

Fits or Convulsions.—These may be trivial or grave. If it is a young woman, the attack is probably hysterical and, as a rule, not dangerous, and a sprinkle of cold water will bring relief. If the patient struggles with regularity of movement, and there is bloody froth on the lips, it is a case of epilepsy, and requires a physician's attendance. Meanwhile, protect the head from injury by putting a pillow or some soft article beneath it; a cork introduced between the teeth will prevent the biting of the tongue. Prevent the person from falling or injuring himself, but do not attempt to forcibly hold him quiet.

In children, apply cloths dipped in water to the head; disturb the child as little as possible; do not use a warm bath until directed by the doctor.

Fainting.—This occurs when the blood is deficient in the brain. The proper position, therefore, is upon the back. Let the window be opened to admit fresh air; fanning, and the sprinkling of water are useful. If the clothing about the chest is tight, let it be loosened. If the faint occurs at church or some public gathering, remove the person promptly to the outer air: for foul air is frequently the cause of the trouble.

Vertigo.—This is "a rush of blood to the brain." The body should be placed in the sitting posture, with the head erect. If the blood escapes into the brain by reason of the rupture of a blood-vessel within it, the case is very grave, and the physician should be summoned at once. Meanwhile, let the position of the body be as above stated. Apoplexy is known, in very many cases, by the helpless condition of an arm or leg, or both.

Sunstroke is seldom produced in this climate in persons who have not labored too hard. Fatigue and sun-heat are commonly the joint causes of sudden prostration in summer; although "heat-stroke" may occur in an artificially-heated atmosphere, without exposure to the sun. In the tropics, the least possible exertion is by the natives put forth during the midday hours. On very hot days, therefore, avoid fatigue and labor in the open air as much as possible. Keep the head cool. If any unusual, dizzy feeling comes on, apply cold water to the head and neck. If a person falls unconscious and the skin is decidedly hot and dry, he should be taken to a cool place. If the face and head are red and hot, apply ice-water on cloths. If pale, give stimulants gradually and use cold water sparingly.

Shock may be caused by a fall or a blow upon the head or the pit of the stomach. It is known by slowing of the pulse and respiration; the face is pale and the skin becomes cool. The head should be placed low, some ammonia in water be given and warmth applied to the surface of the body.

The Home and Health.

The location of the house should be airy, dry, and sunny.

A certain amount of elevation is necessary, in order to secure proper drainage. Too much shade must not fall upon the house, as sunlight is very necessary to a proper degree of animal vigor. Young children, as is well known, especially profit by the tonic influence of sunlight.

The cellar is an important part of the dwelling; therefore, unless care be taken for its ample ventilation, it will be the source from which is supplied much of the air breathed in the upper chambers of the house. If the cellar is damp the house is liable to become so, and if vegetables are stored in the cellar, an especial degree of care is needed to ventilate it thoroughly and constantly.

House Drainage.—An English writer has stated that "the most important part of the house is the drains." This, no doubt, sounds strangely to the ears of many, who have been brought up to view the parlor or drawing-room as the true centre of the house, and yet it is no foolish saying, when we reflect that with a bad system of drainage to a house every dweller therein stands in peril of several forms of disease that, mild as the cases may be, are a source of anxiety, and when severe, too often have a fatal termination. Drain-diseases, such as typhoid fever, dysentery, diphtheria, and scarlet fever, often destroy entire families. These diseases do not always spring upon a home through defective drainage, but when they do, they frequently show themselves in a very violent form.

Drainage (as applied to dwellings) consists in conveying away from the house the liquid and solid impurities that would otherwise accumulate in or near the dwelling. Waste is a necessary accompaniment of all animal life, to the preparation and the taking of food, to the clothing of the body, to bathing and other simple acts of daily life. The waste material of houses tends to decay and to become offensive. It must, therefore, not only be put out of sight and smell, but must be removed so far away that it cannot return in the form of dangerous, invisible gases of decomposition.

The best house-drains are made of iron or glazed earthenware, carefully selected and well laid. The joints of the pipes should be gas-tight. The soil-pipe should be carried up to and through the roof. All the waste-pipes from basins, etc., in the rooms should be joined in a gas-tight manner to the soil-pipe, and each and every basin and other fixture should have a separate trap. What is a trap? It is a device that is designed to retain a certain portion of the water running through it—called the "water-seal"—so that the ascent of air or gas, from the drain back into the room, is prevented. It "traps" the sewer gas away from us. Whenever a fixture has been used and there is not, beyond all doubt, a sufficiency of water to fill the trap, additional water should be poured in. Traps are of various sizes, and of an infinite variety of patterns and patents, and must vary greatly according to their situation, but one thing should be made sure of in their use, namely, that they hold not less than two inches of water as a "seal."

There is at almost all seasons of the year an upward, because warmer, current of air through the main pipes. It is therefore better to have a fresh-air inlet pipe near the point where the drain leaves the house-wall. This helps to prevent the unsealing of traps. It also brings about a purer condition of the air in the interior of the system of pipes: so useful is this air-current through the soil-pipe that if applied there is little danger of the escape of sewer gas into the living rooms.

What is sewer gas or sewer air? It varies greatly in different places and at different times. It is not a definite gas, like oxygen, nitrogen, etc., but varies in composition, and what is still more worthy of note, it varies in its dangerous qualities. It is not always offensive, although it is generally so; its odor has been described as being "sweetish and sickish." Its dangerous qualities have not yet been determined by chemistry or the microscope, but one practical point may be borne in mind, namely, that when a case or cases of contagious disease occur in any house along any given line of sewer pipes, it is best to use disinfectants in the drainage of the other dwellings along the same line of sewer. Children should avoid playing over or around the sewer gratings in the streets at all times, and especially when scarlet fever and like contagious diseases are known to be in the neighborhood, for the exit of sewer air at these points is always very free, unless it be directly after a rainfall.

One other point must be remembered, that the best laid system of house plumbing is not indestructible. In the course of time, defects will arise, breaks will occur; for this reason it would be well for every householder to have an examination made at intervals of every joint and along the whole line of the house connection with the sewer or drain.

It is thought by many that sewer gas is not found in the country because there are no sewers: they have been misled by the word. If the words "drain air" or "filth gas" had been adopted, the universal production of this injurious substance, in close connection with every abode of man, wherever located, might have been better understood. In country houses there are, perhaps, fewer dangers of contamination of the air we breathe by waste products, because there are fewer water-closets, wash-basins, sinks, etc., and the rooms are less exposed to impure air.

But in the country danger is apt to come by or through the pollution of the water supply. The well, which furnishes that cool and refreshing draught, is the point to be watched. It is convenient to have the well near the house, because when snow is on the ground and the weather is cold, the distance to the well from the house is a matter of no small moment. Near the house must be the stable and pens for animals: the waste from the house goes upon the ground, and not very far away from the house: the chamber slops and the more offensive matters go into a pit, which must not be too distant. The result of all these conditions is a pollution of the soil at all these points—a pollution which spreads with every rainfall, and which, sooner or later, reaches the well; yet the water may appear as pure as ever. It only remains to have the suitable disease-germ lodged in this polluted territory to bring down the whole household with a fever. This is the kind of soil-pollution which is hard to cure, and which, in long-settled countries, causes laws to be enacted requiring all vaults for the reception of house and human waste to be made water-tight, so as to save the soil from its poisoning influence.

This is the kind of poisoning which, in the Dark Ages, caused so much unrighteous persecution of the innocent. In those days, no care whatever was taken in the towns, high-walled, crowded, and unsewered, to protect the water supply from pollution: as a result, some terrible epidemic of fever would arise. Then the angry populace would, in their ignorance, cry out: "The Jews have poisoned the wells." The wells were poisoned, no doubt, but the Jew was no more worthy of blame than were his accusers. Nevertheless, the Jews were not spared: they were robbed, imprisoned, executed.

Drainage in the city is a comparatively easy problem when the city's sewers are laid in the streets. In the country it is more difficult, and on this account the fewer fixtures or "modern improvements" there are in the house the better it will be. There should be no less care within the country house, where waste-pipes are put in, than in the city house.

The material should be well selected, tightly joined, and properly ventilated. The water-closet should be remote from the house. Earth-closets are better than the ordinary vaults—house-waste from kitchen and laundry should be taken to a considerable distance from the house, and far away from the well, and either deposited in a water-tight cesspool or conveyed away, by a system of subsoil drainage tiles, arranged so as to fertilize some unoccupied plot of ground.

On Going into the Country.

To spend the summer in the country would be the choice of all city-dwellers, whenever their purses will permit of it. And there are not a few advantages in such a course; the change of scene is good, the mountains and the seaside give a purer and cooler air: an air that invigorates and aids in restful sleep at night, so different from the midsummer atmosphere in hot cities. There are fewer excitements in the country; we do not "live so fast," and there is full scope for healthful life and activity in the open air, with the green and blue of nature all about us, instead of the monotonous walls of towering houses.

But this course, pleasant and helpful to so many, is not without its danger. Many who "go away" on vacation are brought home sick on account of fever or other sickness caused by defects and faults of drainage existing in these temporary summer homes. Scarcely a year goes by that one or more summer resorts have not gained the ill name of being the hotbeds of typhoid fever, dysentery, and the like.

In view of this, how important it becomes that we exercise judgment and seek skilled advice in the selection of our summering places.

Again, there is another danger that must not be overlooked. Let us suppose that the summer vacation has passed by without accident; that we return invigorated by the experience; and that the home in the city has been empty and closed during our absence; what has happened that the air in the rooms newly reopened should be foul and stifling? This has taken place; the water that stands in the traps of house pipes, and shuts off gases from the sewer, when the rooms are in use and water is daily entering the different wash-basins, etc., has during our absence been evaporated. For weeks, perhaps, there has been no "water-seal" in the traps, and the ascent of sewer air has been going on continuously, so that not only is the air utterly unfit to live in, but all the curtains, carpets, and other absorbing materials have become saturated with the pollution thus allowed to enter. Let it be remembered that when a sink, etc., is not in use, it is gradually losing the trap-water by the evaporation.

What is the remedy, you will ask, for the condition of things caused by closing up the house, as above stated? To this the reply is, that the house should from time to time be opened and aired, and water should be poured down each and every sanitary fixture, in sufficient quantity to renew the supply of water in the trap of each.

GLOSSARY.

AB-DO′MEN (Latin *abdo*, to conceal). The largest cavity of the body, containing the liver, stomach, intestines, etc.; the belly.

AB-SOR′BENTS (L. *ab* and *sorbeo*, to suck up). The vessels which take part in the process of absorption.

AB-SORP′TION. The process of sucking up fluids by means of an animal membrane.

AC-COM-MO-DA′TION of the Eye. The alteration in the shape of the crystalline lens, which accommodates or adjusts the eye for near and remote vision

AC′ID, LACTIC (L. *lac*, milk). The acid ingredient of sour milk; the gastric juice also contains it.

AL-BU′MEN, or Albumin (L. *albus*, white). An animal substance resembling white of egg.

AL-BU′MI-NOSE (from *albumen*). A soluble animal substance produced in the stomach by the digestion of the albuminoid substances.

AL-BU′MIN-OID substances. A class of proximate principles resembling albumen; they may be derived from either the animal or vegetable kingdoms.

AL′I-MENT (L. *alo*, to nourish). That which affords nourishment; food.

AL-I-MENT′A-RY CA-NAL (from *aliment*). A long tube in which the food is digested, or prepared for reception into the system.

AN-ÆS-THET′ICS (Greek, *αν*, *an*, without, *αἰσθησία*, *aisthesia*, feeling). Those medicinal agents which prevent the feeling of pain, such as chloroform, laughing-gas, etc.

AN-I-MAL′CULE (L. *animal′culum*, a small animal). Applied to animals which can only be seen with the aid of the microscope. Animalculum (plural, animalcula) is used with the same meaning.

A-OR′TA (Gr. *ἀορτέομαι*, *aorteomai*, to be lifted up). The largest artery of the body, and main trunk of all the arteries. It arises from the left ventricle of the heart. The name was first applied to the two large branches of the trachea, which appear to be lifted up by the heart.

A′QUE-OUS HUMOR (L. *aqua*, water). A few drops of watery colorless fluid occupying the space between the cornea and crystalline lens.

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A-RACH'NOID MEM'BRANE (Gr. ἀράχνη, *arachne*, a cobweb, and εἶδος, *eidos*, like). An extremely thin covering of the brain and spinal cord. It lies between the *dura mater* and the *pia mater*.

AR'BOR VI'TÆ (L.). Literally, "the tree of life;" a name given to the peculiar appearance presented by a section of the cerebellum.

AR'TERY (Gr. ἀήρ, *aer*, air, and τηρεῖν, *terein*, to contain). A vessel by which blood is conveyed away from the heart. It was supposed by the ancients to contain air; hence the name.

AR-TIC-U-LA'TION (L. *articulo*, to form a joint). The more or less movable union of bones, etc.; a joint.

A-RYT'E-NOID CAR'TI-LA-GES (Gr. ἀρύταινα, *arutaina*, a pitcher). Two small cartilages of the larynx, resembling the mouth of a pitcher.

AS-SIM-I-LA'TION (L. *ad*, to, and *similis*, like). The conversion of food into living tissue.

AU-DI'TION (L. *audio*, to hear). The act of hearing sounds.

AU'DI-TO-RY NERVE. One of the cranial nerves; it is the special nerve of hearing.

AU'RI-CLE (L. *auris*, the ear). A cavity of the heart.

BAR'I-TONE (Gr. βαρύς, *barus*, heavy, and τόνος, *tonos*, tone). A variety of male voice between the bass and tenor.

BEL-LA-DON'NA (It. beautiful lady). A vegetable narcotic poison. It has the property of enlarging the pupil, and thus increasing the brilliancy of the eye; so called from its use by Italian ladies.

BI-CUS'PID (L. *bi*, two, and *cuspis*, prominence). The name of the fourth and fifth teeth on each side of the jaw; possessing two prominences.

BILE. The gall, or peculiar secretion of the liver; a viscid, yellowish fluid, and very bitter to the taste.

BRONCH'I (Gr. βρόγχος, *bronkos*, the windpipe). The two first divisions or branches of the trachea; one enters each lung.

BRONCH'I-AL TUBES. The smaller branches of the trachea within the substance of the lungs, terminating in the air-cells.

BRONCH-I'TIS (from *bronchia*, and *itis*, a suffix signifying inflammation). An inflammation of the larger bronchial tubes; a "cold" affecting the lungs.

CAL-CA'RE-OUS (L. *calx*, lime). Containing lime.

CA-NAL' (L.). In the body, any tube or passage.

CA-NINE' (L. *canis*, a dog). Name given to the third tooth on each side of the jaw; in the upper jaw it is also known as the eye-tooth, pointed like the tusks of a dog.

CAP'IL-LA-RY (. *capil'lus*, a hair, *capilla'ris*, hair-like). The name of the extremely minute blood-vessels which connect the arteries with the veins.

CAR'BON DIOX-IDE (CO_2). Chemical name for carbonic acid gas.

CAR-BON'IC A'CID. The gas which is present in the air expired from the lungs; a waste product of the animal kingdom, and a food of the vegetable kingdom.

CAR'DI-AC (Gr. καρδια, *cardia*, the heart). The cardiac orifice of the stomach is the upper one, and is near the heart; hence its name.

CAR-NIV'O-ROUS (L. *ca'ro*, flesh, and *vo'ro*, to devour). Subsisting upon flesh.

CA-ROT'ID AR-TE-RY. The large artery of the neck, supplying the head and brain.

CAR'TI-LAGE. A solid but flexible material, forming a part of the joints, air-passages, nostrils, ear; gristle.

CA'SE-INE (L. *ca'seus*, cheese). The albuminoid substance of milk, it forms the basis of cheese.

CER-E-BEL'LUM (diminutive for *cer'ebrum*, the brain). The little brain, situated beneath the posterior third of the cerebrum.

CER'E-BRUM (L.) The brain proper, occupying the entire upper portion of the skull. It is nearly divided into two equal parts, called "hemispheres," by a cleft extending from before backward.

CHO'ROID (Gr. χόριον, *chorion*, a membrane or covering). The middle tunic or coat of the eyeball.

CHYLE (Gr. χυλός, *chulos*, juice). The milk-like fluid formed by the digestion of fatty articles of food in the intestines.

CHYME (Gr. χυμός, *chumos*, juice). The pulpy liquid formed by digestion within the stomach.

CIL'I-A (pl. of *cil'i-um*, an eyelash). Minute, vibratile, hair-like processes found upon the cells of the air-passages, and other parts that are habitually moist.

CIR-CU-LA'TION (L. *cir'culus*, a ring). The circuit, or course of the blood through the blood-vessels of the body, from the heart to the arteries, through the capillaries into the veins, and from the veins back to the heart.

CO-AG-U-LA'TION (L. *coag'ulo*, to curdle). Applied to the process by which the blood clots or solidifies.

COCH'LE-A (L. *coch'lea*, a snail-shell). The spiral cavity of the internal ear.

CONCH'A (Gr. κόνχη, *konche*, a mussel-shell). The external shell-shaped portion of the external ear.

CON-JUNC-TI'VA (L. *con* and *jun'go*, to join together). A thin layer of mucous membrane which lines the eyelids and covers the front of the eyeball; thus joining the latter to the lids.

CON-TRAC-TIL'I-TY (*L. con* and *tra'ho*, to draw together). The property of a muscle which enables it to contract, or draw its extremities closer together.

CON-VO-LU'TIONS (L. *con* and *vol'vo*, to roll together). The tortuous foldings of the external surface of the brain.

CON-VUL'SION (L. *convel'lo*, to pull together). A more or less violent agitation of the limbs or body.

COR'NE-A (L. *cor'nu*, a horn). The transparent, horn-like substance which covers the anterior fifth of the eyeball.

COR'PUS-CLES, BLOOD (L. dim. of *cor'pus*, a body). The small bi-concave disks which give to the blood its red color; the *white* corpuscles are globular and larger.

COS-MET'IC (Gr. κοσμέω, *kosmeo*, to adorn). Beautifying; applied to articles which are supposed to increase the beauty of the skin, etc.

CRA'NI-AL (L. *cra'nium*, the skull). Pertaining to the skull. The nerves which arise from the brain are called cranial nerves.

CRI'COID (Gr. κρίκος, *kri'kos*, a ring). A cartilage of the larynx resembling a seal-ring in shape.

CRYS'TAL-LINE LENS (L. *crystal'lum*, a crystal). One of the so-called humors of the eye; a double convex body situated in the front part of the eyeball.

CU'TI-CLE (L. dim. of *cu'tis*, the skin). The scarf-skin; also called the *epider'mis*.

CU'TIS (Gr. σκῦτος, *skutos*, a skin or hide). The true skin, lying beneath the cuticle; also called the *der'mis*.

DE-CUS-SA'TION (L. *decus'sis*, the Roman numeral ten, X). A reciprocal crossing of fibres from side to side.

DI'A-PHRAGM (Gr. διαφράσσω, *diaphrasso*, to divide by a partition). A large, thin muscle which separates the cavity of the chest from the abdomen; a muscle of respiration.

DIF-FUS'ION OF GASES. The power of gases to become intimately mingled, without reference to the force of gravity.

DUCT (L. *du'co*, to lead). A narrow tube; the *thoracic duct* is the main trunk of the absorbent vessels.

DU-O-DE'NUM (L. *duode'ni*, twelve each). The first division of the small intestines, about twelve fingers-breadth long.

DU'RA MA'TER (L.). Literally, the hard mother; the tough membrane which envelops the brain.

DYS-PEP'SI-A (Gr. δυς, *dus*, difficult, and πεπτω, *pepto*, to digest). Difficult or painful digestion; a disordered condition of the stomach.

E-MUL'SION (L. *emul'geo*, to milk). Oil in a finely divided state suspended in water.

EN-AM'EL (Fr. *email*). The dense material which covers the crown of the tooth.

EN'ER-GY, Specific, of a Nerve. When a nerve of special sense is excited, whatever be the cause, the sensation experienced is that peculiar to the nerve; this is said to be the law of the specific energy of the nerves.

EP-I-GLOT'TIS (Gr. ἐπί, *epi*, upon, and γλῶττις, *glottis*, the entrance to the windpipe). A leaf-shaped piece of cartilage which covers the top of the larynx during the act of swallowing.

EX-CRE'TION (L. *excer'no*, to separate). The separation from the blood of the waste particles of the body; also the materials excreted.

EX-PI-RA'TION (L. *expi'ro*, to breathe out). The act of forcing air out of the lungs.

EX-TEN'SION (L. *ex*, out, and *ten'do*, to stretch). The act of restoring a limb, etc., to its natural position after it has been flexed, or bent; the opposite of *Flexion*.

FE-NES'TRA (L.). Literally, a window; the opening between the middle and internal ear.

FI'BRIN (L. *fi'bra*, a fibre). An albuminoid substance found in the blood; in coagulating it assumes a fibrous form.

FLEX'ION (L. *flecto*, to bend). The act of bending a limb, etc.

FOL'LI-CLE (L. dim. of *fol'lis*, a bag). A little pouch or depression in a membrane; it has generally a secretory function.

FUN'GOUS GROWTHS (L. *fun'gus*, a mushroom). A low grade of vegetable life.

GAN'GLI-ON (Gr. γάγγλιον, *ganglion*, a knot). A knot-like swelling in the course of a nerve; a smaller nerve-centre.

GAS'TRIC (Gr. γαστήρ, *gaster*, stomach). Pertaining to the stomach.

GLAND (L. *glans*, an acorn). An organ consisting of follicles and ducts, with numerous blood-vessels interwoven; it separates some particular fluid from the blood.

GLOS'SO-PHAR-YN-GE'AL NERVE (Gr. γλῶσσα, *glossa*, the tongue, and φάρυγξ, *pharugx*, the throat). The nerve of taste supplying the posterior third of the tongue; it also supplies the throat.

GLU'TEN (L.). Literally, glue; the glutinous albuminoid ingredient of wheat.

GRAN'ULE (L. dim. of *gra'num*). A little grain; a microscopic object.

GUS-TA'TION (L. *gusto*, to taste). The sense of taste.

GUS'TA-TO-RY NERVE. The nerve of taste supplying the front part of the tongue, a branch of the "fifth" pair.

HEM'OR-RHAGE (Gr. αἷμα, *hai'ma*, blood, and ῥήγνυμι, *regnumi*, to burst). Bleeding, or the loss of blood.

HEM-I-PLE'GIA (Gr. ἥμισυς, *hemisus*, half, and πλήσσω, *plesso*, to strike). Paralysis, or loss of power, affecting one side of the body.

HEM'I-SPHERES (Gr. σφαῖρα, *sphaira*, a sphere). Half a sphere, the lateral halves of the cerebrum, or brain proper.

HE-PAT'IC (Gr. ἧπαρ, *hepar*, the liver). Pertaining to the liver.

HER-BIV'O-ROUS (L. *her'ba*, an herb, and *vo'ro* to devour). Applied to animals that subsist upon vegetable food.

HU'MOR (L.). Moisture: the humors are transparent contents of the eye-ball.

HY-DRO-PHO'BI-A (Gr. ὕδωρ, *hudor*, water, and φοβέω, *phobeo*, to fear). A disease caused by the bite of a rabid dog or other animal. In a person affected with it, convulsions are occasioned by the sight of a glittering object, like water, by the sound of running water, and by almost any external impression.

HY'GI-ENE (Gr. ὑγίεια, , *huygieia*, health). The art of preserving health and preventing disease.

HY'PER-O'PI-A. Abbreviated from HY'PER-MET-RO'PI-A (Gr. ὑπέρ, *huper*, beyond, μέτρον, *metron*, the measure, and ὤψ, *ops*, the eye). A defect of vision dependent upon a too short eyeball; so called because the rays of light are brought to a focus at a point behind the retina; the true "far sight."

IN-CI'SOR (L. *inci'do*, to cut). Applied to the four front teeth of both jaws, which have sharp cutting edges.

IN'CUS (L.). An anvil; the name of one of the bones of the middle ear.

IN-SAL-I-VA'TION (L. *in*, and *sali'va*, the fluid of the mouth). The mingling of the saliva with the food during the act of chewing.

IN-SPI-RA'TION (L. *in*, and *spi'ro*, *spira'tum*, to breathe). The act of drawing in the breath.

IN-TEG'U-MENT (L. *in*, and *te'go*, to cover). The skin, or outer covering of the body.

IN-TES'TINE (L. *in'tus*, within). The part of the alimentary canal which is continuous with the lower end of the stomach; also called the intestines, or the bowels.

I'RIS (L. *i'ris*, the rainbow). The thin muscular ring which lies between the cornea and crystalline lens, and which gives the eye its brown, blue, or other color.

JU'GU-LAR (L. *ju'gulum*, the throat). The name of the large veins which run along the front of the neck.

LAB'Y-RINTH (Gr. λαβύρινθος, *laburin'thos*, a building with many winding passages). The very tortuous cavity of the inner ear, comprising the vestibule, semicircular canals, and the cochlea.

LACH'RY-MAL APPARATUS (L. *lach'ryma*, a tear). The organs for forming and conveying away the *tears*.

LAC'TE-ALS (L. *lac*, *lac'tis*, milk). The absorbent vessels of the small intestines; during digestion they are filled with chyle, which has a milky appearance.

LA-RYN'GO-SCOPE (Gr. λάρυγξ, *larugx*, the larynx, and σκοπέω, *skopeo*, to look at). The instrument by which the larynx may be examined in the living subject.

LAR'YNX (Gr.). The cartilaginous tube situated at the top of the wind-pipe, or trachea; the organ of the voice.

LENS (L.). Literally, a lentil; a piece of transparent glass or other substance so shaped as either to converge or disperse the rays of light.

LIG'A-MENT (L. *li'go*, to bind). A strong, fibrous material binding bones or other solid parts together; it is especially necessary to give strength to joints.

LIG'A-TURE. A thread of silk or other material used in tying around an artery.

LYMPH (L. *lym'pha*, spring-water). The colorless, watery fluid conveyed by the lymphatic vessels.

LYM-PHAT'IC VESSELS. A system of absorbent vessels.

MAL'LE-US (L.). Literally, the mallet; one of the small bones of the middle ear.

MAR'ROW. The soft, fatty substance contained in the central cavities of the bones: the spinal marrow, however, is composed of nervous tissue.

MAS-TI-CA'TION (L. *mas'tico*, to chew). The act of cutting and grinding the food to pieces by means of the teeth.

ME-DUL'LA OB-LON-GA'TA. The "oblong marrow," or nervous cord, which is continuous with the spinal cord within the skull.

MEM-BRA'NA TYM'PAN-I (L.). Literally, the membrane of the drum; a delicate partition separating the outer from the middle ear; it is sometimes incorrectly called the drum of the ear.

MEM'BRANE. A thin layer of tissue serving to cover some part of the body.

MI'CRO-SCOPE (Gr. μικρός, *mikros*, small, and σκοπέω, *skopeo*, to look at). An optical instrument which assists in the examination of minute objects.

MO'LAR (L. *mo'la*, a mill). The name applied to the three back teeth of each side of the jaw; the grinders, or mill-like teeth.

MO'TOR (L. *mo'veo*, *mo'tum*, to move). Causing motion; the name of those nerves which conduct to the muscles the stimulus which causes them to contract.

MU'COUS MEMBRANE. The thin layer of tissue which covers those internal cavities or passages which communicate with the external air.

MU'COUS. The glairy fluid which is secreted by mucous membranes, and which serves to keep them in a moist condition.

MY-O'PI-A (Gr. μύω, *muo*, to contract, and ὤψ, *ops*, the eye). A defect of vision dependent upon an eyeball that is too long, rendering distant objects indistinct; near sight.

NA'SAL (L. *na'sus*, the nose). Pertaining to the nose; the *nasal cavities* contain the distribution of the special nerve of smell.

NERVE (Gr. νεῦρον, *neuron*, a cord or string). A glistening, white cord of cylindrical shape, connecting the brain or spinal cord with some other organ of the body.

NERVE CELL. A minute, round and ashen-gray cell found in the brain and other nervous centres.

NERVE FI'BRE. An exceedingly slender thread of nervous tissue found in the various nervous organs, but especially in the nerves; it is of a white color.

NU-TRI'TION (L. *nu'trio*, to nourish). The processes by which the nourishment of the body is accomplished.

Œ-SOPH'A-GUS (Gr.). Literally, that which carries food. The tube leading from the throat to the stomach; the gullet.

O-LE-AG'I-NOUS (L. *o'leum*, oil). Of the nature of oil: applied to an important group of food-principles—the fats.

OL-FAC'TO-RY (L. *olfa'cio*, to smell). Pertaining to the sense of smell.

OPH-THAL'MO-SCOPE (Gr. ὀφθαλμός, *ophthalmos*, the eye, and σκοπέω, *skopeo*, to look at). An instrument devised for examining the interior of the globe of the eye.

OP'TIC (GR. ὄπτω, opto, to see). Pertaining to the sense of sight.

OR'BIT (L. *or'bis*, the socket). The bony socket or cavity in which the eyeball is situated.

OS'MOSE (Gr. ὠσμός, *osmos*, a thrusting or impulsion). The process by which liquids are impelled through a moist membrane.

OS'SE-OUS (L. *os*, a bone). Consisting of, or resembling bone.

PAL'ATE (L. *pala'tum*, the palate). The roof of the mouth, consisting of the hard and soft palate.

PAL'MAR. Relating to the palm of the hand.

PAN'CRE-AS (Gr. πᾶς, παντός, *pas*, *pantos*, all, and κρέας, *kreas*, flesh). A long, flat gland situated near the stomach; in the lower animals the analogous organ is called the sweet-bread.

PA-PIL'LÆ (L. pl. of *papil'la*). The minute prominences in which terminate the ultimate fibres of the nerves of touch and taste.

PA-RAL'Y-SIS. A disease of the nervous system marked by the loss of sensation, or voluntary motion, or both; palsy.

PAR-A-PLE'GI-A (Gr. παραπλήσσω, *paraplesso*, to strike amiss). A form of paralysis affecting the lower half of the body.

PA-TEL'LA (L. dim. of *pat'ina*, a pan). The knee-pan; a small bone.

PEL'VIS (L.). Literally a basin; the bony cavity at the lower part of the trunk.

PEP'SIN (Gr. πέπτω, *pepto*, to digest). The organic principle of the gastric juice.

PERICARDIUM (Gr. περί, *peri*, about, and κάρδια, *kardia*, heart; the sac enclosing the heart.

PER-I-STAL'TIC MOVE'MENTS (Gr. περιστέλλω, *peristello*, to contract). The slow, wave-like movements of the stomach and intestines.

PER-I-TO-NE'UM (Gr. περιτείνω, *periteino*, to stretch around). The investing membrane of the stomach, intestines, and other abdominal organs.

PER-SPI-RA'TION (L. *perspi'ro*, to breathe through). The sweat, or watery exhalation of the skin; when visible, it is called *sensible* perspiration, when invisible, it is called *insensible* perspiration.

PE'TROUS (Gr. πέτρα, *petra*, a rock). The name of the hard portion of the temporal bone, in which is situated the drum of the ear and labyrinth.

PHAR'YNX (Gr. φάρυγξ, *pharunx*, the throat). The cavity between the back of the mouth and gullet.

PHYS-I-OL'O-GY (Gr. φύσις, *phusis*, nature, and λόγος, *logos*, a discourse). The science of the functions of living, organized beings.

PI'A MA'TER (L.). Literally, the tender mother; the innermost of the three coverings of the brain. It is thin and delicate; hence the name.

PLEU'RA (Gr. πλευρά, a rib). A membrane covering the lung and lining the chest. There is one for each lung.

PLEU'RISY. An inflammation affecting the pleura.

PNEU-MO-GAS'TRIC (Gr. πνεύμων, *pneumon*, the lungs, and γαστήρ, *gaster*, the stomach; it is the principal nerve of respiration.

PNEU-MO'NIA (Gr.). An inflammation affecting the air-cells of the lungs.

PRES-BY'O'PI-A (Gr. πρέσβυς, *presbus*, old, and ὤψ, *ops*, the eye). A defect of the accommodation of the eye, caused by the hardening of the crystalline lens; the "far-sight" of adults and aged persons.

PROC'ESS (L. *proce'do*, *proces'sus*, to proceed, to go forth). Any projection from a surface. Also, a method of performance; a procedure.

PTY'A-LIN (Gr. πτύαλον, *ptualon*, saliva). The peculiar organic ingredient of the saliva.

PUL'MO-NA-RY (L. *pul'mo*, *pulmo'nis*, the lungs). Pertaining to the lungs.

PULSE (L. *pel'lo*, *pul'sum*, to beat). The striking of an artery against the finger, occasioned by the contraction of the heart, commonly felt at the wrist.

PU'PIL (L. *pupil'la*). The central, round opening in the iris, through which light passes into the depths of the eye.

PY-LO'RUS (L. πυλωρός, *puloros*, a gate-keeper). The lower opening of the stomach, at the beginning of the small intestine.

RE'FLEX ACTION. An involuntary action of the nervous system, by which an external impression conducted by a sensory nerve is reflected, or converted into a motor impulse.

RES-PI-RA'TION (L. *res'piro*, to breathe frequently). The function of breathing, comprising two acts: *inspiration*, or breathing in, and *expiration*, or breathing out.

RET'INA (L. *re'te*, a net). The innermost of the three tunics or coats of the eyeball, being an expansion of the optic nerve.

SAC'CHA-RINE (L. *sac'charum*, sugar). Of the nature of sugar; applied to the important group of food substances which embraces the different varieties of sugar, starch, and gum.

SA-LI'VA (L.). The moisture or fluids of the mouth, secreted by the salivary glands, etc.

SCLE-ROT'IC (Gr. σκληρός, *skleros*, hard). The tough, fibrous outer tunic of the eyeball.

SE-BA'CEOUS (L. *se'bum*, fat). Resembling fat; the name of the oily secretion by which the skin is kept flexible and soft.

SE-CRE'TION (L. *secer'no*, *secre'tum*, to separate). The process of separating from the blood some essential important fluid; which fluid is also called a secretion.

SEM-I-CIR'CU-LAR CANALS. A portion of the internal ear.

SEN-SA'TION. The perception of an external impression by the nervous system; a function of the brain.

SEN-SI-BIL'I-TY, GENERAL. The power possessed by nearly all parts of the human body of recognizing the presence of foreign objects that come in contact with them.

SE'RUM (L.). The watery constituent of the blood, which separates from the clot during the process of coagulation.

SKEL'E-TON (Gr.). The bony framework of an animal, the different parts of which are maintained in their proper relative positions.

SPEC'TRO-SCOPE (from *spec'trum* and σκοπέω, *scopeo*, to examine the spectrum). An instrument employed in the examination of the spectrum of the sun or any other luminous body.

SPHYG'MO-GRAPH (Gr. σφυγμός, *sphugmos*, the pulse, and γράφω, *grapho*, to write). An ingenious instrument by means of which the pulse is delineated upon paper.

STA'PES (L.). Literally, a stirrup; one of the small bones of the tympanum, or middle ear, resembling somewhat a stirrup in shape.

SYM-PA-THET'IC SYSTEM OF NERVES. A double chain of nervous ganglia, connected together by numerous small nerves, situated chiefly in front of and on each side of the spinal column.

SYN-O'VIA (Gr. σύν, *sun*, and ᾠόν, *oon*, egg, resembling an egg). The lubricating fluid of joints, so called because it resembles the white of egg.

SYS'TO-LE (Gr. συστέλλω, *sustello*, to contract). The contraction of the heart by which the blood is expelled from that organ.

TAC-TILE (L. *tac'tus*, touch). Relating to the sense of touch.

TEM'PO-RAL (L. *tem'pus*, time, and *tem'pora*, the temples). Pertaining to the temples; the name of an artery: so called, because the hair begins to turn white with age in that portion of the scalp.

TEN'DON (L. *ten'do*, to stretch). The white, fibrous cord or band by which a muscle is attached to a bone; a sinew.

TET'A-NUS (Gr. τείνω, *teino*, to stretch). A disease marked by persistent contractions of all or some of the voluntary muscles; those of the jaw are sometimes solely affected, the disorder is then termed locked-jaw.

THO'RAX (Gr. θώραξ, *thorax*, a breast-plate). The upper cavity of the trunk of the body, containing the lungs, heart, etc.; the chest.

THY'ROID (Gr. θυρεός, *thureos*, a shield). The largest of the cartilages of the larynx; its angular projection in the front of the neck is called "Adam's apple."

TRA'CHE-A (Gr. τραχύς, *trachus*, rough). The windpipe, or the largest of the air-passages; composed in part of cartilaginous rings, which render its surface rough and uneven.

TRANS-FU'SION (L. *transfun'do*, to pour from one vessel to another). The operation of injecting blood taken from one person into the veins of another; other fluids than blood are sometimes used.

TRICH-I'NA SPI-RA'LIS (L.). A minute species of parasite or worm, which infests the flesh of the hog, and which may be introduced into the human system by eating pork not thoroughly cooked.

TYM'PA-NUM (Gr. τυμπανον, *tumpanon*, a drum). The cavity of the middle ear, resembling a drum in being closed by two membranes, and in having communication with the atmosphere.

U'VU-LA (L. *uva*, a grape). The small pendulous body attached to the back part of the palate.

VAS'CU-LAR (L. *vas'culum*, a little vessel). Pertaining to, or containing blood-vessels.

VE'NOUS (L. *ve'na*, a vein). Pertaining to, or contained within a vein.

VEN-TI-LA'TION. The introduction of fresh air into a room or building in such a manner as to keep the air within it in a pure condition.

VEN-TRIL'O-QUISM (L. *ven'ter*, the belly, and *lo'quor*, to speak). A modification of natural speech by which the voice is made to appear to come from a distance. The ancients supposed that the voice was formed in the belly; hence the name.

VEN'TRI-CLES of the heart. The two largest cavities of the heart, situated at its apex or point.

VER'TE-BRAL COLUMN (L. *ver'tebra*, a joint). The back-bone, consisting of twenty-six separate bones, called vertebræ, firmly jointed together; also called the spinal column and spine.

VES'TI-BULE. A portion of the internal ear, communicating with the semicircular canals and the cochlea; so called from its fancied resemblance to the vestibule or porch of a house.

VIL'LI (L. *vil'lus*, the nap of cloth). Minute thread-like projections found upon the internal surface of the small intestine, giving it a velvety appearance.

VIT'RE-OUS (L. *vi'trum*, glass). Having the appearance of glass; applied to the humor occupying the largest part of the cavity of the eye-ball.

VIV-I-SEC'TION (L. *vi'vus*, alive, and *se'co*, to cut). The practice of operating upon living animals, for the purpose of studying some physiological process.

VOCAL CORDS. Two elastic bands or ridges situated in the larynx; they are the essential parts of the organs of the voice.

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BONES.

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What are the uses of the bones?

How are the brains and lungs protected?

What can you tell about the size and shape of the bones?

Describe the structure of the bones?

Of what substances are the bones composed?

What is the effect of fire upon the bones?

What is the effect of removing the mineral ingredient?

Why do the bones of old people break more readily than those of the young?

How are the bones adapted to the purposes they are designed to serve?

How many bones are there in the body?

What are they called when united?

What is the skull? The chest? The pelvis?

What do the two latter compose?

How are the skull and trunk kept in position?

How are the arms attached to the chest?

What do the skull, chest, and trunk each protect?

What is a joint?

By what are the movable joints connected?

Describe the ligaments?

Is an injury to them serious?

How are the joints enabled to move easily?

Is the fluid about the joints self-supplied?

What is the spinal column?

How does it protect the brain from injury?

Do the bones change?

How can you prove it by experiments?

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Do the bones change?
How can you prove it by experiments?

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Is a sun-bath beneficial?
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Are hair dyes injurious?

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Why is there a necessity for food?
How long can man exist without food?
How long on water alone?
Does the quantity of food vary for different individuals?
What is the quantity for a healthy man?
How often is the body renewed?
What does the term food include?
How are the substances we use as food classified?
What are organic substances? Inorganic?
What part of the body is water?
Where is it found?
Which can man remain without the longer, food or water?
What is the purest water in nature?
Is water from springs and wells pure?
How does lead affect water?
Are lead pipes injurious?
How is salt obtained?
How is the importance of salt shown?
What effect does the loss of salt have upon animals?
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What kind of food is most used in hot climates?
Are sugars producers of heat?

What is the proportion of starch in breadstuffs?
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Can an animal be starved on any one of these?
Will milk sustain life? Why?
What should be eaten with eggs, and Why?
Why should meats be eaten?
Is salted meats as nutritious as fresh? Why?
What is the object of cooking?
How should you boil meat for food? For soup?
What is the best method of cooking meat?
What is the effect of frying?
Should any form of pork be eaten raw?
What disease does raw pork often produce?
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What form of bread is most easily digested?
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Is bread and butter a wholesome diet?
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What kinds of food are most easily digested?
What is the effect of ice water upon the stomach?
Does strong emotion check digestion?

What other causes affect it?
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How are other organs affected by it?

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What is the total quantity in the body?
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What are the blood corpuscles?
How many are there in a cubic inch of blood?
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What is the general direction of the heart-currents?
Describe the action of the ventricles and auricles?
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What influence have mental emotions?
Do they ever cause death?
What is the amount of blood moved in one minute? In a lifetime?
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How is the pulse an index of health or sickness?

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What is it, and what its use?
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What causes suffocation?
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How many cubic inches of air pass in and out of the lungs with every breath?
What do bad odors indicate, and against what do they guard us?
Is man's breath impure?
What care should people take who nurse the sick?
What effect do filters of cotton wool have?
How is carbonic acid produced in our houses?
What effect does impure air have?
Does it produce consumption?
Does impure air affect animals? Give instances.
How does nature purify the air?
How shall we ventilate our houses?
What is the temperature of the human body?
How is it regulated?

THE NERVOUS SYSTEM.

What name is given to the functions of digestion, circulation, and respiration? Why so called?

What has the animal in addition?
If a hydra be cut in pieces, what properties has each piece?
Of what is the nervous tissue composed?
When the tissue is examined under the microscope, what do you find?
Which substance predominates?
What part of the nervous system is concerned in the animal functions?
What is the other set of organs called?
What is the brain? What is its shape?
How many parts, and what are they?
How is the brain protected?
How much blood is sent to the brain?
What is the cerebrum? How divided?
How is the surface divided?
What is the true source of nervous power?
What is the cerebellum?
What is the medulla oblongata?
What are the cranial nerves, and how many of them are there?
Describe the spinal cord.
Is this an important part ot the system?
Where do the spinal nerves originate?
How are these nerves hardened and strengthened?
Is there a difference in the sensations communicated by different nerves? Example.
Describe the sympathetic system?
What is the difference in the uses of the gray and white substances?
Of what two functions of the system are the nerves the instruments?
How do you prove that there are two sets of fibres in the nerves?
Can a limb be injured so that it wiil retain motion and lose sensation?
What columns of the spinal cord are concerned in motion and sensation?
Is the spinal cord the true centre of sensation?
If one lateral half of the spinal cord be injured, what fact is observed?
What course do the motor fibres pursue?
What the sensory fibres?
What is the reflex action of the cord?
What are the uses of that action?
What reflex motions take place in certain involuntary muscles?
What are the objects of reflex action?

What are the functions of the medulla oblongata?
Of the cerebellum?
Of the cerebrum?
Do great men possess large brains?
What mental acts are developed through the action of the brain?
What are the effects of alcohol upon the brain?
What are its effects on the mind?
What is its effect upon the will?
Is this habit once formed hard to break?
What is the effect of drunkenness upon man?
What was proved, by the labors of Father Matthew, with regard to the advantages of temperance?
What are the poisonous effects of alcohol upon man?
What is its effect as a stimulant?
Describe tobacco?
What use is made of it?
What effect has it upon the young?
How is it hurtful to adults?
What are the effects of its limited use?
What of its prolonged use?
What is the testimony of the naval and military academies as to its effects upon the young men?
What have been the advantages of its prohibition?
How is cigarette smoking particularly injurious?
How is snuff-taking injurious?
To what substances is the term narcotic applied?
Which are next in importance to alcohol?
What is opium?
What is its active principle?
What are the effects of this principle upon the system?
What is its use?
What danger to be feared from the use of Dover's Powders, Sooth ing Syrups, etc.?
What is the effect of the habitual use of opium?
From what is chloral hydrate produced?
What are its effects, and the danger of its use?
What is Hasheesh?
For what is it used?
What is chloroform?
For what is it used?
What are its dangers?
Ought narcotics to be used without proper medical advice?

THE SPECIAL SENSES.

Where is the true centre of sensation?
Does the mind receive impressions at that point, or to what points are they referred?
What faculty of the brain is necessary to complete a sensation?
Do you receive sensations when asleep?
Have all animals sensibility?
Has man more or less than animals?
What is the lowest form of sensation?
The highest form?
How are sensations modified by use?
What is general insensibility?
What is the most painful part of a surgical operation? Why?
Are all impressions received from without?
What is pain?
What is the difference between sensibility and pain, as illustrated by the effect of sunlight?
What are the uses of pain?
What are the special senses?
Are special organs furnished?
Can the eye hear or the ear see?
What other sense do some writers give us?
Where do you find the sense of touch most developed?
What is the office of the cuticle, as illustrated by the hand?
Does the sense of touch assist other senses?
How do you illustrate it?
Which sense is least liable to error?
How do you illustrate the delicacy of touch?
Is it acquired by practice?
What can you say of the sensations of temperature and weight?
What is the organ of taste?
Tell how it receives sensations.
What nerve at the back of the tongue?
What conditions are necessary to the sense of taste?
Do all parts of the tongue perceive equally the same flavors?
Does the sense of taste affect internal organs?
Is taste a simple sense?
Upon what other sense is taste dependent? Illustrate it.
What is the use of taste?

Are articles that gratify the taste of a child generally wholesome?
Where is the sense of smell located?
What nerves endow the nose with sensibility?
What are the uses of smell?
Does it aid us in the choice of food?
What is the sense of sight?
Does sight bring us into contact with the bodies examined?
What gives this sense its wide range?
What is the undulatory theory?
What is that part of the eye sensitive to the waves of light?
Has science done anything to prevent blindness?
Does the loss of one eye impair sight?
How is the eyeball protected from injury?
What use are the eyelids?
What is the conjunctiva, and its uses?
What are the uses of the sebaceous glands?
Where is the lachrymal gland situated?
What is the use of it?
By what duct are the tears carried off?
What is the use in moistening the eye by tears?
What is the shape of the eyeball?
Of what is it composed?
Name the three coats of the eyeball.
Describe them.
What is the iris, and of what use is it?
Does it regulate the admission of light?
What is the retina?
Are impressions made upon it at once lost? Give examples.
What is color blindness?
What is the crystalline lens?
What is cataract?
What are the uses of the crystalline lens?
As the image upon the retina is inverted, how do we see objects in their true position?
What is the cause of short sight? Of long sight?
Has the eye the capacity of adjusting itself to distances?
How is the eye affected by old age?
What is sound? How is it propagated?
Is the earth a good conductor of sound?
Upon what does the pitch of the sounds depend?
Into what three portions is the ear divided?

Of what two parts is the external ear composed?
Describe the auditory canal.
Of what use is ear-wax?
What is the middle ear?
What is the membrana tympani?
What is the eustachian tube?
Where is the auditory nerve found?
What is the most essential part of the organ of hearing?
Of how many parts does the labyrinth consist?
What is ear-sand?
How many nerves have been counted in the cochlea?
How is sound conveyed to the brain?
Does cold water injure the ear?
Is cold air hurtful to the ear?
What effect upon the ear do solid substances have?
How can you remove foreign objects from the ear?

THE VOICE.

How are the sounds which animals make produced? Of insects?
What is the difference between the speech of parrots and men?
Is speech related to hearing?
Why is a child born deaf also dumb?
What is the essential organ of the voice?
Where is it situated, and of what composed?
Give the names of the cartilages.
With what is the larynx lined?
To what is the epiglottis attached? What is its office?
What are the vocal cords? Describe them.
If one or both cords are injured, what is the effect?
In ordinary breathing, is any sound produced?
What enables us to recognize a person by his speech?
Are the teeth, lips, and tongue important in speech?
How many varieties of voice are there? What are they?
When does the voice change?
What change is there in the larynx?
What is the ordinary range of the voice?
Can the vocal organs be trained? What is the effect?
What is ventriloquism?
What are the mysterious responses of the ancient oracles thought to have been?

Satérmo Seleido mastoy

Rom. X. 12.
I. Cor. XII. Eph. IV.