AN ELEMENTARY TEXT-BOOK

MAY'S ANATOMY PHYSIOLOGY AND HYGIENE

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ANATOMY

PHYSIOLOGY AND HYGIENE

WITH SPECIAL REFERENCE TO THE EFFECTS OF STIMULANTS AND NARCOTICS

FOR USE IN PRIMARY AND INTERMEDIATE SCHOOLS

BY

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PREFACE.

In the following pages the author has endeavored to present the most important facts relating to the anatomy, physiology, and hygiene of the human body, in as simple and clear a manner possible without undesirable omissions.

Of late years, physicians have laid great stress upon the study of the prevention of disease; and, keeping pace with this improvement, the laity have become better informed about matters pertaining to the care of the body than formerly. The great utility of such knowledge has led to the enactment of laws in New York and other States making provision for the study of physiology and hygiene in the public schools, with special reference to the effects of stimulants and narcotics upon the human system. Such legislative provisions are very gratifying; proper instruction to children on these subjects must do much to diminish the amount of sickness and raise the general standard of health.

The author has endeavored to use the simplest terms compatible with clearness. A certain number of technical terms are unavoidable; these are defined in the glossary at the end of the volume.

The lessons will be made more interesting and valuable if illustrated by the various tissues obtainable at the butchers';

thus the heart of a calf will serve nicely to show the general shape and arrangement of cavities and valves in the human heart. In the same way other organs and tissues should be utilized by the teacher to elucidate the account of various parts of the body. The skeleton and its different parts should be before the class in reciting upon the bones.

In the description of the effects of stimulants and narcotics upon the human body, only such statements have been made as can be found in the works of standard authors on these subjects; it is not necessary to deviate from the truth, in order to impress children with the great amount of bodily harm and misery, which the extensive indulgence in stimulants and narcotics causes.

The synopsis given at the end of each chapter is intended to be of use in reviews and in guiding the teacher in a systematic presentation of the subject.

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CHAPTER I.

INTRODUCTION.

1. The human body is the highest form of living being; consequently, greater care is required to keep it in health and to ward off disease than is the case with the lower animals.

2. **Hygiene.**—The study of how to take care of the body and how to prevent disease is called *Hygiene.* It is a very important subject. "An ounce of prevention is worth a pound of cure" is an old saying, and is certainly a true one. If we wish to avoid sickness we must keep our bodies healthy. In order to know how to do this, we must learn about the things around us which are harmful and poisonous, so as to avoid them; we must become acquainted with what is good and what is improper in our food, what are bad habits to be avoided, and also the injurious effects of drink containing alcohol, and of tobacco and narcotics. All these things are taught us by the study of *Hygiene.*

3. But if we are to remember them, we must understand how and why it is that certain things and habits are injurious; and to do this intelligently, we must know something about the *structure* of our bodies, and the manner in which they perform their *work*—that of *living.*

4. **Anatomy.**—The study of the *form and structure* of the different parts of the body is called *Anatomy.*

5. **Physiology.**—The study of *how we live* is called *Physiology.* It explains how we digest our food, how our blood circulates, how we breathe, grow, and move, and perform the

many actions—some simple, some very difficult—which are necessary to life. It is a very interesting subject.

6. These three branches—anatomy, physiology, and hygiene—naturally go together. To explain their differences, let us take an easy example: Suppose a man wishes to be an engineer upon a locomotive. To perform his duties well there are many things connected with the locomotive which he must understand. In the first place, he must have a knowledge of the different parts of which it is built—this would correspond to the study of *anatomy* in the human being. Again, he must understand how the locomotive works—what causes the wheels to move, how steam is produced, and how to regulate the speed—this we would liken to the study of *physiology* in the human being. Finally, such an engineer must be acquainted with the proper care of his locomotive—what fuel to use, how to keep it clean, and other things to prevent it from getting out of order; similar knowledge applied to the human body, *hygiene* gives us.

7. We have been making use of the words *life* and *living beings*; it is well to understand exactly what is meant by these: There are a great many different forms of life. The human being represents the highest form, while some very small animals, that cannot be seen except with the microscope, belong to the very lowest classes. Both are examples of animal life. In ordinary drinking-water we can see certain of the lowest forms of life if we look through a drop of such water that has stood for some time; these animals are so small that they must be magnified hundreds of times before we can see them; they are perfectly innocent, and do no harm when we drink them.

8. There is also *life in plants;* but it is different from that in animals. Plants grow, and they also breathe; a few of them have the power of moving some of their parts, as in the case of the *Venus Fly-trap.* This plant grows in North Carolina; each of its leaves has a part at the top which opens and shuts

just like a steel-trap. These trap-like ends of the leaves are usually open when the sun shines, and whenever a fly alights upon one of them and brushes against the bristles that grow from their edges, the trap suddenly closes, capturing the insect and usually soon depriving it of life.

9. **Differences between Plants and Animals.**—The main differences between plants and animals are :

(1.) *Plants exist upon water, gases, and mineral matters* found in the earth ; this would not be enough to support life in animals.

(2.) Plants consist of *different materials* from those forming animals.

(3.) Plants have *no organs of digestion*, such as animals have in nearly every instance.

10. **Organ.**—The word *organ*, applied to the human body, means a part which performs some special work. For instance, the stomach is one of the organs of digestion, because it helps to prepare the food so that the blood can be nourished by it ; the eye is the organ of sight ; the tongue is the organ of taste.

11. **Function.**—The special work which any organ of the body does is called its *function*. Thus, it is the function of the ear to hear, of the heart to propel the blood through the blood-vessels.

SUBDIVISIONS OF THE BODY.

12. We may divide the body in many different ways :

(1.) Into different *parts* of the body ; such as the head, the trunk, the limbs. These again may be subdivided.

(2.) We may further divide these into the different *tissues*. A *tissue* is one of the simple forms of material of which the different parts of the body are composed ; thus, the finger consists of bone, fat, muscle, arteries, veins, nerves, skin—all these are tissues.

(3.) If we subdivide still further, and again and again,

until we come to the very smallest part, we have the *cell*, the *fibre*, and a *substance between these*, which may be jelly-like or may be hard. The entire body is formed of millions of these cells and fibres and this substance between them. They are all very small and we must use a strong microscope to see them. It is only when millions of them are gathered together that they form a mass large enough for us to see with the unaided eye. The *cells* are of different shapes, but usually they are more or less rounded. The *fibres* are thread-like.

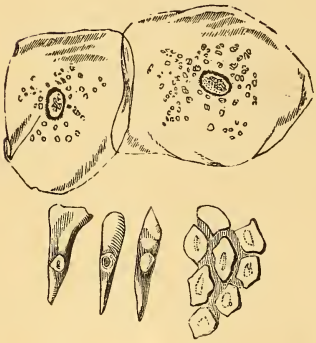


FIG. 1.—Some Different Forms of Cells.

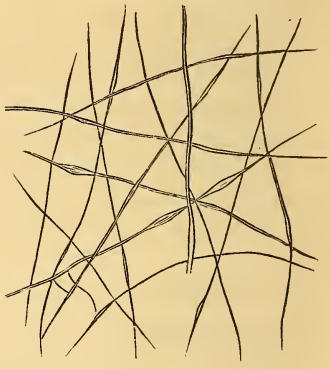


FIG. 2.—A Collection of Fibres, Separated.

PARTS OF THE BODY.

13. The human body can be divided into:
    (1.) The head and neck.
    (2.) The trunk.
    (3.) The limbs.

14. **The Head and Neck.**—The head has a large *cavity for the brain*, and *smaller ones* to receive the *eyes*, *ears*, *nose*, and *tongue*. It is divided into the *crown* (the top part), and the *face*.

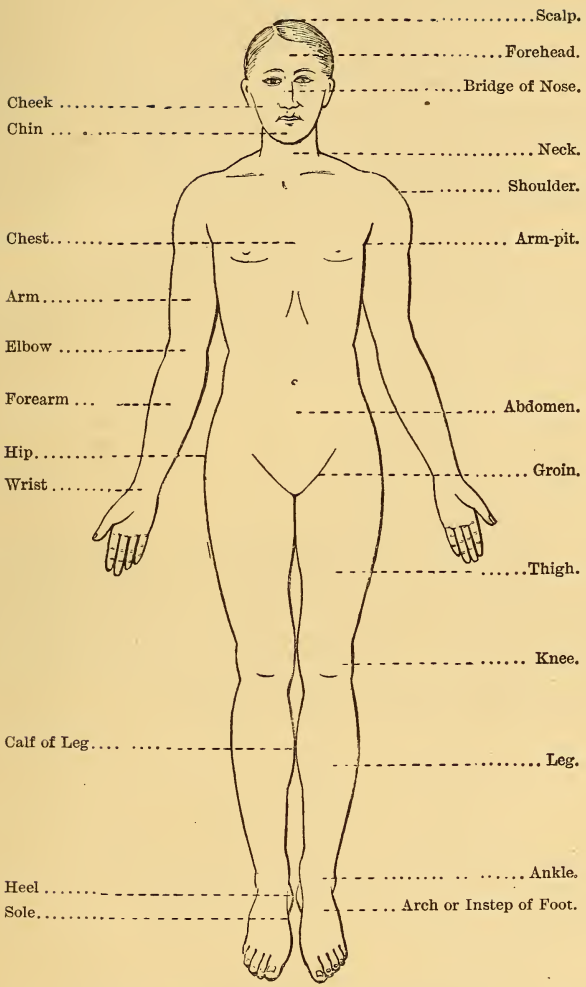


FIG. 3.—The Names of the Different Parts of the Body.

15. **The Trunk** is that part of the body between the neck above, the upper limbs above and on each side, and the lower limbs below. It has *two large cavities:* an upper one, called the *chest* or *thorax*, for the heart and lungs; and a lower one, called the *abdomen*, for the organs of digestion.

16. **The Limbs** are attached to the trunk.

The upper limbs start from the shoulders. There are two; each consists of an *arm*, a *forearm*, and a *hand*. Where the upper limb joins the trunk we have the *shoulder* and the *armpit*. Where the arm and forearm meet we have the *elbow*. Where the forearm and hand meet is the *wrist*. The front of the hand is called the *palm*, the opposite side the *back* of the hand.

The *fingers* are named as follows:

First—Thumb.
Second—Index finger.
Third—Middle finger.
Fourth—Ring finger.
Fifth—Little finger.

The lower limbs start from the hip; each consists of a *thigh*, a *leg*, and a *foot*. Where the lower limb joins the trunk we have the *hip* and the *groin*. Where the thigh and leg meet we have the *knee*. Where the leg and foot meet we have the *ankle*. The under surface of the foot is called the *sole*, the upper surface the *arch* of the foot, or *instep*.

SYNOPSIS.

Hygiene—Care of body and prevention of disease.
Anatomy—Form and structure of parts of body.
Physiology—How we live.
Life—1. Animals.
2. Plants.
Differences between plants and animals:
1. Plants exist upon water, gases, and mineral matters only.

2. Plants consist of different materials from those forming animals.

3. Plants have no organs of digestion.

Organ—A part which performs some special work.

Function—The special work which an organ does.

Subdivisions of the body:

a. Structure—Tissues, simple forms of material:

1. Cell. 2. Fibre. 3. Substance between.

b. Parts:

1. Head and neck.
   - *a.* Crown.
   - *b.* Face.
2. Trunk.
   - *a.* Thorax.
   - *b.* Abdomen.
3. Upper limb.
   - *a.* Arm.
   - *b.* Forearm.
   - *c.* Hand.
4. Lower limb.
   - *a.* Thigh.
   - *b.* Leg.
   - *c.* Foot.

QUESTIONS.

1. What is hygiene? 2. What are some of the things which it teaches us? 3. What is anatomy? 4. What does physiology teach us? 5. Mention some of the things which it explains. 6. Explain the differences between these three branches: Anatomy, physiology, and hygiene. 7. Is there more than one form of animal life? 8. Give examples. 9. Do plants live? 10. How do we know this? 11. Do plants ever have the power to move any of their parts? 12. Give an example of this. 13. Mention the differences between plants and animals. 14. What is an organ of the body? 15. Give examples of organs. 16. What is meant by the word "function?" 17. Give examples of this. 18. How do we divide the body? 19. Give an example of a part of the body. 20. What is a tissue? 21. Give an example. 22. What are the very smallest subdivisions of the body called? 23. What is a cell? 24. What is a fibre? 25. Name the three main parts of the body. 26. Into what parts can the head be divided? 27. What is the trunk and what large cavities does it contain? 28. Name the different parts of the upper limb. 29. Name the different parts of the lower limb.

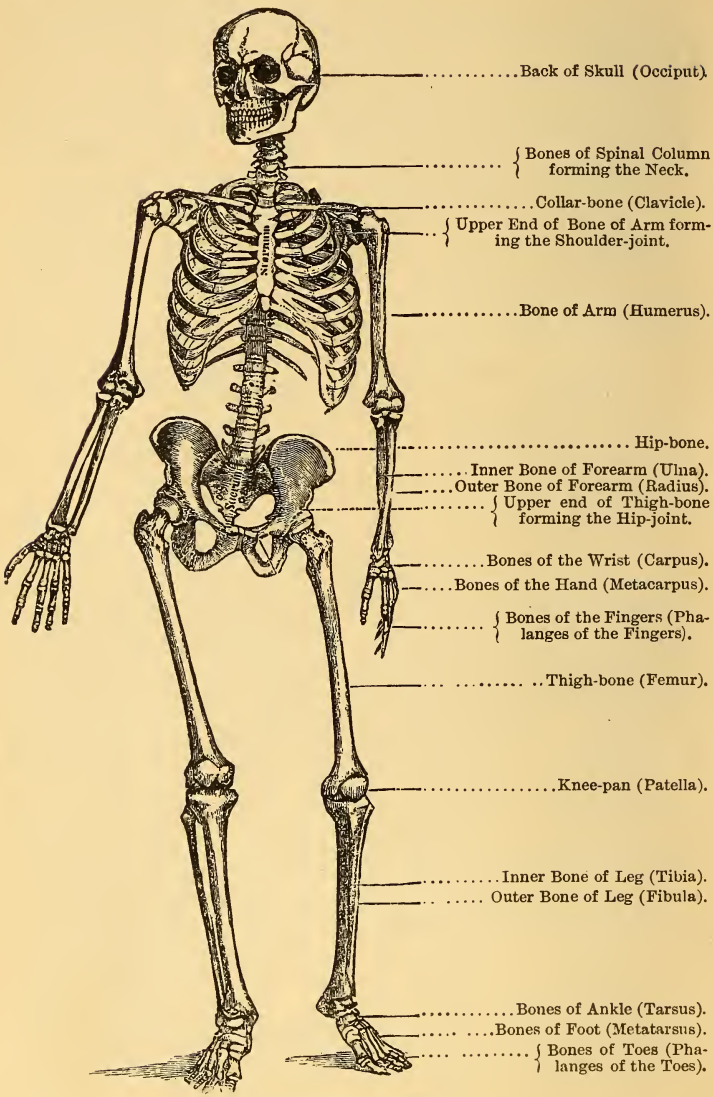


FIG. 4.—The Skeleton, Viewed in Front.

CHAPTER II.

THE FRAMEWORK OR SKELETON.

17. **The Skeleton** is the name given to all the bones in the body taken together. These form a framework around which all the soft parts of the body are arranged, just as the walls and rafters of a building support the rest of it. In man, and in all the higher animals, the skeleton is on the *inside*, and the soft parts are placed around this bony framework ; in some animals, such as the crab and the lobster, the hard shell on the outside corresponds to the skeleton.

18. **Uses of Bones.**—The uses of bone are :

(1.) To give the body *support* and to keep it *erect ;* this we see especially in the spinal column and in the lower limbs.

(2.) To *protect* soft parts which would otherwise be easily injured ; the brain, for instance, is enclosed in a sort of oval box formed by a number of flat bones joined together ; in the same way, the heart and lungs are protected from injury by the bones which form the chest.

(3.) To give great *strength* and *hardness*, and at the same time leave the part *elastic ;* as an example of this use, the wrist and the foot may be mentioned. In the foot, for instance, we have many small bones joined together in such a way that though they are strong enough to bear the weight of the body, they are still elastic enough to allow us to jump upon the foot without injury.

(4.) Lastly, bones are necessary for the purpose of *motion :* For walking and running, for grasping objects, and

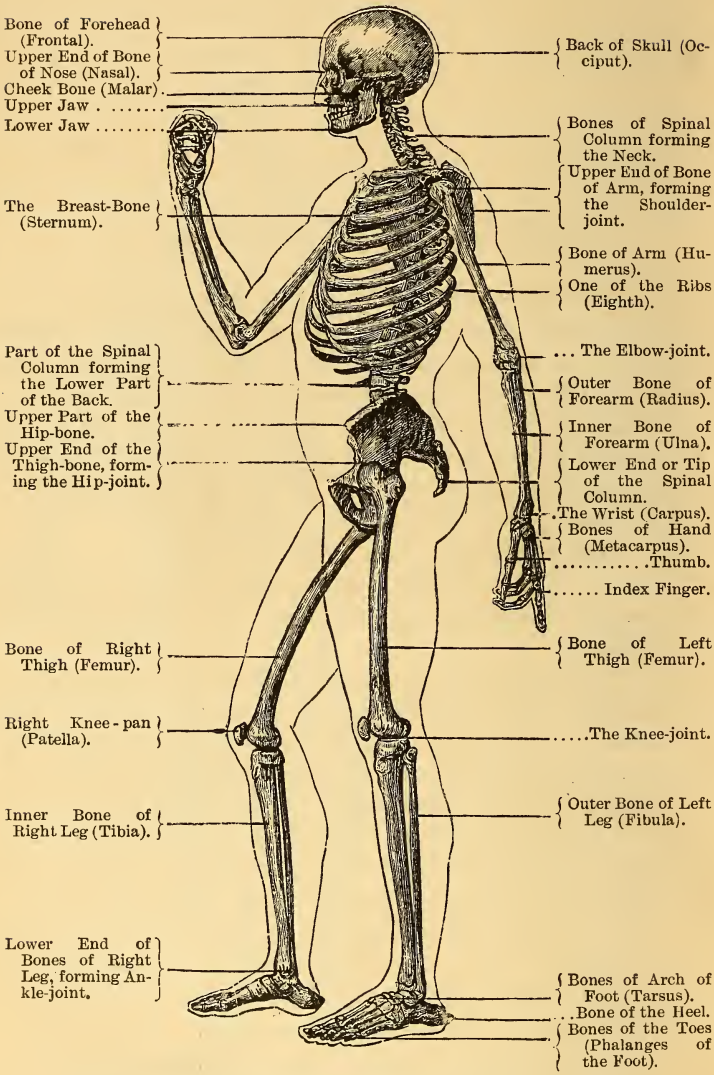


FIG. 5.—The Skeleton, Viewed from the Side, with Outline of the Body.

for performing the many actions required of us. The thigh-bones and the bones of the leg, for instance, are necessary for walking. Bones serve as points of attachment for muscles, and they are moved through the action of these muscles; they simply carry out the will of the muscles, and these again are directed by our nerves and brain.

19. **Number of Bones.**—There are *two hundred* bones in the human body.

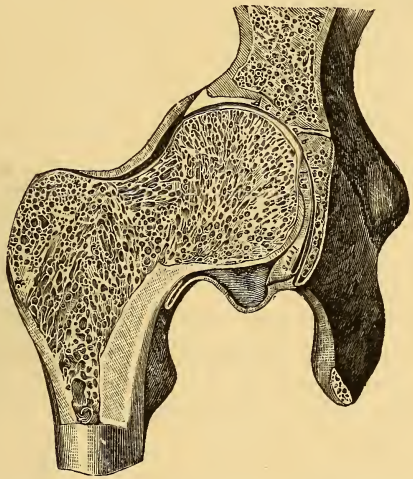


FIG. 6.—The Upper End of the Thigh-bone, where it Forms Part of the Hip-joint, Sawed through Lengthwise, Showing the Porous and Spongy Nature of Bone in Its Interior, and also the Commencement of the Central Canal for the Marrow.

20. **Forms of Bones.**—Bones vary very much in form and in size. Some of them are *long*, as the thigh-bones (Fig. 21); others are small and *short*, such as the eight bones which form the wrist (Fig. 20); others are *flat*, as for example the bones forming the skull (Fig. 11); finally others are of very odd and *irregular* forms, such as the bones which form the spinal column (Fig. 16).

21. **Structure of Bone.**—Each bone is surrounded by a very hard layer on the outside; within this the bone is looser and is porous, having a large number of small spaces through which the blood-vessels run (Fig. 7). The long bones, such as those of the arm, thigh, and fingers, are hollowed out in the centre, and in this canal we find a fatty substance called "*marrow*." This hollowing out of the bone makes it lighter and also stronger than it would otherwise be. Bones are closely covered by a tough membrane called the *periosteum*, which gives additional strength and protection to them. They are of a pinkish color during life, on account of the small blood-vessels running through them; when dead, the color of bone changes to white.

FIG. 7.—A Thin Slice of Bone, Cut Crosswise, as Seen under the Microscope.

22. If we take a thin slice of bone, and look at it under the microscope, we will see a large number of dark spots, with small lines running from these (Fig. 7). They correspond to the minute spaces which exist even in the densest bone, and show that it is never entirely solid.

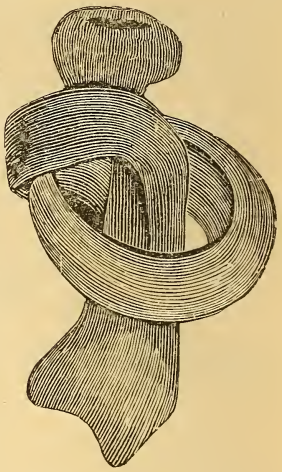


FIG. 8.—The Outer Bone of the Leg, Tied into a Knot after the Hard Mineral Matter has been Dissolved out by Acid.

23. **Composition of Bone.**—Bone is composed of two parts of a hard mineral substance containing a great deal of lime, and of one part of a soft material like *gelatin*. The mineral substance gives the bone its hardness; the soft material makes it tough and elastic. To prove this we have only to dissolve out the mineral substance by a weak acid, and we

find that we can now bend the bone in any direction because it has lost its hardness; if it be long enough, we can even tie it in a knot without breaking it, as is shown in Fig. 8.

24. If, on the other hand, we put the bone into the fire, this will drive off all the gelatin, and then the bone will have the same form as before, but will now be very brittle and crumble to pieces very easily.

25. In the baby the bones consist very largely of a soft material—*gristle* or *cartilage;* this is the reason why the baby cannot stand, or, if it is allowed to stand too soon, the bones of the legs may become bent, because they are not yet hard enough to bear the weight of the body. Gradually, as the baby grows, the hard matter is added. In younger persons the bones are always softer than in the aged, and therefore they do not break as easily. In old persons there is less gelatin and a larger proportion of the brittle mineral substance than in youth; hence the bones are more brittle and are more easily broken, or, as the surgeon would say, are more liable to *fracture.*

26. **Care of the Skeleton.**—If we wish to have erect and graceful bodies when we grow up we must take care of them while we are young. It is while we are young that the bones are still soft, and thus easily shapened. We should always remember to *stand and to sit erect,* with the chest thrown forward and with the shoulders back; in this way we will avoid stooping and round shoulders.

27. We should not wear any clothing which is *too tight.* How often do we see a misshapen chest in girls because they have worn dresses which were too tight. Fig. 72 is the picture of a chest which has become deformed through *tight dress.* If we compare it with Fig. 18, which represents a healthy chest, we cannot fail to notice the change.

28. We must be careful to get *shoes of proper size;* if they are too small or too pointed our feet will become deformed, our toes bent and crooked, and painful corns and bunions will

result. Such deformities are shown in Fig. 10. Girls should remember not to wear high heels, for these crowd the foot into the front part of the shoe, thus making the toes overlap each other. Shoes with high heels do not support the weight of the body properly, because they throw the upper part of the body forward. Another objection is the danger of accidents in falling and of spraining the ankle when high heels are worn.

29. **Fracture of a Bone.**—When a bone is broken the accident is quite a serious one; it is called a *fracture.* The doctor is called and he *sets* the bone; that is, he brings the two broken

FIG. 9.—A Natural Foot.

FIG. 10.—A Foot which has Become Deformed and Affected with Corns and Bunions as a Result of Tight and Ill-fitting Shoes.

ends of the bone together, and keeps them in position by bandaging them to a piece of thin board so that they cannot be moved; then a soft material is formed between the two pieces, which gradually hardens and joins the two ends together. If properly taken care of, a broken bone becomes united again in several weeks, and is then as strong as it was before. If we happen to break a bone we must remember to keep as quiet as possible until the doctor arrives, so as not to move the injured part, or else we may make matters much worse.

30. **Effects of Stimulants and Narcotics.**—Drinks containing alcohol, and the use of tobacco, may prevent our bones

from growing to their natural size. Many boys smoke cigarettes because they think it makes them look big and manly. This is a mistake. No one will consider them so because they smoke, and the habit often results in preventing them from growing to their natural size. The bones of drunkards break more easily than do those of others.

31. If we wish to be large and finely-built we must try to preserve our health, for when the health suffers the growth of the bones is interfered with.

Having studied about bones in general, let us now examine

THE DIFFERENT PARTS OF THE SKELETON.

32. We may divide the skeleton into four parts:

(1.) Bones of the head.
(2.) Bones of the trunk.
(3.) Bones of the upper limbs.
(4.) Bones of the lower limbs.

33. **Bones of the Head.**—The bones of the head taken together form the *skull* (Figs. 11, 12, and 13). The skull is made up of twenty-two bones. Eight of these are joined together at the upper and back part, forming an oval box of bone in which the brain is contained, and called the *cranium.* The front part of the skull, formed by the remaining fourteen bones, is called the *face.*

34. **The Cranium.**—The portion of the cranium which forms the forehead is called the *frontal* bone (1, Fig. 13). In the lower animals, such as the dog and the cat, the forehead is very low and slanting; in the negro race it is less slanting; while in the white races it is almost upright. Usually the prominence of the forehead indicates the development of the brain; in those who have spent much time in study it is usually very prominent. Behind, the cranium is formed by the *occipital* bone (3, Fig. 13). Above, two bones, known as the *parietal* (2, Fig. 13), join together to form the top of the skull.

On the side of the head, just below where the hair ends, is a spot called the *temple*; the bone which forms this part of the skull is called the *temporal* bone (4, Fig. 13).

35. Most of the bones of the cranium have *ragged edges* looking like the teeth of a saw (Figs. 12 and 13), and when the bones are joined these teeth fasten the bones together just as if you spread out the fingers of one hand and then put them in the

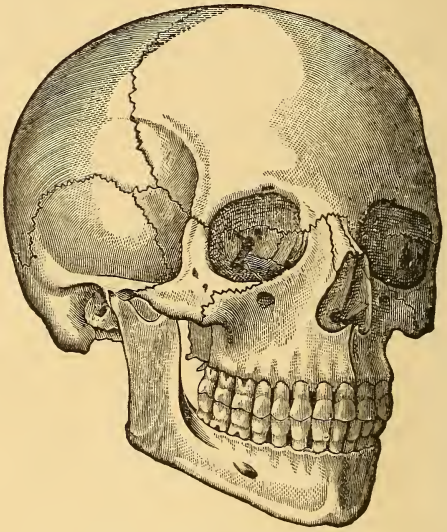


Fig. 11.—The Skull, Front View.

spaces between the fingers of the other. In this way the bones are firmly united, and yet there is space between the edges so that they can give a little. This is very important, for if these bones could not give at all, every blow upon the head would injure the soft, delicate brain within. The muscles, skin, and hair on the head also serve to break the force of blows.

36. **The Face.**—Looking at the skull in front (Fig. 11) we see two large openings just below the forehead; they are

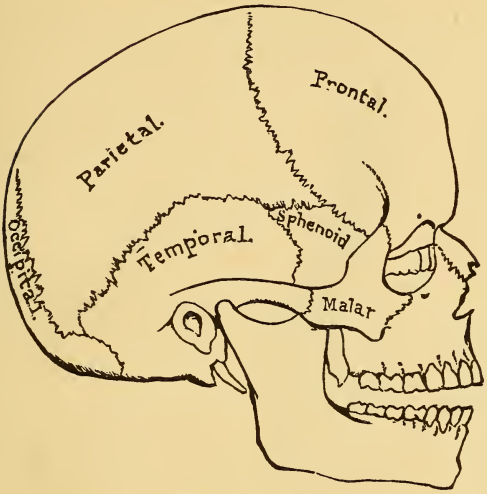


FIG. 12.—The Human Skull, Looked at from the Side.

FIG. 13.—The Bones of the Skull Separated. 1, Frontal; 2, Parietal; 3, Occipital; 4, Temporal; 5, Nasal; 6, Malar; 7, Upper Jaw; 8, Lachrymal; 9, Lower Jaw.

known as the *orbits* and receive the eyes. Below and between these is the triangular opening of the nose, bounded above by two small bones (5, Fig. 13), the *nasal* bones. To the outer side and below the orbits are the bones which form the prominence of the cheeks, and are called the *malar* bones (6, Fig. 13). At the lowest part of the face are the two jaws, the upper (7, Fig. 13) and the lower (9, Fig. 13); the *upper jaw* is firmly joined to the rest of the skull; the *lower jaw* resembles a horse-shoe in shape, and is separate from the rest of the skull—of course, during life, it is connected to the sides of the face by strong bands and muscles. Each jaw has a circular row of teeth, about which more will be said in the chapter on Digestion; between these two rows of teeth is the opening of the mouth.

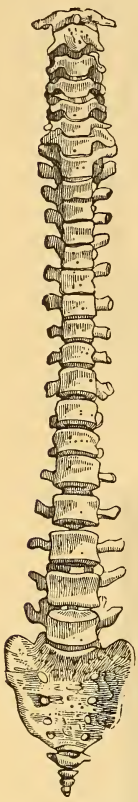


FIG. 14.—The Spinal Column, as Seen from Front.

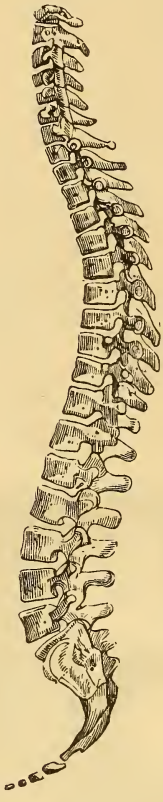


FIG. 15.—The Spinal Column as Seen from the Side.

37. The skull rests upon the upper end of the spinal column; it is very movable, so that it can be bent forward or backward, or from side to side, and can be turned in any direction.

38. **Bones of the Trunk.**—The bones of the trunk are: the bones forming the spinal column, the hip-bone, the collar-bone, the shoulder-blade, the breast-bone, and the ribs.

39. **The Spinal Column.**—This is the row of bones

which extends from the skull above to the lower limbs below. There are thirty-three of these bones piled one upon the other; but in the grown person there are fewer, because the nine lowest bones unite so as to form two bones; five go to form the upper one, called the *sacrum*, and four unite to form the tip of the spinal column, called the *coccyx*. So that there are really only twenty-six bones in the spinal column. Each of these twenty-six bones is called a *vertebra*, and all of them taken together are known as the *vertebræ*. The spinal column is often called the backbone, on account of its extending along the middle of the back. The vertebræ are connected by circular plates of gristle or cartilage, and by fibres; this cartilage and the fibres are elastic, and thus it is that our backbone is very movable—we can bend it in any direction or twist it; this is because this cartilage gives. This also explains why it is that at night we are a trifle shorter than in the morning, for the weight of the body has caused these plates of cartilage between the vertebræ to be compressed slightly, while after a rest during the night, they regain their usual thickness. There is an opening in each of the vertebræ, and when they are all in position, these openings connect and form a canal, the *spinal canal*, which runs all through the backbone. This canal holds the delicate *spinal cord*, from which nerves emerge through small openings on each side of the spinal column. At the upper end of the spinal canal it communicates with the cavity of the skull by means of

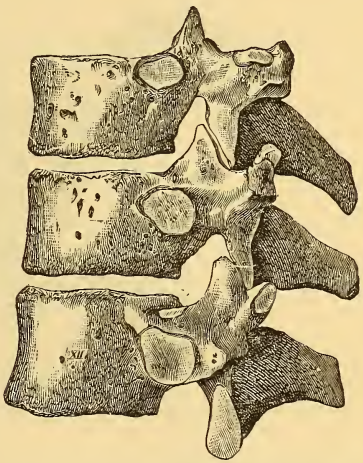


FIG. 16.—Three Vertebræ from the Lower Part of the Spinal Column, Separated.

a large oval opening; through this opening the spinal cord and the brain are directly continuous. If you run your finger along the middle of the back, you can feel projecting points; these are the tips of the vertebræ.

40. **The Hip-bones** (*H*, Fig. 21 and Fig. 17), are the two large and strong bones which are placed on each side of the lower end of the spinal column, forming with it a sort of basin which is called the *pelvis*. On the outer side of each hip-bone,

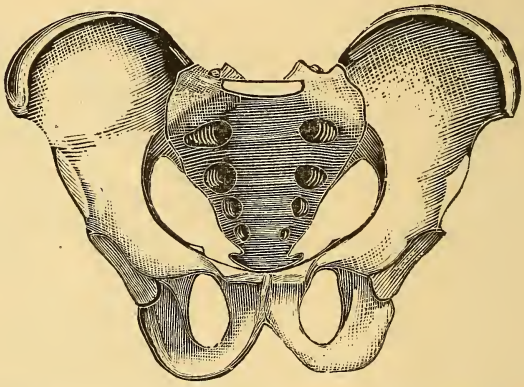


Fig. 17.—The Pelvis, formed by the Lower End of the Spinal Column and the Hip-bones.

at about its middle, will be noticed a deep, round depression; in this fits the upper end of the thigh-bone.

41. **The Collar-bone,** or **Clavicle** (Fig. 19, *C*), is the curved bone which we see at the upper part of the chest in front, being connected with the breast-bone at its inner end.

42. **The Shoulder-blade,** or **Scapula** (Fig. 19 *B*), is the large triangular bone which we see at the upper part of the chest, behind. It lies behind the upper ribs. At its outer angle is a round depression into which the upper ball-like end of the bone of the arm fits.

43. **The Breast-bone,** is also called the *sternum* (Fig. 19, *S*); it is a flat bone which is broad above and gradually

tapers toward its lower end. It forms a strong guard to the front of the chest. Along its edges the ribs are attached on each side.

44. **The Ribs.**—There are twenty-four ribs, twelve on each side. They are long, slender, curved bones, which form the outer boundary of the chest. They are very elastic. All the ribs are joined behind to the vertebræ of the back; the first seven are attached to the breast-bone in front, and are called

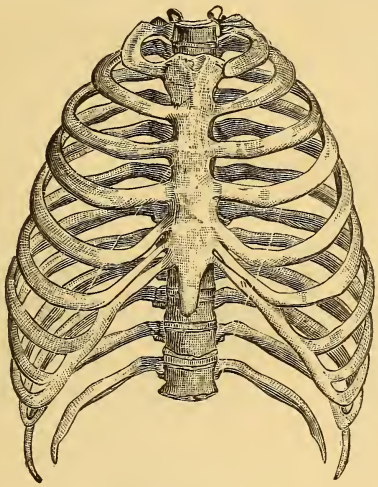


Fig. 18.—The Chest, or Thorax.

true ribs; the last five are not attached to the breast-bone in front, and are called *false* ribs; the three upper of these, namely, the eighth, ninth, and tenth, are connected with cartilage in front, but the last two are entirely free in front, and are called *floating* ribs.

45. **The Chest,** or **Thorax** (Fig. 18).—It has already been explained that this is the large cavity just below the neck which serves to hold the heart and lungs. These organs are of great importance, and are nicely boxed in by the bones we have just

studied ; namely, the breast-bone in front, the ribs on each side, the collar-bone above, and the backbone behind. There are, of course, spaces between these different bones, but in the living body these are filled by muscles. A flat sheet of muscle-tissue also bounds the chest below and separates it from another cavity situated just below it, the *abdomen ;* this muscular partition is called the "*diaphragm.*"

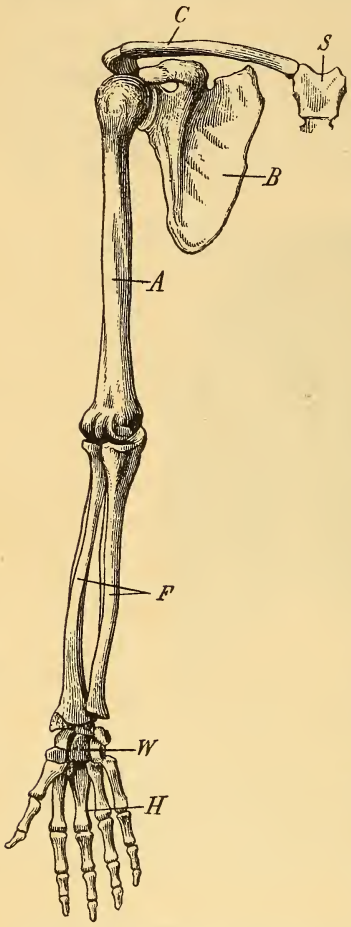


FIG. 19.—The Bones of the Upper Limb. *S*, Breast-bone (Sternum) ; *C*, Collar-bone (Clavicle) ; *B*, Shoulder-blade (Scapula) ; *A*, Bone of Arm (Humerus) ; *F*, Bones of Forearm (Radius, Ulna) ; *W*, Bones of Wrist ; *H*, Bones of Hand.

46. **Bones of the Upper Limb.**—These are : the bone of the arm (humerus) ; the two bones of the forearm (radius and ulna) ; and the small bones forming the hand.

47. **The Bone of the Arm** is a single bone, known as the "humerus ;" it is a strong bone and extends from the shoulder to the elbow. Its upper end has an enlargement, shaped like a ball, which fits into the cup-shaped depression, seen at the outer angle of the shoulder-blade.

48. **The Bones of the Forearm.**—There are two bones in the forearm, an outer, the *radius*, and an inner, the *ulna*. They are placed side by side, the space between them being filled up by a membrane

and by muscles. They extend from the elbow to the wrist. In twisting the forearm the radius revolves around the ulna, which is the more stationary of the two.

49. **The Bones of the Wrist and Hand.**—There are twenty-seven bones in each hand. The hand may be divided into three parts: The *wrist* or *carpus*, the *palm* or *metacarpus*, and the *fingers* or *phalanges*. The *wrist* is the most solid part and is made up of eight small bones, more or less rounded or cubical in shape, closely held together by tough bands; this arrangement serves to make the wrist very strong and still very light. The bones forming the *palm* of the hand are five in number. Each *finger* has three bones, the end of one being joined to that of the other, except the thumb, which is shorter and has but two such *phalanges;* this arrangement of the bones of the fingers allows them to move very dexterously.

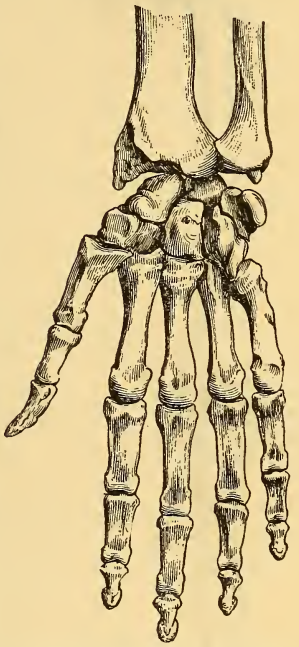


Fig 20.—The Bones of the Wrist and Hand. Above is also seen the lower ends of the radius and ulna, taking part in forming the wrist-joint.

50. **Bones of the Lower Limb.**—These comprise the *thigh-bone* (*femur*), the bones of the leg (*tibia* and *fibula*), the *knee-pan* (*patella*), and the bones of the *foot*.

51. **The Thigh-bone,** or **Femur,** is the largest and strongest bone in the body, and is surrounded by more muscle than any other bone. Where it is attached to the hip-bone it has a large spherical part called its *head*, and this forms an angle with the rest of the bone by a part called the *neck*. Below, the thigh-bone joins with the bones of the leg and with the knee-pan.

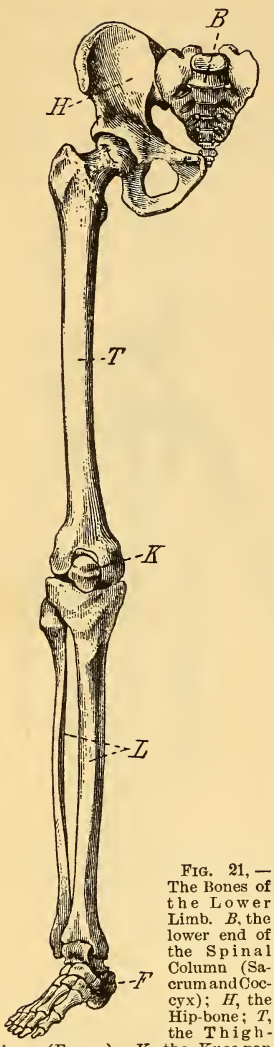


FIG. 21, — The Bones of the Lower Limb. *B*, the lower end of the Spinal Column (Sacrum and Coccyx); *H*, the Hip-bone; *T*, the Thigh-bone (Femur); *K*, the Knee-pan (Patella); *L*, the Bones of the Leg (Tibia and Fibula); *F*, the Bones of the Foot.

52. **The Knee-pan,** or **Patella,** is the small, round, flattened bone which can be felt at the knee. It serves as a protection to the joint, and often saves it from injury in falls and blows.

53. **The Bones of the Leg.**— There are two bones in each leg. The inner bone is the shorter and stronger of the two, and is called the *tibia.* The outer bone is longer and more slender; it is called the *fibula.* These two bones, placed side by side, extend from the knee to the ankle.

54. **The Bones of the Foot.**— Each foot is formed by twenty-six bones, one less than in the hand. Seven of these form the solid back part of the foot, called the *tarsus,* which includes the *heel;* five form the *arch* or *instep,* also known as the *metatarsus;* and the remaining fourteen form the *toes* or *phalanges.* Thus, it will be seen, that there are as many bones in the toes as in the fingers; but the toes are much less movable, being simply intended for support of the body and for walking; however, when they are trained to do other things, they may become almost as nimble as the fingers are. The *heel* is the most solid part of the foot and the strongest. The *sole* of the foot, between the heel and the toes, forms an arch at the inner border of the foot;

this arch breaks the force of jumps from heights. If we are compelled to jump from a height, there is the least disagreeable effect and danger to the body if we alight on our toes, or just behind the toes; when we reach the ground upon the heel, the shock is transmitted through the entire body, and gives rise to a very disagreeable sensation, and even to injury.

SYNOPSIS.

Position—1. Internal in higher animals.
2. External in some of lower animals.

Uses of the bones:
1. Support to rest of body.
2. Protection to delicate organs.
3. Strength and hardness.
4. Motion, by serving as points of attachment for muscles.

Number of Bones: Two hundred.

Forms of Bones:
1. Long. 2. Short. 3. Flat. 4. Irregular.

Structure of Bone:
1. Outer dense layer.
2. Interior porous and light.
3. Central canal filled with marrow in long bones.
4. Blood-vessels pass through it, giving pink color during life.
5. Covered by membrane (periosteum).

Composition of Bone:
1. Animal matter—About one-third in amount.
Larger proportion in early life.
Gives toughness and elasticity.
2. Mineral matter—About two-thirds in amount.
Larger proportion in advanced life.
Gives rigidity.

Care of the Skeleton:
1. Avoid faulty positions, to prevent stooping and round shoulders.
2. Avoid tight clothing, to prevent deformed chests.

3. Avoid faulty shoes, to prevent deformities of the feet, corns, bunions, and accidents.

4. Extensive indulgence in stimulants and narcotics (alcohol and tobacco) may prevent bones from growing to natural size.

5. When general health suffers, growth of bones is interfered with.

Fracture of a Bone :

1. "Setting" the bone.

2. To prevent further injury, the broken part should be kept quiet until the doctor arrives.

3. Method of healing by material binding the two ends together.

Parts of the skeleton :

1. The Head :
   - *a.* Cranium—1. Frontal.
     2. Parietal.
     3. Occipital.
     4. Temporal, etc.
   - *b.* Face—1. Nasal.
     2. Malar.
     3. Upper jaw.
     4. Lower jaw, etc.

2. The Trunk :
   - *a.* Spinal column (composed of 33 vertebræ).
   - *b.* Chest (formed by vertebræ, sternum, clavicle, and ribs).
   - *c.* Ribs—1. True.
     2. False (including two floating ribs).
   - *d.* Collar-bone (Clavicle).
   - *e.* Shoulder-blade (Scapula).
   - *f.* Breast-bone (Sternum).
   - *g.* Pelvis (formed by lower end of spinal column and hip-bones.

3. The Upper Limb :
   - *a.* Bone of arm (humerus).
   - *b.* Bones of forearm—1. Radius.
     2. Ulna.
   - *c.* Bones of hand—1. Wrist (Carpus).
     2. Palm (Metacarpus).
     3. Fingers (Phalanges).

4. The Lower Limb:
   - *a.* Bone of thigh (Femur).
   - *b.* Knee-pan (Patella).
   - *c.* Bones of the leg—1. Tibia.
     2. Fibula.
   - *d.* Bones of foot—1. Heel (Tarsus).
     2. Arch (Metatarsus).
     3. Toes (Phalanges).

QUESTIONS.

1. What is meant by the word "skeleton?" 2. How does the skeleton of a crab and lobster differ from that of man? 3. What are the uses of bone? 4. How many bones are there in the human body? 5. Mention the different forms of bones. 6. Which part of the bone is the hardest? 7. How does the inner part of the bone differ from the outer layer? 8. What is marrow? 9. Of what substances is bone composed? 10. How can you show that bone is made up of these two substances? 11. How do the bones of a baby differ from those of a middle-aged man? 12. How do the bones of an old man differ from those of a younger man? 13. Tell something about the care of the skeleton. 14. Why is it necessary to sit and to stand erect? 15. What happens when we wear our clothing too tight? 16. What is a fracture? 17. What effect may alcohol and tobacco have upon our skeleton? 18. What effect does smoking have upon the size of boys? 19. Will the growth of our bones take place properly if our health is poor? 20. Into what four different parts can we divide the skeleton? 21. What are the bones of the head taken together called? 22. What is the cranium and how many bones join to form it? 23. How are the bones of the cranium united? 24. Where is the frontal bone? 25. What does the prominence of the forehead show? 26. Where are the orbits? 27. What is peculiar about the lower jaw? 28. Name the bones of the trunk. 29. What are the vertebræ? 30. How many are there? 31. How are they connected together? 32. What opening is there in the spinal column? 33. What can you say about the hip-bones? 34. Where is the collar-bone? 35. Where is the shoulder-blade? 36. What is another name for the breast-bone? 37. What is its

use? 38. How many ribs are there? 39. What does a rib look like? 40. Which are the true ribs? 41. Which are the false ribs? 42. What is a floating rib, and which ribs are called floating? 43. What is the chest, and what does it contain? 44. What is another name for it? 45. What bones form the boundaries of the chest? 46. What is the diaphragm, and what cavities does it separate? 47. What bones are there in the upper limb? 48. How many bones are there in the arm? 49. How many in the forearm? 50. How many bones are there in the hand? 51. How is the wrist formed? 52. How many bones are there in each finger? 53. How many bones are there in each lower limb? 54. Which is the largest bone in the body? 55. Describe the thigh-bone. 56. How many bones are there in the leg? 57. Describe the knee-pan and its use. 58. How many bones in the foot? 59. Which are the more movable, the toes or the fingers? 60. Which is the strongest part of the foot? 61. In jumping from a height, upon what part of the foot should we alight, and why? 62. What are the dangers of high heels? 63. What are the effects of too small or badly-formed shoes?

CHAPTER III.

THE JOINTS.

55. Wherever two or more bones meet we have a *joint.* Joints are necessary in order that one part of the body may move independently of the other. If this arrangement did not exist we would have to move the entire body whenever we wanted to move any part of it. If you observe how a man walks when his knee-joint, for instance, is stiff and cannot be used, you will appreciate how useful joints are. The more joints there are in any part of the body the more movable is that part; notice, for instance, how movable the fingers are and how many joints there are in the hand.

56. According to the amount of motion which they permit, joints are divided into three classes:

(1.) Immovable joints, in which there is no visible motion.

(2.) Slightly-movable joints, in which there is slight motion only.

(3.) Movable joints, in which there is free motion.

57. **Immovable Joints.**—The best example of this form of joint is seen in the skull. The flat bones of the skull are fastened together by means of the small projections from their edges; such joints are called *sutures.* They are very well adapted to what is required here, because being closely joined they make a strong box of the bones of the skull, and yet they are capable of a very little motion, enough to break the force of blows upon the head; in this way they serve as additional protection to the brain.

58. Fig. 22 shows the sutures which we find on the upper surface of the skull. In front, joining the frontal bone with

the two parietal bones, we have a suture which extends across the skull from one side to the other; it is called the *coronal* suture, from the Latin word *corona*, which means "a crown," because the front part of the crown of a king is supposed to rest upon this line. Behind, where the occipital bone meets the two parietal bones, is another suture, called the *lambdoid*,

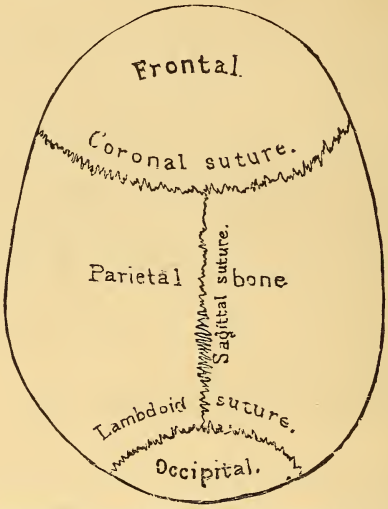


FIG. 22.—View of the Skull from Above, Showing the Sutures.

on account of its resemblance to the Greek letter *lambda* (Λ). Between these two sutures, the coronal and the lambdoid, is another which connects the two parietal bones; it is called the *sagittal* suture, from the Latin word *sagitta* (an arrow), because it was thought to join the coronal suture as an arrow meets the string of a bow.

59. **Slightly-movable Joints.**—In these joints a fair amount of motion is allowed, but much less than in the next class—the movable joints. We find examples of slightly-movable joints between the different vertebræ forming the spinal column.

60. **Movable Joints.**—These are the most numerous and

the most interesting. In all movable joints the same general arrangement exists: the ends of the bones forming the joint are covered with gristle or cartilage—this is a dense, semi-transparent substance which is much softer than bone—it acts as a sort of cushion to the ends of the bones in the joint, so that they are not bruised or injured when the joint is moved, or when the ends are brought together forcibly, as in jumping. If two surfaces rubbing against each other were dry they would soon be rubbed off; hence it is necessary to keep a joint moist all the time. In machinery this is accomplished by oil. In the living body the same thing is done by a yellowish fluid looking like the white of an egg, which constantly covers the ends of these bones; this fluid is given off from the inner surface of a sort of sac which lines all movable joints. This sac or membrane is called the *synovial* membrane, and the fluid which it gives off is called *synovial* fluid. The ends of the bones forming joints are held in place and connected by strong bands of tough tissue, which pass from one bone to the other, and are called *ligaments*. This is shown in Fig. 23, which represents a joint cut in two; the bands on the outside, one on each side, passing from the upper to the lower bone, are the ligaments. Sometimes these are so extensive as to surround the entire joint, and thus be a sort of cover to it. This entire covering is called the *capsular ligament*, because it is like a capsule; this is seen in Fig. 24.

61. **Varieties of Movable Joints.**—There are four varieties of movable joints:

(1.) *Gliding*-joint—in which one bone slides upon the other, as is seen between some of the small bones forming the wrist.

(2.) *Hinge*-joint—in which one bone swings forward and backward from the end of the other, just as a door opens and closes upon its hinges. A good example of this form of joint is seen in the connection of the arm with the fore-arm at the elbow.

(3.) *Pivot*-joint—in which one bone turns upon the other by an arrangement resembling a pivot. This is seen in the connection between the skull and the upper end of the spinal column.

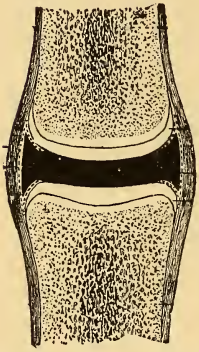


FIG. 23.—One of the Movable Joints Sawed through Lengthwise, with the Different Parts in their Proper Position, thus Showing the General Arrangement in Joints.

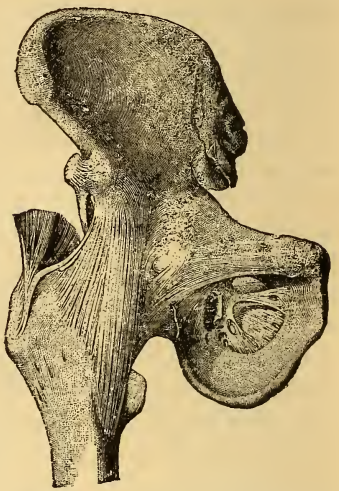


FIG. 24.—The Hip-joint, Showing the Capsular Ligament Surrounding the Junction between the Hip-bone Above and the Thigh-bone Below.

(4.) *Ball-and-socket*-joint. This is a form of movable joint in which the greatest amount of motion is allowed. One bone ends in an enlargement like a ball; this fits into a hollowing-out of the other bone, hence the term "ball-and-socket." Examples of this form of joint are seen in the shoulder and hip.

62. **Accidents to Joints.**—When one of the bones which forms the joint is not in its correct position and no longer fits on the end of the other, we may say it is *out of joint* or *dislocated*. This is a very painful accident. The bones must be put *in joint* again by the surgeon; often the capsular ligament is torn. The accident usually is the result of falls; many such falls take place in getting off street-cars, especially if the car

has not come to a complete stop, and the person does not remember to get off facing the horses.

SYNOPSIS.

Definition—The place of meeting of two or more bones.
Uses—To allow greater freedom of motion.
Varieties—According to amount of motion permitted:
1. Immovable—no visible motion—sutures:
   a. Coronal.
   b. Lambdoid.
   c. Sagittal, etc.
2. Slightly-movable—slight motion.
3. Movable—free motion.
   a. Ends covered with cartilage.
   b. Upon this is synovial membrane.
   c. Kept lubricated by synovial fluid.
   d. Bones connected and held in place by ligaments.
   e. Four different forms:
      1. Gliding-joint.
      2. Hinge-joint.
      3. Pivot-joint.
      4. Ball-and-socket-joint.

Accidents—Dislocations—"out of joint."

QUESTIONS.

1. What is a "joint" in anatomy? 2. What advantage is there in having joints in the body? 3. What classes of joints are there? 4. Give an example of an immovable joint. 5. What is a "suture?" 6. Name the most important sutures of the skull, and describe each one. 7. Give an example of a slightly-movable joint. 8. Describe the general arrangement in movable joints. 9. How are such joints kept moist? 10. What is cartilage? 11. What are ligaments? 12. How are the ends of bones forming joints held in place? 13. What is a capsular ligament? 14. What forms of movable joints are there? 15. What is a gliding-joint? 16. Give an example. 17. What is a hinge-joint? 18. Give an example. 19. What is a pivot-joint? 20. Give an example. 21. What is a ball-and-socket-joint? 22. Give an example. 23. What is a dislocation?

FIG. 25.—The Muscles of the Human Body (the Skin having been Removed).

CHAPTER IV.

THE MUSCLES AND MOTION.

63. Thus far we have been studying the framework of the body and we found this to consist of about two hundred bones, which together we spoke of as the *skeleton;* we found also that these bones were held together by tough tissues, which we called *cartilage* and *ligaments;* we saw that there were a great many joints, so that one bone could move upon the other. All these formed the *framework.* Now will be considered some of the tissues which cover the framework, or fill up the spaces between the different parts of the skeleton. The first of these to be considered are the muscles; we will consider particularly the great mass of muscles which we find covering the skeleton.

64. **Function or Work of the Muscles.**—Muscles give us the *power of moving the different parts of the skeleton.* Our skeleton would be of very little value to us if we could not move the different bones; just as the sails of a ship would be of little use unless there were ropes and pulleys to hold and move them.

65. **Description of Muscle-tissue.**—Muscles are the red masses which we commonly call *flesh.* What the butcher sells as *meat* is a mass of muscles from some animal. When we eat roast beef for our Sunday dinner we are consuming a number of large muscles from the ox. Muscle is of a blood-red color. We can separate each muscle into small *fibres,* which are thread-like bodies joined side by side to form a fleshy mass which we call muscle. If we look at such a *muscle-*

fibre under a strong microscope we see a peculiar striped appearance, which shows that each muscle-fibre is composed of a large number of smaller pieces joined together at their surfaces (Fig. 26).

FIG. 26.—A Piece of a Muscle Separated into its Fibres and Showing the Striped Appearance of the Fibres. (Magnified several hundred times.)

66. **Tendons.** — Muscles are strong, but still they are too soft to be attached directly to bone—they would not hold. So that we have strong, tough cords, known as *tendons*, which are attached to the muscles and connect them with the bones. The tendons are white and shining and hence can easily be distinguished from the muscles. They are of great strength, and it is very rare for any of them to break. The central, thick, fleshy part of a muscle is called its *belly*. In Fig. 27 the belly of the muscle is marked *B*, the ends or tendons *T*. If you feel the fleshy mass on the front of the forearm, you are feeling *muscle*. But if you put your finger at the wrist, and open and close your hand, you will feel hard cords move ; these are the tendons of the muscles of your forearm and serve to attach the muscles to the bones of your fingers.

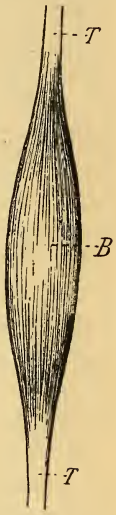


FIG. 27.—A Long, Fleshy Muscle. B, Belly ; T, T, Tendons.

67. **Fat.**—The different muscles always have a little fat mixed with them which cannot be separated. But, besides this smaller quantity, there is more or less fat in layers between the different muscles ; there is also fat covering the muscles and between the muscles and the skin. Meat free from fat is said to be *lean*.

68. **Uses of Fat.**—A certain amount of fat is necessary; it is useful in the following ways:

69. (1.) It *keeps the body warm.* Fat does not allow the heat of the body to pass out readily, and so it protects us from the cold.

70. (2.) It *protects the body from pressure.* Just beneath the skin is a layer of fat; this is thick at some places, and thin at others. Where the body is exposed to much pressure the layer of fat is thick, preventing us from feeling the weight of the body. In the palms of the hands and the soles of the feet, for example, there is much fat; otherwise our hands and feet would ache every time we used them considerably.

71. (3.) Fat is a sort of *food.* When persons are deprived of food they may live for a number of days; the fat of their bodies is changed into nourishment which the blood takes up and furnishes to different parts of the body. As examples of this we have cases in which persons who were shipwrecked, or who stowed themselves away in the hold of a ship so as to steal a passage, have survived many days. The tissue which suffers most is the fat; this disappears, and on this account such persons rapidly become very thin.

72. (4.) Another use of fat is to give a fine *appearance* to the body: it fills up the uneven spaces that would be left between muscles and bones. If it were not for this the entire body would be uneven and lumpy. In the baby, where the muscles are small and undeveloped and there is considerable fat, the outline of the body is nice and round. As the baby gets older the muscles become larger, and the amount of fat smaller, and the body is no longer as plump and rounded. Where the muscles are well-exercised much of the fat is absorbed and the muscles stand out prominently. But still there is always some fat present.

73. **Kinds of Muscle-tissue.**—Muscle-tissue is of two kinds. One variety, to which most muscles belong, is under the *control of the will;* hence such muscles are known as *volun-*

tary muscles—directed by the will. Such muscles remain in a state of rest until we desire to use them. All the muscles on the outside of the body are of this class. The muscles of our arm, for instance, remain at rest during sleep, and at other times when we do not care to make use of them. Voluntary muscle-tissue appears striped when looked at under the microscope.

74. The other class of muscles we call *involuntary*, that is, *not directed by the will.* These muscles are situated inside the body; as examples may be mentioned the heart, the layer of muscles which is found in the walls of the stomach and intestines, and the muscular fibres which we find in the walls of the arteries and by which these blood-vessels are made to contract. We cannot control the action of these muscles; they act without our being conscious of it, and it is well that it is so. Take the heart, for instance; day and night it is at work pumping the blood into the blood-veseels, to be carried all over the body. If we had to watch over this organ, to see that it kept on beating, we would always have to stay awake; and if we were careless and fell asleep, and the heart stopped because we were not directing it to keep on beating, life would soon cease. As another example, let us look at the working of the stomach. After food enters this organ the muscular fibres in its wall begin to contract and move the food about, so as to break it up into finer particles; this is done without our knowing anything about it, and without our being able to control it. Involuntary muscle-tissue presents *no* striped appearance under the microscope.

75. **Mixed Muscles.**—Some muscles belong partly to one class and partly to the other; for instance, the muscles between the ribs, which move the latter in breathing. These act all the time; yet we may not be aware of their action, which continues whether we are asleep or awake. Still we can stop breathing for a very short time, or we can breathe more rapidly than is natural for a very short time—but only for a short

time. These muscles are *partly voluntary and partly involuntary.*

76. **How Muscles Act.**—When a muscle acts we say it "*contracts;*" as a result of this it causes some part of the body to move. If we watch a muscle while it is contracting we find it becomes shorter, broader, thicker, and at the same time

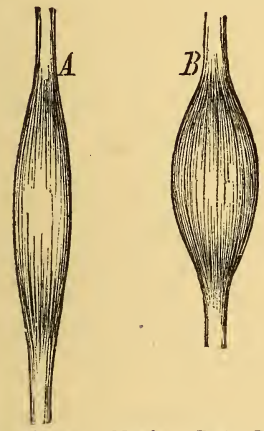


FIG. 28.—*A*, a Muscle at Rest; *B*, the same Muscle Contracted. It has become shorter, broader, and thicker.

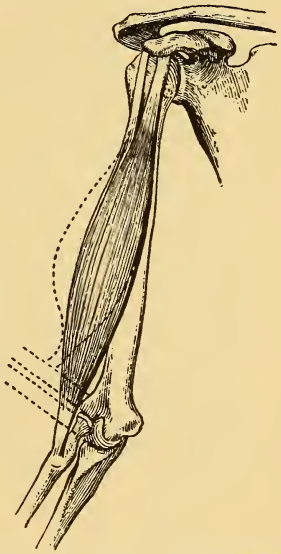


FIG 29.—The Action of the Biceps Muscle of the Front of the Arm. (The dotted figure shows the effect of the contraction upon the position of the forearm.)

harder. Place your left hand upon the front of your right arm; now bend your fingers into the palm of your right hand and then bend your right forearm upon the arm; you will feel the muscle on the front of the arm become hard and swell up —it has become shorter, broader, and thicker. Since the muscle cannot break loose from its attachment to bones, it must bring these bones nearer together when it shortens. Fig. 28 shows a long, fleshy muscle at rest (*A*), and the same muscle

after contraction (having become shorter, thicker, and broader), to the right (*B*). In Fig. 29 the manner in which the contraction of a muscle causes motion is shown. The picture illustrates the biceps muscle on the front of the arm. It is attached above to the shoulder-blade (which is the fixed point), and below to one of the bones of the forearm (the movable attachment). The dotted figure shows the muscle after it has contracted—in order to shorten it must bend the forearm, so as to bring its two points of attachment nearer together.

77. Though muscles have the power to contract, they cannot do this unless we direct it; the order to act comes from the brain. If the brain wishes a certain muscle to act, it sends it a message, and then the muscle responds. This message goes from the brain to the soft, whitish matter in the canal running through the centre of the spinal column, known as the *spinal cord;* from the spinal cord the message is sent directly to the muscle by certain white threads, which we call *nerves.*

78. This whole arrangement is very much like a *telegraph office:* the brain corresponds to the office to which messages come and from which messages are sent out, and the nerves we may liken to the telegraph wires or messengers which carry the despatches. The following example will illustrate this: Suppose you see an orange on the table before you. The eye sends a message to the brain, by means of the nerve of the eye, that the orange is there. You are heated and thirsty, and would like to eat the orange. The brain then sends out a message to the muscles that move your fingers and to those that move your arm that they are to seize the orange; then they do so. The message from the brain was carried down through the nerve-tissue in the backbone, the spinal cord, then through the nerves of the arm to their smallest branches, which pass to the muscles.

79. Although the muscles contract, and thereby cause the movement of the arm, forearm, and fingers, they are only the *servants of the brain and nerves;* without an order from

the brain through the nerves they could not move. This is proven by the fact that when, from an injury, the nerves of the forearm are cut across, the muscles of the forearm and hand become lame, and we say they are *paralyzed;* if we examine them we may find no change; but they can no longer receive orders to act from the brain, and on this account are motionless.

80. **Ordinary Muscular Movements are very Complex.**—It is so easy for us to make use of our muscles that we are apt to believe every act which they perform is very simple, but this is not the case. Even the very simplest acts involve the use of a great many different muscles. When we walk, for instance, we do not even give it a thought, yet very many different muscles are acting, each one with great skill and nicety. It is on this account that man cannot construct machinery that will perform many of the things done by his hands. No machine could be constructed, for instance, that could write, or draw, or paint, and resemble the work done by hand. Even when we stand there are a number of muscles at work balancing the body. After standing a long while, owing to the fact that these muscles become worn out, we feel tired.

81. **Groups of Muscles.**—Usually we find that muscles occur in sets or groups, and that one set accomplishes just the opposite action from the other. Thus the muscles on the front of the forearm serve to close the fingers and hand, while those on the back of the forearm serve to open them. The large muscle on the back of the arm, called the *triceps*, straightens out the forearm, while the thick muscle in front of the arm, called the *biceps* (Fig. 30), bends the forearm upon the arm.

82. All the different *expressions of the face* are produced by the action of the small muscles of the face. When they draw up the corners of the mouth they give rise to a look of pleasure and smiling; or they draw down the corners of the mouth and produce an expression of sadness and displeasure. They may wrinkle the forehead horizontally and make the face look in

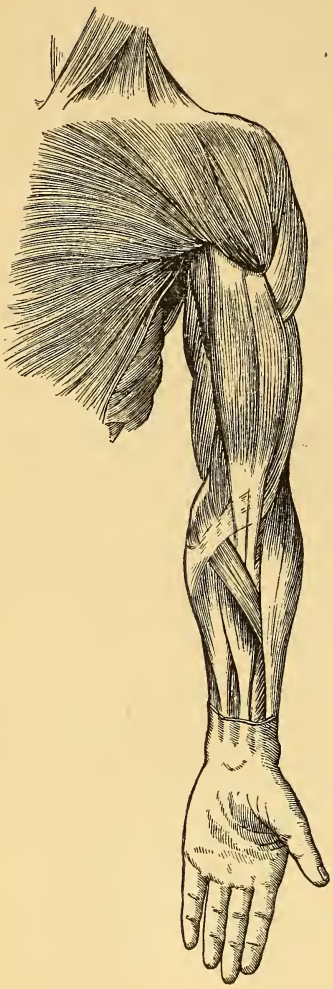


FIG. 30.—The Muscles of the Front of the Chest, Arm, and Forearm. The fan-like muscle above and to the left is the "pectoralis;" in the centre of the arm is seen the "biceps."

doubt, or by wrinkling it vertically produce a frown. There are many other varieties of expression. The expression of the face soon becomes that which the person himself habitually makes. If you look sullen and angry all the time the face will soon have this expression, because the muscles become so accustomed to acting in this way that they cannot do otherwise. In the same way you may have a constant silly expression, if you act the part of a fool every time you are with your companions. Some children are in the habit of twisting their eyes so that they look cross-eyed; this they often do to make their friends laugh; they should remember that from constantly doing this the eyes may be injured.

83. **Number of Muscles.**—There are about *three hundred* muscles on each side of the body, making about six hundred in all.

Nearly all the muscles occur in pairs, that is, are the same on one side as on the other. A few muscles which exist in the middle line of the body are single.

84. **Shape of Muscles.**—Muscles vary greatly in shape.

The most frequent form is that of a long, fleshy bundle with a tendon at either end for fastening it to bone. Sometimes they are flattened and placed in layers, as is the case in the muscles of the wall of the abdomen. Some muscles consist of flattened bundles which come together toward a single point like a fan; such is the muscle of the temple—the *temporal* muscle. Other muscles are square-shaped, and still others form a circular ring; so that there is great variety in the shapes of muscles.

85. **Size of Muscles.**—Here, too, there are the greatest differences. Some of the muscles in the interior of the ear are only a fraction of an inch in length. Some of those of the eye are about an inch in length, while the longest muscle is one which extends from the hip to below the knee; it is over two feet in length. Between these two extremes there are many different sizes.

86. **A Few Important Muscles.**—It is not necessary for you to remember the names of many of the muscles, but there are a few which are worth knowing about, because they are important, and because we often see them mentioned in books and in newspapers. They are the following:

Fig. 31.—The Biceps and Triceps Muscles.

87. *The Biceps* is the large fleshy muscle on the front of the arm, which bends the forearm upon the arm (Figs. 30 and 31). It can be felt upon making this motion.

88. *The Triceps* is the muscle of considerable size which can be felt upon the back of the arm. It serves to straighten out the forearm after the biceps has bent it.

89. *The Chest-muscle,* or *Pectoralis* (Fig. 30), forms the prominence at the upper part of the chest on each side. It is trian-

gular in shape, like a fan. It draws the arm inward across the chest.

90. *The Diaphragm* is the sheet of muscle which separates the cavity of the chest from that of the abdomen. It is of great importance, and is one of the principal muscles concerned in breathing; it is an involuntary muscle.

91. **The Tendon of Achilles.**—This is the strong, thick cord which you can feel at the back and lower part of the leg, just above the heel. It is the end of a very large and powerful muscle which raises the heel when we walk. It has received its name from the following story: Achilles was a Grecian hero. There was supposed to be a river, the Styx, of which it was said that whoever bathed in its waters could not be wounded. The mother of Achilles wishing to preserve her son from all future danger, dipped him into this river Styx, holding him by the heel. All parts of his body were wet except the heel by which he was held, and at this place he is said to have received his death-wound.

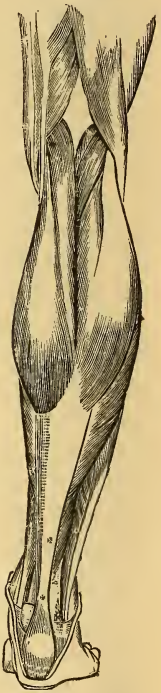


FIG. 32.—The Muscles of the Back of the Leg, showing Below (* *) the Tendon of Achilles.

92. **The Care of Muscles.**—The muscles form such a large part of the body that they soon show changes whenever our health is poor. During sickness they waste away and become smaller. Even after being confined to bed for a few days only we are surprised how weak we feel on getting up, and how difficult it is for us to stand. During this short period our muscles have become weaker because we could not exercise them. So that in order to get strong muscles they must be *exercised well.*

93. **Exercise.**—Look at the arm of a blacksmith and see how well-developed his muscles are. This is because he is

constantly exercising them. In the same way the legs of a man who walks or runs a great deal will be well developed; they become prominent and hard. It is a fine sight to see a man who has large muscles which stand out and make him look strong and manly. Such a man is not as apt to get sick as another; he feels stronger and is more useful in the world because of his strength.

94. All children should *exercise regularly and sufficiently.* It is not enough to walk slowly to school each day; if this is all the exercise a person takes his muscles will become small and weak, and he will become delicate. Children should have at least *two or three hours exercise each day.* The best exercise is that which is taken *in the open air.*

95. Playing with one's companions is the best kind of exercise, because it rests the mind and exercises the body at the same time. Walking fast, moderate running, rowing, swimming, skating, bicycle-riding, and playing base-ball, foot-ball, tennis, and croquet are all *good forms of exercise.*

96. We must remember to *quit exercise when we begin to feel tired,* for this is a sign that we have exercised enough and need rest. If exercise be continued *too long* it is *harmful* instead of beneficial. Often we see girls jumping the rope—one is trying to outdo the other in the number of times she jumps without stopping; many of the girls will be so tired that they can scarcely continue, and yet they go on simply to outdo their companions. They do themselves great harm by this excessive exercise; even death has resulted from it.

97. We should also *avoid all violent exercise,* for this does more harm than good. When boys try to lift heavy weights which would be a task even for men, or do too difficult feats in the gymnasium, producing too great a strain upon the muscles, it only harms them instead of causing them to improve in strength.

98. **Effects of Alcohol and Tobacco on Muscles.**—Of all enemies to the development of muscle there are none greater

than *alcohol and tobacco.* This is so well known that all persons who "train" in order to accomplish great physical feats requiring unusual strength and the best of health, *give up* all use of *tobacco* and either use very little *alcoholic* drink or none at all. What alcohol is will be explained in the next chapter; it will be sufficient to say here that all those drinks which, taken in considerable quantity, cause men to become intoxicated, contain alcohol and are called "alcoholic drinks."

99. The word *train* also requires an explanation. It means to live in the most healthy way; to go to bed early and rise early, to eat the most digestible and strength-giving food, to take plenty of out-of-door exercise, to avoid all tobacco, and to abstain entirely or almost so from drink containing alcohol. All this is done so as to put the person in a very fine, healthy condition, and to develop his muscles, so that he may be as strong as possible.

100. Everyone has probably heard of the great boat races which take place every year between Columbia and Harvard Colleges, and between Harvard and Yale Colleges. There is great rivalry between the colleges, and of course each one likes to win the race. Each of these crews "train" throughout the winter and spring until the day of the race, so as to make them strong and increase their chances of winning. They lead a most regular life, and smoking and the liberal use of alcoholic drink is absolutely forbidden.

101. *Alcohol is the enemy of muscle* because it *changes it into fat.* When a muscle contains much fat it becomes *weak and useless.* Look at the drunkard and see how weak and flabby his muscles are. He may look big, but this is due to fat and not to muscle, and though he looks big he is bloated and puffed up; he really is weak and tires easily. Nor is this all. The *heart* also is formed of muscle-tissue, and this becomes *changed to fat* in the drunkard; then it cannot beat as strong as it should. It *becomes weak,* and the blood is no longer pumped into the arteries as it should be, and the entire body suffers.

Sometimes there is so much fat mixed with the muscle of the heart that its wall becomes thin, and it may even burst; then instant death ensues.

SYNOPSIS.

Function of Muscle—Power of moving parts of skeleton.

Description:

1. Red masses commonly called flesh.
2. Divisible into "fibres."
3. Have the power of "contracting" or shortening.
4. There are three kinds:
   a. Voluntary—Under control of the will—muscles on outside of body.
      1. Appear striped under the microscope.
      2. End in tendons for attachment to bones.
      3. In contracting, become shorter, thicker, and harder.
   b. Involuntary—Not under control of the will—heart, walls of stomach and arteries, etc.
      1. Are not striped when seen under microscope.
      2. No tendons.
   c. Mixed—Consisting partly of voluntary, partly of involuntary fibres, such as muscles between the ribs.
5. More or less fat between the fibres, between the different muscles, and covering them.
6. Muscles usually occur in groups.

Uses of Fat:

1. To keep the body warm.
2. To protect the body from pressure.
3. To serve as a food.
4. To improve the appearance of the body.

The Way in which Muscles act:

1. Become shorter.
2. Become broader.
3. Become thicker.
4. Become harder.
5. Bring together the parts to which attached.

6. Dependent upon the influence of the brain, spinal cord, and nerves.

7. Ordinary muscular movements very complex.

Number of Muscles—About three hundred on each side.

Shape of Muscles—Varies greatly: Most frequently, long fleshy bundle; flat, fan-shaped, square-shaped, circular, etc.

Size of Muscles—Varies greatly; smallest, a fraction of an inch (found in ear); largest, over two feet in length (extends from hip-bone to leg).

A Few Important Muscles:

1. Biceps—Front of arm—bends forearm upon arm.
2. Triceps—Back of arm—straightens arm.
3. Pectoralis—Muscle of chest—draws arm across chest.
4. Diaphragm—Involuntary muscle separating abdomen from chest—muscle of breathing.
5. Tendon of Achilles—Just above heel—lower end of a large muscle of leg—has received its name from story concerning Achilles.

Care of Muscles:

1. They suffer when general health is poor.
2. They need regular and sufficient exercise.
3. Children should have at least two or three hours' exercise every day, in the open air.
4. Good forms of exercise—Rapid walking, moderate running, rowing, swimming, skating, bicycle-riding, horseback-riding, base-ball, foot-ball, tennis, croquet.
5. Stop exercise when begin to feel tired.
6. Avoid violent exercise.
7. Effects of alcohol and tobacco on muscles:

a. Enemies to the development of muscles.

b. Alcohol changes muscle into fat (becomes weak and flabby).

c. Alcohol changes heart into fat (becomes weak and does work poorly).

QUESTIONS.

1. What use do we make of muscles? 2. What does muscle-tissue look like? 3. What is it commonly called? 4. What are muscle-fibres? 5. What are tendons? 6. Of what use are tendons? 7. What can you say about the appearance and the strength of tendons? 8. How does fat occur with muscle? 9. What are the uses of fat in the body? 10. What proof is there that fat is used as nourishment by the blood? 11. Is there a larger proportion of fat in the baby or in the grown person? 12. What three kinds of muscle are there? 13. What is a voluntary muscle? 14. Give an example? 15. What is an involuntary muscle? 16. Give an example? 17. Why is it necessary that some muscles shall be involuntary? 18. Give an example of the working of an involuntary muscle. 19. Do muscles ever belong to both classes? 20. Give an example. 21. What do we mean when we say a muscle "contracts?" 22. How does the muscle change when it acts? 23. Can the muscles contract of their own accord? 24. What causes the muscle to act? 25. What part does the brain take in the contraction of muscles? 26. What part do the nerves take in this? 27. How can you prove that muscle itself cannot act without the influence of the nerves? 28. What two sets of muscles do we usually find together, and how does one set act toward the other? 29. Give an example of two muscles which have just the opposite actions? 30. How are the different expressions of sorrow, joy, and the like produced in the face? 31. What may result from continually having an ugly or a foolish expression in the face? 32. How many muscles are there in the human body? 33. Do muscles usually occur singly or are they usually the same on one side of the body as on the other? 34. Mention some of the shapes of muscles. 35. How do muscles vary in size? 36. Where is the *Biceps* muscle? 37. Describe the *Triceps* muscle. 38. Describe the *Diaphragm.* 39. Describe the *chest-muscle,* and give its other name. 40. Where is the *Tendon of Achilles?* 41. From what circumstance did it receive its name? 42. How does the condition of our health affect the state of our muscles? 43. What happens when we do not use our muscles? 44. What effect has exercise upon our muscles? 45. How much exercise should children have every day? 46. Where

is the best place to take this exercise, in the open air or in-doors? 47. What is the best kind of exercise for children? 48. Mention some of the good forms of exercise? 49. What effect has exercise when it is continued too long? 50. What effect has exercise which is too violent and heavy? 51. What effects have alcohol and tobacco upon the development of muscle? 52. What do you mean by "alcoholic drinks?" 53. What is meant by *training?* 54. What is the effect of training? 55. Why is alcohol injurious to muscle? 56. What effect has alcohol upon the heart-muscle?

CHAPTER V.

FOOD AND DRINK.

102. As we shall see further on, the different tissues of our bodies are being used up constantly. They are then replaced by materials taken from the blood. The blood receives the nutritious matters from our food and drink. Of course, our food has to be changed very much before the blood can absorb it to build up the different parts of the body. When we drink milk we say it is nourishing, and no doubt it is; but the milk must become changed in the stomach and intestines, before it can enter the blood and circulate through the body, to replace used-up tissues.

103. **Food and Drink are Essential to Life.**—Without food and drink we could not live; they are necessary for life and growth. We often hear of people fasting for a long time; it has happened that persons have lived for a few weeks without any food, but never without drink. If the body be deprived of both food and drink, death takes place, usually after several days. It is easy to see why this must be so. Even when we are as quiet as possible, the different tissues of our body are constantly changing, and are constantly being changed into material which is waste and must be cast off; we must breathe, and our heart must act constantly, and both of these are muscular actions and consume nutrition furnished by the blood. If the blood does not get a supply of this from our food and drink, it must take it from the tissues, and thus they would soon waste; the person would die from weakness, because both blood and solid tissues would become changed so much that they would be unable to perform their functions.

104. **Difference in the Food of Plants and of Animals.**—The food of plants is quite different from that of animals; it is very much simpler. *Plants live* upon *air*, the *gases* contained in the air, the *moisture* from the ground, and certain *salts* which are in the ground and which this moisture dissolves. These things are, of course, entirely too simple for animals to exist upon. Animals require something more. If you tried the experiment of feeding your pet dog upon nothing but water, air, and salts, you would find he would soon become very thin and weak, and would die from lack of food.

105. **Difference in the Food of Different Animals.**—Some animals live almost entirely upon flesh, and are therefore called *carnivorous*—a long word, meaning that they devour flesh. The cat, the dog, the lion, and the tiger are examples of this class.

106. Other animals exist upon vegetables, grass, grain, and the like; they are called *herbivorous*—that is, "herb-devouring;" of this class the cow, horse, and rabbit are examples.

107. Man belongs to neither of these two classes; he *combines the two;* he *requires both fleshy* food *and the other variety —vegetable*—the kind produced by plants.

108. **Different Kinds of Food Required by Man.**—It has just been stated that man requires fleshy food and vegetable food; with these he must also have water and a certain amount of mineral salts.

109. **Fleshy Food.**—By fleshy food is meant *meat*, whether from the ox, sheep, or other animal of this class, or from fishes.

110. **Vegetable Food.**—This is the name given to the food which plants produce; it contains starch, sugar, and other matters. One variety of this kind of food contains a large amount of *starch*, and is therefore called *starchy* food; another name is *farinaceous* food. Examples of this kind are wheat, which furnishes the flour from which bread is made, corn, barley, rice, oats, and the like. Hay also belongs to this class.

Man could not, of course, eat hay, since his stomach is not arranged so that he could digest it; but the ox eats hay, and it is converted in his body into nutritious materials from which his flesh (beef) is formed, and the latter is then eaten by man.

111. **Starch.**—It is important to thoroughly understand what *starchy food* is. You may have seen starch used for stiffening linen. When used in this way, it is first mixed with water and then placed on the fire; this causes it to swell up, and it becomes changed into a paste. Raw starch is not suit-

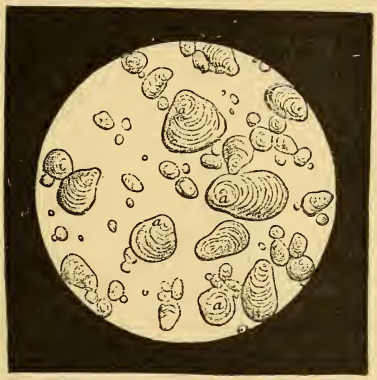


Fig. 33.—Starch Granules (from Potato) as Seen under the Microscope.

able for food for man; it must first be boiled; this changes it so that it can be digested. All starchy food must first be boiled before it can be used as food. The cow and ox can eat hay and oats and can digest them; but man would not think of taking oat-meal raw, but only after it had been boiled. The same applies to rice, farina, barley, and all other farinaceous food. There is no starch in fleshy food and there is none in animals; it occurs only in plants.

112. Starch is a white powder which has a strange, dry feeling. When looked at under the microscope, each grain of

the powder has a peculiar form and is marked by rings or lines (Fig. 33).

113. Another form of vegetable food has a large quantity of *sugar* in it; so that we are constantly taking in sugar with our food, and it forms nourishment.

114. Then it is also necessary that we should eat *green vegetables*, such as peas, spinach, string beans, salad, and the like. When deprived of these for any length of time, the blood becomes poor, and the body suffers.

115. **Fat and Fatty Food.**—Fat or fatty food forms an essential part of our food. This is why we eat butter with our bread. The fat which we take in with our food may be vegetable, as for instance, certain nuts, or it is (more often) animal food in the form of butter from cows' milk and the fat around meat. In the body, starchy and sugary food is changed into fat; this is why we say potatoes, bread, and the like are fattening.

116. **Water.**—Water is even more necessary to life than is food. A person could live longer without food than without drink. The great drink is, of course, *water*. Three-fourths of the weight of the human body is water; consequently water is an absolutely essential addition to our food.

117. **Tea and Coffee.**—A good deal of the liquid which we drink consists of *tea and coffee*. Grown people are not usually harmed by tea or coffee if they do not take too much; but both of these are injurious to children, and they are better off without them. Milk and water are the best drinks for children. Even grown people often make themselves nervous and trembling by drinking too much tea or coffee. *Chocolate* is like tea and coffee, but it also contains considerable fatty matter which is nutritious. Hence chocolate is more of a food, while tea and coffee are only stimulants—that is, they excite the system for the time and are luxuries. Children do not need any stimulants.

118. **Man must Combine all Forms of Food with Water.**—Man is so constituted that he *cannot exist upon any*

one form of food alone. Meat is very nourishing, but a man could not exist on meat alone ; he would soon become thin and weak. He must have meat, fatty food, vegetable food, and water, all combined.

Some of the Simplest Forms of Food.—We will now consider some of the different forms of food.

119. **Meat and Fish.**—There are a great many different kinds of meat. *Beef* is used more than any of the others. There is always some fat mixed with the meat, even when we cannot trim off any more. Under this head also come chicken, turkey, and other fowl ; also the various birds. Fish is a very useful form of fleshy food, and is usually quite easily digested.

120. **Bread.**—Bread is made from flour. In America, this is usually wheat ground up fine. The baker takes the flour and adds water and a little salt ; with these he makes the dough. He also adds yeast, and he will tell you he does this so as to make it raise, so that it will be light and easy of digestion. What does the yeast do ? When it is added to the dough it changes some of the starch so that a gas is given off. This gas escapes in bubbles but cannot get through the dough ; when it tries to work its way out it puffs out the dough and makes it light and porous. Then this dough is put into the oven and baked ; a hard crust forms on the outside. Bread is often called "the staff of life," on account of its importance.

121. **Milk.**—Most of the milk used by man is obtained from the *cow ;* but in some countries milk is obtained from the *goat* and from the *ass.* Milk is one of the *most nutritious* articles of food, and at the same time one of the most easily digested. Milk contains substances which are like all the different kinds of food which man requires—it contains materials like those found in flesh, fat, and others which resemble those found in vegetable food, and it contains a large amount of water. Thus it has in it

FIG. 34.—A Drop of Milk Seen under the Microscope, Showing the Fat-globules (Cream).

everything that we require, and *we could get along on milk without any other food.* The baby thrives on milk alone for a long time, but after a while man longs for more variety in his food.

The fatty part of the milk floats on top after the milk has stood for a time, when it can then be taken off; it is the *cream.*

122. **Butter** is nothing but this cream pressed together. Cream consists of fat-globules (Fig. 34); when milk is churned, these fat-globules stick together, and in this way form a mass called *butter.*

123. Milk from which the cream has been taken is called *skimmed milk.* If the milkman is dishonest, he may *skim* the milk and add water to it; it then has a bluish tint, and is much less nourishing.

124. If we add a little piece of the stomach of the calf to the milk, it causes one of its substances to separate and fall to the bottom; if we take this and press it together, we have *cheese.*

125. **Eggs** are obtained from the hen, and from other birds of this kind. They are *very nutritious* and are easily digested. The shell of the egg is lime. The contents of the egg consist of two parts—the white and the yellow. In the yellow or yolk of the egg is much fatty matter. Both portions of the egg correspond to fleshy food.

126. **Variety in Food.**—We could not eat the same kind of food every day, for we would soon get tired of it; it is necessary to have different kinds of food. Certain things, however, we seem never to tire of; such are milk, butter, bread, beef.

127. **Proper Food.**—If we want to remain healthy we must *not eat improper food.* Girls who eat too much candy, or too many pickles, usually have very little appetite for any proper food, and soon become pale and delicate. And boys who eat green apples before they are ripe, in summer, or unripe fruit of any kind, are sure to repent it; they are apt to become sick, and to have great pain in the stomach.

128. **Methods of Cooking.**—Sometimes we eat our food *raw;* as for instance, fruit. But usually we cook it, because it becomes more digestible and tastes better. In cooking, we may make use of a great many different plans. If it is meat, for instance, we may put it into water and *boil* it, or if we let it get a little thicker, we *stew* it. We may put it into the pan with some fat and *fry* it. By holding directly to the fire we *broil* it or *roast* it. Finally, by putting it into the oven, we *bake* it. Of all these different methods, *boiling*, *stewing*, and *broiling*, are most to be recommended, because they make the food most easy to digest.

129. You must remember also to take food at *regular times* in the day. Usually three meals a day are enough. *Never eat in a hurry*, but chew your food well. *Never eat so much* at one meal that you feel heavy, full, and uncomfortable.

130. **Our Drinking-water.**—Water is the great drink, and it is very necessary that it should be *pure*. Clear water is not always pure; water may be very impure and still be very clear and transparent. And again, water may look a little cloudy, and yet be perfectly innocent and healthy. What makes some water unhealthy and injurious is poison dissolved from the soil. In cities where the water is brought from a distance in pipes, this poison is not apt to occur; but in the country, where the water from *wells* is used, it is often present. In the country, very often no other water can be obtained except that from the well; for convenience sake, the well is built near the house and the stable; it is then very apt to be poisoned. Fig. 35 illustrates very nicely the manner in which well-water may become poisoned. It is a good example of what occurs constantly in many places in the country where well-water is used without proper precautions having been taken to prevent poisoning.

131. An examination of the picture on p. 70 shows the following: To the right is the dwelling-house; to the left is the stable with its manure-heap and pig-pen; between these two is the

well. The surface of the ground is fairly level, and is sandy, and beneath this is gravel. The rain soaks into the porous ground, and in doing so dissolves poisonous matters from the manure-heap and the pig-pen; after it has soaked into the ground it remains there, since below there is a layer of rock, which will not allow the water to pass. This poisoned water collects here, and then gradually enters the lower part of the well. When water is drawn from the well it will be easily

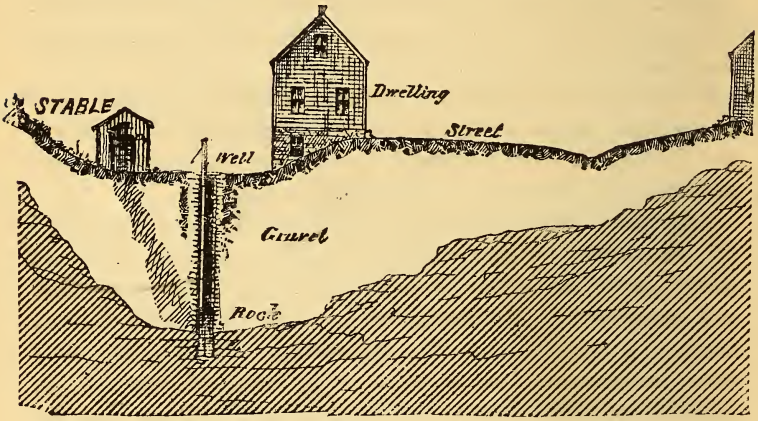


FIG. 35.—A Section of a Dwelling, and its Accompaniments, as is often Found in the Country. The shading extending from the stable to the layer of rock at the bottom of the well, shows the course of the poisonous material from the stable, with its manure-heap and pig-pen, to the well.

understood that it is partly the same water which has passed over and through the manure-heap and the dirt of the pig-pen before passing into the ground. The shading extending, on the figure, from the stable to the bottom of the well, shows the course which this poisoned water takes. Such water causes typhoid fever and other diseases in those who drink of it. It has often happened that a great many persons became sick in a village at the same time. When a great many persons become sick at the same time, and have the same disease, an *epidemic* is said to exist. Many epidemics have been found

to have been produced by the drinking of poisoned well-water.

132. The water of a *pure river* should be preferred to that of a well. But sometimes we have no choice and must drink well-water. In this case we should see that the well is thirty feet or more from any inhabited building, and that no refuse or slops of any kind are allowed to soak into the ground. Such refuse should be kept in water-tight barrels and carted off regularly. If we are in doubt about whether the water is good or not, we may *boil it* thoroughly; this destroys the poison, and then we are safe in drinking it.

133. Water which has stood in leaden pipes all night dissolves a little of the lead : hence when we use the water in the morning, we should allow it to run a few minutes before taking any.

ALCOHOLIC DRINKS.

134. These are called so because they contain *alcohol*. Let us now study what alcohol is, how it is made, its uses, and the injury and danger to man which it causes :

135. **Properties of Alcohol.**—It is a clear, colorless liquid, resembling water in appearance, but lighter ; it has a pleasant smell ; it takes fire easily and burns ; its taste is very hot, and it burns the mouth. If we leave a little in a saucer, we soon find that it has disappeared into the air, and we say it has "evaporated." It is very useful to us in many ways, for it dissolves oils and other things which water will not dissolve. It also extracts the good part of many roots, herbs, and barks ; in this way it is used a great deal by the druggist to make the different medicines. So that alcohol is very useful in its way. It is only when misused as a drink that it causes such great harm.

136. **How Alcohol is Made.**—If you take anything which contains much starch, whether it be corn, rye, potatoes, or anything of this sort, add yeast and water to it, and mix them,

you will soon find that the starch in these substances has turned into sugar. If you allow the mixture to stand longer and warm it slightly, little bubbles of gas will be seen escaping into the air; we say it is *fermenting*. If anyone has seen sweet cider becoming sour, he will have noticed the bubbles of gas rising —this is an example of *fermentation*.

137. At the same time that this gas is given off, we find the liquid is becoming less sweet than it was. After a time it will have lost all its sweetness and have the taste of alcohol. So that, first the starch has been changed into sugar, and then the sugar has become changed into alcohol. The alcohol remains in the liquid, while the gas, which is poisonous, escapes into the air. Sometimes a sugary liquid is taken at once, such as the juice of grapes from which wine is made; in this case it is not necessary to change starch into sugar, for sugar is already present.

138. If the preparation is to be an alcoholic drink it requires clearing and flavoring. If the drink is to be wine or beer this is done by allowing the liquid to stand, and pouring off the clear part, and straining it. If it is to be one of the liquors—whiskey, brandy, rum, and the like—the liquid is placed in a large vessel and is heated. The heat drives off the alcohol and some of the water and some flavoring matters; these are collected and make liquor.

139. If pure alcohol is wanted, it must be driven off by heat several times in succession, being collected again each time.

140. **Varieties of Alcoholic Drinks.**—All alcoholic drinks are intoxicating; but they differ in degree according to the amount of alcohol which each contains, and can be divided accordingly into three classes:

141. (1.) *Beers and Ales* usually contain from two to four per cent. of alcohol, and are made from barley, which is heated in the oven, so as to change the starch into sugar; this makes it sweet, and it is then called *malt*. Afterward hops are added

to make the beer bitter. Ales and beers contain the least alcohol.

142. (2.) *Wines* usually contain from eight to seventeen per cent. of alcohol; they are made from the juice of grapes.

143. (3.) *Liquors* contain about one-half alcohol; the only difference in the various kinds is the flavor; this depends upon the kind of grain used to furnish the alcohol, or upon whatever flavoring is added afterward. Whiskey is made from rye or from corn, brandy from grapes, rum from molasses, gin is flavored with juniper, absinthe is flavored with wormwood.

144. **Effects of Alcohol and of Alcoholic Drinks.**—Having studied what alcohol is and the nature of alcoholic drinks, the effects will now be considered. It would be untruthful to say that everyone who takes the least amount of alcoholic drink is seriously harmed by it; for there are undoubtedly persons who can take a little drink without doing them any harm that we can notice. But it can certainly be said that, in general, it *does them no good.* Persons who can take any drink at all without any harm to themselves, take it *only in small quantities and at meals.* Alcohol, in the form of wines and liquors, is often *prescribed by the doctor*, and then it is a *medicine*, and is really useful. With this exception it can be said, and cannot be denied, that the *world would be a thousand times better off if there was no such thing as alcoholic drink.* If a prison be visited, and the convicts be asked about the crimes which brought them there, it is astonishing how many of them will blame drink. Many a man, who would otherwise have been good and useful, has been made a criminal by this poison. It may safely be said that there is *no cause of crime so great and widespread as drink.*

145. Men do not become drunkards at once, but only after a while; they commence with small quantities of drink, and the *habit grows* until they need larger and larger amounts to satisfy them.

146. Alcohol, in the form of drink, has the following effect upon the tissues : It *irritates the stomach* and constantly makes it red ; after a while, the wall of the stomach becomes tough, and is no longer suited for its work. When a large quantity of alcoholic drink is added to the food, *it prevents it from being digested.* It *irritates the intestines.* It *makes the heart act too rapidly,* and, after a while, also *irregularly.* It changes *muscle-tissue into fat.* It causes the *liver* to become *enlarged* and afterward to *shrink.* The *blood-vessels become stiff* and *lose their elasticity.* Upon the nose can be noticed how the veins of a drunkard stand out.

147. There may be a *feeling of warmth to the body* after alcoholic drink has been taken, but this is only on the surface and soon leaves, and then the *warmth of the body is lessened.* This was shown very well in several North Pole expeditions, where men who drank freely of liquor were frozen before the rest. Persons who are exposed to great cold know from experience that they do better without alcoholic drink.

148. Upon the *brain* alcohol acts by first *exciting* it, but this is soon followed by the *opposite effect,* and the person becomes *dull and stupid.* People who do much brain-work know that they are more active when they let wine, beer, and liquor alone. Alcohol excites the brain in one way, but it excites it so that the person becomes *noisy,* and often wishes to fight—hence it does not excite the most desirable function of the brain, namely, the intellect.

149. The *nerves* are soon made *unsteady,* as is shown by the *trembling hands* and the *unsteady walk* of the drunkard.

150. Finally, the *moral* view of the effects of alcoholic drink in large amount must be considered. One has only to think how shocking it is to see an intoxicated man stagger along the street, holding on to anything for support, with bad breath and dirty appearance, to be warned never to take alcoholic drink at all—certainly not before he is a full-grown man. One should also consider the large amount of money which is uselessly spent

in liquor-saloons; how many useful things could it buy, and how much good could be done with it. The time wasted in these rum-shops, which would otherwise be spent at home with the family, should also be considered.

SYNOPSIS.

Uses of Food and Drink:
1. To support Life.
2. To allow growth.

Differences in Food of Plants and of Animals:
a. Food of Plants:
1. Air.
2. Gases in the air.
3. Moisture from the ground.
4. Salts from the ground.

b. Food of Animals:
1. Fleshy food (meat and fish).
2. Fatty food.
3. Starchy and sugary food, including green vegetables.
4. Water (forms three-fourths weight of body).

Differences in Food of Different Animals:
a. Carnivorous—Flesh-eating.
b. Herbivorous—Eating vegetables, grass, grain, etc.
c. Man—Mixed food.

Drink:
Water.
Tea and coffee—Unnecessary for children—often harmful.

Necessity for Combining all Forms of Food with Water.

Some of the Simplest Forms of Food:
Meat and Fish—Beef most common.
Bread—Should be light and porous.
Milk—Most nutritious—contains:
a. Cream, making butter.
b. A material forming cheese.
Eggs—Very nutritious.

Methods of Cooking:
1. Boiled—Placed in water and heated.

2. Stewed—Somewhat thicker than boiled.
3. Broiled } —Exposed directly to fire.
4. Roasted }
5. Baked—Placed in oven.
6. Fried—Placed in pan with fat.

Boiling, stewing, and broiling are most nutritious.

Cautions Regarding Food:

1. Variety.
2. No improper food, such as much candy, unripe apples, etc.
3. Regularity in meals.
4. Plenty of time for meals.
5. No overloading.

Drinking-water:

Should be pure.

Clear water may not be pure.

Healthy water may be a little cloudy.

Danger of water from certain wells—

Occurring through contamination from soil.

Avoided by removal of well to distance of thirty feet or more from habitations, and removal of refuse without allowing it to poison the soil.

Water from pure river preferable.

Danger of poisoning from leaden pipes.

Alcoholic Drinks:

Properties of Alcohol:

1. Clear and colorless liquid.
2. Resembles water, but lighter.
3. Pleasant odor.
4. Takes fire readily and burns.
5. Taste hot and burns mouth.
6. Evaporates easily.
7. May be useful in dissolving oils, etc., and preparation of medicines.

How Alcohol is Made:

1. Addition of yeast and water to starchy or sugary substance.
2. Moderate heat.
3. Boiling to drive off alcohol.

Varieties of Alcoholic drinks:

1. Beers and Ales—Two to four per cent. alcohol; made from malt.

2. Wines—Eight to seventeen per cent. alcohol; from grapes.

3. Liquors—Fifty per cent. alcohol; from grains, and variously flavored.

Effects upon man:

a. Very common cause of crime.

b. Morally objectionable; neglect family, etc.

c. Injurious to body:

1. Irritates and hardens stomach and interferes with digestion of food.

2. Irritates intestines.

3. Causes heart to beat too rapidly and irregularly.

4. Changes muscle to fat.

5. Enlarges, then contracts liver.

6. Blood-vessels become stiff.

6. Lessens bodily warmth.

8. Excites objectionable functions of brain and dulls the intellect.

9. Weakens the nerves and causes trembling.

QUESTIONS.

1. Why must we take food and drink? 2. What must happen to the food before it can be changed into our tissues? 3. Describe the food upon which plants live. 4. Do all animals have the same kind of food? 5. What difference is there between the kind of food which the cow takes and that which the dog eats? 6. What is meant by a "carnivorous" animal? 7. What is meant by a "herbivorous" animal? 8. To which class does man belong? 9. What is meant by "fleshy" food? 10. What is meant by "vegetable" food? 11. What is "farinaceous" food? 12. What is starch? 13. Do we find starch in animals? 14. Why is it necessary to eat green vegetables? 15. Do we need fat in our food? 16. Can man exist on any one form of food alone? 17. Why do we naturally eat butter with our bread? 18. How is bread prepared? 19. Why is yeast

added? 20. Could we exist on milk alone? 21. Why? 22. What part of the milk does the cream represent? 23. What is butter? 24. What is cheese? 25. What can you say about eggs as food? 26. Could we eat the same kind of food every day? 27. What follows when we eat improper food? 28. Why is most of our food cooked? 29. Name some of the different plans of cooking food. 30. What makes our drinking-water unhealthy? 31. Explain how well-water is often poisoned. 32. How can you prevent poisoning of well-water? 33. What is meant by alcoholic drink? 34. What are the properties of alcohol? 35. How is alcohol made? 36. From what is the alcohol formed? 37. What kinds of alcoholic drinks are there? 38. From what are beer and ale made? 39. About how much alcohol do they contain? 40. From what is wine made? 41. About how much alcohol do wines contain? 42. From what are the different liquors made? 43. About how much alcohol do they contain? 44. What effect has alcoholic drink on the stomach? 45. On the heart? 46. On the liver? 47. On the blood-vessels? 48. On the heat of the body? 49. Upon the brain and nerves? 50. Why is alcoholic drink objectionable, even aside from its bad effects upon the health? 51. What opinion would you have of a man whom you saw drunk? 52. What effect has the liquor-saloon upon a man's time and upon his purse?

CHAPTER VI.

DIGESTION.

151. The word *digestion* means the changing of the food by the organs in the abdomen, so as to liquefy it in order that the blood can take it up and make tissues out of it. Digestion commences in the mouth and ends in the large intestines ; if we commence from above, the following parts are met with : Mouth, throat, gullet, stomach, small intestine, pancreas, liver, large intestine. All of these except the pancreas and the liver, are hollow organs through which the food passes. All of these hollow organs taken together form the *alimentary canal.* Each of the organs of digestion will now be considered :

THE MOUTH.

This is the commencement of the alimentary canal (Fig. 36) and is the cavity in which the food is chewed and mixed with saliva.

152. **The Teeth.**—The chewing is done by means of the *teeth ;* these are supported by the jaws and occur in two rows, an upper and a lower. We do not have the same teeth when we are grown that we had when we were very small ; all the teeth which we have when very young children fall out ; they are only temporary, and they are called *temporary* or *milk teeth.* There are ten of these in each jaw, and thus twenty altogether.

153. In the sixth year the temporary teeth begin to fall out,

and others commence to grow from the jaws to take their places. These are stronger than the first, and there are more

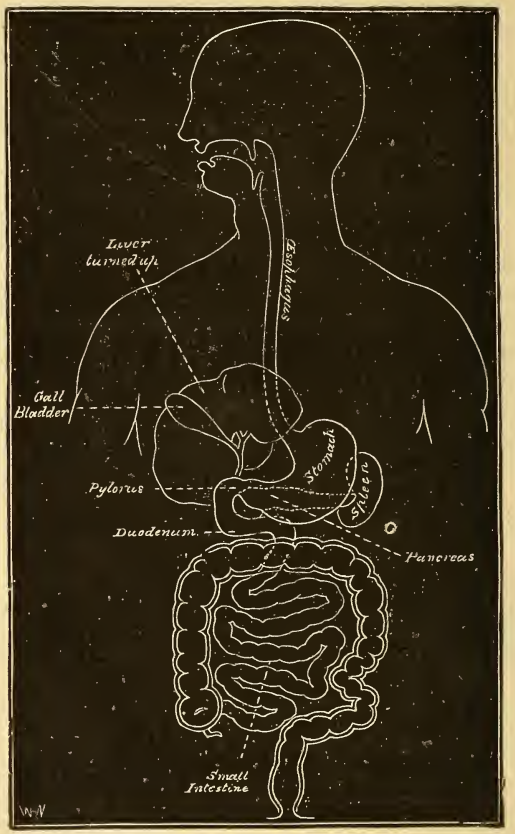


FIG. 36.—Outline Sketch of the Organs of Digestion.

of them. They are called the *permanent teeth ;* there are sixteen in each jaw. After the sixth year, the other permanent

teeth gradually replace the temporary ones which fall out. The last tooth to appear is that placed farthest back, called the *wisdom-tooth ;* this comes about the twenty-first year.

154. Each tooth can be divided into the part which projects

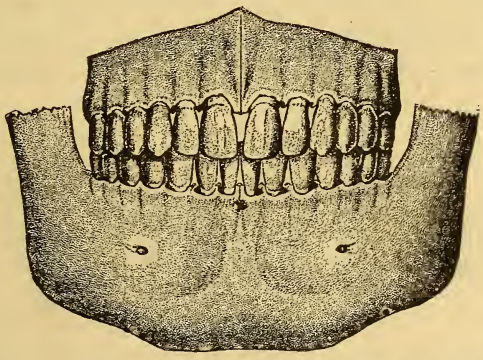


FIG. 37.—The Upper and Lower Jaws with the Permanent Teeth.

into the mouth and which is called the *crown*, the part which sinks into the jaw, the *fang* or *root*, and the line between these two, called the *neck*. Teeth are composed of a very hard material, consisting very largely of lime, called *dentine*. They are hollow in the centre (Fig. 38) and this central space is filled up with a soft material called the *pulp*. On the surface of the crown is a covering of very hard material, formed principally of lime, called *enamel*. Each tooth is supplied with a small nerve which enters it through an opening in the end of the root. It is the exposure of this nerve through the formation of cavities in the tooth which most often gives rise to toothache.

FIG. 38.—Section of One of the Molar Teeth.

155. Upon examining the teeth, we find they differ greatly in size and in shape. They are similar on the two sides of the mouth and are the same in the upper as in the lower jaw. In

Fig. 37 we see the teeth in position; in Fig. 39 they are separated, those on the right of the figure corresponding to the middle line, while those on the left are the back teeth. Commencing in the centre and proceeding toward each side (from right to left in Fig. 39) there are first two sharp-pointed teeth, having chisel-like edges; these are the *incisor* teeth; their sharp edges are intended to *cut the food* and to bite it into pieces. Next to these is a long, pointed tooth, called the

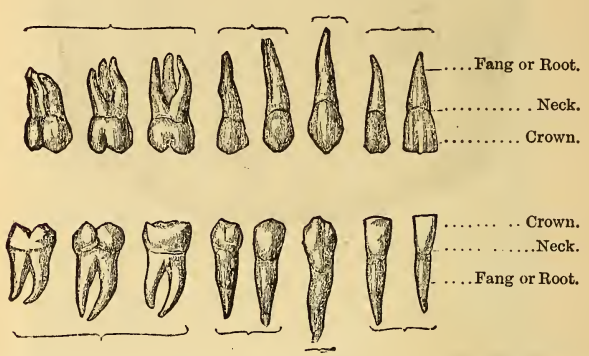


Fig. 39.—The Permanent Teeth. Above are those of the upper jaw; below, those of the lower jaw. The teeth of one side of the jaw only are represented. The two teeth to the right are *incisors*. The long tooth next to these is the *canine* tooth. The two following ones are *bicuspids*. The last three (to the left) are *molars*.

canine, also known as the *eye-tooth;* in the dog and cat, and animals of this type, it is of great length and sharpness, and is used for tearing meat. Next to the canine are two broader teeth having two sharp points each; they are known as the *bicuspid* teeth. Still further back there are three large, broad teeth; the surface of their crowns is very uneven, but they are very strong; they are the *molars* and serve to *grind up* the food into small particles.

156. The teeth are intended to chew the food so that it is in small enough particles to be received and digested by the

stomach. *Hasty eating* results in the swallowing of food which has not been chewed sufficiently, giving rise to *indigestion*, *pain* in the stomach, and, if continued, *dyspepsia* (which means difficult digestion).

157. *Care of the Teeth.*—Teeth are natural *ornaments* when nice and healthy; they are very disfiguring when dirty or decayed. Teeth should be brushed every morning upon rising, and every night before retiring; they should be kept clean at all times. If particles of food lodge between the teeth, they should be removed with toothpicks of wood or quill—never with pins, needles, or metallic points. Teeth are apt to decay and cavities form, if the general health becomes poor, also if much improper food be taken; by improper food is meant, a great many pickles, much candy and cake, and food which is difficult to digest or too acid. Teeth should not be used to crack nuts with, nor for anything but chewing. When cavities have formed in the teeth, the dentist fills them with gold or silver foil so as to prevent them from decaying more.

158. The vulgar habit of chewing tobacco discolors the teeth; smoking also does this, unless great care be taken to clean them often.

THE SALIVARY GLANDS.

159. We give the name *glands* to certain bodies, usually small and round, in which fluid is formed, to be used in various ways. For instance, around the mouth there are many such glands, and they form the *saliva*—that is, the fluid which constantly keeps the mouth wet, and also moistens our food; hence, these glands around the mouth are called the *salivary* glands. There are a great many of them, but most of them are very small. Three, however, are larger and are worth mentioning.

160. The largest is placed in front of the lower end of the ear, around the joint of the lower jaw, and has a small tube

leading to the mouth; it is called the *parotid* gland. Another is placed just below the tongue, and is therefore called the *sublingual* gland. A third is found underneath the chin on each side, and is called the *submaxillary* gland.

161. These glands pour some of the saliva into the mouth all the time, but they are especially active when we use the jaws either in speaking or in eating; if it were not for this fluid, the saliva, the mouth would soon feel dry after talking a little. In eating anything dry, such as a cracker, we notice that enough fluid forms in the mouth to moisten it thoroughly and thus enable us to swallow the mass; it would be difficult to swallow if it were dry. When the saliva is mixed well with the food, the stomach can act on the food at once and digest it easier. This is another reason why we should chew our food well.

162. There is still another reason: A small part of starchy food is digested by the saliva before it reaches the stomach; this is an aid to the stomach in its work of digestion.

163. **Effects of Chewing Gum.**—The habit of constantly chewing gum not only looks bad, but by making the saliva flow in large quantity all the time it makes it thin and watery; such saliva is apt to be inefficient in the proper performance of its work during meals. This habit is, therefore, not only vulgar, but unhealthy.

THE THROAT.

164. This is the wide part of the mouth behind, into which the food passes after it has been thoroughly chewed and when we swallow it. While we are swallowing, it passes into the throat. Once swallowed, the food passes into the canal leading to the stomach, the *gullet*, or *œsophagus*, then it continues its way without our knowledge or will (Fig. 36).

THE TONGUE.

165. This is also one of the organs of digestion, since by its movement the food is rolled around in the mouth and mixed thoroughly with saliva. The tongue also assists in swallowing. This organ will be described under the special senses, as it is also the organ of taste.

THE GULLET, OR ŒSOPHAGUS.

166. This is a long tube (Fig. 36) which connects the mouth and throat with the stomach. Its walls are formed of rings of muscle-tissue. When these rings contract, the food is forced downward until it reaches the stomach.

THE STOMACH.

167. *The Stomach* is a sort of bag about a foot long, placed in the upper part of the abdomen, just below the diaphragm. The latter, as has already been mentioned, is the sheet of muscle-tissue separating the abdomen from the chest. The stomach commences near the middle of the body, and then extends over toward the right. There are two openings into the stomach. One is *for the entrance of food*, which is carried by the gullet from the mouth; in order to reach the stomach, the gullet must, of course, pass through the diaphragm. The other opening of the stomach is at the farther end, and *allows the food to pass on* into the intestines after the stomach has done its work. Around this opening is a sort of narrowing which remains closed until the food is ready to be sent to the intestines. This narrowing is produced by a thickening of the tissue at this point, and is called the *pylorus*.

168. The wall of the stomach is not very thick, but it is very strong. On the outside there is a smooth, shining coat, which is merely part of a membrane lining the whole inside of the

abdomen and the organs in it. This membrane is known as the *peritoneum.* On the inside there is a soft, velvety coat,

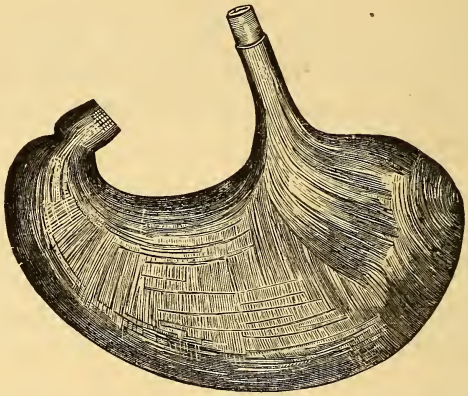


FIG. 40.—The Stomach, Showing the Layer of Muscle-tissue by which it Contracts and Propels the Food.

called the *mucous* layer (Fig. 41). We often meet with the term *mucous membrane* in anatomy; it refers to a soft, smooth,

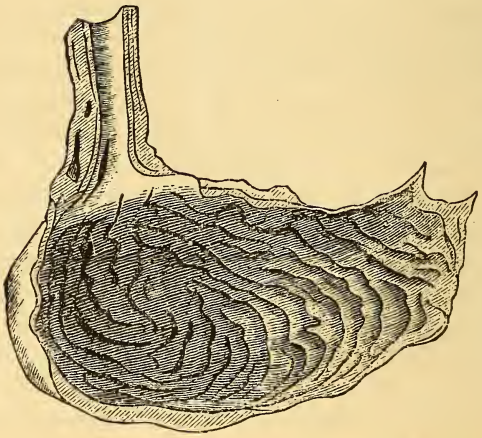


FIG. 41.—The Inner Surface of the Stomach, Showing the Mucous Layer Arranged in Folds

velvety membrane which is called mucous because it forms and is kept moist by a watery, slippery fluid called *mucus;* the fluid from the mouth between meals and the fluid which runs from the nose are examples of mucus. In between these two surfaces, the mucous and the peritoneum, is a layer of muscle-tissue which forms the main part of the thickness of the stomach (Fig. 40).

169. **Gastric Juice.**—The inner, or mucous, layer of the stomach is arranged in a series of folds which are especially marked when the stomach is empty. It is usually of a pink or of a grayish color, but the color and appearance differ greatly according to the time at which we examine it—whether the stomach contains food or is empty. When food reaches the stomach, it excites it, and the soft lining then begins to swell, and becomes reddened. We also notice in this mucous layer, when looked at under the microscope, a large number of small dots or openings. When food is in the stomach, we can see drops of fluid escape from these dot-like openings; this fluid is called the *gastric juice.*

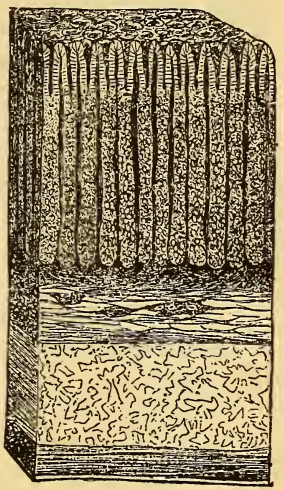


Fig. 42.—A Section of the Lining Membrane of the Stomach, Very Highly Magnified, Showing the Gastric Tubules in Position.

170. **The Gastric Tubules and the Gastric Juice.**—The gastric juice is a very important fluid; it is only found in the stomach when food is present; the presence of food causes it to flow. Of course the lining of the stomach is never dry, but it is moistened only with mucus, except when excited by food; then gastric juice begins to flow. Upon examining this internal layer of the stomach under the microscope, we find thousands of small tubes, lined by little

oblong bodies, which we call *cells* (Figs. 42 and 43). These cells pour the gastric juice into the small tubes, and from these it passes into the stomach and is mixed with the food. But, it may be asked, where do these cells take the gastric juice from? They get it from the blood. There are tiny blood-vessels everywhere, and certain portions of the blood pass through the walls of the blood-vessels into the cells, and are mixed there with other substances; in this way the gastric juice results.

FIG. 43.—One of the Gastric Tubules, Very Highly Magnified, Showing the Central Canal and the Cells Lining the Tubule.

171. *Pepsin.*—The substance in the gastric juice which enables it to digest fleshy food is called *pepsin.*

172. **Function of the Gastric Juice.**—The work of the gastric juice is to digest food. But it does not digest every sort of food. It *will digest only fleshy food.* Vegetable food is digested elsewhere—a little by the saliva, but chiefly in the small intestine. Fat, also, remains undigested in the stomach, and passes on to be digested in the small intestine.

173. (1.) **Uses of the Stomach.**—One of the uses we have just stated, namely, *to digest the fleshy part of the food.*

174. (2.) The second use of the stomach is to be a sort of *storehouse for the food.* It takes between two and three hours to digest an ordinary meal; if there were no large bag in which the food could be kept until digested we would have to keep eating little by little all the time. The large size of the stomach also allows the gastric juice to be mixed quickly and thoroughly with the food, and thus digestion takes place quicker than it otherwise would.

175. (3.) Still another use of the stomach is to churn the food, and to roll it about so that it is ground into the smallest particles and is well-mixed with the gastric juice. One of the coats of the stomach consists of muscle-tissue, and it is this coat which causes these motions of the stomach. Besides, the lining of the stomach has a large number of raised lines or

ridges (Fig 41); these projections make the breaking-up of the food still easier.

176. Man has but one stomach. Some of the lower animals, such as the ox and cow, have four stomachs. Such animals swallow grass and hay without thoroughly chewing them. Afterward this food passes up into the mouth again. It is then chewed over again, swallowed, and after passing through the series of stomachs, it is finally digested.

177. **Effect of Tobacco on the Stomach.**—When a person smokes tobacco for the first time, it makes him sick at his stomach. He may get used to the tobacco after a while; but still, if he smokes too much, he has the same disagreeable sensation. Many persons make their stomachs weak and delicate, and spoil their appetites, by smoking and chewing tobacco.

178. **Effect of Alcohol on the Stomach.**—Alcohol reddens the lining of the stomach and irritates it. After a while it hardens it, thins it, and renders it unfit to digest the food properly.

179. **The Discovery of How the Stomach Acts.**—Many years ago, a Canadian named St. Martin was shot in the abdomen; he recovered with a permanent opening leading from the outside into the stomach, through which the doctors could watch and see what happened after eating. They found that ordinarily it took the stomach *from two to three hours* to finish its work, and to discharge what it could not digest into the small intestine or bowel. This man lived a great many years with the curious opening, and was quite strong and healthy.

180. Certain kinds of food require a longer time than other kinds for digestion, and hence we call them *heavy*, or *indigestible;* other food is digested very quickly, and is called *light*, or *easily digestible.* As examples of heavy food may be mentioned, hard-boiled eggs, pies, cheese, etc. As examples of easily digested food, there are milk, soft-boiled eggs, toast, broiled steak, etc.

THE BOWELS OR INTESTINES.

181. These consist of a long, hollow tube, of about twenty-five feet, commencing at the stomach (Fig. 36). Where stomach and intestines meet is a narrow opening, which is closed, except when the stomach has digested what it can of the food, and wishes to empty what is left into the intestines.

182. This narrowing is called, as has already been mentioned, the *pylorus*, meaning *gatekeeper*, and it will be seen that it is well-named, for it guards the outlet of the stomach. The remnants of food which the stomach refuses to digest pass this point in the form of a soft, creamy mass.

SUBDIVISIONS OF THE INTESTINES.

183. The intestines can be divided into three parts: the first part, which is next to the stomach, is called the *duodenum*, a long word, which was given to it in olden times because it is about as long as twelve fingers put side by side—so that this part of the bowel is quite short. The second part is very long —twenty feet—and forms the principal part of the bowels; it is called the *small intestine*, and the word small is used because it is narrower than the rest. The remainder of the bowels (about five feet long) is the last portion, and it is called the *large intestine*, because it is wider than the rest.

184. The intestines are twenty-five feet long. In order that they may be contained in the abdomen they are folded together many times around a sort of stem which is attached to the backbone. In this way they can move around somewhat, and yet they are kept in place by being held to the backbone. It will be seen later why it is necessary that they should be allowed a certain amount of motion so as to cause the remains of the food to move on.

185. The intestines have the same coats as the stomach.

There is on the outside a smooth, shining coat (the peritoneum). On the inside is a soft, smooth, velvety coat (the mucous coat). Between these two there is a coat formed of muscle-fibres, which run around the intestine in circles; there is much less muscle-tissue around the intestine than in the walls of the stomach.

186. **The Peritoneum.**—The shining outside coat of the intestine is very important, and is formed of the same layer of tissue that lines the whole abdomen. The whole inside of the abdomen and the outside of all the organs in it are covered with this smooth sheet of tissue which we call the *peritoneum*. This covering is necessary so that the organs can move one upon the other without pain, injury, or friction. The smooth surface is always kept moist by fluid.

187. **Motion of the Intestines.**—The intestines are never quiet. They are in motion all the time. This motion resembles that of a worm—slow, gradual, and creeping. It is accomplished by means of the muscle-fibres which exist in the walls. The object of this motion is to propel the food along so as to spread it out and hasten the absorption of the liquid and nourishing portions of the digested food.

188. **Projections on the Inner Surface of the Intestines.**—The inner surface of the intestines looks pinkish and is velvety. It has a large number of *valves* or *ridges* (Fig. 44) running across it; these prevent the food from passing along too rapidly, so that all the nutritious portions may be absorbed. Besides these projections we find that the velvety appearance is due to the presence of millions of other very *small projections* (Fig. 45), which resemble hairs in shape but are soft, and when looked at with the microscope are found covered with cells. We also find, when we examine the mucous lining of the intestines, a great many small tubes similar to those found in the stomach.

189. **The Work of the Intestines.**—The intestines finish the digestion of the food. They also afford a lengthy surface

over which the liquid and digested nutritious parts of the food can pass and be absorbed by the blood, which then brings them to different parts of the body. We found that a small part of starchy food is digested by the saliva and that the stomach digests the fleshy portions of the food. The intestines digest the rest, namely : (1) the larger part of *starchy food* which is not affected by the saliva, (2) the entire *fatty portion of the food*, and (3) any *remnants of fleshy food* which the stomach may have failed to act upon.

190. Starch cannot be taken up by the blood until it has

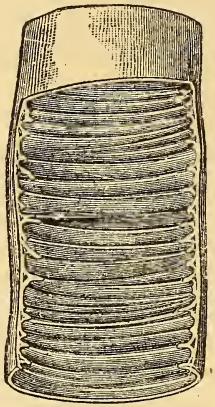


FIG. 44.—The Inner Surface of the Small Intestine, Showing the Valves or Ridges.

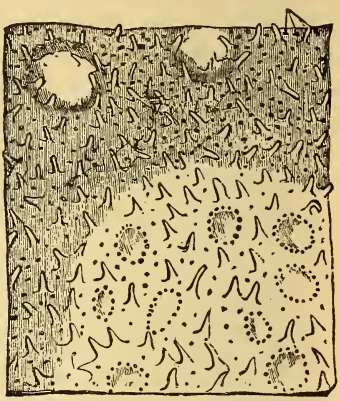


FIG. 45.—The Small Hair-like Projections from the Inner Surface of the Intestine. (Very highly magnified.)

become *changed into sugar*. Fat must also first become altered by fluids in the intestines before the blood can absorb it.

191. **Openings into the Small Intestine.**—The main work of the intestine takes place at the upper part near the stomach. Just below the stomach we find *two openings* leading into the part of the intestine known as the duodenum. One of these openings is the *canal from the liver and the gall-bladder*,

the other is *the canal from the pancreas.* Previous to discussing digestion in general, the organs furnishing these two canals will be considered.

THE LIVER AND THE GALL-BLADDER.

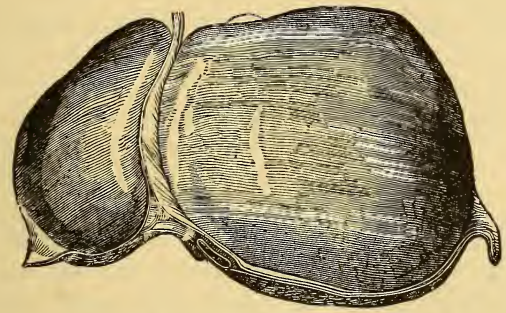


FIG. 46.—The Liver, Upper Surface.

192. The liver (Figs. 36, 46, and 47) is a large organ of a brownish color, placed in the upper part of the abdomen, to the right of the stomach. It is just below the diaphragm and the

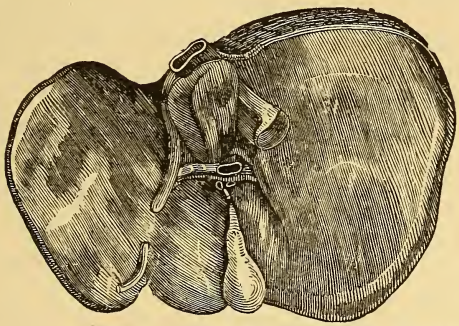


FIG. 47.—The Liver, Under Surface; Below, the Gall-bladder is Seen.

lower ribs, which cover it in front and above by forming an arch over it. The liver is very heavy; it is smooth on the outside,

being covered by the same smooth membrane which covers all the organs of the abdomen, the peritoneum. It is subdivided into five sections called "*lobes*" by deep lines.

193. **Uses of the Liver.**—The liver is a very important organ. Its uses are

(1.) To make the *bile.*

(2.) To *purify the blood* which passes through it.

(3.) To add a certain *nourishing body* to the blood which passes through it.

194. **The Gall-bladder and Bile.**—If we look at the liver under the microscope, so that it is very much enlarged, we will see that it is formed entirely of small cells, like cubes, packed one against the other (Fig. 48). These cells manufacture *the bile* and it is then collected by small tubes. Along the lower edge of the liver a bag about the size of an egg will be seen; it is called the "*gall-bladder*" (Figs. 36 and 47) and the tubes which collect the bile empty into it. This bag keeps the bile until it is wanted. The liver is making bile all the time and yet the intestines do not need it except when food is present; hence there must be such a storehouse.

FIG. 48. — The Liver-cells, Very Highly Magnified.

195. **Action of the Bile.**—After the stomach has finished its work and the changed food has passed into the intestine, the bile which has been stored up in the gall-bladder is allowed to escape into the intestine by a small tube leading to one of the two openings in the duodenum already described. The bile is of a green or brown color. We do not know what the bile does to the food exactly; but we are certain that bile must be mixed with it, for if absent the person cannot live very long. Sometimes bile gets into the blood and then causes a yellow color of the skin, which we call *jaundice.*

196. There is a great deal of blood passing through the liver ; it is *purified* while it passes through, and certain *unhealthy parts are removed.*

197. After a meal there would be a great deal of nourishing matter thrown into the blood all at once ; this would soon be used up and then there would be no more until the next meal. In order to prevent this, the liver takes care of a large amount of sugar and *keeps it stored up,* and then gradually lets it return little by little into the blood.

198. **The Unhealthy Liver.**—Many sicknesses are caused by changes in the liver. If we *eat too much* at a time, or eat *food which is too rich,* such as a good many wealthy people do, the liver becomes diseased and does not remove the impurities of the blood as it should ; these then remain in the blood and give much trouble. Perhaps some of you have seen old gentlemen limp along with the aid of a cane. They cannot walk well because their big toes are swollen and sore ; they often have *gout* from *too rich food, too much wine,* and *too little exercise.*

199. **The Drunkard's Liver.**—The liver suffers very much as the result of large quantities of *alcoholic drink.* It sometimes grows too large, and sometimes gets too small. The blood cannot flow through it as it should ; the liver cannot do its work properly. Thus the entire body suffers as the result of this, and the most serious symptoms trouble the unfortunate man who leads the life of a drunkard.

THE PANCREAS.

200. This is one of the organs of digestion (Fig. 36). The pancreas of the calf is sold by the butcher as *sweetbread.* This organ is not large, but is very important. It is placed just below the stomach. Its work is to prepare a fluid called the *pancreatic juice.* This is made by cells, just as in the liver ; small tubes then collect the fluid and open into one large

tube which empties into the commencement of the small intestine.

201. **Uses of the Pancreatic Juice.**—The pancreatic juice digests all parts of the food which are left after the saliva and the gastric juice of the stomach have acted upon them. Thus it *digests fat* and *starch;* and it will also digest any of the *fleshy food* which the stomach has neglected to change. It is consequently a very important fluid.

ABSORPTION.

202. All the fluids of digestion just described—the saliva, gastric juice, and pancreatic juice—simply change the chewed food, so that the blood can take it up or *absorb* it as nourishment; this action of these fluids is called *digestion.* There still remains to be seen how the blood absorbs this nourishment, and what it does with it.

203. If we look at one of the smallest blood-vessels (Fig. 53) it will be found that the walls consist of the very thinnest membrane, and that this allows fluids to pass through quite readily. In the lining of the stomach and intestines we find a great many of these tiny blood-vessels; as the food reaches these places and has become digested, it passes into the blood-vessels and is carried with the blood to the different parts of the body, to be used in forming and building up tissues which are constantly being consumed.

204. **Lacteals.**—Besides passing directly into the blood-vessels, the digested food also passes into certain other tubes of very small size, like blood-vessels, except that they do not contain blood. These small tubes are called *lacteals*, from a Latin word meaning *milk*, because the nourishing fluid which they carry and afterward add to the blood looks white, like milk, during digestion. These lacteals finally empty into large veins at the lower part of the neck (Fig. 62).

HABITS WHICH ARE INJURIOUS TO PROPER DIGESTION.

205. (1.) *Eating too quickly.* When the food is eaten too quickly it cannot be chewed properly, and the result is that it is swallowed in large pieces. The stomach has great difficulty in digesting these large pieces and thus *indigestion and dyspepsia* result if the practice be continued.

206. (2.) *Eating too much at a time.* This gives the organs of digestion too much work to do, and on this account all the food cannot be digested. We should not continue to eat until we feel heavy and uncomfortable, but should stop before we feel this way.

207. (3.) *Eating too many sweets and sours.* While a pickle occasionally at meals, or candy and cake now and then, will do no harm, if these things are taken constantly they are injurious, because they destroy the appetite for nourishing food.

208. (4.) *Chewing gum* gives the salivary glands too much work, and thus the saliva soon becomes too thin and does not act as it should.

209. (5.) *A large amount of ice-water.* A little ice-water, taken slowly, will do no harm, whether during meals or at other times; but to drink down a gobletful rapidly when the body is heated is very unhealthy; it chills the stomach and delays digestion.

210. (6.) *Violent exercise immediately after a meal.* This should not be indulged in, for at that time the stomach needs all the blood it can get. Violent exercise would drive all the blood to the muscles.

211. (7.) *Severe brain work* is not good directly after meals.

212. (8.) *Bathing* should not be indulged in until two hours after an ordinary meal.

213. (9.) *Excitement of any kind,* such as good news or bad news just before a meal usually takes away our appetite. If we eat, nevertheless, the food will not be digested, or only very imperfectly.

214. (10.) *Alcoholic drink* makes the food less digestible, especially if it be strong drink; it also irritates the stomach needlessly.

215. (11.) *Smoking* will destroy the appetite and interfere with digestion in many persons.

THE SPLEEN.

216. The *spleen* (Fig. 36) is not one of the organs of digestion; but its description will be given at this place, because it is placed in the abdomen. It is a round, flattened organ, solid, and contains a great deal of blood. It is found on the left side of the abdomen just underneath the lower ribs. Its use is not exactly known; lately, however, it has been thought to take part in supplying the globules to the blood. It becomes enlarged in all malarial diseases, and then sometimes reaches an enormous size.

SYNOPSIS.

Digestion—The changing of the food and its liquefaction, so that the blood can absorb it.

Organs of Digestion: Mouth.
Teeth.
Tongue.
Throat.
Gullet.
Stomach.
Intestines. { Duodenum. / Small Intestine. / Large Intestine.
Liver.
Pancreas.

Mouth—To chew the food and mix it with saliva.

a Tongue—Assists in mixing food with saliva and in swallowing.

b. Teeth:

1. { *a.* Temporary or milk teeth—ten in each jaw. / *b.* Permanent—sixteen in each jaw.

Four incisors.
Two canine.
Four bicuspid.
Six molars.

2. Divisible into

a. Parts : { Crown. Neck. Root.

b. Structure : { Enamel. Dentine. Pulp (cavity).

3. Care of—Should be kept clean.
Brushing.
Toothpicks.
Improper use.
Tobacco.

c. Salivary Glands :

1. Location :
(1.) Parotid—In front and below ear.
(2.) Sublingual—Below tongue.
(3.) Submaxillary—Below jaw.

2. Saliva.
(1.) Produced during chewing.
(2.) Moistens food.
(3.) Digests a part of starchy food.
(4.) Keeps mouth moist.
(5.) Watery, clear fluid.
(6.) Necessity for thorough chewing.
(7.) Effect of chewing gum.

Throat :

1. Between mouth and gullet.
2. Concerned in swallowing.

Tongue :

1. Mixes food with saliva.
2. Assists in swallowing.

Gullet or Œsophagus :

1. Connects throat and stomach.
2. Formed of rings of muscle-tissue.
3. These force food into stomach.

Stomach :

1. Position—Upper part of abdomen, just below diaphragm.
2. Openings—One for entrance of food ; other (pylorus) into intestines.
3. Coats :
   (1.) Outer—Peritoneum.
   (2.) Middle—Muscle-tissue.
   (3.) Inner—Mucous membrane.
4. Uses :
   (1.) To secrete gastric juice, which—
      a. Is formed during digestion.
      b. Digests fleshy food.
      c. Contains pepsin.
      d. Is formed in the gastric tubules.
   (2.) A storehouse for the food.
   (3.) To churn the food and break it into small particles.
5. Effects of alcohol and tobacco—Alcohol irritates, tobacco sickens.
6. Discovery of action—St. Martin ; opening in stomach.
7. Digestibility—Heavy and light food.

The Intestines :

1. Connection with stomach—By pylorus.
2. Subdivisions :
   a. Duodenum.
   b. Small intestine.
   c. Large intestine.
3. Length—Twenty-five feet.
4. Attachment—To backbone.
5. Coats—Same as stomach :
   a. Outer or peritoneum.
   b. Middle or muscle tissue.
   c. Inner or mucous membrane.
6. Motion—To propel food and digested fluids.
7. Projections from inner surface :
   a. Valves or ridges.
   b. Hair-like projections.
8. Function :
   a. Digest starchy food.

b. Digest fatty food.
c. Digest remnants of fleshy food.

9. Openings :
a. From liver and gall-bladder.
b. From pancreas.

The Liver and Gall-bladder :

1. Position—Upper part of abdomen, to right of stomach.
2. Description—Large, solid, brownish, subdivided into five sections or lobes.
3. Uses :
a. To make bile.
b. To purify the blood.
c. To add nourishment to the blood ; storehouse.
4. Bile :
a. Color—Greenish or brownish.
b. Action—Not exactly known.
c. If gets into blood—Jaundice.
5. Unhealthy Liver—From too rich food, too much wine, too little exercise, gout.
6. Drunkard's Liver—Too large or too small.

The Pancreas :

1. Position—Just below stomach.
2. Use—To form pancreatic juice, which—
a. Digests fat.
b. Digests starch.
c. Digests remains of fleshy food.

Absorption—The taking up of digested food in fluid form by the blood and lymphatics :

1. By blood-vessels.
2. By lymphatic vessels.
3. By lacteals.

Habits Injurious to Proper Digestion :

1. Eating too quickly.
2. Eating too much at a time.
3. Eating too many sweets and sours.
4. Chewing gum.
5. Ice-water in large amount.
6. Violent exercise immediately after meals.

7. Severe brain-work immediately after meals.
8. Bathing after meals.
9. Excitement before, during, or after meals.
10. Alcoholic drink.
11. Smoking or chewing tobacco.

The Spleen :

1. Description—Round, flattened, solid organ full of blood.
2. Position—Left side of abdomen, underneath lower ribs.
3. Use—Probably to supply globules to the blood.
4. Enlarged—In malarial diseases.

QUESTIONS.

1. What is meant by the word "digestion"? 2. Name the organs of digestion? 3. What are the teeth for? 4. What are the temporary teeth? 5. When do we begin to have our permanent teeth? 6. How many permanent teeth are there in each jaw? 7. What are the parts of each tooth? 8. Are the teeth solid or hollow? 9. What names are given to the different teeth? 10. Which are the incisor teeth, what is their shape and their use? 11. What is peculiar about the canine tooth? 12. What about the bicuspid teeth? 13. What about the molar teeth? 14. Of which three parts does each tooth consist? 15. What is the proper way of taking care of the teeth? 16. What effect has tobacco on the teeth? 17. What are the salivary glands? 18. Where are they found? 19. What is their use? 20. What is saliva? 21. What are the uses of saliva? 22. What are the effects of chewing gum upon the saliva? 23. Where is the gullet? 24. Where does it lead to? 25. What is the shape of the stomach? 26. Where is it placed? 27. What openings are there in the stomach? 28. What coats are there to the wall of the stomach? 29. How does the inside of the stomach look when it is empty? 30. How does it look when food enters the stomach? 31. What is the gastric juice? 32. How is the gastric juice made? 33. Of what use is the gastric juice? 34. When does the gastric juice flow? 35. What kind of food is digested by the gastric juice? 36. What is pepsin? 37. What are the three uses of the stomach? 38. Have any animals more than one stomach? 39. How does the ox digest hay? 40. What effect have tobacco and alcohol upon the stomach? 41. How was the way in which the

stomach acts in man discovered? 42. What is meant by "heavy" food? 43. What is meant by "light" food? 44. Give examples of each. 45. What is another name for the bowels? 46. How long are the bowels? 47. How do the bowels connect with the stomach? 48. What kinds of food are still undigested when they leave the stomach? 49. What is the "pylorus?" 50. Into what three parts can the intestines be divided? 51. What is the name given to each part? 52. How are the intestines arranged so that they can all find room in the abdomen? 53. To what are the intestines attached? 54. What coats have the intestines? 55. What can you say about the outside shining coat of the intestines? 56. What is the "peritoneum," and what does it cover? 57. Tell about the lining of the intestines. 58. What is the work of the intestines? 59. What kinds of food are digested by the small intestine? 60. In what part of the small intestine does most of the work take place? 61. What openings are there into the first part of the small intestine? 62. Where is the liver placed? 63. What are the three uses of the liver? 64. Where is the gall-bladder? 65. How is bile made? 66. What does it look like? 67. When is bile needed in the intestine? 68. How does the bile get into the intestine? 69. What can you say of the uses of bile? 70. What is "jaundice?" 71. How does the liver become diseased? 72. What is the cause of gout? 73. What effect has alcohol upon the liver? 74. Where is the pancreas? 75. What is it commonly called by the butcher? 76. What fluid is made by the pancreas? 77. What are the uses of the pancreatic juice? 78. What kinds of food are digested by the pancreatic juice? 79. How does the blood take up the nourishing parts of the food which have become digested? 80. What are the "lacteals," what do they do, and why are they so-called? 81. Are the intestines usually quiet or in motion? 82. Why is it necessary for them to be in motion? 83. Mention some of the habits which are injurious to digestion? 84. Explain why eating too quickly or too much at a time is injurious. 85. How should ice-water be taken? 86. Why should we not exercise directly after meals? 87. What effect has excitement of any kind upon digestion? 88. What effect has alcohol and alcoholic drinks upon digestion? 89. Where is the spleen? 90. What does it look like? 91. What do we know about its use?

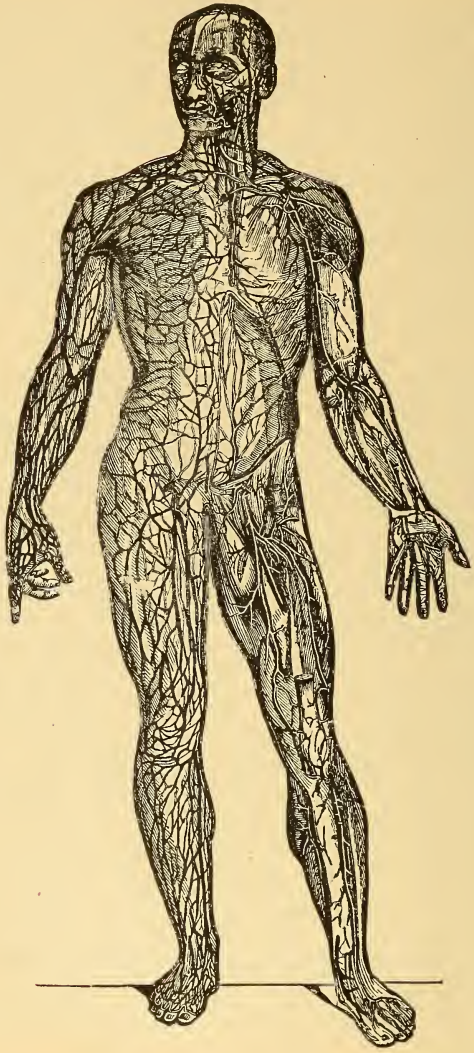


FIG. 49.—The Blood-vessels. In the right half of the figure the arteries are shown; in the left half, the veins.

CHAPTER VII.

THE BLOOD AND THE CIRCULATION—THE HEART AND THE BLOOD-VESSELS.

217. If you cut your finger you notice a red fluid escaping from the wound which you call blood. If the cut be a slight one, only a little blood will be lost, and the accident will not worry you much; but if it be deeper, you may have trouble in stopping the bleeding, and you would feel alarmed, for everyone knows how important the blood is. It is called *life's fluid*, and it deserves the name; for if one-quarter of the blood is lost, life would be in danger; and if one-third were lost, certain death would result.

218. **Appearance of Blood.**—Blood is a thin fluid of a red color. If we look at the blood of an *artery*, the color is *bright red;* in the *veins* the blood is of a *dark red* color. Why this difference exists will be explained later on. Although it has this red color, the fluid part of the blood is not red, but yellowish; it looks red because there are a great many small red bodies floating in it; these we call the *blood-globules.*

219. **Composition of the Blood.**—The blood is composed of a *yellowish fluid*, and in this yellowish fluid we find millions of small bodies, mostly of a red color, which we call the *blood-globules.*

220. **Blood-globules.**—If we take a drop of blood and look at it under the microscope, we can easily see these blood-globules. Even in a small drop of blood, there are about ten millions of them, which will give an idea of how numerous they are, and how many there must be in the entire body.

221. **The Microscope.**—This instrument has often been alluded to in these pages, and is constantly used in studying the finer structure of different parts of the body. Probably everyone knows what a magnifying-glass is, and has seen it used for making objects look larger. Perhaps, too, many of you have brought the rays of the sun together into a small spot on your hand and found how this burns; on this account, the magnifying-glass is often called a burning-glass. Such a magnifying-glass makes objects appear five or six times as large as they really are. If several very strong magnifying-glasses were placed one over the other in a metal tube (Fig. 50), objects looked at through all of them would appear a hundred, or even a thousand times larger than they really were, and this would constitute a microscope.

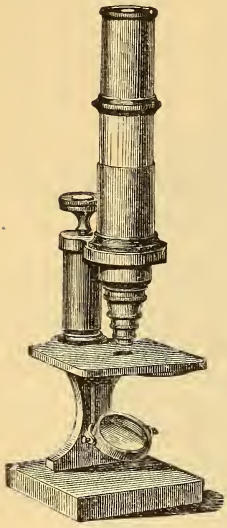


Fig. 50.—The Microscope.

222. **Red Blood-globules.**—If a drop of blood be looked at under the microscope, the yellow fluid is seen plainly, and in it we also see the blood-globules in great numbers. Most of these globules are of a *reddish color*, *flat*, with the edge a little thicker than the centre; these are called the *red blood-globules*. After the blood leaves the body, these red blood-globules are apt to stick together at their sides (Fig. 51), and in this way columns are formed looking like rolls of coin piled one upon the other.

Fig. 51.—Human Red and White Blood-globules. The red globules are seen to be flattened and in rolls; the white ones are alone, dotted, and larger.

223. **White Blood-globules.**—Besides the red blood-globules there are others which are white, and a little bit larger than the red (Fig. 51); these are not flat,

but perfectly round, like a sphere, and have two or three spots in their centre ; there are very few of these white bodies, which we call *white blood-globules*, compared to the large number of the red ones. We call both the red and the white ones globules, because of their shape, the word "globule" meaning "a little sphere."

224. **The Plasma.**—The watery, fluid portion of the blood in which the red and the white blood-globules float is called the *blood-plasma.*

225. **Blood of Other Animals.**—In other animals, as in man, the blood is red and is formed of plasma and red and white blood-globules. There is, however, one difference in some animals : In man the red blood-globules are flattened, circular, and perfectly clear, having no spots in the centre.

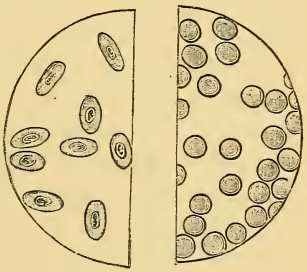


FIG. 52.—The Red Blood-globules in Birds, Fishes, and Reptiles (on left of figure) as Compared with Those of Man (right half of figure).

In many of the larger animals, and in all of our domestic animals, the red blood-globules have this same shape. But in the blood of *birds, fishes,* and certain other animals like snakes and alligators, which we call *reptiles,* the red blood-globules, while still of the same color as in man, are oval in shape, and have a spot in the centre (Fig. 52).

226. **Use of the Red Blood-globules.**—The red blood-globules have a very important use, to explain which it will be necessary to say something about the air we breathe. The air is made up principally of two gases : One-fifth is a rich gas called "*oxygen*"—it is the gas which is necessary for life. The rest (four-fifths) is a gas called "*nitrogen*" which serves to dilute the oxygen so that it is not too rich and so that it is just right for breathing. When we breathe in air it passes into our lungs and stays there a short time, and while there

the blood takes some of the oxygen from the air. In the lungs there are a great many small blood-vessels and the oxygen passes through the thin walls of these and the blood flowing along takes it up. The watery part of the blood cannot take up the oxygen, it is the red blood-globules which do this. At the same time the color of the blood which was dark red before the oxygen was taken up, changes to a bright red. After the red blood-globules have taken up this valuable gas, they carry it to different parts of the body and give it to the tissues which have become used up, so that they become built up again.

227. **Use of the Plasma.**—The fluid part of the blood also has a special use. When the different tissues of the body are being used up, they give off a poisonous gas which is called "*carbonic acid gas.*" This gas is quite heavy and often collects at the bottom of wells or in cellars that have been dark and shut up for a long time. You sometimes read of people losing their lives by going down into such wells and cellars; for this gas is so poisonous that the people cannot breathe it and they choke to death. If it is thought that such gas may be collected in old wells or cellars, men usually let a lighted candle down before they go; if the candle will not burn, this is a sign that it would be dangerous there for a human being. For where this carbonic acid gas is present, the oxygen is absent or very little is present, and the candle requires oxygen to burn just as we do to breathe and live. After the plasma has taken up this poisonous carbonic acid gas, it carries it to the lungs and there it passes through the walls of the blood-vessels and escapes into the air. This is one of the reasons why the air which we breathe out is not as pure as that which we breathe in.

228. **Difference between the Blood in Arteries and the Blood in Veins.**—The blood flowing in the arteries is of a bright red color, because it has just received a supply of oxygen from the air in the lungs, and has given up its poisonous gas to the air. The blood in the veins is of a dark red color because the tissues have robbed it of the oxygen which it had

before, and have given it a large supply of the poisonous carbonic acid gas. The blood in veins is warmer than that of arteries.

229. **Clotting of the Blood.**—While the blood is in the body and in the vessels through which it usually moves, it is fluid. But if taken from the body, and placed in the air, we find that very soon it becomes thicker and thicker, and finally it gets to be a soft solid, about as thick as jelly. Its shape now will be exactly that of the vessel in which we allowed it to get thick; if we have it in a cup, for instance, it will have the shape of the cup. In addition to the thick part, a quantity of yellow fluid will also be found to have separated. Blood never becomes hard, even when it solidifies; it becomes a soft jelly-like solid. This change of the blood from the fluid to the solid state after it is removed from the blood-vessels is called *clotting*. The thickened blood we call a *clot*, while the yellow fluid which separates is called the *serum*. It is, of course, not natural for blood to clot; it only happens when the blood is exposed to the air, or when there has been some change in the blood-vessel. It is rather difficult to understand why this thickening occurs, but if we examine the blood under the microscope after it has clotted we see that there are a large number of very fine hair-like bodies called fibres, and that these run in every direction and cross each other and that the blood-globules get caught and entangled between them; this makes the blood thicken.

230. **Value of the Clotting of Blood.**—This thickening or clotting of blood is of the greatest importance. If it were not for this we would have to bleed to death every time we cut ourselves. For when we inflict a wound, the blood flows until a crust forms, and this crust stops the bleeding. This crust is the same thickening or clotting of which we have been speaking and there would be no other way of stopping bleeding if it were not for this. You might press your finger on the wound and stop the bleeding in this way, but as soon as

you took your finger off the blood would flow again, if a clot did not form.

231. **The Circulation.**—Thus far we have been speaking of the blood itself. Now we will study how the blood flows through the body; for our *blood is constantly moving.* This we can see very well in the frog. If we take some part of the frog, as for instance, one of the thin parts of the foot, and spread it out and look at it under the microscope, we will see the blood in motion. The only reason we cannot see it in man is that there is no part thin enough and transparent enough for us to see through. If we examine the thin part of the frog's foot in this way we will see a number of tubes, and in the cen-

FIG. 53.—The Blood in Motion, as Seen in the Small Blood-vessels of the Frog's Foot.

tre a fluid full of small bodies—some red, some white—these are the blood-globules. It will be seen that there are a great many red ones and only a few white ones. And you can also notice that the red ones hurry along, a great many in company, in the centre of the stream, while there are few white ones which seem to rub against the wall of the blood-vessel, and hence, go along quite slowly. It is a beautiful sight and is an-

other illustration of how wonderfully we are constructed. In studying the manner in which blood flows through our bodies it will be necessary to commence with a description of the heart, the arteries, the veins, and the capillaries.

THE HEART.

232. **Situation of the Heart.**—The heart is the most important organ in the body. It is placed in the chest, having

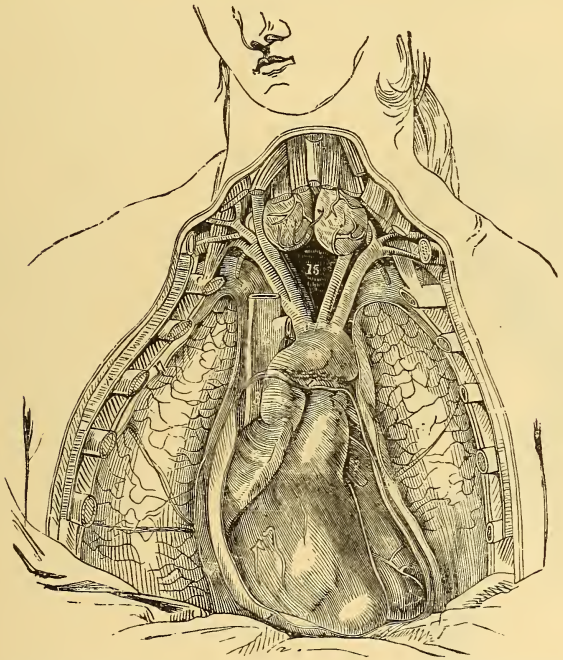


FIG. 54.—The Heart in Its Natural Position. It is surrounded by its sac, the pericardium; on each side the lungs are seen; above, the large vessels are seen springing from it. In order to see all this the front of the chest is represented as having been removed.

the lungs on each side, and covered in front by the breast-bone (Fig. 54); it projects beyond the breast-bone on each side, but

more to the left than to the right. If the hand be placed upon the front of the chest on the left side the beat of the heart can be felt. This corresponds to the position of the pointed end of the heart. If the ear be placed over this spot the sound made by the beating of the heart can be heard.

233. **Form of the Heart.**—The heart is shaped like a *cone*, with the wide part above and the point below. It measures five inches from one end to the other. It is *hollow* (Figs. 56 and 57), and its walls are formed of muscle-tissue.

234. **The Pericardium.**—The heart is surrounded by a sac, called the *pericardium*, meaning "around the heart." Between this sac and the heart is a space in which a little fluid is found.

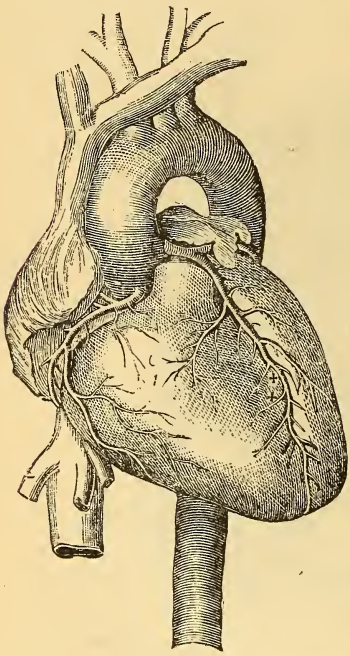


FIG. 55.—The Heart and the Large Vessels Given off from It.

235. **Cavities of the Heart.**—The heart is hollow, so as to have spaces through which the blood can flow. It has four such spaces. If we look at the heart from the outside, we can first divide it into two halves—a left half and a right half; the right and the left side of the heart are separated by a groove which runs from the wide part of the heart above to the point below. Then there is a horizontal groove, which runs across this vertical one and divides each side into two smaller parts, an upper and a lower. If we examine the interior of the heart we find four spaces; the partitions which separate these spaces are placed within

exactly where the grooves are found on the outside. So that each side of the heart has two spaces, an upper and a lower (Figs. 56 and 57). The upper spaces are called *auricles*, and the lower *ventricles*. Consequently, there is a *right auricle* and a *left auricle*, and a *right ventricle* and a *left ventricle*. The lower spaces, the ventricles, are much larger than the upper, the auricles. The wall of the heart is much thicker on the left side than it is on the right.

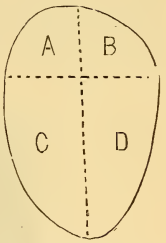


FIG. 56.—Outline Sketch Showing the Arrangement of the Cavities of the Heart. A, Right Auricle; B, Left Auricle; C, Right Ventricle; D, Left Ventricle.

236. **Function of the Heart.**—The heart serves to pump the blood into the blood-vessels with some force, so that it flows all over the body. The walls of the heart are made of muscle, and this muscle is constantly contracting; each time it contracts we say it *beats;* and when it does this the whole heart becomes smaller, and its cavities become smaller, and thus the blood is forced out. After this, the heart expands again, its auricles and ventricles become wider, and the blood flows into them from the veins until the heart becomes filled. Then the same thing takes place over and over again.

237. **Frequency of the Heart-beats.**—In the grown person, the heart beats about seventy times a minute. In the child, it beats eighty or more. In the old person it may only beat sixty a minute. When sick with fever, the heart works more rapidly than in health, and it then often beats over a hundred a minute.

238. **Course of the Blood.**—When the blood leaves the heart it passes from the right side of the heart to the lungs; from the lungs it returns to the left side of the heart; from the left side of the heart it passes into the arteries all over the body; then it is returned from all parts of the body to the right side of the heart by the veins (Fig. 58). The way in which the blood circulates and its course was discovered in

1618, by an Englishman, Harvey. It was a wonderful discovery. Before Harvey's time nothing was known about the way in which the blood flows. The ancients imagined the arteries contained air.

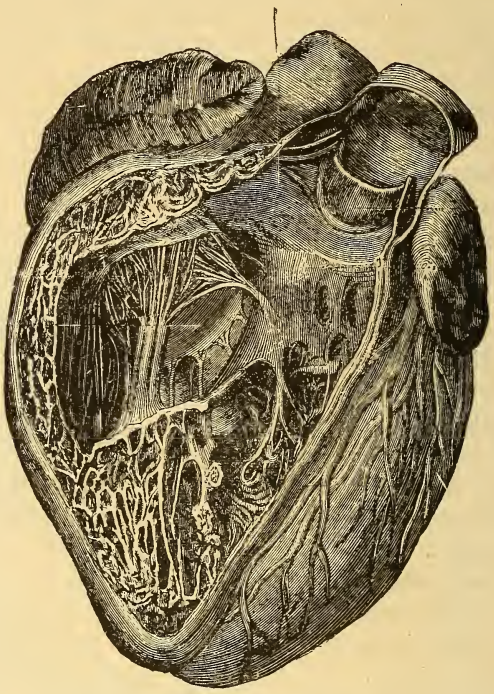


FIG. 57.—The Heart (the Front has Been Removed), Showing the Interior.

239. **The Circulation through the Lungs.**—All the blood passes from the veins into the right side of the heart, first into the upper space (auricle), and from here it flows into the lower space (ventricle). When these two become full of blood the heart contracts and squeezes out the blood into a large artery (the *pulmonary* artery), which carries it to the lungs. Here the blood passes into smaller and smaller arteries,

and, finally, into the very finest tubes, which we call the *capillaries* (from a Latin word meaning "a hair," because they are so very small).

240. While the blood flows through these capillaries of the lung, it meets the air taken in when we breathe; and from this

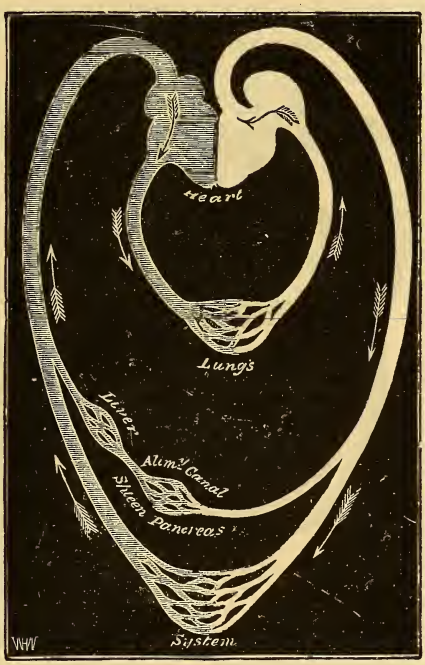


FIG. 58.—Diagram Showing the Course of the Blood Through the Heart, Lungs, and Body in General.

air it takes oxygen, and it gives to it the poisonous carbonic acid gas. So that in passing through the lungs the blood has *gained oxygen* and *lost the poisonous gas;* and in doing this it changes from the dark red color it had before to a bright red color; it is now *purified.* The capillaries soon join to form

larger and larger tubes, and these unite to form several large blood-vessels, which carry the purified blood back to the heart. But this time it passes to the *left* side of the heart, first through the left auricle and then through the left ventricle. When enough blood has flowed into the heart it contracts and squeezes it out into a very large blood-vessel (the *aorta*), which carries it to the tissues in different parts of the body.

241. All this is shown very well in diagram in Fig. 58.

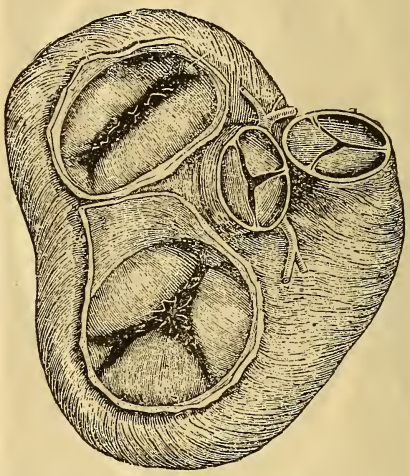


FIG. 59.—The Valves of the Heart, and Between the Heart and the Large Vessels which Leave It.

Starting above, we see the heart; the shaded part to the left represents the right side of the heart. The impure blood passes from here to the lungs, gradually becoming purified and brighter as it passes through this organ. From the lungs it is seen to pass in its bright color to the left side of the heart (which is the portion of the heart unshaded on the diagram). From here we see it pass along, as the arrow indicates, to the different parts of the body, called on the diagram the *system*. Passing through the system and through the abdominal organs,

as shown in the diagram, the blood gradually becomes darker, and is shown to be carried by the large veins back again into the right side of the heart, the point at which we began to trace it.

242. **Valves of the Heart.**—The valves of the heart resemble lids which are placed between the different spaces in the heart. They allow the blood to flow one way, but when it attempts to return in the opposite direction, they close up and prevent it. Fig. 59 shows them closed, thus shutting off and separating the different cavities of the heart. There are also similar valves placed between the heart and the large vessels which leave it. It will readily be seen how important it is that such a valve should exist between the left ventricle and the large artery which distributes the blood to the different parts of the body, the *aorta;* this valve prevents the blood from flowing back into the heart after it has been forced into the aorta.

THE BLOOD-VESSELS.

243. Those blood-vessels which take the *purified blood* from the heart and distribute it to all parts of the body are called *arteries.* The blood-vessels which return the *used-up* blood from the tissues to the heart are called *veins.* Between the smallest arteries and the smallest veins are the very finest blood-vessels, which are called *capillaries.* So that the blood, after being purified, passes through arteries, then capillaries, then veins.

244. **The Arteries.**—The large artery which leaves the left side of the heart, the *aorta,* soon divides and subdivides, and these branches pass in many different directions, constantly giving off other and smaller branches. A tree forms a very good example of how the arteries run in the body ; the large trunk of the tree corresponds to the large artery which leaves the heart, and the branches correspond to the branches of these arteries.

245. **The Pulse.**—When you are sick, and the doctor is called, one of the first things he does is to feel your pulse: he will put his finger upon your wrist and he will take out his watch. What does he do this for? He is counting your *pulse.* If you put your finger upon your own wrist, in front, on the side on which the thumb is, you will feel something beating; this is an artery, and the beating you feel is your pulse. Every time the heart beats the arteries beat, and this gives the pulse. This will be understood if it be remembered that every time the heart contracts it pumps some blood into the arteries; every time another heartful of blood is forced into the arteries these must expand and grow wider, or else they would burst; they are elastic, and hence they can expand; and it is this expansion, or growing wider, which you feel with your finger, and which you call the pulse. When the doctor takes the pulse, he can tell how slowly or how rapidly the heart is beating; for the pulse is the same in number as the heart-beats. The reason we usually take the pulse at the wrist is because it is most convenient; but there is a pulse in every artery of any size in the whole body; you can feel one at your temples, at the side of your neck, and in many other places.

246. **The Capillaries.**—These are the very smallest blood-vessels, and they connect the arteries with the veins. We find the capillaries almost everywhere. They are so small that we cannot see them without the use of the microscope. If you scratch yourself and a little blood comes, this is from some of the capillaries, not from an artery or vein; for if an artery or vein is injured it is more serious. It is while the blood is passing through the capillaries from the arteries to the veins, that the tissues take from it the oxygen and give up to it the poisonous carbonic acid gas. And after this change has taken place, the color of the blood has changed from the bright red of the purified blood in the arteries to the dark red of the impure blood in the veins.

247. **The Veins.**—After the blood has passed through the different tissues by means of the capillaries these unite to form the smallest veins, and many of these join to form larger ones, until finally we have a single large vein, just as we had a single large artery. But there is this difference: The artery started from the heart and went to the tissues; the veins start at the tissues and gradually join into a large one which goes to the heart. The arteries, too, contained bright-red, pure blood; the veins are filled with dark-red or purple, impure blood.

248. **Valves of the Veins.**—There is still another difference between veins and arteries: Veins have *valves* (Fig. 60). In the arteries there is no difficulty for the blood to go anywhere, even up-hill, because the heart pumps it along with quite some force. But there is nothing of this sort behind the blood in the veins, for by the time the blood has travelled through the capillaries it has lost the force given it by the heart. It would therefore be impossible for the blood to flow up-hill in the veins, as, for instance, in the legs, if there were not some arrangement for this purpose. This arrangement consists in having valves (Fig. 60) which allow the blood to flow toward the heart, but close up, and thus prevent it from going in the opposite direction.

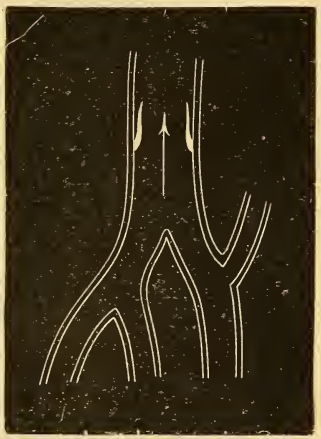


FIG. 60.—A Pair of Valves in One of the Veins. They are open; the direction of the flow of blood is indicated by the arrow.

249. **Rapidity of the Circulation of the Blood.**—The blood flows through its vessels very quickly, and it takes about half a minute for it to pass from the heart through the lungs, all through the body and back again to the heart. How many blood-vessels must it pass through in this short time!

250. **Fainting.**—When a person becomes pale and would fall if he did not hold on to something, we say he has *fainted ;* this often happens after we have been sick and we try to walk before we are strong enough. The proper thing to do is to lay the person down perfectly flat. There should be no pillow underneath the head. If possible, the head should even be lower than the rest of the body so that the blood runs into the head and fills the blood-vessels of the brain ; for the reason

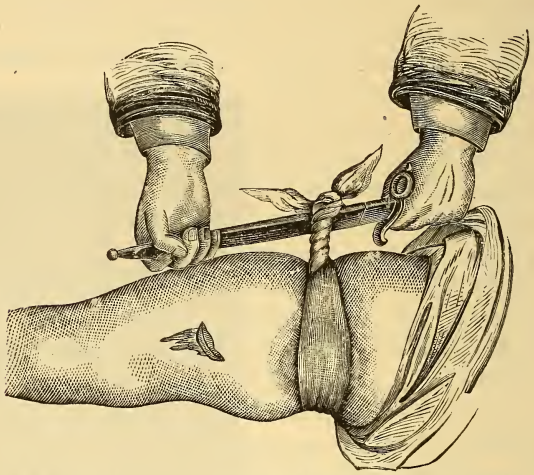


FIG. 61.—Method of Controlling Bleeding from a Large Wound.

for the fainting usually is that the heart becomes weak and has not sufficient force to send enough blood to the brain. It is also important that no crowd should gather around the person, so that he can get all the air possible. The extremities should be stroked or rubbed toward the trunk, so as to facilitate the flow of blood.

251. **Bleeding.**—If we hurt ourselves in any way and the bleeding is slight, it will usually stop by itself or after we apply a little court-plaster. But suppose we have received a deep cut and the blood flows freely and we cannot stop it, what shall

we do until the doctor can be sent for? We should press upon the injured part *just above the cut.* Or we can tie a string around it instead of pressing with the finger. For instance, if it is the tip of the finger which is bleeding very much, we can tie a string around the finger an inch or so above the cut and this will stop the bleeding. If it is a larger part such as the arm or the forearm, tie a handkerchief around the limb *above* the injury and tighten this by means of a stick which you put under the handkerchief and twist until it is very tight (Fig. 61). Another name for bleeding is *hemorrhage.*

252.—**How to have a Good Circulation.**—If we wish to be in good health, the circulation must be good and brisk. If the circulation be sluggish, we are apt to suffer in all parts of the body, because no part gets as much blood as it should. With a poor circulation the feet are apt to be cold in winter, the person catches cold easily, he is quickly *chilled,* he may have headache, and he is not in the best of health. If we want good health, our circulation must be good.

253. *Exercise* is the great medicine for a good circulation. Any good form of exercise will answer and exercise in the open air is the best, because while we are making our blood go faster we are also getting more oxygen to the tissues and building them up quicker. Too much exercise, so as to be very tired, or too severe exercise, such as lifting too heavy weights, is injurious, because it tires out the heart and makes it weak. And if the exercise be much too severe there is even danger of bursting a small blood-vessel, though this does not happen often.

254. **Effects of Alcohol upon the Heart and the Circulation.**—Alcoholic drink passes into the blood and irritates the heart, and as a result the heart may become too large. It might be thought that there would be no objection to having the heart too large ; but this is not so. For when the heart is not of the right size it does not act properly and sickness results. The heart of a drunkard often contains a large amount

of fat, which *weakens it* and it then has not power enough to force the blood into the arteries properly, and the different parts of the body receive too little blood and become pale and thin.

255. You may have noticed the *flushed face* which some people have after drinking; this is because the alcohol drives the blood into the blood-vessels of the skin and this becomes warm; but it takes blood from other parts which are more important, and these suffer.

256. The *arteries* of the drunkard become *changed* so that they are *brittle.* This often takes place in the arteries of the brain and they may burst; this is what is called "*apoplexy*" and it often causes the person to fall down dead. Of course apoplexy may occur in persons who are not drunkards, but it occurs often in drunkards.

257. **Effects of Tobacco upon the Heart and the Circulation.**—The use of tobacco very often affects the heart and causes it to throb so that the person feels it and is very much annoyed by it. Often it causes the heart to beat too quickly and then too slowly; sometimes too strong and then too weak. All these effects are so common that such an irregular heart due to tobacco is often called by doctors *tobacco heart.* Of course, the circulation cannot be carried on properly if the heart acts so irregularly.

THE LYMPHATICS.

258. Besides the blood-vessels there are other small tubes, in which there flows a colorless fluid, looking like water, which is called *lymph*, and these tubes are therefore called *lymphatics.* They are shown in Fig. 62. They differ from the blood-vessels in not containing blood; another difference is that all the lymphatics *run toward the heart.*

259. The lymphatics begin by the very smallest tubes, as small or smaller than the very finest capillaries. They then join together and form larger tubes, and finally they form two

large tubes which open into the large veins in the neck (Fig. 62).

260. The lymphatics help the veins in returning the used-up fluids of the tissues to the heart. We have already learnt that

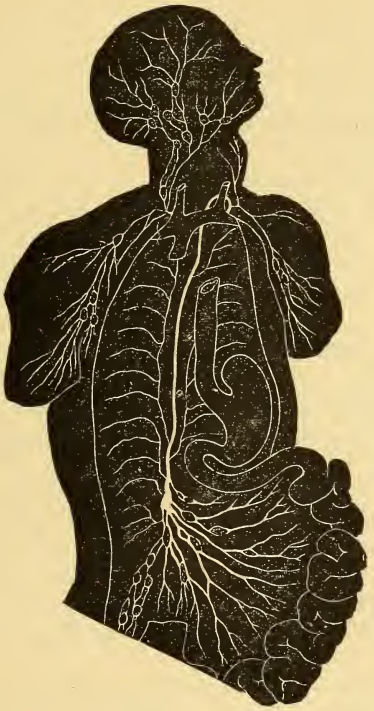


Fig. 62.—The Lymphatics.

fresh, bright blood is brought to the tissues by the arteries, and that it circulates through the capillaries of the tissues. After the tissues have removed the nutritious portions, the used-up fluid is returned to the heart, partly by the veins and partly by the lymphatics.

261. In studying digestion we found that there were certain

vessels in the abdomen which collected the nutritious juices from the stomach and intestines and conveyed them to the blood. These are called *lacteals*, and they are merely a part of the lymphatics.

SYNOPSIS.

The Blood:

1. Importance—"Life's fluid," death when one-third is lost.
2. Appearance—Thin, watery fluid; red color, bright or dark.
3. Composition:
   (1.) Globules:
   a. Red—Flat, edge thicker than centre, circular in man and many animals; oval and spot in centre in birds, reptiles, and fishes; serve to carry the oxygen to the tissues; very numerous.
   b. White—Larger, dotted; much less numerous.
   (2). Plasma—The fluid of the blood serves to carry the poisonous carbonic acid gas from the tissues to the lungs.
4. Difference in Arteries and Veins:
   (1.) In arteries—Bright red; contains more oxygen and less carbonic acid gas; cooler; purer.
   (2.) In veins—Dark red; contains less oxygen and more carbonic acid gas; warmer; more impure.
5. Clotting:
   (1.) Occurrence—When removed from the blood-vessels.
   (2.) Products—Clot and serum.
   (3.) Value—Serves to stop bleeding.

The Heart:

1. Situation—Between the lungs, behind the breast-bone.
2. Form—Cone-shaped, pointed end downward; hollow.
3. Covering—Sac called the "pericardium."
4. Structure—Muscle-tissue; a horizontal and a vertical groove divides it into two upper and two lower portions, a left and a right half.
5. Cavities—Four: right auricle, right ventricle, left auricle, left ventricle.
6. Function—To pump the blood into the lungs and all parts of the body through the arteries.

7. Frequency of Beats—In adults, about seventy times per minute; in children, more; in the aged, less; in fevers, more.

8. Valves—To separate the different cavities, when necessary, and to prevent the return of blood pumped into the aorta.

The Circulation—discovered by Harvey in 1618:

1. From right auricle to

2. Right ventricle, then through pulmonary artery to

3. Lungs; here the blood meets the air and is purified, taking up oxygen and losing the poisonous carbonic acid gas. From the lungs it returns to

4. Left auricle, then to

5. Left ventricle; then it is forced into

6. The aorta, and then through the branches of this into

7. The arteries, carrying it to different parts of the body; from these it passes into

8. The capillaries, which join to form

9. Veins, and these gradually grow larger, and finally empty into a very large one which enters the right auricle of the heart.

10. Rapidity—It takes about half a minute for the blood to pass from the heart through the lungs and the system back to the heart again.

The Arteries:

1. Function—To carry pure, bright blood to the tissues.

2. Origin—From the aorta, which springs from the heart.

3. Branches—Constantly become smaller.

4. Pulse—Owing to the contraction of the heart.

5. Direction of Flow—From the heart to the tissues.

The Veins:

1. Function—To carry impure, dark blood from the tissues to the heart.

2. Origin—From the capillaries, smaller ones gradually uniting to form larger ones.

3. Branches—Gradually becoming larger.

4. No pulse.

5. Direction of Flow—from the tissues toward the heart.

6. Valves—To aid the flow of the blood toward the heart.

The Capillaries:

1. Connect arteries and veins.

2. Allow the tissues to abstract oxygen and nutritious matters and to add carbonic acid gas and used-up fluids.

3. Very small, can only be seen by microscope.

Accidents to and Care of Circulation:

1. Fainting—Due to scarcity of blood in brain; lay person horizontal, with head low; plenty of air; rub extremities toward the trunk.

2. Bleeding:

a. If slight will stop by itself, or after use of court-plaster.

b. If severe, press upon the injured part just *above* the cut, or tie something around it here.

3. Good Circulation necessary to good health.

4. Necessity of proper exercise to keep up a good circulation.

5. Effects of Alcohol upon the Heart and Circulation:

a. Enlarges heart.

b. Weakens it.

c. Makes heart fatty.

d. Flushed face.

e. Changes arteries.

f. Apoplexy, bursting of one of arteries of brain.

6. Effects of Tobacco upon the Heart and Circulation:

a. Causes heart to beat too rapidly or too slowly.

b. Causes heart to beat too weakly or too strongly.

c. Causes heart to beat irregularly.

The Lymphatics:

1. Description—Small tubes containing a colorless fluid called "lymph."

2. Differ from blood-vessels in not containing blood, and in that they all run toward the heart.

3. Begin by very smallest tubes, which by joining together form larger ones.

4. End by two large tubes, which empty into the large veins of the neck.

5. Function, to help the veins in returning the used-up fluids of the tissues to the heart, and also to convey nutritious fluids from the intestines to the blood-vessels by means of the

6. Lacteals—A part of the lymphatics.

QUESTIONS.

1. What is meant by the words "life's blood?" 2. What happens if the body loses a large amount of blood? 3. What does blood look like? 4. Why does blood look red? 5. What difference is there in the appearance of the blood in arteries and of that in veins? 6. Of what two parts is blood composed? 7. Are the blood-globules very abundant? 8. What is a microscope? 9. What is it used for? 10. What do you see when you look at a drop of blood under the microscope? 11. Are any of the blood-globules white? 12. What is the color of the blood of other animals than man? 13. How do the red blood-globules in birds and fishes differ from those of human blood? 14. What is the use of the red blood-globules? 15. Of what gases is the air made up principally? 16. Which is the more useful gas? 17. What happens to the air when we take it into our lungs? 18. What part of the blood takes oxygen from the air? 19. What do the red blood-globules do with this oxygen? 20. What do the tissues do with it? 21. Of what use is the fluid part of the blood? 22. What is carbonic acid gas? 23. Is it harmless or poisonous? 24. Where is it sometimes found outside of the body? 25. How can we tell that no poisonous gas exists in cellars or at the bottom of old wells? 26. What part of the blood takes up this poisonous gas from the tissues? 27. What does the blood do with this poisonous gas? 28. What becomes of this poisonous gas in the lungs? 29. What is the difference in color, heat, and purity of the blood in veins and of that in arteries? 30. What happens if blood is taken from the blood-vessels and allowed to stand in the air? 31. What is this thickening called? 32. What do we see when we examine clotted blood under the microscope? 33. Of what use is this clotting of the blood? 34. What would happen when we cut ourselves if the blood did not clot? 35. What is the best way of seeing the blood in motion? 36. What do we see when we examine the circulation of the blood through the thin part of the frog's foot? 37. What is the most important organ in the body? 38. What is the shape of the heart? 39. What surrounds the heart? 40. About how long is the heart? 41. Of what kind of tissue are the walls of the heart formed? 42. Where is the heart? 43. Where can you feel the heart beat? 44. If you put your ear over this spot what do you hear?

45. Is the heart solid or hollow? 46. How many spaces are there in the heart? 47. How is the heart divided? 48. How are the sides of the heart divided? 49. What are the upper spaces called? 50. What are the lower spaces called? 51. Which are the larger? 52. What is the use of the heart? 53. What does the heart do when it beats? 54. How often does the heart of a grown man beat in a minute? 55. How often does the heart of a child beat per minute? 56. How often does the heart of an old man beat per minute? 57. How does the heart beat when we have fever? 58. Describe the course which the blood takes. 59. Where does the blood pass to from the right side of the heart? 60. Where from the lungs? 61. Where from the left side of the heart? 62. Where from the arteries? 63. How is the blood returned to the heart from the different parts of the body? 64. Who discovered the circulation of the blood and when? 65. How does the blood get from the right side of the heart into the lungs? 66. After the large artery carries it to the lung, where does it pass to? 67. What is a capillary? 68. What happens to the blood when it is passing through the capillaries of the lung? 69. How does it change its appearance while passing through the capillaries of the lungs? 70. Where does the blood pass after it has been purified by the lungs? 71. Where does the purified blood pass to after it reaches the heart? 72. What are the valves of the heart? 73. What is their use? 74. What three kinds of blood-vessels are there? 75. What is an artery? 76. What is a vein? 77. What is a capillary? 78. Do arteries branch? 79. What is meant by "the pulse?" 80. How can we feel the pulse? 81. How is the pulse produced? 82. Where do we usually take the pulse, and why? 83. What sets of blood-vessels are connected by the capillaries? 84. What change takes place in the blood while it is passing through the capillaries? 85. What differences are there between the vein and the artery? 86. What have the veins which the arteries do not have? 87. Of what use are these valves? 88. How long does it take the blood to travel through the entire body? 89. What is fainting? 90. What should you do when a person has fainted? 91. Why should the head be low? 92. What should we do for slight bleeding? 93. What should we do for serious bleeding which will not stop? 94. What is apt to result if our circulation is sluggish? 95. What effect has exercise upon the circulation? 96. What effect has too much or too violent exercise? 97. What effect has

alcohol on the heart? 98. What effect has alcohol on the arteries? 99. What is apoplexy? 100. What effect has tobacco upon the heart? 101. What other set of tubes is there in the body besides the arteries? 102. What are the lymphatics? 103. Of what use are the lymphatics? 104. What is the part of the lymphatics which we find in the abdomen called? 105. Into what do the lymphatics finally empty?

CHAPTER VIII.

THE ORGANS OF VOICE AND BREATHING.

262. Another name for "breathing" is *respiring*, and hence the act of breathing is called *respiration*. When air is takėn into the lungs we *breathe* IN or IN*spire;* when the air passes out again, we *breathe* OUT or EX*spire*.

263. **Course of the Inspired Air.**—When we inspire the air first passes through the *nose*, then into the *throat*, next into the sound-producing organ in the neck, the *larynx;* then it passes through a tube running down the front of the neck, called the *trachea* or *windpipe* and this leads to the *lungs*.

264. Each one of these parts will require special study. The nose will be left until the study of the sense of smell is taken up. The throat has already been discussed in the chapter on digestion (Chapter VI.).

THE ORGAN OF VOICE—THE LARYNX.

265. The organ which produces sound is called the *larynx*.

266. **Form and Situation of the Larynx.**—The larynx is a triangular box (Figs. 63 and 69) the walls of which are formed of gristle or cartilage. It is placed at the upper and front part of the neck, and can readily be felt as a hard prominence just below the chin.

267. **Parts of the Larynx.**—The larynx is formed of several pieces of cartilage joined together. The principal part is formed by a large *triangular piece* which is prominent and pointed in front, and can be felt beneath the skin. This

pointed portion is called *Adam's apple;* it is larger in men than in women, and in some persons it stands out very much.

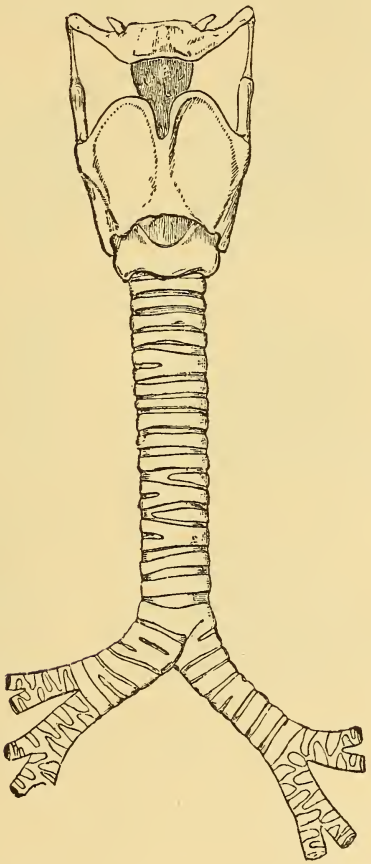


Fig. 63.—The Larynx, the Trachea or Windpipe, and the Bronchi.

Just above this triangular cartilage of the larynx, and covering up its upper opening somewhat, is another piece of cartilage,

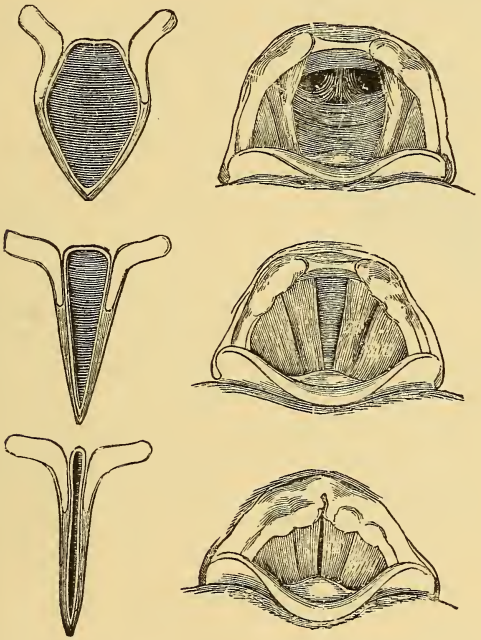
called *the epiglottis.* Below the triangular cartilage is a *circular* piece of cartilage which resembles a seal-ring in shape. These three pieces of cartilage, the triangular, the circular, and the epiglottis, form the main part of the larynx, though there are a few smaller pieces.

268. **Epiglottis.**—This is the name given to the piece of cartilage, shaped like a leaf, which covers over the top of the larynx when we swallow. Usually it stands up straight, but in swallowing it is pressed down over the top of the larynx, and then the food slides over it into the gullet. If it be remembered that the larynx is placed in front, and that the food must pass across it (Fig. 67), it will be seen how important such an arrangement is; but as shall soon be explained, there is another way in which the food is prevented from going into the larynx and windpipe.

269. **The Vocal Cords.**—If we look into the larynx, we will find that there is a sort of shelf projecting on each side (Figs. 64, 65, and 66) and that these two shelves can be moved; sometimes they move toward the middle and meet each other, at other times they separate, and then there is a large space between them. These are called the *vocal cords*, because they produce the voice-sounds by their motion.

270. **Protecting the Windpipe.**—The vocal cords are found at the upper part of the larynx; when they come together tightly, they close the larynx completely, so that nothing can pass into it. This is what they do whenever any food or solid body tries to get into the larynx or windpipe. It will be seen how necessary this is; otherwise we would always be in danger of being choked. Sometimes the food is swallowed unexpectedly, and the vocal cords forget to close; then we say the food has *gone down the wrong way.* This is very distressing, causing coughing until the piece of food is dislodged. In speaking or laughing during meals care should be taken that the mouth is not full, otherwise this accident may happen.

271. **The Vocal Cords in Breathing.**—When we breathe in or inspire, the vocal cords separate widely, so as to let the air pass readily into the windpipe and into our lungs (Fig. 64). When the air passes out (expiration), the vocal cords again



FIGS. 64, 65, and 66.—Showing the Position of the Vocal Cords in Breathing and in Using the Voice. In Fig. 64 the cords are widely separated, as they are in inspiration; in Fig. 65 the cords are slightly separated, as they are in expiration; in Fig. 66 the cords are brought together closely, as they are when sounds are produced.

come together, but not tightly, there being still some space left between the two (Fig. 65).

272. **How Sounds are Produced.**—Previous to making a sound we always take a deep breath. Then this air is blown out again; as it passes through the larynx, between the vocal cords, it makes these vibrate, and through the rapid motion of

the vocal cords, sound is produced. There are many differences in the quality of the human voice, being coarse in some, sweet in others, high in some, low in others. Then there are other peculiarities of the voice, so that we can distinguish our friends by hearing them speak.

273. It depends very much upon how the vocal cords are placed what kind of sound is produced. If the vocal cords are brought closely together and are made very tight the sound will be high. If you could look into the larynx of a lady with a soprano voice, while she were singing, you would find the vocal cords very close together; if, on the contrary, the sound is produced while the cords are far apart and loose, the sound will be low, like that of a bass voice, for instance.

274. **Speaking.**—Although sound is produced in the larynx, it is changed by other parts, principally the throat, the mouth, the tongue, and the lips. These change the sound so that words are spoken. With the vocal cords alone we could make sounds as in singing; but to speak, we must change these sounds by means of the parts already mentioned. For instance, in pronouncing the word "paper," the manner in which the lips come together will be noticed; if the word "law" be pronounced, the tongue will touch the top of the mouth.

THE TRACHEA OR WINDPIPE.

275. **Situation and Form.**—If the finger be passed along the front of the neck, from the larynx downward, a hard tube can be felt and traced down to the top of the breast-bone; then it can no longer be felt, for it passes behind this bone into the chest. This hollow tube is called the *windpipe* or *trachea* (Fig. 63). It serves to conduct the air to the lungs, after it has passed through the nostrils, nasal passages, throat, and larynx.

276. **The Air-passage and the Food-passage.**—The existence of another tube running along the middle of the neck —the *œsophagus* or *gullet*—has already been mentioned in the

chapter on Digestion; its purpose is to carry the food to the stomach after it has been chewed in the mouth and swallowed. The windpipe is placed in front of the gullet (Fig. 67); both of these tubes pass into the chest. The windpipe then passes to the lungs. The gullet passes through an opening in the diaphragm and connects with the stomach in the abdomen.

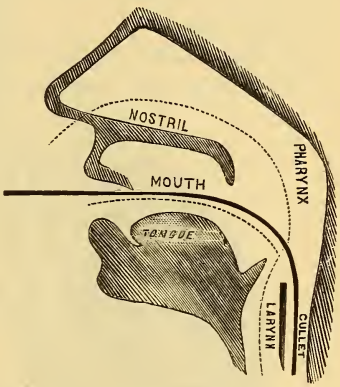


FIG. 67.—The Air-passage and the Food-passage. The heavy line indicates the course of the food through mouth and gullet; the dotted line shows the course of air through nostril into pharynx, and then into the larynx and trachea, which are placed in front of the gullet.

277. **Rings of the Windpipe.**—The windpipe is formed of a large number of rings of gristle, joined together by a thin membrane (Fig. 63).

278. **Branching of the Windpipe.**—After having passed into the chest for a short distance, the windpipe divides into two smaller tubes (Figs. 63 and 69). These branches are called the *bronchi*, there being two of them, a *right* and a *left bronchus*. Each carries the air from the windpipe to the corresponding lung, the right bronchial tube naturally passing to the right lung, and the left to the other side.

THE LUNGS.

279. The lungs are the organs with which we breathe. The entire lung may be divided into two halves (Figs. 68 and 69), a *right lung* and a *left lung*. Between these two the heart is placed (Fig. 68). The lungs and the heart fill up the entire space in the chest.

280. **Shape of the Lungs.**—Each lung is shaped somewhat like a cone, with the apex above and the base below (Fig.

69). The lungs are very light and contain a great deal of air; they float when placed on water. Even after squeezing out all the air we can, there will still be a considerable quantity remaining in the lung.

281. **Structure of the Lungs.**—If we cut into the lungs, we find they are formed of a large number of tubes and

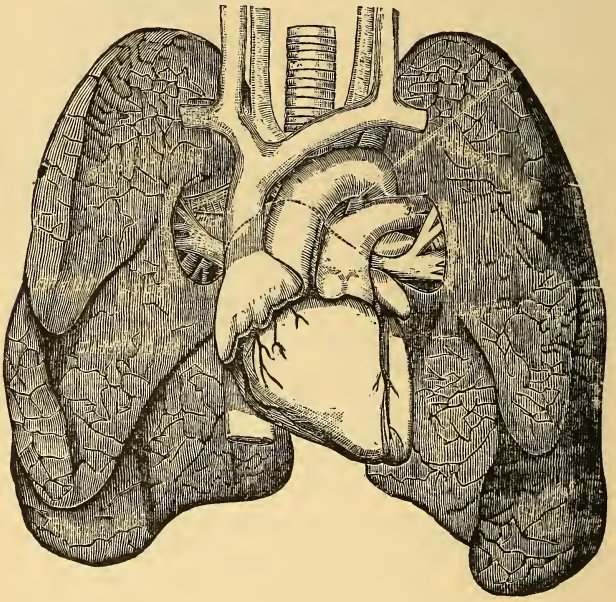


Fig. 68.—The Heart and Lungs. On each side the lungs are seen; in the centre is the heart; above are the windpipe, and the large blood-vessels passing to and from the heart.

spaces containing air. After entering the lungs each bronchus divides again and again (Fig. 69), each branch, known as a "bronchial tube," becoming smaller, until finally the branches of each bronchial tube have become so small that they can no longer be seen without the microscope (Fig. 70, *a*).

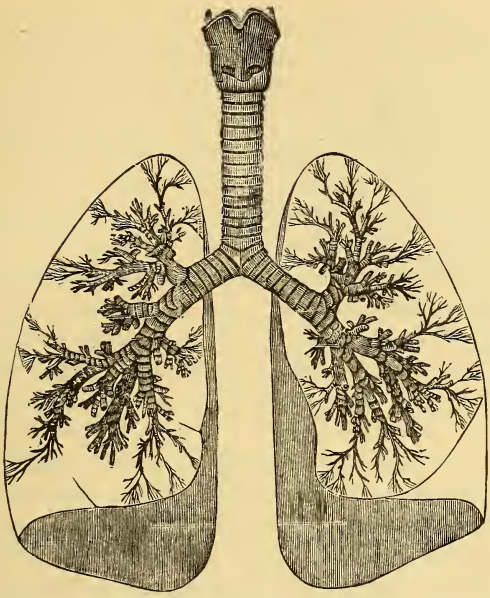


FIG. 69.—The Larynx, Trachea, Right and Left Bronchus, and the Lungs. The latter have been cut open to show the method of division and subdivision of the bronchus.

282. **The Air-Vesicles.**—The smallest branch of a bronchus (Fig. 70, *a*) swells so as to end in a little bag containing air, called an "*air-space*" (Fig. 70, *b*). The walls of these air-spaces are again subdivided so as to form a large number of small sacs called "air-vesicles." The walls of these air-vesicles are very thin and contain many blood-vessels. From this description it will be seen that the lungs really consist of a great collection of small sacs or spaces filled with air.

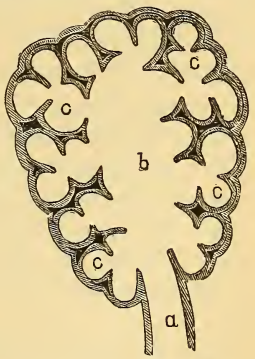


FIG. 70.—The Air-vesicles. *a*, The smallest branch of the subdivisions of a bronchial tube: *b*, the dilated passage or *air-space*, into which this expands; *c*, the smallest spaces, *air-vesicles*.

283. **The Pleura.**—Upon their surface the lungs are covered with a sheet of smooth membrane, called the "*pleura*," which also lines the inner surface of the chest. This smooth membrane allows the lungs to rub against the wall of the chest without pain or friction. The pleura resembles the peritoneum of the abdomen and serves a similar purpose.

284. **Breathing is Involuntary.**—Like the beating of the heart, breathing takes place without the use of our will-power. It continues whether we are awake or asleep, and even when we are unconscious. It is possible to breathe faster than usual for a little while, or to hold the breath for a very short period, but these are merely temporary changes which cannot be continued, for breathing is not under the control of the will.

285. **Movements of the Chest in Breathing.**—In inspiration air is taken in which passes to the lungs and expands these. Watching the chest while this is taking place, it is found that the ribs rise and that the chest becomes wider. In expiration, the air is allowed to pass from the lungs; these become smaller; the ribs fall and the chest again becomes narrower. When the lungs are filled with air, they press down the diaphragm; this then crowds down upon the organs contained in the abdomen, which are pushed out; hence the bulging of the abdomen in inspiration.

286. **Mouth-breathing.**—In breathing, the air should be drawn through the nose and not through the mouth. Many children breathe through the mouth—an injurious practice which results in keeping the mouth open constantly, giving rise to a stupid expression of the face and allowing the air to reach the lungs in an improperly warmed and impure condition.

287. **Frequency of Breathing.**—Usually we breathe about *twenty times a minute.* Young children breathe more often. After exercise, we breathe more often than twenty times per minute. When asleep, we breathe less frequently.

288. **Changes which Breathing Produces in the Blood and Tissues.**—It has already been stated that the object of breathing is to purify the blood. How this is done has also been explained. But the subject is so important a one that it will be well to review it briefly : The air passes into the air-spaces of the lungs. In the thin walls of these air-spaces there are a large number of very small capillaries ; in this way the blood in the capillaries is only separated from the air by very thin tissue, and gases can pass from the air to the blood and from the blood to the air very readily. In breathing, the blood takes oxygen from the air, and in exchange it gives it the poisonous carbonic acid gas, moisture, warmth, and a second poisonous gas which will be described shortly.

289. **Changes Produced in the Air by Breathing.**—While the air passes into and out of the lungs it has *oxygen taken from it*—this is the first change. The second change is that it *receives* some of the *poisonous carbonic acid gas* from the blood. Third, it takes *moisture* from the blood. If you breathe upon the window-pane you can easily see this moisture ; and in winter when it is cold you can notice the moisture in the air which we expire, because it becomes visible as soon as it meets the cold air. Fourth, the air which we breathe out is *warmer* than that which we inspire, because it has taken some of the heat from the blood.

290. Finally, the air takes from the blood a certain *poisonous gas* which has a *disagreeable smell.* The exact nature and the name of this gas is not known and it is thought to be a mixture of many gases. But it is known by its smell. If you come from the open air into a crowded room you find it disagreeable to breathe for a little while, because the air does not seem fresh ; you call it "close," and if it is very bad you say it is "foul." It is this bad-smelling gas which gives this odor. It is fortunate that this exceedingly poisonous gas has a bad smell, for otherwise we would not know that the air needed changing and was no longer fresh. If we stay in such a close

room for a little while, we no longer notice the smell, because we have become accustomed to it.

291. **Effects of Impure Air.**—If much time be spent in close rooms, it produces a sleepy, dull, and tired feeling; the complexion suffers and we no longer look as bright as we did. The blood cannot be purified in such bad air; in this way all the tissues of the body become pale and weak, and the organs no longer work as they should.

292. **Purification of the Air.**—If the air is being made impure constantly by our breathing, it would seem quite natural to ask: Why is it that the air does not become so impure after a while that we cannot live in it? This would result if God had not provided two great purifiers—*sunlight* and *plants*. These are the great *natural purifiers* and change the bad air, making it as good as it was before. You have no doubt noticed how stale it smells in all dark places, such as cellars; it is because the sunlight never enters to purify the air.

293. The way in which the plants purify the air is still more wonderful; they make use of the poisonous gases as their *food;* the carbonic acid gas is necessary for plants to live and grow. Let us stop to consider how plants live and grow.

294. **How Plants Live and Grow.**—Plants *breathe in poisonous gases* from the air and *breathe out pure oxygen*. Besides the poisonous carbonic acid gas which they take from the air, they also absorb moisture and salts from the ground. From all these, plants form their stems and their leaves, and they grow, until we could hardly believe that the big tree has grown from a small plant with no other nourishment but what has just been mentioned. In order to do this, plants must have *sunlight*—they will not grow in the dark. So that what is poisonous to us is food to the plant. And in this way pure oxygen is returned to the air and the poisonous carbonic acid gas is gotten rid of.

295. **Ventilation.**—Ventilation means allowing impure air to escape from our rooms and letting fresh air take its place.

It is very necessary. We have already spoken of the effects of impure air. If a man were locked in a room and everything were tightly closed so that no fresh air could enter, no matter how much food and drink he had, he would soon die, because his breathing would be constantly making the air of the room more and more impure, and finally he would die from want of pure air.

296. In the summer it is quite easy to ventilate our rooms, for all we need to do is to open the windows wide and the fresh air will stream in and the impure air escape at the same time. But in the winter it is more difficult; for the outside air, while it is fresh and pure, is also cold; and if we opened the windows very wide it would cause us to feel cold. It is fortunate that our windows are not, as a rule, very tight-fitting; hence more or less air gets in through the cracks. But it is well to draw down the window a little from the top, for the foul air is lighter than the fresh air and is always found near the ceiling of the room.

297. Another very good way of ventilating a room is to push up the lower window about six inches and to fasten a piece of board in front of the open space which you make in this way. Or instead of a board a piece of canvas will be better yet, and it can be made to look nice by painting or embroidering on it. In this way the fresh air will come in through the canvas below, and the foul air will go out in the opening between the upper and lower portions of the window, as is shown in Fig. 71. Certain methods of heating rooms are also valuable as means of ventilating them; thus the open-grate fire is one of the best means of supplying warmth, because at the same time it furnishes such a ready escape for the impure air, which passes up the chimney.

298. In ventilating rooms it must be remembered that there should be no draughts of air upon the persons in the room, for otherwise they will catch cold. And also that a room cannot be healthy if no sunlight ever enters it. In some of our houses

nowadays, and especially in what we call flats, many of the rooms are dark and never have any sunlight; these must be

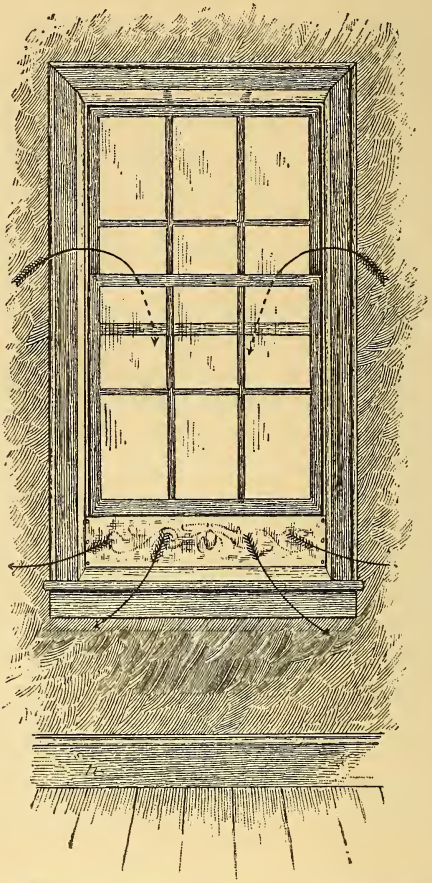


FIG. 71.—A Ready Method of Ventilating Rooms. The arrows above indicate the escape of the impure air; those below, the entrance of fresh air.

unhealthy, and the air in them never can be as pure as in light rooms.

299. **Effect of Tight Clothing upon Breathing.**—Tight clothing presses upon the chest, and does not allow the lungs to expand as they should (Fig. 72); in this way not enough air can enter the lungs and the blood suffers, and from this also the rest of the body. Besides, if children dress so tightly about the chest it will keep the chest from getting its

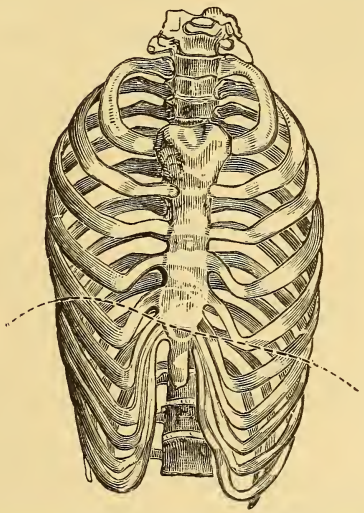


FIG. 72.—A Deformed Chest, the Result of too Tight Clothing. Compare with the natural chest shown in Chapter II., Fig. 18.

proper shape and size. We should try to have as broad a chest as possible, and should remember always to throw our shoulders back, and to sit and stand erect.

300. **Effects of Tobacco-smoke upon the Lungs and Throat.**—Tobacco-smoke is irritating to the lungs of many people, and makes them cough. The throat also suffers, and it becomes red and sore; such a throat is called by the doctor "smoker's sore throat."

SYNOPSIS.

The Organ of Voice—The Larynx:

1. Form—Triangular box.
2. Structure—Walls formed of cartilage.
3. Situation—Upper and front part of neck, just below chin.
4. Function:
   - *a.* Passage of air to windpipe and lungs.
   - *b.* Production of sound.
5. Parts:
   - *a.* Triangular piece (including "Adam's apple").
   - *b.* Circular piece.
   - *c.* Epiglottis.
   - *d.* Vocal Cords:
     - (1.) Protect windpipe.
     - (2.) Move in respiration.
     - (3.) Produce the voice-sounds by their vibration.

The Organs of Breathing:

1. Larynx.
2. Trachea or windpipe.
3. Right and left bronchus.
4. Lungs.

Trachea:

1. Situation—Along front of neck in middle line.
2. Form—Cylindrical tube.
3. Structure—Rings of cartilage joined together by membrane.
4. Function—Conveys air from larynx to lungs.
5. Branches—Right and left bronchus.

The Lungs:

1. Situation—The cavity of the chest, on each side of the heart.
2. Form—Cone-shaped, with apex above.
3. Function—To purify the blood by allowing it to be brought in close contact with the air.
4. Divisions—Right and left lung.
5. Structure:
   - *a.* Bronchial tubes.

b. Air-vesicles.

c. Pleura, covering outside.

Breathing:

1. Is involuntary.
2. Accompanied by certain movements of chest:
   a. In inspiration, chest becomes wider and ribs rise.
   b. In expiration, chest becomes narrower and ribs fall.
3. Frequency—About twenty per minute; more frequently in young children and after exercise.
4. Changes produced in blood:
   a. Gains oxygen and becomes brighter.
   b. Loses carbonic acid gas, other poisonous gas, moisture, and heat.
5. Changes produced in air:
   a. Loses oxygen.
   b. Has added:
      (1.) Carbonic acid gas.
      (2.) Poisonous ill-smelling gas.
      (3.) Moisture.
      (4.) Warmth.
6. Effects of impure air:
   a. Poor health.
   b. Sleepy, dull, and tired feeling.
7. Effects of bad habits:
   a. Mouth-breathing; stupid expression; air improperly warmed and cleansed.
   b. Tight clothing about chest; deformed chest.
   c. Tobacco-smoke; cough; sore throat.

Purification of the air:

1. Natural:
   a. Sunlight.
   b. Plants, by using the carbonic acid gas as part of their food and giving back oxygen to the air.
2. Artificial—affecting dwellings; ventilation.

QUESTIONS.

1. What is the meaning of the word "respiration?" 2. What is the definition of "to inspire?" 3. What is the definition of "to expire?" 4. Through what different parts does the air pass before it reaches the lungs? 5. What is the organ of voice called? 6. Where is the larynx? 7. What is its shape? 8. How is it formed? 9. What is "Adam's apple?" 10. What is the epiglottis? 11. Of what use is the epiglottis? 12. What are the vocal cords? 13. How do they protect the larynx and the windpipe? 14. How do we prevent food from going the wrong way? 15. How do the vocal cords move in breathing? 16. How is sound produced? 17. What makes the difference in the kind of sound produced? 18. In what position are the vocal cords in singing high notes? 19. In what position in breathing? 20. What other parts change the sound in speaking? 21. Could we speak with the larynx alone? 22. How can you prove that the lips and the tongue take part in speaking? 23. Where is the windpipe? 24. What is another name for it? 25. Where does it lead to? 26. What tube runs along together with the windpipe? 27. Which is in front, the windpipe or the gullet? 28. How is the windpipe formed? 29. Where does it end and what becomes of it? 30. What are the bronchi, and where do they go to? 31. What are the lungs? 32. Where are they? 33. How many are there? 34. What is the shape of each? 35. Are they light or heavy? 36. Why are they so light? 37. How are the lungs formed? 38. What are the air-spaces? 39. What are the lungs covered by on the outside? 40. Do we use our will-power in breathing? 41. Can we stop breathing when we want to? 42. How do we breathe? 43. What change do we see when we look at the chest while we are breathing? 44. What change if we look at the abdomen? 45. Should we breathe through the mouth or through the nose? 46. How often per minute do we usually breathe? 47. What difference is there when we exercise? 48. When we are asleep? 49. What changes does breathing produce in the blood? 50. Where and how do these changes occur? 51. What changes are produced in the air by breathing? 52. What is taken from the air? 53. What is given to it? 54. What poisonous gases are added to the air by breathing? 55. What makes rooms

smell close and foul when many people are in them and they are not properly aired? 56. What are the effects of impure air? 57. How is the air purified? 58. What are the two great purifiers of nature? 59. How do plants purify the air? 60. What does the food of plants consist of? 61. Can plants thrive without sunlight? 62. What is ventilation? 63. Could we live in a room if the air were not changed? 64. What is a good method of ventilating rooms in winter? 65. In what part of the room do we find most of the impure air? 66. Why are cold draughts undesirable? 67. What effect has sunlight upon the air of a room? 68. Can a room into which the sun never shines be healthy? 69. What effect has tight clothing around the chest upon breathing? 70. What effect has tobacco-smoke upon the lungs? 71. What effect has it upon the throat?

CHAPTER IX.

THE HEAT OF THE BODY.

301. Have you ever stopped to think how it is that on the coldest day in winter our bodies remain warm, even though we go out into the open air? It may be necessary to have a big fire in our rooms, but still our blood remains just as warm as in summer. You may say it is due to the clothing we wear, but this is not so. For if you took a cold stone and wrapped ever so much clothing around it, you could not warm it. Our clothes keep in the heat of the body, but they cannot produce any.

302. **The Body may be Compared to a Stove.**—We can compare the human body to a stove, for there is some resemblance in the manner in which heat is produced. The food which we take in by the stomach and the air which we breathe combine to form the "fuel," just as coal and wood form the fuel in the stove. This human fuel is then received by the organs of digestion, and changed and liquefied, so that it can be made use of by the various parts of the body. The blood distributes the fluid nourishment to the tissues of the body; it also serves to relieve these tissues of the poisonous carbonic acid gas, and to supply them with oxygen which it has absorbed while passing through the lungs. As the tissues of the body are used up in performing the work required of them, they are constantly being built up again by the nourishing materials which the blood conveys to them.

303. **Combustion.**—This process of building up the various parts of the body by the nutritious portions of the food, changed

to a fluid form by the organs of digestion, is followed by a consumption or using up of the tissues when we use them in any way—in other words, when we work. This is called *combustion;* it means a *slow burning;* and is accomplished by means of the oxygen which the blood carries to the tissues.

304. **What Results from the Burning of Fuel—Work.**—If we recall the resemblance of the human body to a stove, and the similarity of our food to the fuel, it will be instructive to ascertain what becomes of the fuel consumed in an ordinary fire. Take a locomotive, for example. Its fuel consists of *coal;* in *burning,* this coal combines with the oxygen of the air—this is another example of *combustion.* As a result of this combustion, *heat* is produced, which changes the water in the boiler into *steam.* The steam turns the wheels of the locomotive and furnishes the *power* which draws the cars, and enables us to travel many hundred miles a day.

305. **Another Result of the Burning of Fuel—Refuse.**—As has just been explained, one result of the burning of fuel in the locomotive is *steam,* this combustion taking place with the aid of the air: if there is no access of air there can be no combustion. Besides steam there is also produced *refuse*—ashes and smoke. These are of no value, and hence they are correctly called "refuse," and are allowed to escape—the smoke passes into the air, and the ashes are thrown away. What was wanted from the fuel was the *steam;* this does the *work,* whether it moves a locomotive or a steamboat, or lifts an elevator, or pumps up water; all these are merely examples of different kinds of *work. Fuel,* then, *consumed* with the aid of the *oxygen of the air* has resulted in *work,* which is of the greatest value to us, and *smoke and ashes,* which are *refuse,* and which we throw away.

306. **What Results from the Combustion of Our Food.**—If, now, we examine what becomes of the food which is consumed by our tissues, both that which we take in by the stomach and the oxygen which the blood takes from the air,

we find that the same things are produced, namely, *heat* and *work*, which are of value to us, and *refuse materials*, which are of no use to us, and which are removed from the body. It has already been explained how the food is changed and then is carried to the tissues by the blood, and also how the oxygen of the air is carried to the tissues. Both of these are fuel, and they unite with the tissues; the oxygen unites with the tissues and consumes them, and then the new food builds them up again. It may be asked, Why must the tissues constantly be used up and then restored? The answer is: Because we are constantly doing *work* and require *heat*; and to get these, the tissues must be consumed in our body, just as wood and coal are in the locomotive.

307. **Casting off the Refuse Materials from the Body.**—The refuse materials, which are no longer of any use, which would be harmful if retained in the body, may be compared to the smoke and the ashes which escape from the locomotive. These refuse materials are given off from the body in the form of gaseous, fluid, and solid substances. The organs which serve to remove them from the body are the skin, the lungs, the kidneys, and the intestines. The skin removes certain poisonous gases, and also certain other materials in the perspiration—hence the necessity of keeping the pores open. The lungs, as has just been explained, remove carbonic acid gas and other poisonous gases in the expired air.

308. **Food and Oxygen Produce Heat and Work.**—It does not require much study to appreciate how much work the body is constantly doing. Even when asleep the body is doing work. The heart is working faithfully, beating to supply all parts of the body with "life's fluid"—the blood; the chest is rising and falling and the lungs expanding to take in air; and there are many other examples of work, of constant work. When a man is deep in thought, it might be considered that he is idle and resting; but this would be incorrect. Such a man is working very hard with his brain, and such work is

as tiring as working with the hands. Other examples of work we see around us every day—the men digging, paving the streets, and building the houses. When hard work is required more food is necessary than when persons are idle.

309. **Warm-blooded and Cold-blooded Animals.**—If you touch a stone in the street it will be cold in winter, but warm in summer, if the sun has been shining on it. But though it may feel warm, it has no heat of its own, and is simply warm or cold according as the air around it is warm or cold. If you put it in a fire it will become hot, but if taken out again it becomes as cold as the bodies around it. This is the case with all bodies which have no life. But with animals it is different; they have heat of their own, and it does not matter whether the air around them is cold or warm, their blood will be about the same. Animals can be divided into two classes: One class, like the fishes, have cold blood; you will remember how cold and clammy a fish feels. Fishes belong to the *cold-blooded* animals. Most animals, however, have warm blood, and hence are called *warm-blooded* animals. Most of the animals we see are of this class. Birds have especially warm blood.

310. **Heat of the Human Body.**—The heat of the human body is about 98 degrees as measured with the thermometer. All of you have probably seen a thermometer; it is a long, hollow tube of glass, containing a silvery fluid called quicksilver. Heat makes the quicksilver rise, and the more heat the higher it rises; so that we tell how hot anything is by the height to which the fluid in the thermometer rises, there being numbers attached to the frame of the instrument so that we can express the heat; 98 degrees expresses the heat of our blood, and hence this is called *blood-heat.* On a very warm day in summer you may read about the thermometer having risen to "blood-heat;" this means 98 degrees.

311. The skin is never as warm as the blood. In winter the skin may be quite cold, especially that of the hands, and yet

the blood-heat remains the same. On the other hand, our skin may be very warm in summer, and still the heat of the blood does not rise. So that the blood and the interior of the body have the same heat in summer as in winter, namely, 98 degrees.

312. **Heat of the Body in Sickness.**—When sick with fever, the blood becomes hotter; if this increase of heat is more than a few degrees, it is very dangerous.

313. **Regulation of the Body Heat.**—In summer, when it is warm, there does not need to be so much heat produced in the body, and we naturally take less food, and wear lighter clothing, and do not work as hard as in the cold months. In winter, on account of the coldness in the air, we must have an extra supply of body heat; we produce this by eating more, by wearing heavier clothing, and by doing more work. You know how warm exercise makes us feel; in winter we should take more exercise than at any other time of the year. Nature usually gives us a better appetite in winter than in summer, and we usually eat more meat than when the weather is warm.

314. There is another way in which we increase the warmth of the body in winter; it is by wearing warmer clothing. But it may be said that it has just been stated that clothes do not produce heat; then why do we wear thicker and warmer clothes in winter than in summer? This statement is true—clothes do not produce heat; but they prevent the warmth from leaving the body too quickly. In winter the air is very cold, and the heat of the body would pass into the air very soon; to prevent this we put on warm clothing.

315. **Warm Clothing.**—*Woollen* clothing is the warmest. In winter it is well to wear flannel next to the skin. In summer, linen clothing is the coolest. Black clothes are warmer than white ones. This can easily be shown in the following way: If you take two pieces of cloth of the same kind and of the same size, and place them on the snow, that under the black cloth will be melted before that under the white one.

This is the reason for wearing dark clothing in winter and light colors in summer.

316. **How to Keep Warm in Winter.**—In winter we depend upon *exercise*, *additional food*, and *warmer clothing* to keep us warm. And all three of these must be combined if we want to feel comfortable. You have noticed the car-drivers slap their arms about on a cold day ; this is to give them exercise and make them warm ; it makes the warm blood circulate faster, and this brings heat to the tissues. If you stand still on a wintry day the feet soon become cold ; this is very unhealthy, and it is a sign that you should exercise in order to get more blood back into the feet. If we go out on a cold day before breakfast we feel very chilly ; everyone knows how much better he is able to stand the cold after having had a warm meal.

317. **How to Keep Cool in Summer.**—In summer we should eat *less meat* and *less food* than in winter. Usually our appetite is not as good in summer as it is in winter, and naturally, therefore, we take less food. We should have *light clothing*. Everything we do during the warm parts of the summer days we should do *slowly* and should *not hurry*. We should not walk in the sun for any distance without being shaded.

318. **How the Body is Kept Cool in Summer.**—It would seem difficult to prevent the body from being overheated in summer when the air around us is so warm; you might wonder, too, why it is that the blood of a locomotive engineer, or of a cook who is in front of a hot fire all day long, is no warmer than that of persons who can keep cool. There are two ways in which the bodily heat is prevented from rising above 98 degrees when persons must be near furnaces and fires or are otherwise exposed to the heat.

319. Both methods depend upon the fact that *whenever moisture or water leaves any surface it makes that surface cold ;* that is, it takes some of the heat of that surface with it. In India, the drinking-water is cooled by placing it in porous clay

vessels which allow a little of the water to soak through ; after it has done this, it passes off into the air and thus makes the rest of the water cool. If you wet your hand and then hold it in the air, it feels cold, because the water in passing into the air takes some of the heat of the hand with it.

320. In this way our blood does not get any warmer in summer than in winter. For in summer more moisture leaves the body than in winter. Moisture leaves the body in two ways : By the *lungs* and by the *skin*. We breathe more rapidly in summer than in winter, especially if it is very warm, and in this way, more moisture is given off to the air from the blood passing through the lungs. Then again, the expired air contains more moisture in summer.

321. **Perspiration.**—The moisture which passes off by the skin is called *perspiration*. This is taking place constantly through the pores, but in summer so much passes off that it collects in drops and is then called *visible* or *sensible* perspiration.

322. **Ice-water in Summer.**—There is no objection to ice-water in summer if you do not drink too much, and if you take a little at a time. Some people get into the habit of drinking ice-water constantly ; this is very unhealthy and will make them suffer. But if it be remembered to drink it slowly and only a little at a time, it will not usually do any harm.

323. **Sunstroke.**—When a person has been in the sun a long time, the heat of the blood may become so great that it makes him dangerously sick; this is called *sunstroke*. It is a very dangerous condition. If you have to walk much in the sun, you should stop and go into the shade and rest as soon as you feel the least bit faint or dizzy.

324. **Effects of Cold.**—If we are in the cold a long time, it sometimes happens that we freeze the nose, ear, toes, or fingers. When this occurs, the frozen part of the body becomes pale or purple. At first it becomes painful but when really frozen it has no feeling at all. The reason these parts of the body

freeze is because the blood does not flow in them as it should ; there is too little blood in them, and so there is too little heat to keep off the cold. When the ears or the nose begin to bite we know that they are beginning to feel the effects of the cold, and we should rub them so as to bring the blood back. When we are very cold and have frozen a part of the body, we should not go near the fire at once ; the change from cold to heat would be too sudden and the frozen parts might become dead. We should rub the frozen part with the hand.

SYNOPSIS.

Combustion—The slow consumption of the tissues :

a. Requires food and oxygen.

b. Produces :

1. Life.
2. Growth.
3. Work and heat.

Refuse of the Body :

a. Gaseous, given off by :

1. Lungs—expiration.
2. Skin.

b. Liquid, given off by kidneys.

c. Solid, given off by intestines.

Heat of Animals :

a. Warm-blooded animals.

b. Cold-blooded animals.

Heat of the Human Body :

1. About 98° in health in the interior.
2. Colder on the surface of the skin, depending upon the warmth of the air.
3. Higher in sickness (fever).
4. Regulated by :

(1.) Amount and kind of food.
(2.) Amount and kind of clothing.
(3.) Amount of exercise.
(4.) Perspiration.

To Keep Warm in Winter:

1. Much clothing, especially woollen; flannel next to skin.
2. Much food, especially meat.
3. Much exercise.

To Keep Cool in Summer:

1. Light clothing, especially linen.
2. Less food, and less meat.
3. Less exercise.

The Control of Bodily Heat in Summer—By increased escape of moisture by lungs and by skin.

Undesirable Effects of Heat and Cold:

1. Sunstroke.
2. Freezing parts.
3. Bad effects of too much ice-water.

QUESTIONS.

1. What effect has our clothing upon the body heat? 2. In what way can the body be compared to a stove? 3. What corresponds to the fuel of the stove? 4. What do we call the slow burning which takes place in the body? 5. How does fuel do work in the locomotive? 6. What results from the fuel in a locomotive besides the steam which does the work? 7. What results from the combustion of our food? 8. What does the oxygen of the air do? 9. Why are the tissues constantly used up and then restored? 10. What gases are given off from the body? 11. What is the object of taking food into our stomach, and oxygen from the air into our blood? 12. What do these produce? 13. Is the body ever idle? 14. What work does it do even when we are asleep? 15. Is the body doing any work when we think? 16. Can a hard-working man get along on as little food as one who is idle? 17. Do all animals have the same warmth of the blood? 18. What is meant by a cold-blooded animal? 19. Give an example. 20. What is meant by a warm-blooded animal? 21. Give an example. 22. Have bodies without any life in them any heat of their own? 23. What is the heat of the human body? 24. What is a thermometer? 25. Is our skin warmer or cooler than the rest of our body? 26. What change is there in the heat of the body when we have fever? 27. What do

we do in summer so that less bodily heat shall be produced? 28. Do we need more heat or less heat in winter than in summer? 29. How do we produce more heat in winter? 30. Do clothes *produce* heat? 31. What do they do to the heat? 32. What is the warmest kind of clothing? 33. What is the coolest kind of clothing? 34. What color of cloth is the warmer, black or white? 35. How can you show this? 36. What should we do to keep warm in winter? 37. What should we do to keep cool in summer? 38. How is the body kept cool in summer? 39. Does the blood become warmer if we stand in front of a fire all day? 40. What effect is produced when moisture passes into the air? 41. How can you show this effect by an example? 42. In what ways does moisture leave the body? 43. What is perspiration? 44. How does perspiration keep the heat of the body from rising? 45. How can you take ice-water in summer without harming you? 46. What is sunstroke? 47. What should you do to avoid being sunstruck? 48. What are the effects of great cold? 49. What parts of the body are we most apt to freeze? 50. Why may certain parts of the body freeze? 51. How does the nose or ear feel when it is freezing? 52. How do they feel when they are frozen? 53. Should we go near the fire immediately when we have frozen a part of the body? 54. What should we do?

Fig. 73.—General View of the Nervous System in the Human Being.

CHAPTER X.

THE NERVOUS SYSTEM.

325. Thus far the bony framework of the body and the muscles which cover and move the skeleton have been spoken of. The food and drink which man should take and what becomes of this have been considered; also how this food is digested and taken up by the blood, forming new tissues. The heart and the blood-vessels which convey the blood to all parts of the body have been described. The lungs and breathing and the effects of pure and impure air, have been studied. Finally, the necessity of the body having and keeping a certain warmth has been spoken of.

326. These functions are found in all animals, but they are not peculiar to animals for they also exist in plants. The word "function" was defined to be the *work* which any part of the body does. All these different kinds of work that we have been studying about, and which are necessary for animal life, are also found in plants.

327. **Similarity in the Structure of Plants and Animals.**—The plant has a framework which corresponds to our skeleton, though of course it is not made of lime. This can often be seen in leaves that have been in the water a long while; the soft parts have rotted away, leaving the stems and ribs of the leaf, as is shown in Fig. 74. In plants there is a soft green matter to clothe this skeleton. Plants take in food and drink by their roots and by their leaves. They also breathe through pores in their leaves, and take in air and give up air just as animals do, except that in addition they take in

the poisonous gases and give up the pure oxygen; this is just the reverse of what animals do. It may be well to explain what pores are: they are the very small openings in the skin or in the coverings of leaves; they are usually too small to be seen by the eye without a microscope.

FIG. 74.—The Skeleton of a Leaf. After long-continued soaking in water, the soft part of the leaf has been removed, leaving the woody portion forming the framework, which gives the leaf its shape and strength.

328. Then again plants have *sap*, which serves as their blood; it is not of a red color but it takes the place of blood, and, like the blood in animals, it carries the nutritious juices to the different parts of the plants. There are tubes which carry the sap, just as blood-vessels do the blood. Finally, plants have a certain warmth of their own, just as do animals; it is not as great as in animals, but if a great many plants are placed in a closed room the air in this room soon becomes quite warm.

329. **Absence of Nervous System in Plants.**—Thus it will be seen that plants have all the parts and the same functions which have been described in animals thus far. But now will be considered certain parts in animals which plants do not possess, and the first and most important of these is *the Nervous System*. Let us first see what is meant by the word *system*. It is a *collection* of tissues of the same kind. So that nervous system is a collection of nerves, or in other words, all the nerves of the body taken together are called "the nervous system;" all the arteries taken together would be called the "arterial system." All the muscles of the body are called the "muscular system."

330. **Most Perfect Nervous System in Man.**—The nervous system is something *peculiar to animals* and does not exist in plants. In animals there is a great difference in regard to how perfect this nervous system is. The higher the form of the animal, the more perfect is its nervous system. Man being the highest form of animal, the nervous system of man is much more developed than in any other animal. In some of the lowest animals it is very imperfect indeed. This is the main distinction between man and the lower animals. In other functions, such as respiration, circulation, and digestion, there are many classes of animals which are the equals of man; but in the nervous system man stands far ahead of any.

331. **Function of the Nervous System.**—The nervous system gives us information of the condition of the body and of what is going on around us, so that we can do what is best and avoid danger. It is also the work of the nervous system to connect the different organs of the body so that they will work in harmony. If it were not for the nervous system we would constantly be in danger of losing our lives. It enables us to feel, think, see, hear, etc., and in this way we avoid injury. When a large number of persons are working separately there must always be a head or chief to direct them. Imagine what disorder there would be in the class-room if every pupil did as he or she wished and there were no teacher. Think of an army of soldiers over which there were no general, and every soldier did as he wished; how dreadful the confusion would be! In the same way there would be great disorder among the organs of our bodies if there was not something to connect them and to direct their work; this is done by the nervous system.

332. **Divisions of the Nervous System.**—We can divide the nervous system into certain parts. These parts are all connected. We separate them only for the purpose of study.

333. There is first the *brain*, the head or chief that superintends the entire work of the system, just as the president of a railroad manages the running of all the trains. The brain is

placed in a rounded, bony box, made by the bones of the skull, called the cranium.

334. Next we have the *spinal cord*, which is still very important, though not so important as the brain. It is a sort of assistant to the brain, relieving it of a good deal of work, and also doing some work which the brain does not do. The spinal cord runs in the canal or tunnel which we find in the back part of the vertebræ.

335. Finally, we have the *nerves*. These are sent out from the brain and from the spinal cord to different parts of the body; they also run in the opposite direction—from the various parts of the body to the brain and spinal cord. They are the messengers, or the telegraph wires so to speak, which carry the wishes of the brain to the different parts of the body; and they also carry messages from the different parts of the body to the brain. These different parts of the nervous system are illustrated in Figs. 73 and 79.

336. **Examples of the Action of the Nervous System.**—The uses of the nervous system can best be understood by a few examples. Suppose a man is walking along the street and is about to cross the car-track. His ear hears the jingle of the bells and by means of a nerve sends a message to the brain; the brain then sends an order along the nerves of the eyes to these organs to look in the direction in which the ear has heard the sound and to see whether a car is approaching. The eyes obey the orders of the brain and look and see the car very near, and also perceive that the person is in danger of being run over. They immediately send back word to the brain about this danger. Then the brain sends word to the muscles which move his legs; this message is also transmitted by nerves; it tells these muscles to act immediately. The result is that they obey; he quickens his steps and thus escapes the coming car.

337. Let us take another example. Suppose it is time for the noon recess; you have taken your breakfast early in the

morning and have had no food since. The stomach sends a message to the brain that it has been empty for some time; the tissues also send messages by numerous nerves that they would like some more nourishment since they have exhausted all that the blood had to give them. Upon receiving these messages, which, in short, mean that you are hungry, the brain gives out its orders. It directs the legs to carry you home as soon as school is dismissed; it directs them to take you to the dining-room and to seat you at the table; it directs the eyes to look at the food and see whether it is wholesome; it orders the hands to seize knife and fork and to convey food to the mouth; the jaws are directed to chew it, the throat to swallow it and the stomach to digest it. All this the brain does.

338. **Rapidity of Action of the Nervous System.**—It has taken a little while to describe these two examples of the manner in which the nervous system acts, but it must not be imagined from this that so much time is consumed. All these messages are sent back and forth with lightning-like rapidity, and it only takes a very small part of a second for a message to travel from the tip of the finger to the brain and back again.

THE BRAIN.

339. **Coverings.**—The brain is a large, rounded mass of soft nervous tissue which is contained in the oval box of bones formed by the skull. These flat bones which cover it protect it from injury. Besides these, it is covered on the inside of the skull by three membranes or sheets of tissue; it is therefore very well protected.

340. **Size and Weight of the Brain.**—The brain is about *eight inches long.* If looked at from above (Fig. 75) it appears *hemispherical;* if viewed on its under surface (Fig. 76) it is *flat.* It weighs about *forty-seven ounces* on the average—about three pounds. The brain of a man is larger and weighs more than

that of a woman. It was formerly thought that highly educated persons had very heavy brains, but this is not so in every case. It is true in certain cases, however, for the brain of Daniel Webster weighed sixty-three ounces. On the other hand, the brain of Gambetta, who was one of the brightest statesmen

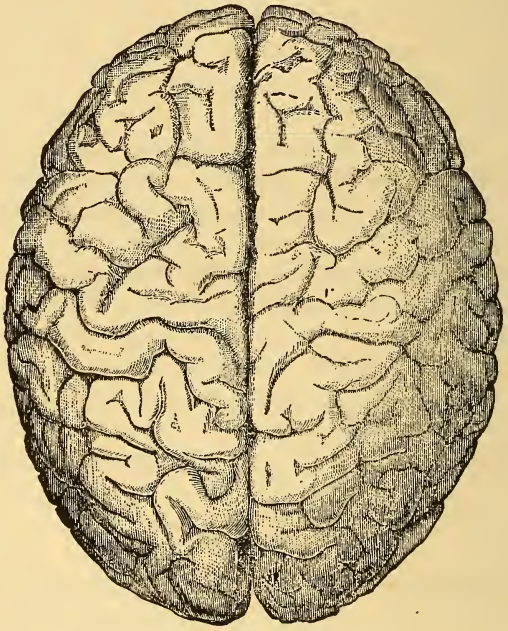


FIG. 75.—The Brain, Upper Surface.

France ever had, was said to weigh only thirty-five ounces. So that there are exceptions to this opinion. However, the brains of idiots are always small and light in weight. It will be explained further on in what way the brain of a very intelligent man differs from that of an idiot. The human brain is *heavier* than that of any other animal except the whale and the elephant.

341. **Divisions of the Brain.**—The brain is divided into three parts: There is first the greatest part of the brain, the large, round mass which you see when you look at it from above, and which forms about seven-eighths of the entire brain; this is called the *cerebrum* (Figs. 75, 76, 77, and 79).

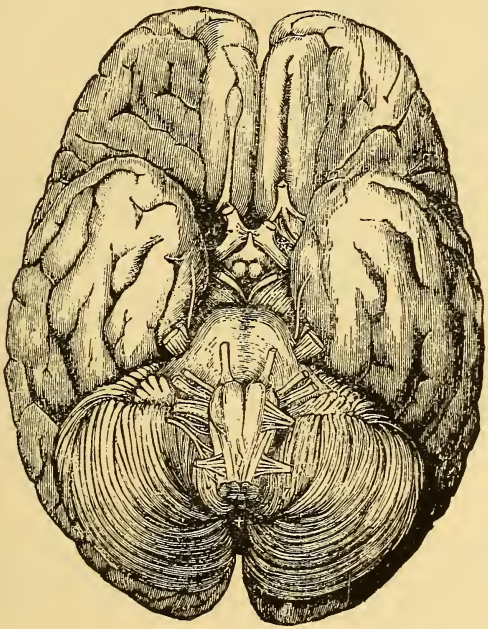


Fig. 76.—The Brain, Lower Surface.

342. Then beneath the cerebrum, at the back part, is a smaller portion, looking like two pouches; this forms only one-eighth of the entire brain, and is called the *cerebellum*, or the *little brain* (Figs. 76, 77, and 79).

343. Third, there is the portion which is a sort of bridge between the brain and the spinal cord; this is called the *medulla* (Figs. 77 and 79).

344. **The Cerebrum.**—As already stated, this is the main part of the brain. If you look at it from above you will see that it dips in along the centre, and you will find this cleft to be quite deep, separating the brain into two halves; these are called the *hemispheres*—a very appropriate name. The surface of the cerebrum is very uneven, due to the fact that it is covered by a great many winding elevations, between which the surface

FIG. 77.—The Brain, Looked at from the Side, Showing Very Nicely the Divisions of the Brain. The large mass above is the cerebrum; the smaller portion, below and behind, is the cerebellum. From the cerebrum above, a cylindrical portion is seen passing directly downward to the end of the illustration below, this is the medulla; the cerebellum is seen to be connected with its upper and back part.

dips in about an inch. In a person whose brain is very much developed and who is very bright, these elevations are very winding and complex, and between them the brain matter dips in very much; while in the lower animals the elevations are quite straight and simple, and there is very little dipping in between them.

345. **Gray and White Parts of the Cerebrum.**—On the outside the cerebrum is *gray*, but internally it is white. The

gray part consists of cells—that is, small bodies with a number of branches given off from them, and these branches connect with the nerve-fibres. The interior of the cerebrum is white, and is formed by millions of nerve-fibres (Fig. 78).

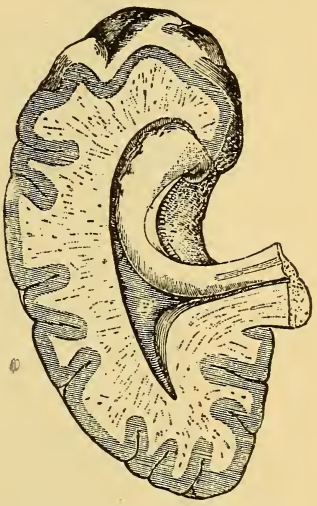


Fig. 78.—A Portion of the Cerebrum Cut Across, Showing the Gray Border on the Outside and the White Matter Within.

346. **The Cerebellum.**—This, like the cerebrum, is gray on the outside and white within. It is much smaller than the cerebrum, and is placed behind and below it, being covered in by it (Figs. 77 and 79).

347. **The Medulla** (Figs. 77 and 79) serves to connect the brain with the spinal cord. It is very important. There is one part of it which, if it becomes injured in any way, will produce instant death.

348. **The Cranial Nerves.**—What is a nerve? A nerve is a collection of nerve-fibres forming a small cord. These nerve-fibres are very small, and can only be seen with the microscope. But when a great many of them run alongside of each other they are joined into a bundle, and this we call a *nerve*. Some nerves are very large and others quite small. At the ends, where they pass to the tissues, they are very small indeed.

349. The *brain gives off twelve sets of nerves*, and these all pass to the tissues of the head and face. They are important, for among them are the nerves of smell, taste, sight, and hearing. There are small holes in the bones of the skull by which these nerves pass out. It has already been stated that the cranium is the bony box in which the brain is contained;

hence these nerves are called *cranial*, because they come from this bony box. They are arranged in pairs, one behind the other; on this account they are often called in numerical order, first, second, third, etc.

350. **Functions of the Brain.**—The brain is the *seat of the mind, of the will, of thought, of memory,* and of *intelligence.* It is through the brain that we are rendered superior to the lower animals. The lower animals accomplish different actions through what we call "instinct," that is, without the action of the mind. But we can do many more things than they, and more difficult acts, because our brains are more developed.

351. Let us examine into the work of the brain and see what it does for us: In the first place, it is where the *will* exists; it is where our desires come from. Then as to *memory*, it is the brain which enables us to *think* about things and to *remember* names, figures, faces, and all other things. Imagine how useful this is and how difficult it would be to get along without it! Think also of the wonderful action of the brain when it is possible to remember things all our lives!

352. The brain gives us *reason*, so that when we see a thing we know what it means and whether it is important or not. It gives us *judgment* which enables us to do the right thing in order to accomplish what we want.

353. **Intelligence** has its seat in the brain. This prevents us from being stupid; it enables us to understand things and allows us to express ourselves just as we wish, by language. It enables us to see the difference between right and wrong, so as to avoid the latter.

354. **Training of the Brain.**—A great deal of our memory and intelligence depends upon the way in which our brain is trained. If we use our brain a great deal, it will become better than if we allow it to remain idle. Many things which we study at school are taught us for the purpose of training the brain. We should remember that we cannot think of more than one thing at a time. When you study your lessons, you

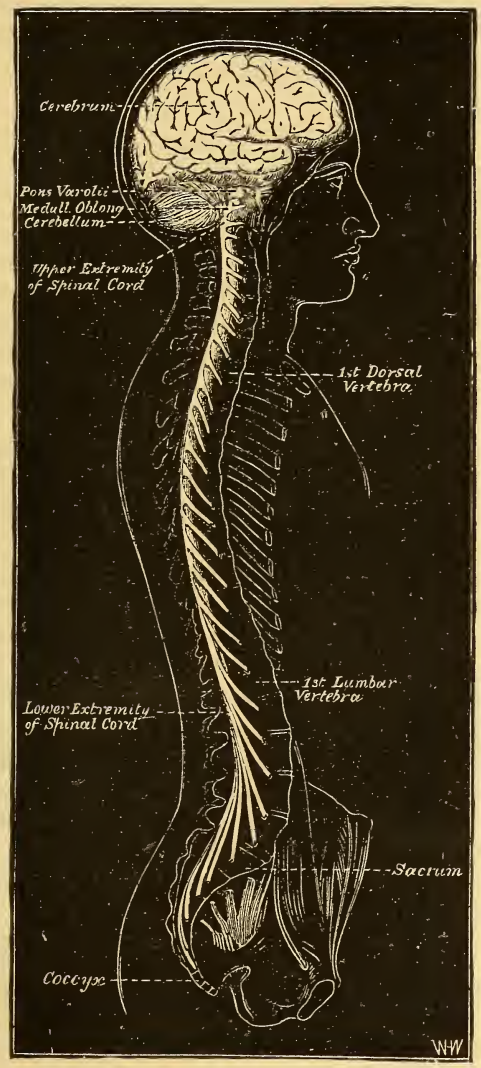


FIG. 79.—The Brain and Spinal Cord, with the Spinal Nerves Issuing from the Latter.

should not think of play ; and when you play, you should enjoy yourself, and need not think of your studies. There is a time for play and a time for study.

THE SPINAL CORD.

355. The spinal cord is the soft bar of nerve-tissue which runs down from the brain through the canal of the backbone. It is about as thick as the thumb. Besides being protected by bone, it has, like the brain, a covering of three membranes. While the spinal cord is not as important a part of the nervous system as the brain is, it is still very important, especially the part which runs through the neck. One often hears of people falling down stairs and "breaking their necks;" what is meant by this is that this upper part of the spinal cord is broken and death occurs immediately. When murderers are hanged they die, because in hanging this upper part of the spinal cord is broken across.

356. If the spinal cord be sliced across it would be seen that although it is white on the outside, it is gray on the inside. This gray matter in the interior is arranged in a peculiar manner, resembling two crescents joined together, as is shown in Fig. 80. As in the brain, this gray part is formed of cells, while the white portion consists of nerve-fibres.

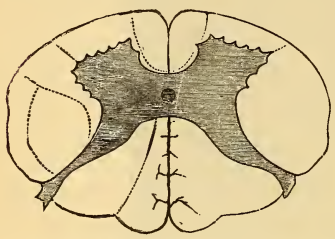


FIG. 80.—A Portion of the Spinal Cord Cut Across, Showing the Gray Crescents in the Interior Surrounded by the White Nerve Material.

357. **Spinal Nerves.**—The nerves which leave the brain are called *cranial nerves;* those which leave the spinal cord are called, in the same way, *spinal nerves.* There are thirty-one pairs of spinal nerves ; they are connected to the side of the spinal cord in a line. Each nerve when it leaves the spinal cord consists of two parts, one in front and

the other behind ; but these two portions soon unite to form a single nerve.

358. **Kinds of Nerves.**—There are two kinds of nerves—the nerves of *sensation* and the nerves of *motion*. The *nerves of sensation* are those which give feeling to different parts of the body and especially to the skin ; when you cut or burn yourself it is a nerve of sensation which carries the message of pain to the brain. The *nerves of motion* are those nerves which go to the different muscles and cause them to act when the brain wishes it.

Fig. 81.—A Nerve, Very Highly Magnified, Showing How it is Made up of Numerous Nerve-fibres.

359. **Functions of the Spinal Cord.**—The spinal cord is a sort of *agent* or *assistant to the brain*, and it also serves to carry the large number of nerve-fibres which leave the brain, travel through the spinal cord and then to the limbs. But besides this, the spinal cord has a very important use : When the brain is engaged at something else, the spinal cord takes its place, and acts for it if any occasion arises.

360. **Reflex Action.**—This action without the knowledge of the brain is called *reflex action*, and it is the spinal cord which carries it out. Let us take a few examples of reflex action : Suppose you want to go to school in the morning. Your brain directs the muscles of your lower limbs to move in such a manner that you walk. But after you have started walking, you do not need to think about it ; perhaps you reach school and have crossed many streets and have turned many corners without knowing it. It was the spinal cord which looked out for all this.

361. If a fly alights upon your face, you put up your hand to brush it off, without really thinking of it. This is another example.

362. During sleep reflex action is shown very well. If you

tickle the feet of anyone who is asleep, he will draw up his lower limbs so as to draw them away; all this will be done without waking. It is the spinal cord which looks after this. In the same way, if you walk along, thinking of something else, and suddenly some one appears before you and makes a motion as though to strike you, you will draw up your arm to protect yourself before you can realize that anyone is there. If some one makes believe striking you in the face, you cannot help closing your eyes—you cannot keep them open even if you want to. This is reflex action. It is also reflex action which explains how it is that a chicken can run around after its head is chopped off.

363. **Sleep.**—Sleep is the *natural rest of the brain.* Just as every other part of the body needs rest during each twenty-four hours, so does the brain. In fact, many other parts of the body can exist longer without rest than can the brain. We may rest any other part of the body without sleep; but the only sign that the brain is resting completely, and is not active, is sleep.

364. **The Amount of Sleep** which is necessary varies with different people. Men who think a great deal require more than those who do bodily work. The *average sleep* necessary for a man is from *seven to eight hours.*

365. **Children require more Sleep** and should have *nine or ten hours,* for while the body is growing rapidly more rest is needed.

366. **Uses of Sleep.**—During sleep the brain and all other parts of the body rest and regain the strength which they have lost by the day's work.

367. **Time for Sleep.**—*Night* is the time for sleep. Persons who work at night and sleep by day are not usually quite as bright and healthy as those who sleep during the natural time. Young people who dance all night and then sleep by day to make up for it, soon look pale and tired out, and often weaken their bodies so much that they become sick. The

proper time for children to go to bed is at nine or ten o'clock; they should then rise at six or seven.

368. **Nervousness.**—We often hear people say they are "nervous." By this they mean that their nervous system is out of order. They start at the least noise; they become cross and irritable; and the rest of the body suffers. Nervousness is often due to too little sleep or too much excitement. Very often, too, it is due to indigestion, or to coffee, tea, or tobacco. When we are nervous we are apt to do things in haste, and are apt to talk cross and to get angry easily. All these things we should be careful to avoid.

369. **Wakefulness.**—When unable to sleep at night, we are said to suffer from *sleeplessness* or *wakefulness*. Lying awake at night when all is quiet and everyone else is asleep is very annoying. Not only does the body remain tired after the day's work, but the person becomes worried and cross because he cannot sleep. There are, of course, many causes of being unable to sleep, but some of the most common are laziness, coffee, tea, and tobacco. It is quite natural for us to feel a little tired at night, and then we will have no trouble in falling asleep; but if we are idle all day long, we do not feel tired, and on this account we may find it hard to fall asleep. Coffee, tea, and tobacco excite the nervous system, and on this account prevent sleep.

NARCOTICS.

370. Narcotics are drugs which benumb the brain and thus produce an artificial sleep. The sleep produced by narcotics is not refreshing like natural sleep, but persons often wake up stupid and with a headache. The narcotics used most frequently for producing sleep are *chloral* and *opium*.

371. **Chloral** comes in white crystals which dissolve in water. People sometimes get in the habit of taking it regularly to make them sleep, and soon they cannot do with-

out it; and they have then what is called the *chloral habit.* They become nervous, pale, and weak, and have indigestion.

372. **Opium.**—This is a narcotic, but it is probably the most useful medicine there is when ordered by the doctor in the proper cases which need it. It is a brown, sticky substance, or it may come in the form of a brown powder. Most of it comes from India and the warm countries of this neighborhood. It is the juice of the unripe fruit of the poppy-plant; this juice is allowed to dry and then makes this sticky substance. With water we can extract white crystals, which have the same effect on the body as opium itself; these crystals are called *morphine.*

373. Everyone has probably heard of the *opium habit,* or, what is the same thing, the *morphine habit.* It is a habit people get into of taking these drugs whether they need them or not. It has already been said, that morphine and opium are very useful medicines when the doctor orders them and they are needed. They take away pain, and they make persons sleep when they are sick and restless; in such cases they do a great deal of good.

374. **The Opium, or Morphine Habit.**—But persons who have the "morphine," or "opium habit," do not take the drug for this purpose; they take it because they think it makes them feel good for the time being, and makes them forget any cares they may have. But after the effects pass off, they feel miserable. The stomach is upset, they are tired and nervous, have a very bad headache, and often feel like vomiting. They feel so bad that they take more and more, until finally they keep under the effects of it all the time. Some of them take the narcotic by the mouth, others smoke it in long pipes. There is still another way in which these wretched people take morphine, and that is by piercing the skin with a hollow needle. Some of the morphine, dissolved in water, is forced under the skin from a small glass tube which is attached to the hollow

needle. This is probably the most dangerous way of taking the drug, when used merely as a habit.

375. Many persons who have this horrible habit have *commenced very innocently.* Their doctor may have ordered the drug for them at a time when they needed it. But instead of stopping its use when they were well, perhaps they have continued it, imagining it made them feel better, until it was too late, and they were prisoners of the habit. It is a habit which is more difficult to break off than any other habit; it is worse to stop than either drinking or smoking.

376. The *effects* of the opium and morphine habit upon the health show themselves very soon. The poor wretch soon becomes nervous; he cannot sleep at night; he has no appetite; if he takes any food he cannot digest and often vomits it; he becomes thin and has a yellow complexion; his mind changes and he loses his memory; he has no longer the power to do right, and he is known to tell lies without hesitation in order to get some of the drug. He becomes worse and worse, until, finally, when he has no more money to buy the drug, and his health is all broken up, he dies in the hospital or lunatic asylum, or often commits suicide. This is a horrible picture that has been drawn, but a true one.

377. **Cocaine.**—Lately, a very important medicine has been used to take away pain when painted on a part which is painful; it is called *cocaine.* This is also taken internally, and some persons have gotten into the habit of taking it regularly. It excites them and makes them feel rested and it removes tired feelings for a time. But this is only temporary and soon the person feels worse than before. If he gets into the habit of taking the drug regularly, it makes him nervous, and he gets a great many of the symptoms which were spoken of as occurring in the opium habit; this habit often affects the mind, and the unfortunate person becomes crazy as a result of the cocaine habit.

378. **Effects of Alcohol upon the Nervous System.**—The nervous system has no greater enemy than alcohol. Every

part of the nervous system—the brain, the spinal cord, and the nerves—suffers when large quantities of alcoholic drinks are taken. The brain becomes affected very soon. If a large quantity is taken at one time and the person becomes intoxicated, he becomes stupid in his intelligence, but excited in other ways—he sings, or cries, or begins to laugh like a fool or begins to scold, and he often fights. He forgets that he is a human being and acts like a brute. He is unable to walk straight and staggers along in a pitiable way, catching on to lamp-posts or any other place for support. The stomach becomes affected and he vomits. The effect upon the nerves is shown by the way every part of his body trembles, and the great unsteadiness. A drunken man is a disgusting sight! And if this be repeated many times and becomes a habit, the memory begins to fail, the person becomes bloated and fat but very weak, his health fails, his hands tremble, his eyes and nose are constantly bloodshot, he becomes dirty and careless, and the individual changes into a good-for-nothing.

379. **Delirium Tremens.**—As a result of drunkenness there is often produced a disease of the nerves called *delirium tremens*. This means that the person is out of his mind and has trembling of the body. It is a condition which kills many men, and which is dangerous to the drunkard, because he gets out of his mind and tries to do all sorts of violent things, especially to jump out of the window. He imagines that he sees animals such as mice, rats, and snakes, and he thinks these are chasing him, and he wants to run away. It is difficult to keep him quiet. The whole body trembles from the poisonous effects of the alcohol. The heart is often weakened so much that the person dies because this organ has become too weak.

380. **Effects of Tobacco upon the Nervous System.**—This shows itself chiefly by the trembling hands and the nervousness which we often notice in people who smoke a great deal. Many persons, especially young men, cannot smoke at all without producing nervousness.

381. **Effects of Coffee and Tea upon the Nervous System.**—Coffee and tea excite the nervous system. They are often the cause of nervousness and trembling ; also of palpitation of the heart, which is a form of nervousness. Children should not drink coffee or tea, as they do not need any stimulants—certainly not until they are full-grown.

382. **The Sympathetic System of Nerves.**—Besides the great nervous system to which this chapter has been devoted, there is a smaller collection of nerves, which is known as the *sympathetic system.* Along the front of the backbone are found two nerves, with many knob-like enlargements at numerous points. This is the central part of the sympathetic system ; from it the branches of this system are given off. Unlike the nerves of the general nervous system, which pass to the outside of the body and to parts which are subject to our will, the branches of the sympathetic system pass to the internal organs which cannot be controlled by our will, and which are therefore called "involuntary."

SYNOPSIS.

The Nervous System :

1. Present in animals, but not in plants.
2. Functions :
   a. To give information in regard to the condition of various parts of the body.
   b. To give information of what is going on around us, so that we can act accordingly, and can avoid danger.
   c. To connect the different organs of the body, so that they can act in harmony.
3. Divisions :
   a. The general nervous system ; nerves passing to external parts, and those controlled by our will.
   b. The sympathetic nervous system ; main part arranged in two chains, with knob-like enlargements along the front of the vertebral column ; from these branches are given

off; branches pass to internal organs which are not under control of the will —"involuntary."

The General Nervous System:

Divisions:

A. Brain:

1. Coverings:
   - *a.* Membranes.
   - *b.* Bones forming cranium.
2. Shape—hemispherical.
3. Size—about eight inches long.
4. Weight—*a.* Average about forty-seven ounces.
   - *b.* Heavier in man than in woman.
   - *c.* Very light in idiots.
   - *d.* Weighs more in man than in any other animal, except the whale and elephant.
   - *e.* In some cases, weight is proportionate to intelligence.
5. Gives off the cranial nerves.
6. Natural rest—Sleep:
   - *a.* Necessary amount varies.
   - *b.* Hard work necessitates more.
   - *c.* Average for man, seven to eight hours.
   - *d.* Children require more, nine to ten hours.
   - *e.* Use, to give body, and especially brain, a complete rest.
   - *f.* Proper time, at night.
   - *g.* Disordered sleep—wakefulness—may be due to laziness, tea, coffee, or tobacco.
7. Divisions:
   - *a.* Cerebrum:
     1. Largest part of brain (seven-eighths).
     2. Large, round mass.
     3. Divided into halves, called hemispheres.
     4. Surface uneven, owing to winding elevations, between which the surface dips in.
     5. The height of these elevations and depressions is proportionate to the intelligence.
     6. Exterior gray and formed largely of cells.

7. Interior white, and formed entirely of nerve-fibres.

8. Controls mind, will, thought, memory, and intelligence.

9. Gives reason and judgment, elevating man above the lower animals.

10. Admits of training.

b. Cerebellum, or "little brain."

1. Much smaller than cerebrum.

2. Forms one-eighth entire brain.

3. Forms lower and hind part of brain.

4. Like cerebrum, is gray on outside and white within.

c. Medulla:

1. Connection between brain and spinal cord.

2. Very important part, since injury to one portion causes instant death.

B. Spinal Cord:

1. Long bar of nerve-tissue.

2. Protected by: *a*, membranes.
b, bones forming vertebral column.

3. Interior formed of gray matter, arranged in crescents, and composed largely of cells.

4. Outside is white and formed of nerve-fibres.

5. Gives off the spinal nerves.

6. Acts as an agent or assistant to the brain.

7. Controls reflex action—action without the knowledge of the brain, serving to protect us from injury.

C. Nerves:

Divisions:

1. According to action: *a*, sensation; *b*, motion.

(1.) Nerves of sensation, carrying impressions of feeling, such as pain, etc., from the surface to the brain and spinal cord.

(2.) Nerves of motion, carrying messages from the brain and spinal cord to the muscles, and causing these to act.

2. According to source: *a*, cranial; *b*, spinal.

(1.) Cranial nerves, twelve pairs, pass from brain, through openings in bone, to various parts of the head and neck.

(2.) Spinal nerves, thirty-one pairs, emerge from spinal cord by two roots, which soon join together, pass to different parts of the trunk and limbs.

Disorders of the Nervous System, due to :

1. Coffee and Tea :
   a. Often excite nervousness, trembling, etc.
   b. Children should not be allowed any.
2. Tobacco—Often causes nervousness, trembling, etc.
3. Alcoholic Excess :
   a. Great enemy to nervous system.
   b. Stupefies intelligence.
   c. Excites brain in undesirable ways, such as fighting, etc.
   d. Causes trembling and staggering.
   e. Other effects on rest of system.
   f. Delirium tremens—Result of drunkenness, person out of mind ; great trembling ; person violent, often wishing to jump from window ; person imagines he sees enemies, mice, rats, snakes, etc. ; heart often seriously weakened, and may die from this cause.
4. Narcotics—Produce an artificial sleep, which lacks the refreshing qualities of natural sleep.
   a. Chloral :
      1. Often taken to produce sleep.
      2. Danger of habit, so that a person cannot sleep without it.
      3. Chloral habit causes nervousness and other bad effects upon system.
   b. Opium :
      1. Useful as medicine when prescribed by the physician.
      2. Contains white crystals called "morphine," which have the same effect as does opium.
      3. Persons often acquire the habit of taking it by mouth, smoking, or beneath the skin.

4. The opium habit is very injurious, and is the most difficult to break.

5. As a result of the opium habit, the health suffers very much; the poor victims often end their lives in hospitals and lunatic asylums, or attempt suicide.

5. Cocaine—A new drug, used to relieve pain, when painted on certain surfaces; it is not a narcotic, but it presents the same danger as in opium, of having the person become in the habit of taking it regularly. The cocaine habit causes weakness of the nervous system, and often ends in insanity.

The Sympathetic Nervous System—(see above).

QUESTIONS.

1. What different parts are found in plants as well as in animals? 2. What is the skeleton of a leaf? 3. Do plants take in food and drink? 4. How? 5. How do plants breathe? 6. What difference is there in the breathing of plants and of animals? 7. What are pores? 8. What fluid is there in plants corresponding to the blood of animals? 9. How is the sap carried along? 10. Do plants have any warmth of their own? 11. How can you prove this? 12. What part of animals is absent in plants? 13. What is a system? 14. Give an example. 15. Does the nervous system exist in plants? 16. In what animal is there the highest form of nervous system? 17. What is the function of the nervous system? 18. What might happen if we did not have a nervous system? 19. Give an example to show that there must be a chief to everything where there are many parts. 20. Into what parts can we divide the nervous system? 21. What is the office of the brain? 22. What of the spinal cord? 23. What of the nerves? 24. Give an example of the action of the nervous system. 25. Does it take the nervous system a long time to act? 26. Give an example to show how quickly it acts. 27. Where is the brain situated? 28. What protects it? 29. Is it soft or hard? 30. What is its form? 31. What is its size? 32. What is its weight? 33. Is it heavier in man or in woman? 34. Does its weight depend upon the intelligence of the person? 35. Give examples. 36. What can you say about the brains of idiots? 37. Into what parts can the brain be divided? 38. Where is the cere-

brum? 39. What are the hemispheres? 40. What can you say about the surface of the cerebrum? 41. What is peculiar about the surface of the cerebrum in very intelligent persons? 42. How is it different in the lower animals? 43. What is the color of the cerebrum on the exterior? 44. What is the color of the interior? 45. Of what does the gray matter consist? 46. Of what does the white matter consist? 47. Describe the cerebrum. 48. Describe the medulla. 49. Why is it very important? 50. What is a nerve? 51. Where are the cranial nerves? 52. To what are they attached? 53. Name the functions of the brain. 54. What is meant by doing things "by instinct?" 55. Where does the will exist? 56. What is meant by memory? 57. What is intelligence? 58. What is reason? 59. What is judgment? 60. How can we train the brain? 61. What is the spinal cord? 62. How is it protected? 63. What is meant by "breaking the neck?" 64. Of what is the spinal cord formed? 65. How does it look inside? 66. What are the spinal nerves? 67. How many are there? 68. How do they leave the spinal cord? 69. What two kinds of nerves are there? 70. What are the functions of the spinal cord? 71. What is reflex action? 72. Give an example of reflex action. 73. Of what use is reflex action? 74. What is sleep? 75. How must the brain be rested? 76. What is the average amount of sleep required for a man? 77. How much for a child? 78. What are the uses of sleep? 79. What is the proper time for sleep? 80. When should children go to bed? 81. When should they rise? 82. What is nervousness? 83. What is nervousness due to? 84. What is wakefulness? 85. What are some of the most common causes? 86. Is it natural for us to feel a little tired at night? 87. Why can some persons who are idle all day long not sleep at night? 88. How do coffee, tea, and tobacco act on the nervous system? 89. What are narcotics? 90. Which are used most frequently for producing sleep? 91. What does chloral look like? 92. Why do people take it? 93. What effect does the "chloral habit" produce? 94. What does opium look like? 95. Where does it come from? 96. How is it obtained? 97. What is morphine? 98. What is the morphine or the opium habit? 99. Of what use is opium in sickness? 100. Why do persons form the morphine or opium habit? 101. What are the effects of this narcotic afterward? 102. In what ways do they take opium or morphine? 103. How do persons sometimes contract this hor-

rible habit? 104. Is it a difficult habit to break off? 105. What are the effects of the habit upon the health? 106. How does it end? 107. What is cocaine? 108. Of what use is it? 109. Why do some people form the habit of taking cocaine? 110. What effects does this have? 111. How does the habit end very often? 112. What effect has alcohol upon the nervous system? 113. How is the brain affected in drunkenness? 114. Name some of the disgusting actions of the drunkard. 115. How are the nerves affected? 116. What are the effects of repeated drunkenness? 117. What is delirium tremens? 118. What are the symptoms of delirium tremens? 119. What effect has tobacco on the nervous system? 120. What effect have coffee and tea on the nervous system? 121. What is the sympathetic system of nerves? 122. What is the function of the sympathetic system? 123. What is its arrangement? 124. To what parts is the sympathetic system distributed?

CHAPTER XI.

THE SENSES.

383. There are certain organs in the body which add a great deal to our comfort and enjoyment and give us knowledge and pleasure. The functions of these organs are called the *senses.* There are five of them.

1. Touch—The *skin.*
2. Taste—The *tongue.*
3. Smell—The *nose.*
4. Sight—The *eye.*
5. Hearing—The *ear.*

384. **Special Senses.**—They are often called the *special senses* because each one has a special duty to perform and cannot be used for anything else ; as, for instance, our eyes can be used for seeing only. The skin is the only one of these organs which is necessary to life ; it is an organ of *general* rather than of special sense.

THE SENSE OF TOUCH—THE SKIN.

385. **Thickness.**—The skin forms a soft, elastic layer which covers the entire body. It is not of the same thickness all over. It is thick at certain places where the body is very much exposed or where there is much friction, as in the palms of the hands and the soles of the feet. In other places which are more protected, it is quite thin—for instance, the inner side of the arm.

386. **Uses of the Skin.**—As has already been stated, the skin is necessary to life. In certain accidents, in which a per-

son has burnt or scalded himself severely, he may die because too much of the skin has been lost. There are four principal uses of the skin: 1, As a protection to the entire body; 2, as the organ of sensation or feeling; 3, to throw off water, salts, and poisonous matter from the body; 4, to regulate the bodily warmth.

387. **The Skin as the Organ of Sensation or Feeling.**—The nerves of sensation or feeling end in the skin by little knobs, which are the portions with which we feel the different sensations, such as heat, cold, smoothness, roughness, pain, etc. Some parts of the body are more sensitive than others—this is because they have a greater supply of these nerves. These same nerves also give rise to pain; this is useful, for it protects the body; it tells you when to be careful. If you are holding a lighted match in your fingers, you will drop it as soon as it burns down to your finger-tips because there is pain. If there were no pain to warn you, the ends of the fingers might have been burnt off before you were aware of it. With these nerves we are enabled to feel whether anything is smooth or rough, sharp or dull, cold or warm, soft or hard. The finger-tips are intended as the organs of touch. In the blind, the sense of touch becomes very much developed, and such persons can be trained to do wonderful things by means of the fingers. The books of the blind are printed with letters which are slightly raised; it is marvellous how quickly they can spell the words by means of their fingers.

388. **Throwing off Water, Salts, and Poisonous Matters.**—This is a very important use of the skin. If an animal were to be covered with varnish so as to close all the pores, death would result in a short time.

389. **Regulating the Bodily Warmth.**—The skin serves an important purpose in regulating the bodily warmth. It does this by increasing or diminishing the amount of perspiration, thus cooling the body in summer by permitting free perspiration.

390. **Structure of the Skin.**—The skin is formed of two layers (Fig. 82). The outside layer is called the *scarf-skin*, the deeper one the *true skin*.

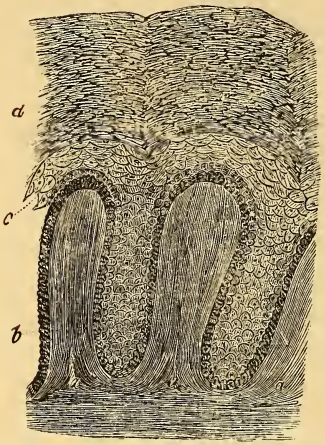


FIG. 82.—A Piece of Skin as Seen Under the Microscope. *d*, The layers of flat cells forming upper layer of the scarf-skin; *c*, deeper layer of scarf-skin; *b*, projections of true skin.

391. The *scarf-skin* is formed of a great many scales or flat cells covering each other; these cells are being constantly rubbed away and cast off, and are then replaced by new ones. In taking a bath, for instance, it will be noticed that in drying a little of the skin comes off—this material is formed of the dead cells which are cast off. The scarf-skin of the scalp is often cast off in small scales which we call *dandruff*. This throwing-off of these scales from the skin of the body takes place all the time and is natural. In snakes the scarf-skin is thrown off in one piece and forms the very pretty tubes sometimes found in the woods.

392. The *true skin* is the part which contains the blood-vessels and the nerves; it also contains the roots of the hair, the perspiration-tubes, and the oil-tubes. If you burn yourself, a blister forms; this separates the scarf-skin from the true skin; if you lift up the blister, the red part you see underneath is the true skin. The true skin is not perfectly smooth, but has a number of small projections upon it; but these do not appear on the surface of the skin because the cells of the scarf-skin fill out the uneven places (Fig. 82).

393. **Color of the Skin.**—The skin is colored differently in different parts of the body. It is darker, for instance, on the back of the hand than on the arm. Some persons have very light-colored skin and are said to have a fair complexion, and

these usually have blonde hair. Others have dark complexions and usually have hair of a dark shade. In the negro, the skin is dark-brown. This difference in the color of the skin depends upon the amount of coloring matter which is found in the true skin. In white people there is very little of this ; in the negro there is a great deal of it, in the form of small dark-brown grains.

394. If you look at the skin of the palms of the hands, you will see fine lines arranged in circles ; this you will see especially at the finger-tips. If you examine these with a magnifying-glass it will be seen that these lines are raised ; it is here that the nerves of feeling end in great numbers.

395. **Attachments of the Skin.**—Upon examining the skin, we find in it, or attached to it, certain parts : *Perspiration-tubes, oil-tubes, hairs*, and, in certain parts, *nails*.

396. **The Perspiration-tubes.**—These are the small tubes in the skin, which give off the perspiration. There are a great many of them. Where they open upon the skin there is a small space called a *pore*. There are thousands of these pores in the space of every inch of the skin. This shows the *necessity of keeping the body clean*, so that these pores remain open, for otherwise the perspiration cannot escape as it should. The perspiration-tubes open upon the surface of the skin ; below, they commence by a series of windings in the deeper parts of the skin, as is shown in Fig. 83.

397. **The Perspiration.**—Perspiration is constantly being given off from the body, day and night. Most of the time, especially when the weather is cool, we cannot see this—it is invisible, and hence it is called *insensible* perspiration. But if more than the usual amount is given off from the skin, the perspiration collects in drops and is called *sensible* perspiration. This occurs in summer and at other seasons of the year when we become over-heated or work hard. Perspiration consists largely of water ; in the water are dissolved certain mineral salts and certain poisonous matters which it is necessary for the body to cast off.

398. **Uses of the Perspiration.**—It has just been stated that the perspiration *takes from the body water, salts, and poisonous matters.* Even when the weather is cold and perspiration is insensible, about a pint of water leaves the body daily by the skin; in summer much more than this escapes. This will give an idea how many of these perspiration-tubes there must be and how active they must be. Perspiration is also very important because it *cools off the body*, as has already been described in the chapter on "The Heat of the Body."

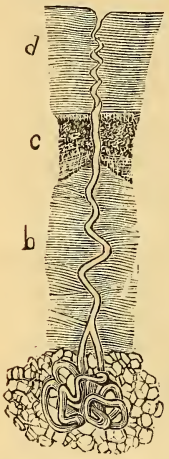


FIG. 83.—One of the Perspiratory Tubes. (Greatly magnified.) The tube is seen to pass through the entire thickness of the skin, through its different layers.

399. **The Oil-tubes.**—Besides the perspiration-tubes, there are others which run through the skin and open on or near its surface, usually where there is hair. These tubes give off a certain oily substance which keeps the skin soft and movable; without it the skin would get dry and cracked. This oily matter also serves to keep the hair glossy and soft; and we find the greatest number of oil-tubes where there is hair. It is to remove the oily matter which has become stale that we need soap in washing. Sometimes there is too much of this oily matter and then the skin has a greasy look, such as we often see on the forehead and nose. Sometimes these oil-tubes become stopped up by a little dirt; as a result the oily matter is kept in and we see a black spot on the nose or forehead; this is often called a worm; it is no worm, but is simply the oily matter which cannot escape because the opening of its tube has become clogged up.

400. **The Hair.**—If a hair be examined it will be found that one end is pointed, while the other, which was attached to the skin, has a white knob; this is its *root*, and it is through this that it is fastened to the skin (Fig. 84). The hair is not

solid but is a tube, and has a canal in its centre which is filled with a soft material. Deep in the skin there are small cup-like spaces into which the root of the hair fits and is attached. Hair differs very much in color, and this is because there is a difference in the amount of the coloring substance present in different cases.

401. **The Nails.**—At the end of the fingers and toes are the nails. They are hard and horny and serve to protect the finger tips and give them firmness. In front they have no feeling and we may cut them without paining us. But further

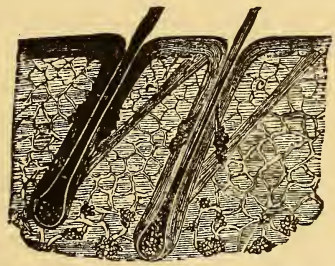


FIG. 84.—A Piece of Skin Cut Across, to Show the Way in which Hair is Attached to the Skin. (Highly magnified). There is seen to be a depression in the skin into which the hair dips. Below, the round, expanded extremity or root of the hair is seen.

back they are very firmly attached to the back of the finger and here they are very sensitive.

402. **Care of the Skin.**—You will now appreciate how important the skin is, and why it is necessary to keep it in good condition. *Cleanliness is next to Godliness* is an old saying; if you wish to be healthy you must be clean. Dirt is, as a rule, a sign of ignorance; and those nations are usually the dirtiest which are the most backward in civilization. On the other hand, the more civilized people are, the cleaner do they keep themselves. There are few things that cause so much disease as *uncleanliness and filth.*

403. **The Results of Uncleanliness and Filth.**—Whenever you read of outbreaks of cholera and such diseases you

will always find that they occur in parts of cities which are overcrowded and filthy; this was shown in the last outbreak of this disease, many years ago, in New York. It is easy to understand why this should be so. The pores of the skin are the openings by which the body gets rid of waste materials, just as the sewer-pipes of a city carry off the refuse. Suppose the sewer becomes stopped up in a large city; what trouble this causes! What dirt! What a stench! In the same way, when we allow the dirt to cover the pores of our skin, the poisonous materials cannot escape, and the body suffers. In taking proper care of the skin it is necessary to pay attention to *bathing*, to our *clothing*, to *exercise*, and to avoid using powder or any like substance upon the skin.

404. **Bathing.**—It is not sufficient to wash the hands and face daily; we should wash off the entire body at least once a week. If you shake out some of your underclothing at night, you will find a great many small white flakes fall to the ground. They represent the uppermost layer of the skin which is constantly being cast off in these small particles and replaced by the deeper layers. The entire body is covered with these scales, and it is necessary to remove them often. Some fall off by themselves, but others must be removed by soap and water. Consequently, at least once a week we should take a warm bath, and use soap in it, for this removes the stale, oily matter also.

405. **Cold Baths.**—Besides the warm bath for cleanliness' sake, we should take cold baths, especially in summer, because they are refreshing and strengthening. After taking a cold bath it is well to rub the body with a coarse towel so as to make the skin glow and tingle; this causes the blood to circulate faster, and increases our strength and appetite. It is injurious to remain in a cold bath until you begin to shiver. As soon as you begin to feel chilly you should go out. Many persons are harmed by cold bathing because they remain in the water for too long a time. Some persons are naturally weak,

and when they take a cold bath they are not able to withstand its effects, so that even though they rub the body afterward they still feel cold and chilly; this is a sign that they are unable to endure cold bathing. Such people should be content to simply sponge off the body with cold water, besides taking a warm bath about once a week for the purpose of cleansing the body. *Never bathe directly after a meal;* wait two or three hours. If you are overheated and perspire freely, it is better to wait until you are somewhat cooled off before you go into cold water. Always *wet the entire head* as well as the rest of the body when bathing.

406. **The Turkish and the Russian Bath.**—Probably all of you have heard of the Turkish bath and the Russian bath. In the *Turkish bath*, the person is kept in a room with very hot air until he perspires freely; he is then scrubbed with soap and water; then he plunges into a cold water bath; next his skin is rubbed and his muscles kneaded by men who are employed for this purpose; this causes the blood to flow faster; then the person rests himself thoroughly before going out into the air. The *Russian bath* is similar, the only difference being that the room is filled with steam instead of with hot air, to make the person perspire freely. These baths are good for grown people, but are not suitable for children.

407. **Clothing.**—Something has already been said about proper clothing in the chapter on "The Heat of the Body," so that little need be added here: We should change underclothing frequently; it is a healthy practice to take off all our underclothing at night and allow it to hang up and be thoroughly aired before putting on again the next morning.

408. **Exercise** helps to keep the skin in good condition, by making us perspire more freely, and in this way keeping the pores open. It also causes the blood to circulate through the skin more rapidly—this gives us the delightful feeling of warmth after exercising.

409. **Cosmetics.**—The use of powders and like substances to the skin is very injurious. These substances, which are called *cosmetics,* stop up the pores and make the skin rough and ugly. Besides, many of them are poisonous, and this poison may get into the blood through the skin and may poison the body. Powdering the face is not done by the better class of people.

410. **Care of the Hair.**—The hair should be combed and brushed every morning. Every few weeks it will be necessary to wash it with soap and water. The oil-tubes of the scalp usually supply enough oily matter to keep the hair glossy; hence the practice of putting *oil or grease* on the hair is not only *very vulgar and nasty* but it is unnecessary. *Crimping* the hair by hot irons destroys the hair and makes it fall out. *Hair-dyes* are injurious; nearly all of them are made of deadly poisons, and these may get into the blood and poison the entire body.

411. **Care of the Nails.**—The nails should be cut with scissors at regular intervals. The finger-nails should not be bitten off. The nails should not be cut too close or else the finger-tips and the ends of the toes will become sore. Many persons have sore toes, especially the big toe, because they do not cut the nail properly; it should be cut straight across and not rounded and short (Fig. 85). *Hangnails* often result from biting the nails or keeping the fingers in the mouth.

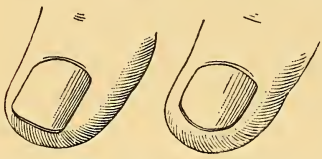


FIG. 85.—Proper and Improper Method of Trimming the Toe-nails. The figure to the left exhibits the proper method—cut off squarely; that to the right the improper method — cut off round and close.

SYNOPSIS.

The Skin:

1. Thickness—Varies in different parts of body.
2. Uses:
   - *a.* Protection.
   - *b.* Organ of sensation or feeling:
     1. Acuteness varies in different parts of body.
     2. Greatest at finger-tips.
     3. May be developed, as in the blind.
     4. Depends on the nerves of sensation, ending in the skin by small knobs.
   - *c.* To throw off water, salts, and poisonous matters from the body.
   - *d.* To regulate the bodily warmth.
3. Structure:
   - *a.* Scarf-skin on the outside.
   - *b.* True skin beneath.
4. Color:
   - *a.* Varies in different parts of body.
   - *b.* Varies in different races.
   - *c.* Depends on the amount of brown coloring matter existing in the true skin.
5. Attachments:
   - *a.* Perspiration-tubes—Openings called pores; necessity for keeping open; perspiration, sensible and insensible; removes matters from body and cools body.
   - *b.* Oil-tubes—Necessity for using soap to remove stale oily matter.
   - *c.* Hair—Root and point; hollow; color varies; should be combed and brushed daily; should be washed every few weeks; no oil or dyes.
   - *d.* Nails—Should be cut regularly, not bitten off; cut across square.
6. Care of Skin:
   - *a.* Cleanliness.
   - *b.* Bathing:
     1. Warm bath and soap for cleanliness.
     2. Cold bath, refreshing.

3. Turkish bath.
4. Russian bath.
5. No bathing directly after meals.
6. No bathing when overheated.
7. Wet head as well as rest of body.

c. Clothing—Necessity for changing underclothes frequently.

d. Exercise.

e. Cosmetics—To be avoided.

QUESTIONS.

1. Name the special senses. 2. Is the skin of the same thickness throughout the body? 3. At what points is it the thickest? 4. What are the uses of the skin? 5. Is it necessary to life? 6. How is this proven? 7. Of what service is pain? 8. Of what use are the nerves of feeling? 9. What parts of the body are intended especially for feeling? 10. What is peculiar of the touch of the blind? 11. What is discharged from the body by means of the skin? 12. What effect has the skin upon the bodily warmth? 13. Is the color of the skin always the same? 14. Upon what does the color of the skin in the negro depend? 15. Of how many layers is the skin formed? 16. What are these layers called? 17. Of what is the scarf-skin formed? 18. What becomes of the scales which form the scarf-skin? 19. What is "dandruff?" 20. Describe the true skin. 21. How do the two layers of the skin become separated in slight burns? 22. Describe the perspiration-tubes. 23. What are the pores? 24. What is "insensible" perspiration? 25. What is "sensible" perspiration? 26. What are the uses of perspiration? 27. What does the perspiration remove from the body? 28. About how much perspiration leaves the body every day? 29. How does perspiration cool off the body? 30. What appearance does the skin of the finger-tips present? 31. What other tubes are there besides the perspiration-tubes? 32. Of what use is the matter which the oil-tubes produce? 33. What happens when the oil-tubes get stopped up? 34. Why does the skin of the nose and forehead sometimes have a greasy look? 35. Describe a hair. 36. How is hair attached to the skin? 37. Of what use are the nails? 38. Why is cleanliness so very important? 39. Of what is dirt a sign in regard to civilization?

40. What effect upon the health has filth? 41. Why is filth so bad for the health? 42. How often should the entire body be washed? 43. Why should the entire body be washed frequently with soap and warm water? 44. What are the effects of a cold bath? 45. What should we do to make the circulation more brisk after a cold bath? 46. What is the sign that you have been in a cold bath long enough? 47. Is it well to bathe directly after a meal? 48. What other precautions should you take when bathing? 49. Explain the Turkish and the Russian bath. 50. Should we wear the same underclothing at night that we have worn during the day? 51. How does exercise affect the skin? 52. What are "cosmetics?" 53. What effect have they upon the skin? 54. What should be done to the hair? 55. What can you say about the practice of putting oil or grease upon the hair? 56. What are most hair-dyes made of? 57. How should the nails be cut?

THE NOSE—THE SENSE OF SMELL.

412. **Functions.**—The nose is the organ with which we *smell.* It is also the part through which the *air* is drawn. The

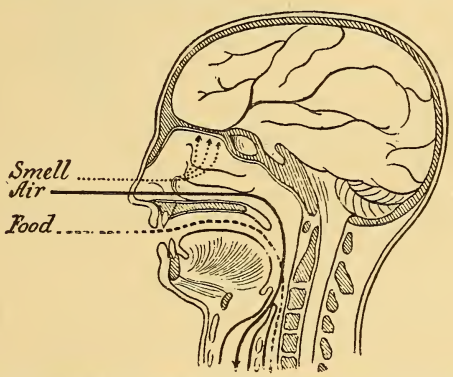


FIG. 86.—Diagram Exhibiting the Channels by which Smell, Air and Food Reach the Interior of the Body.

lower part of the nose represents a passage for breathing, the upper portion is the part devoted to the sense of smell (Fig. 86).

413. **The Breathing Channel and the Smelling Channel.**—When we breathe we draw the air *backward* through the lower part of the nose; this part of the nose runs horizontally backward, and behind joins the throat; so that if a fluid is poured into the nose it will run into the throat. When we smell, we draw the air *upward*, because we want the odor to ascend to where the nerves of smell are.

414. **Parts of the Nose.**—The nose is formed of bones and of gristle. The hard part on the outside, where you usually see people wearing their eye-glasses, is formed of two small bones and is called the *bridge* of the nose. In looking into the nose we find that it is divided into two halves. The openings in front are called the *nostrils*. In the interior of the nose, on each side, are found three shelves of bone covered by a soft membrane; beneath each shelf is a passage-way which runs from the front to the back of the nose.

415. **The Nerves of Smell.**—In the membrane which covers the two upper shelves just described, are found numerous nerves; they are the *nerves of smell*. By consulting Fig. 87, it will be seen that the brain lies immediately above the nose. These nerves of smell come in bunches from the brain, and descend into the nose. Although we are in the habit of saying that we smell with the nose, it would be more correct, strictly speaking, to say that we smell with the front part of the brain. The nerves of smell merely serve to carry the odors to the brain. This is proven by the fact that there is a loss of the sense of smell if the front part of the brain be injured or diseased; there is now no longer any smell, even though the nerves of smell may still be present.

416. **The Sense of Smell in the Lower Animals.**—Many of the lower animals have a much more acute sense of smell than man. Dogs and cats, for instance, can smell the faintest odors at great distances. In hunting-dogs the sense of smell is extraordinarily acute; they can smell game miles away and in this way are valuable in hunting; this is spoken

of as "scenting the game." Before the civil war, bloodhounds were employed to track runaway slaves, and they were able to do this, owing to the acuteness of their sense of smell, when the fugitives were many miles in the lead.

417. **Cold in the Head.**—Nearly everyone has caught cold at some time or other. When we catch cold it may settle in any part of the body; it may attack the lungs, or the stomach, or some other organ. When the cold settles in our head we

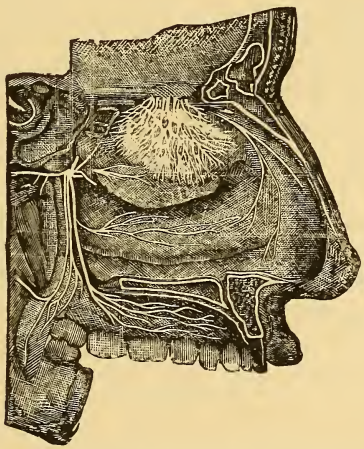


FIG. 87.—View of the Interior of the Nose, showing the Nerves of Smell Descending into the Nose from the Brain, in the Form of a Bunch.

usually feel it principally in the nose and throat; we often get a sore throat and our nose feels stopped up so that we cannot smell, and we cannot breathe through it; it feels this way because there is too much blood in it.

418. Cold in the head is most often due to sitting or standing in the draught, or to going suddenly into the cool air when we are overheated, without putting on some additional clothing. Very often we know that we have been imprudent in this way and can feel the cold coming on, and then a mustard foot-bath may prevent it.

419. **Use of the Sense of Smell.**—With the sense of smell we are able to enjoy agreeable odors. But what is important is, that we are also able to smell bad odors; this protects the body by informing us of the whereabouts of obnoxious things that should be avoided, and especially of impure air. It enables us to select the proper food, and to refuse that which is unfit to eat. It often protects our bodies and homes by enabling us to smell smoke and in this way to discover the existence of a fire.

420. **Sweet Scents.**—To smell the sweet odors which flowers give off, is very agreeable. Odors are given off by the oils existing in the flowers of plants; these oils are extracted from the flowers and this is then called *perfume*. Many persons use this perfume to put upon their handkerchiefs and clothes so that they shall smell sweet; but the nicest kind of people do not use perfumes as a rule. If you always keep the body clean and brush your teeth often you will not need any perfume; for if the body is clean, it always smells sweet. Soap and water are better than perfume to tidy people.

SYNOPSIS.

The Nose:

1. Parts:
   - (1.) Two bones forming "bridge."
   - (2.) Gristle.
   - (3.) Three shelves running from front to rear.
   - (4.) Shelves covered by soft membrane.
   - (5.) Membrane of upper two shelves supplied with
   - (6.) Nerves of smell which descend in a bunch from brain.
2. Function:
   - (1.) Lower passage for air.
   - (2.) Upper part for sense of smell.
     - *a.* Great acuteness in some of lower animals.
     - *b.* Blunted in cold in head.
     - *c.* Use—To protect us from impure air and improper food.

QUESTIONS.

1. What are the uses of the nose? 2. Which part of the nose serves for breathing? 3. Which part is used for smelling? 4. Of what is the nose formed? 5. Where is the bridge of the nose? 6. What are the nostrils? 7. What do we find in the inside of the nose? 8. Where are the nerves of smell? 9. Where do they come from? 10. How is the nose connected with the throat? 11. Where do we find the more acute sense of smell, in man or in the lower animals? 12. Give an example. 13. What is meant by a "cold in the head?" 14. What is this often caused by? 15. What are the uses of the sense of smell? 16. What parts of plants usually give off the sweet scents? 17. What can you say about the habit of using perfume upon the handkerchief or clothing.

THE TONGUE AND THE SENSE OF TASTE.

The tongue is the organ with which we taste our food.

421. **Structure of the Tongue.**—This organ consists almost entirely of *muscle* tissue. Its under surface is smooth. Its upper surface is very rough. This roughness is due to a large number of small projections. These can be seen better in the tongues of the lower animals than in man, and serve two purposes: First, they are the parts which give us taste; the nerves of taste end in rounded extremities in these elevations. The other use is to feel the food in our mouth and to discover whether it is chewed sufficiently fine, and is mixed enough with the saliva, before it is swallowed. The lower animals, such as dogs and cats, are enabled to scrape off bones by means of these projections.

422. **Uses of the Tongue.**—The tongue's functions are: (1) as the organ of taste; (2) to revolve the food in the mouth, to mix it with the saliva, and to assist in swallowing; and (3) in speaking. The importance of the sense of taste need not be

pointed out especially; it enables us to choose our food and to avoid that which is unfit to eat; it prevents us from eating improper food; it increases the appetite and makes us enjoy our meals when the food is to our liking. Besides turning the food about in the mouth and mixing it with saliva, the tongue

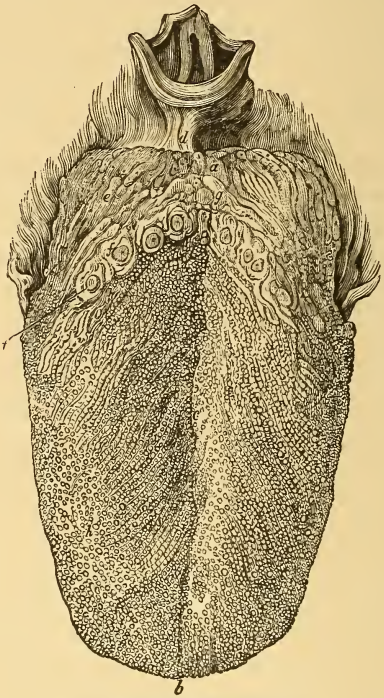


FIG. 88.—The Human Tongue.

separates hard portions of the food, such as seeds and shells, and it also assists in swallowing. Finally, the tongue assists in speaking.

423. **Abuse of the Sense of Taste.**—The sense of taste adds a great deal to our enjoyment; it is necessary, however, to prevent it from enjoying too many liberties, otherwise we

will be eating too much, become gluttons, and suffer in health. In selecting our meals, we are guided by what is wholesome, nourishing, and digestible.

SYNOPSIS.

The Tongue.

Structure—

1. Formed of muscle-tissue.
2. Smooth on under surface.
3. Rough on upper surface, due to
4. Small projections which serve to
   a. Feel food to see if properly chewed.
   b. Taste with, since nerves of taste end here.

Uses—

1. Organ of taste.
2. To revolve food in mouth, mix it with saliva, remove hard portions, and assist in swallowing.
3. To assist in speaking.

QUESTIONS.

1. Describe the tongue. 2. Of what kind of tissue is it made up? 3. Which surface is rough? 4. What is this roughness due to? 5. Of what use are these small elevations? 6. What are the uses of the tongue? 7. What are the uses of the sense of taste? 8. How might we abuse the sense of taste?

THE EYE AND THE SENSE OF SIGHT.

424. **Protections to the Eye.**—The eye is one of the most delicate organs in the body. It is placed in the large opening in the skull found just below the forehead, on each side of the nose, called the orbit. This affords it considerable protection. Besides this, it is also protected by the eyebrows, eyelids, and eyelashes. In the orbit the eye rests upon a soft cushion of fat.

425. **The Eyelids.**—These serve to protect the eyes by their quick movement in closing, thus keeping out dust. They keep out the light when too strong, or during sleep.

426. **The Eyebrows and Eyelashes.**—These keep the perspiration from rolling into the eyes, and keep out dust. They should never be cut, for this will not cause them to grow any longer and spoils them by making them thick and stiff.

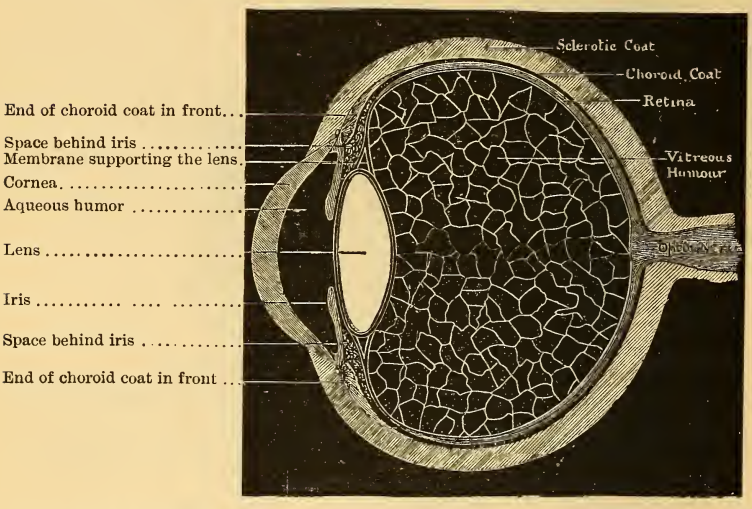


FIG. 89.—The Human Eye (Cut Across and Enlarged), Showing Its Different Parts and the Interior.

427. **Parts of the Eye.**—The eye is spherical in shape, measuring about an inch in diameter. Its front portion is perfectly transparent, and is called the *cornea.* But behind the cornea, which forms about one-fifth of the circumference of the eyeball, it is opaque and white, and can be separated into three layers, or *coats.* The outermost layer is hard and strong, and it preserves the form of the eyeball; it is called the *white* of the eye, or the *sclerotic coat.* The middle layer is dark-colored, and is called the *choroid coat.* The inner layer is called the

retina. It is of great importance, because the nerve of the eye sends its branches to it, and it is the portion of the eye with which we see (Fig. 89).

428. Looking into the eye, we see in the centre a black spot which is called the *pupil;* it is a round opening in a membrane which acts as a partition to this part of the eye. This membrane is a colored ring which surrounds the pupil and is really a curtain hanging behind the clear part of the eye ; it is called the *iris.*

429. Behind this curtain, the iris, is a round transparent body, about the size of a cherry-pit, which is called the *lens.* It is perfectly clear and its shape is like that of a small magnifying-glass ; but it is softer—like a hard jelly. It is supported behind the iris, just where the transparent part of the eye joins the opaque portion, by a delicate membrane, and is flattened somewhat in front and behind.

430. The *interior of the eye* is filled with *fluid.* Just behind the cornea, extending to the lens, is a space which is filled with a *watery fluid* called the *aqueous humor.* The rest of the eye-ball (behind the lens) is filled with a clear substance like white jelly, called the *glassy body* or *vitreous humor.*

431. **The Iris.**—It has just been explained that this is a sort of curtain placed in front of the lens of the eye. There is a round opening in the centre, by which light is admitted to the eye ; this is the *pupil.* The pupil *changes its size* very often. When we look at anything in the distance the pupil becomes large ; when we look at objects close by it becomes very small. The pupil also regulates the amount of light which should enter the eye. In going into a bright light, as for instance into the sun, the pupil becomes very small ; if it did not do so the light would be too bright and would injure the eye. It is very dangerous to the eye to try to look at the sun. In the twilight, when the light is dim, you will notice that the pupil becomes very large.

432. **The Muscles of the Eye.**—It is wonderful how rapidly the eyes move ; this is necessary to protect the body. The rapid motion of the eyes is also necessary so that they can act together. If you were to press upon one eye so that it could not move, and then were to move the other, everything would look double ; so that the two eyes must move together if we want to see singly and plainly. There are six small muscles (Fig. 90) attached to each eye, which make its movements so rapid. Sometimes one of these muscles does not act as well as it should ; then the eye turns in all the time

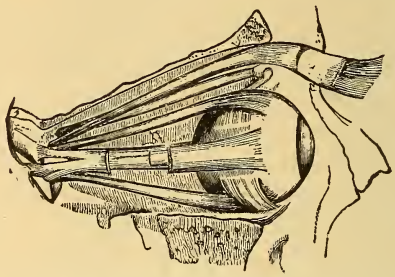


Fig. 90.—The Muscles Attached to the Eyeball and to the Upper Lid.

or constantly looks outward ; the person then is *cross-eyed* or *squints*. Some children are born this way and it is not right to make fun of them. Sometimes children turn their eyes so as to imitate cross-eyed persons ; this habit is very injurious.

433. **How We See.**—It may seem strange to say that we really *see with the brain*, but such is the case. Of course the eyes are necessary, and without them we would be blind ; but the brain is also necessary for sight. If a certain part of the brain be injured we cannot see, even though our eyes remain as clear and bright as they were before.

434. **Resemblance of the Eye to a Photographer's Camera.**—The eye resembles the box which the photographer uses to take pictures, and which is called a *camera*. Let us see how it resembles the photographer's camera : In the first place

the photographer cannot take a picture in the dark, nor can we see in the dark. Secondly, in the front of the camera there is a lens of glass; we also have a lens, though it is of course not of glass, but of a better and softer material. Again, in the back of the photographer's camera is a glass plate, upon which the picture falls and is taken; in the same way in our eyes the retina serves as a plate upon which to take the picture. Anything which we see forms an image upon the retina. This image only lasts a short time; but long enough for us to see it. Finally, you have probably noticed how the photographer puts a black cloth over his head and the back of the camera so as to keep it dark; the middle, colored coat of the eye—the choroid—serves to darken the inside of the eye.

435. **The Nerve of the Eye.**—Connected with the back of the eye is a portion resembling a cord, which passes to the brain; this is the *optic nerve* or nerve of the eye. It is the nerve which connects the eye with the portion of the brain used in seeing. On arriving at the eye the nerve spreads out in the interior of this organ and forms the innermost layer, which is called the *retina*. By looking into the interior of the eye with an instrument, the oculist can see this layer. It is shown in Fig. 91; the central spot is where the nerve enters the eye; at this point blood-vessels also enter the eye and then divide and spread out in a very pretty manner.

436. **Blindness.**—If the optic nerves of both sides become diseased, or both retinæ become changed, the person may become totally blind, even though the eye appears perfectly healthy on the outside. These nerves carry the sight from the eye to the brain, with which seeing is really done.

437. **Images.**—The word image has been used and will require some explanation. If you look into a mirror you will see your face—this is an image of your face. The light strikes your face and from it passes to the mirror; there it forms an image; from this image the light passes into the eye and forms another image upon the retina, which we see.

438. **The Tears.**—The eye is constantly kept moist by being bathed with the tears. At the outer part of each eye, be-

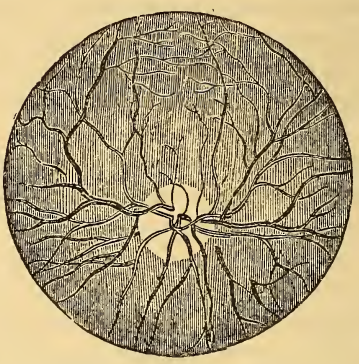


FIG. 91.—A View of the Interior of the Eye, as Seen with the Oculist's Instrument.

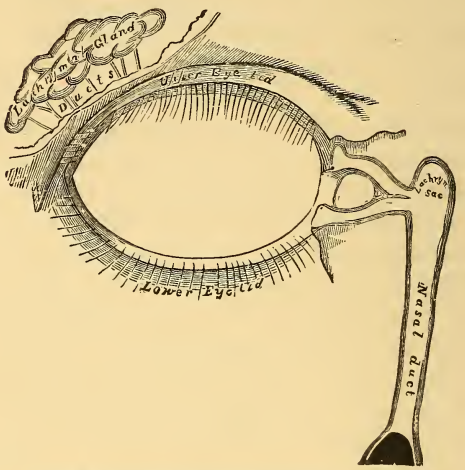


FIG. 92.—The Lachrymal Gland, Sac, and Duct.

tween it and the bone forming the roof of the orbit, is a small body called the *lachrymal gland* (Fig. 92), meaning *tear-gland;* this body is constantly pouring the tears over the eye so as to

keep it moist ; even during sleep this takes place, though there is then much less produced. When we are awake the eye is moving constantly and this spreads the tears over the eyeballs. After the tears have moistened the eye, they are collected again and escape into the nose. If you look at your lids you will notice near the inner corner of the eye, a small spot about the size of a pin's point ; there is one of these on the lower lid and one on the upper ; the tears pass into these openings and then into a small bag near the nose, called the *tear-sac ;* then they are carried down into the nose by a tube called the *tear-duct* or *nasal duct* (Fig. 92). You have noticed how the nose runs after crying ; this is because there is so much more of this fluid discharged into the *tear-duct.* If anything gets into the eye, the lachrymal gland produces more of the tears and they flood this organ until the intruding body is swept away. If we become very sad or very angry, tears become very abundant.

439. **Care of the Eyes.**—There is no organ in the body which contributes so much to our comfort, our enjoyment, and our knowledge, as does the eye. And yet the eye is constantly being misused. If you have good eyesight you should take care of your eyes so that it does not get bad ; if your eyesight has already become bad you should see that it does not get any worse. Some of the most common rules for the care of the eyesight are the following :

440. After having read a long time, it is well to stop and *rest the eyes ;* the eyes, like any other part of the body, cannot be used continuously. It is quite natural that the eyes should feel tired and begin to pain after we have used them a long time ; this is nature's sign that they need rest.

441. Never read in a *poor light.* You may be finishing a chapter in your book and you notice that it is beginning to get dark ; yet you do not stop until you get to the end of the chapter even though you strain your eyes. This is wrong and the eyes suffer for it.

442. Never read *very fine print* if you can help it.

443. In reading, have the *light come over your shoulder* and thus fall upon the book or paper without going directly into your eyes. It is better to sit with your back to the window and thus have the light come over your shoulder. This precaution is especially useful at night, for the glare of the gas-light or lamp is very tiring to the eyes ; while if the light is behind you and falls over your shoulder there is just as much light upon your book or paper and yet the eyes are spared the brightness.

444. *Never read while lying upon the back.* You cannot read comfortably in this position and you have to strain the eyes so that it is very tiring. If for any reason you must read lying down, do so with the shoulders and head raised into a half-sitting position.

445. There may be some excuse for business men *reading in the cars,* for often this may be the only time they have to read the daily papers. But there is no reason why children should do this. It is injurious, in the first place, because the light is usually poor, but chiefly, because the constant jolting of the car makes the page unsteady and requires a constant strain upon the eyes to keep the place.

446. *Never use the water which another person has used to wash their face in for a similar purpose.* Never use a *towel* for wiping your face, which another person has had to his face, unless this person is one of your family and you know he has no eye disease. There is a disease of the eyelids which is called *granular lids* which is very contagious ; many children contract it in school by using the towel which another child who had the disease, has used.

447. *Do not stoop when you read,* but raise the book so that you can hold the head erect.

448. **Weak Sight.**—Some persons are born with weak eyes —that is, they do not see as well as other people and have to wear glasses. Some of these people are called *near-sighted,* others are called *far-sighted.* If the doctor advises you to wear

glasses you should not be ashamed to do so. Only vain persons object to wearing glasses, when they are necessary.

449. **Old Sight.**—After persons get about forty years old they can still see well in looking at things far away; but they need glasses for looking at near objects.

SYNOPSIS.

The Eye:

1. Protections:
   - *a.* Surrounded by bony "orbit."
   - *b.* Rests on cushion of fat.
   - *c.* Eyebrows—Keep off perspiration.
   - *d.* Eyelids. } Keep out dirt, light, and perspiration.
   - *e.* Eyelashes. }
2. Parts:
   - *a.* Coats:
     1. Opaque part behind.
        - *a.* Sclerotic—Outer, white, dense.
        - *b.* Choroid—Middle, colored, brown.
        - *c.* Retina—Inner, composed of nerve-tissue.
     2. Transparent part in front—Cornea.
   - *b.* Iris—Curtain to keep out light; in centre is
   - *c.* Pupil—Size changes.
   - *d.* Lens.
   - *e.* Fluids:
     1. Aqueous humor.
     2. Vitreous humor.
   - *f.* Muscles—Six small ones attached to eye, to move it in all directions.
   - *g.* Nerve—Attached behind and passing to brain, with which we really see.
   - *h.* Lachrymal duct—Near the eye, gives off the tears, which keep the eyeball moist, collected by tear-sac and escape by tear-duct into nose.

Care of the Eye:

1. Requires rest when used for long time.
2. Good light in reading.
3. Injurious to read very fine print.

4. Light should come from behind—over shoulder.

5. Not well to read while lying down.

6. Not well to read while riding in cars.

7. Risk of contracting eye disease in using towels or water that other people have used, to eyes.

8. In reading, sit erect.

9. Weak sight requires glasses.

10. Old sight (after forty) requires glasses.

QUESTIONS.

1. In what are the eyes placed? 2. How are the eyes protected? 3. What do the eyelids do? 4. Of what use are the eyebrows and eyelashes? 5. Why should we not cut the eyelashes or the eyebrows? 6. What is the shape of the eye? 7. What is the cornea? 8. How many layers has the back part of the eye? 9. What is the back part called? 10. Which is the most important of these three layers? 11. What is the pupil? 12. What is the iris? 13. What is the lens? 14. With what is the interior of the eye filled? 15. What two fluids do we have in the eye? 16. Is the pupil always of the same size? 17. When does it become large? 18. When does it become small? 19. Of what use is the pupil? 20. How many muscles are there to each eye? 21. Of what use are these muscles? 22. What is the cause of cross-eyes? 23. With what part of the body do we really see, the eye or the brain? 24. How is this proven? 25. What instrument may our eye be compared with? 26. Explain in what ways our eye resembles the photographer's box? 27. Where is the nerve of the eye? 28. What does it do? 29. What do we mean by an image? 30. How is the eye kept moist? 31. Where is the body which produces the tears? 32. What is it called? 33. How are the tears collected again? 34. What becomes of them? 35. Where is the tear-sac? 36. Where is the tear-duct? 37. What causes the tears to flow more than usual? 38. Why should we stop after we have read a long time? 39. What does a tired feeling or pain in the eye after reading mean? 40. What sort of light should be avoided? 41. Where should the light come from when you read? 42. Should it come from the front? 43. Why not? 44. Can a person read lying down, without injury to his eyes? 45. Why not? 46. Why should we not read on the

cars? 47. Why should we not use towels that other persons have used to their faces? 48. What disease of the eyelids may be contracted in this way? 49. What position should you take when you read? 50. What is meant by weak sight? 51. After what age do people need glasses for reading?

THE EAR—THE SENSE OF HEARING.

450. Like the eye, the ear is an organ which adds very much to our comfort, pleasure, and knowledge.

451. **Parts of the Ear.**—The ear is divided into three parts: An outer, a middle, and an inner.

452. **The Outer Ear** is the portion which you see at the side of the head. It is expanded and formed of gristle, covered with skin. Its shape is not only ornamental, but useful, for it serves to collect the sound and lead it into the deeper parts of the ear. As a rule, we cannot move the ears; but in the lower animals, the ear can be moved in all directions and in this way these animals tell where the sound comes from. From this outer part of the ear there is a *canal* about an inch long which leads to the next part of the ear, the *middle ear*. In this canal is usually found a little yellowish substance, which we call *ear-wax;* this serves to keep the canal soft and moist and to keep out insects, for the latter dislike this wax.

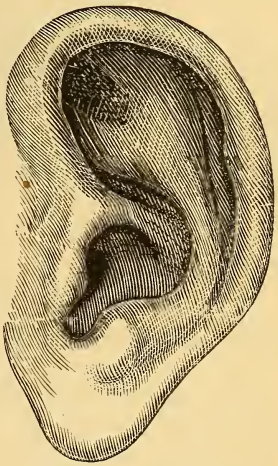


FIG. 93.—The Outer Ear.

453. **The Middle Ear.**—The middle part of the ear contains the so-called *drum;* it is only about half an inch across.

It is at the bottom of the canal which leads from the outer ear. Between the two a sheet of membrane is stretched which is called the *drum-membrane.* In the middle ear itself there is nothing but three small *bones* which are joined one to the other so as to form a small chain. One end of this chain is fastened to the drum-membrane and the other to the inner ear, so that these bones connect the outer ear with the inner ear.

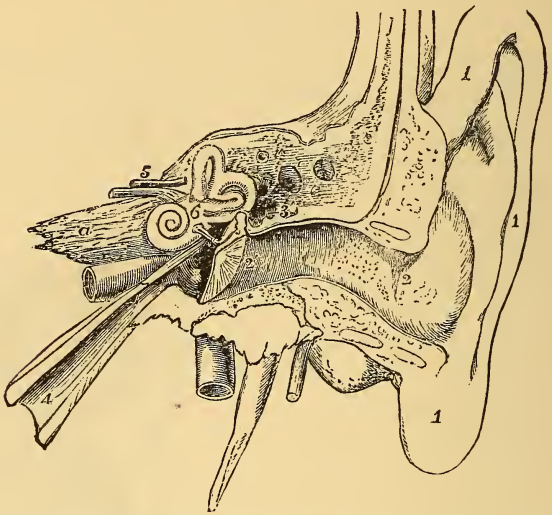


FIG. 94.—The Different Parts of the Organ of Hearing. 1, The outer ear; 2, the canal leading from the outer to the middle ear; 3, temporal bone; 4, Eustachian tube; 5, nerve of hearing; 6, the internal ear.

454. **Bones of the Ear.**—These bones are shown in Fig. 95; they are very interesting. They are named, according to their shape, the hammer, the anvil, and the stirrup.

455. **Connection Between the Ear and the Throat.**—Perhaps you may have noticed that sometimes when you blew your nose hard there was a stuffed feeling in the ears; or that when your throat was sore your ears were also affected. Sometimes, too, when you swallow you feel something in your

ear. This is because there is a tube which runs from the throat to the middle ear. It is very important that this tube remain open, for otherwise air cannot enter the middle ear as it should and we do not hear well. This tube is called the *Eustachian tube,* after the physician who first described it.

456. **The Internal Ear.**—This part of the ear is placed very deeply in the bone. There are several circular passage-ways and a winding passage like a staircase hollowed out of the bone, and in these the inner ear is contained. In these circular canals we find a delicate membrane and a fluid on

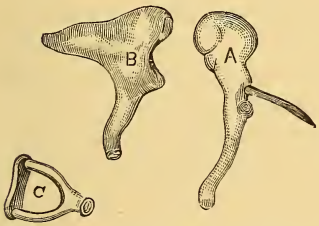


FIG. 95.—The Small Bones of the Ear. A, The hammer; B, the anvil; C, the stirrup.

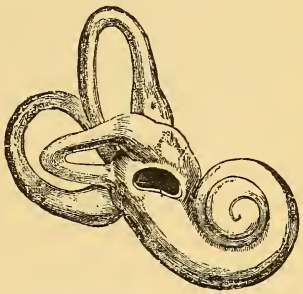


FIG. 96.—The Internal Ear.

each side of it. The arrangements in the internal ear are very intricate.

457. **The Nerve of Hearing.**—The nerve of hearing is attached to the internal ear and from this part it passes to the brain; it therefore conducts the sound to the brain just as the optic nerve conducts sight to the brain.

458. **Sound.**—Before studying how we hear, it is necessary to understand how sound is produced. Sound is produced whenever the air is made to vibrate—that is, whenever the air is put into motion resembling waves. You will understand this better if you think for a moment of the water: suppose when a pond is quiet, you throw in a stone; this causes a mo-

tion in the water and you will then see rings start out from the point where the stone fell, these rings becoming larger and larger until they are finally lost; but all the time these rings or very small waves have been going farther and farther from the centre. Now imagine the same thing occurring in the air. If you strike a bell, for instance, you know that the bell is vibrating, because if you put your finger on it you can feel this motion. This motion is given to the air, and the air vibrates in the same way, except that the vibrations travel through the air to our ear.

459. Solids conduct sound even better than air does; if you place your ear at one end of the table and strike the other end the sound which you hear will be very loud.

460. **How We Hear.**—Now that we know what sound is, let us study how we hear. The waves of sound pass through the air and reach the *outer ear;* this is shaped so as to collect them and lead them into the canal to the *drum-membrane.* The waves of sound beat against this membrane and cause it to vibrate; when this membrane vibrates, the *bones of the middle ear* must also move to and fro, because they are attached to it. The bones of the middle ear carry the vibrations to the *internal ear,* where the nerve of hearing ends in a large number of fine hairs, and these carry the sound to the *brain.*

461. **Deaf-Mutes.**—Persons who cannot hear when they are children, and therefore cannot imitate sounds from other people, are called *deaf-mutes.* These unfortunate people have voices just like others; but they cannot hear the sounds, and therefore they cannot speak in the ordinary way. But they can make themselves understood in two ways: One way is by means of signs and letters which they make with their *fingers;* they learn to do this very rapidly. The second method, and the newest, is to teach the deaf-mutes to talk by having them imitate the motion of our *lips.* It is surprising how well they learn to do this; some of them are able to carry on a conversa-

tion and yet not hear what is spoken, but understanding it by watching the movement of the lips.

462. **Care of the Ears.**—We should never try to pick out the wax in the ears with hairpins and other sharp instruments. A little wax is quite natural, and if too much is there it is best to let the doctor remove it, for we may injure the delicate parts of the ear.

463. If *water* gets into the ear during bathing, hold the head over to one side and pull the outer ear up and down gently, and it will flow out.

464. If an *insect* should crawl into the ear, a little soap and water will kill it, and at the same time bring it out.

465. A *blow* upon the side of the head or over the ear is dangerous, because it sometimes affects the brain ; it may also tear the delicate drum-membrane and thus interfere with good hearing.

466. The ears do not need to be washed out when they are healthy ; simply wash the outer ear and do not meddle with any of the deeper parts.

SYNOPSIS.

The Ear :

Parts :

1. Outer ear—Collects sound.
2. Canal leading from outer to middle ear.
3. Middle ear :
   - *a.* Drum-membrane.
   - *b.* Bones: (1) Hammer, (2) anvil, (3) stirrup.
4. Internal ear—Nerve of hearing ends here in fine hairs, and conveys sound to brain.
5. Eustachian tube—Leading from throat to middle ear.

How we Hear :

1. Vibration of sounding body.
2. Vibration of air.
3. Strikes against drum-membrane.

4. Vibrations conducted by chain of bones to
5. Internal ear, where they strike the hair-like ends of
6. The nerve of hearing, which conducts sound to
7. Brain.

QUESTIONS.

1. Into what three parts can the ear be divided? 2. Why is the external ear shaped as it is? 3. Can the lower animals move their ears? 4. Of what use is this to them? 5. What leads from the outer ear down to the middle ear? 6. What is ear-wax? 7. What are its uses? 8. What is another name for the middle ear? 9. Where is the drum-membrane? 10. What is in the middle ear? 11. How are the bones of the middle ear arranged? 12. What are the names given to the bones of the middle ear? 13. What connects the throat with the middle ear? 14. Where is the internal ear? 15. What is its form? 16. What is in the internal ear? 17. Where is the nerve of hearing? 18. What does it do? 19. How is sound produced? 20. What conducts the sound? 21. Can solids conduct sound? 22. How can you prove this? 23. Explain how we hear? 24. What is meant by a deaf-mute? 25. Has a deaf-mute any voice? 26. Why cannot he talk without special teaching? 27. How do deaf-mutes make themselves understood? 28. Why should we not try to pick out the wax in our ears? 29. How would you get rid of any insect that crawled into the ear? 30. Why is a blow upon the side of the head or over the ear dangerous?

GLOSSARY.

AB-DO'MEN (Latin, *abdere*, to hide). The large cavity of the lower part of the trunk, below the diaphragm, in which the liver and the stomach, intestines, and other digestive organs are placed; the belly.

AB-SORP'TION (Latin, *ab*, and *sorbere*, to suck up). The process of sucking up fluids by means of the blood-vessels or lymphatics.

AD'AM'S AP'PLE. The prominent angle of the larynx which can be seen and felt in the front of the neck. It is said to have been thus named from an old belief that the apple stuck in Adam's throat, thus causing this projection.

AL'CO-HOL (Arabic, *al kohl*, a powder to paint the eyebrows with). A colorless fluid, resembling water in appearance, which forms the intoxicating portion of beer, wine, and spirits.

ALI-MENT'A-RY CA-NAL (Latin, *alere*, to feed). The series of hollow organs in which the food is digested, or prepared for absorption by the blood. It comprises the mouth, pharynx, œsophagus, stomach, and intestines.

A-NAT'O-MY (Greek, *ana*, up, and *temnein*, to cut). The study of the form and structure of the different parts of the body.

A-OR'TA (Greek, *aeirein*, to lift up). The large artery which arises from the left ventricle of the heart and passes down along the backbone, giving off branches in its course.

AP'O-PLEXY (Greek, *apo*, away, and *plessein*, to strike). A sudden loss of consciousness, due to the bursting of a blood-vessel in the brain.

A'QUE-OUS (Latin, *aqua*, water). Watery.

A'QUE-OUS HU'MOR (Latin, *humere*, to be moist). The few drops of watery fluid which fill the space between the cornea and the lens of the eyeball.

AR'TER-Y (Greek, *aer*, air, and *terein*, to contain). A blood-vessel which conducts blood from the heart to the various tissues. The ancients believed that the arteries were filled with air; hence the name.

Au'ri-cle (Latin, *auris*, the ear; *auricula*, a small ear). The upper cavity of the heart on each side; so named from its fancied resemblance to a dog's ear.

Bi'-ceps (Latin, *bis*, twice, and *caput*, head). A large and strong muscle on the front of the arm, serving to bend the forearm upon the arm; so called because it is attached to the bone by two portions called heads.

Bi-cus'pid (Latin, *bis*, twice, and *cuspis*, point). The name given to the fourth and fifth teeth on each side, on account of their possessing two elevations upon the crown.

Bile (Latin, *bilis*, anger, bile). The gall; the peculiar, yellowish or greenish fluid, bitter to the taste, formed in the liver, and emptied into the commencement of the small intestine.

Bow'-el (Latin, *botellus*, a small sausage). The intestine; the long hollow tube into which the partly-digested food passes from the stomach.

Bron'chus / Bron'chi (plural) (Greek, *brogchos*, windpipe). The first two divisions of the windpipe, one passing to each lung.

Bron'chi-al. Relating to the bronchi; *bronchial tubes*, the smaller branches of the bronchi in the substance of the lung.

Bun'ion. An enlargement and soreness of the great toe at the joint connecting it with the body of the foot.

Ca-nine' (Latin, *canis*, dog). The sharp, pointed tooth on each side of the incisors; so-called because they are very prominent in the dog.

Cap'il-la-ries (Latin, *capillus*, hair). The smallest blood-vessels, connecting the arteries and veins; so called on account of their minute, "hair-like" size.

Cap'su-lar (Latin, *capsula*, a small box). A name used to qualify certain ligaments which surround joints "like a box."

Car-bon'ic Acid Gas (Latin, *carbo*, coal). The gas which is present in the air breathed out by animals; it represents waste in animals, but serves as food for plants.

Car-niv'o-rous (Latin, *carnis*, flesh, and *vorare*, to devour). Subsisting largely or entirely on flesh.

Car'pus (Greek, *carpos*, the wrist). The collection of small bones, eight in number, forming the wrist.

Car'ti-lage (Latin, *cartilago*, gristle). A solid elastic substance found in joints, in the nose and elsewhere; gristle.

CELL (Latin, *cella*, a store-room). A small body, often rounded, forming one of the simplest parts of which the body is built up; cells and fibres make up the greater part of the body.

CER'E-BEL'LUM (Latin, diminutive of *cerebrum*, the brain). The little brain, placed beneath the back part of the rest of the brain.

CER'E-BRUM (Latin). The larger portion (seven-eighths) of the brain.

CHEST (Latin, *cista*, a box). The upper cavity of the trunk inclosed by the breast-bone, ribs, and spinal column, and containing the heart and lungs.

CHLO'RAL (Greek, *chloros*, pale green). A drug used to produce sleep.

CHO'ROID (Greek, *chorion*, a membrane). The middle coat of the eyeball.

CIR-CU-LA'TION (Latin, *circulus*, a ring). The course of the blood through the heart and blood-vessels of the body; from heart to arteries, through capillaries to veins, back to heart.

CLAV'I-CLE (Latin, *clavicula*, a little key, from *clavis*, key). The long, slender bone extending across the upper part of the front of the chest; the collar-bone.

CLOT. The dark-red, semi-solid mass which results when blood is withdrawn from the blood-vessels.

CO'CA-INE (Spanish, *coca*, a Peruvian plant). A drug used to make certain parts insensitive to pain.

COM-BUS'TION (Latin, *comburere*, to burn). A burning-up; applied to the process taking place in the body by which the tissues are consumed, to be replaced by elements in the blood.

CORN (Latin, *cornu*, a horn). A small elevation due to thickening of the outer layer of the skin; corns usually appear upon the toes and are caused by pressure from shoes which do not fit properly or are too tight.

COR'NE-A (Latin, *cornu*, a horn). The transparent membrane which forms the front of the eyeball.

COR'O-NAL (Latin, *corona*, crown). A name given to the suture which unites the frontal with the parietal bones, because the crown of a king rests in part upon this line.

COR'PUS-CLES, BLOOD (Latin, *corpus*, a body; *corpusculum*, a small body). The small bodies, some red, some white, found floating in the fluid part of the blood.

COS-MET'IC (Greek, *kosmos*, ornament). Preparations which when applied to the skin are supposed to increase its beauty.

CRA'NI-UM (Latin). That portion of the skull which incloses the brain.

CROWN (Latin, *corona*, a crown). The top of the skull.

Crys'tal-line (Latin, *crystallum*, a crystal). Like glass; applied to the lens in the interior of the eye on account of its transparent properties.

Dan'druff. The small scales, corresponding to the outer layer of the skin, which fall off the scalp.

Deaf'-mute. A person who is deaf and dumb.

De-lir'i-um (Latin, *delirare*, to wander in mind). A condition in which the ideas of a person are wild and wandering.

De-lir'i-um Tre'mens (Latin, *tremere*, to tremble). The condition of being out of the mind which results from over-indulgence in alcoholic drink.

Den'tine (Latin, *dens*, a tooth). The hard material which forms the main part of the tooth between the pulp within and the enamel on the surface.

Di'a-phragm (Greek, *diaphrassein*, to divide by a partition). The sheet of muscular tissue which separates the chest from the abdomen.

Di-gest' (Latin, *digerere*, to separate). To separate the food into nutritious juices which can be absorbed by the system and matters which are cast off.

Dislo-ca'tion (Latin, *dislocare*, to put out of place). The separation, by accident, of the ends of bones forming a joint.

Drum Mem'brane. The small sheet of tissue which separates the outer from the middle ear, and serves to transmit sounds to the interior of the ear.

Duct (Latin, *ducere*, to lead). A narrow tube, such as the *bile-duct*.

Duo-de'num (Latin, *duodeni*, twelve each). The first portion of the small intestine; so called because its length is about twelve fingers' breadth.

Dys-pep'si-a (Greek, *dus*, difficult, and *peptein*, to digest). A disordered state of the organs of digestion giving rise to difficult or painful digestion.

En-am'el. The hard layer which covers the crown of the tooth.

Epi-dem'ic (Greek, *epidemos*, among the people). A disease which attacks a large number of persons of one neighborhood at the same time.

Epi-glot'tis (Greek, *epi*, above, and *glotta*, the tongue). A leaf-shaped piece of cartilage which covers the entrance to the larynx during swallowing.

EU-STA'CHI-AN TUBE. The tube which leads from the throat to the middle ear; so called from the physician who first described it.

EX-PI-RA'TION. The act of breathing out.

EX-PIRE' (Latin, *ex*, out, and *spirare*, to breathe). To breathe out.

FAINT'ING. Loss of consciousness, due usually to an interference with the circulation.

FANG. The long, pointed end or root of a tooth.

FARI-NA'CEOUS (Latin, *farina*, flour). Containing starch; starchy.

FAR'-SIGHTED. Having one of the forms of defective sight.

FE'MUR (Latin). The thigh-bone.

FERMEN-TA'TION (Latin, *fervere*, to be boiling hot). The change by which starch or sugar in a liquid is converted into alcohol and a gas.

FI'BRE (Latin, *fibra*, a thread). One of the tiny threads of which a large portion of the body is formed.

FIB'U-LA (Latin, *fibula*, a clasp). The outer, long, slender bone of the leg.

FLESH'Y. Applied to animal food, especially meat, in distinction from vegetable food.

FRACT'URE (Latin, *frangere*, to break). The breaking of a bone.

FRONT'AL (Latin, *frons*, the forehead). Belonging to the forehead.

FUNC'TION (Latin, *functio*, performing). The special work of any organ of the body.

GALL. The bile.

GAS'TRIC (Greek, *gaster*, the stomach). Belonging to the stomach.

GAS'TRIC JUICE. The fluid secreted by the stomach, which digests fleshy food.

GEL'A-TIN (Latin, *gelare*, to congeal). An animal substance found in bones, cartilage, and other tissues, which dissolves in boiling-water, and forms a firm jelly upon cooling.

GLAND (Latin, *glans*, an acorn). An organ which separates certain substances from the blood.

GOUT (Latin, *gutta*, drop). A disorder of the system in which one of the prominent symptoms is a painful affection of the joints.

GRAN'U-LAR LIDS (Latin, *granum*, grain). A contagious affection of the eyelids, so-called, because the lids, when turned out, often present the appearance of being studded with small grain-like bodies.

GRIS'TLE. Cartilage.

GROIN. The depression on each side, between the abdomen and thigh, just below the hip.

GUL'LET (Latin, *gula*, throat). The tube between the throat and stomach, serving for the passage of food and drink; the œsophagus.

HANG'NAIL. A small flake of skin which hangs from the side or root of a nail.

HEM'I-SPHERES (Greek, *hemi*, half, and *sphaira*, a sphere). The halves into which the cerebrum is divided.

HEM'OR-RHAGE (Greek, *haima*, blood, and *regnumi*, to burst). The escape of blood from the blood-vessels; any bleeding.

HER-BIV'O-ROUS (Latin, *herba*, herb, and *vorare*, to devour). Subsisting on vegetable food.

HIP. The projection on each side of the body just above the thigh formed by the hip-bone.

HOPS. A plant, the flowers of which are used in flavoring beer.

HU'MAN (Latin, *homo*, man). Relating to man.

HU'ME-RUS (Latin). The thigh-bone.

HU'MOR (Latin, *humere*, to be moist). An animal fluid; especially the fluid contents of the eyeball.

HY'GI-ENE (Greek, *Hygeia*, the goddess of health). The science which treats of the preservation of health and the prevention of disease.

IN-CI'SOR (Latin, *incidere*, to cut in). The four front teeth in both jaws; they have sharp, chisel-like edges.

IN'DEX FIN'GER (Latin, *indicare*, to point out). The fore-finger; the finger next to the thumb.

IN-DI-GEST'I-BLE (Latin, *in*, not, and *digerere*, to separate). Not easily converted by the organs of digestion so as to be fit for absorption by the blood and tissues.

IN-DI-GES'TION (Latin, *in*, not, and *digerere*, to separate). A condition in which the food is not properly digested, or digested with difficulty.

IN-SPIRE' (Latin, *in*, in, and *spirare*, to breathe). To draw in breath.

IN-SPI-RA'TION (Latin, *in*, in, and *spirare*, to breathe). The act of inspiring or drawing in breath.

IN'STEP. The raised portion of the foot near the ankle.

IN'TEL-LECT (Latin, *intelligere*, to understand). The power which enables us to judge and understand.

IN-TES'TINE (Latin, *intus*, on the inside). The hollow tube which fills the greater part of the abdomen, and forms the continuation of the digestive organs after the stomach; the bowels.

In-tox'i-cating (Latin, *toxicum*, an arrow-poison). Making drunk; capable of bringing under the effects of alcohol.

In-vol'un-ta-ry (Latin, *in*, not, and *voluntas*, will). Not dependent upon the will.

I'ris (Latin, *iris*, the rainbow). The colored membrane in the front portion of the eye, perforated in its centre by the pupil.

Jaun'dice (Latin, *galbus*, yellow). The yellowish discoloration of the skin and of the white of the eye, due to bile being present in the blood.

Joint (Latin, *jungere*, to bind together). The place of meeting or union of two or more bones.

Judg'ment (Latin, *judicare*, from *jus*, law, and *dicare*, to proclaim). The faculty of judging or deciding correctly.

Kid'ney. An important organ placed in the back part of the abdominal cavity; it separates certain refuse materials from the blood; there are two kidneys.

Lach'ry-mal (Latin, *lacrima*, a tear). Forming tears.

Lach'ry-mal Duct. The small canal which conveys the tears from the eye to the interior of the nose.

Lach'ry-mal Gland. The small organ, placed just above the eye, which produces the tears.

Lac'te-als (Latin, *lac*, milk). The small vessels (part of the lymphatics) which carry the nutritious juices representing the digested food, from the intestines to the blood, emptying into a large vein of the neck.

Lam'b-doid (Greek letter *lambda*, Λ). The name given to the suture which connects the occipital with the parietal bones, on account of its resemblance in shape to the Greek letter lambda (Λ).

Lar'ynx (Greek, *larugx*, a whistle). The upper part of the air-passage in which the voice is produced.

Lean (Latin, *lenis*, soft, moderate). Thin; devoid of fat.

Lens (Latin, *lens*, a lentil). A transparent body with curved surfaces, which influence the course of rays of light. The *lens of the eye* is the transparent body placed just behind the iris and pupil, which causes images to fall upon the retina or nervous layer of the eyeball.

Lig'a-ment (Latin, *ligare*, to bind). The tough bands or sheets of tissue which cover the joints and bind the ends of the bones together.

LIMBS. The extremities of the human body attached to the trunk on each side, above and below; there are two upper and two lower limbs.

LIQ'UOR (Latin, *liquere*, to be liquid). A name given to strong alcoholic fluids, such as whiskey, brandy, rum, etc.

LITTLE FINGER. The smallest finger; situated on the opposite side of the hand from the thumb.

LUNGS. The organ of breathing, occupying the greater part of the cavity of the chest.

LYMPH (Latin, *lympha*, pure water). The colorless or white fluid contained in the lymphatics.

LYM-PHAT'ICS (Latin, *lympha*, pure water). The small vessels which run from the tissues and finally empty into two large veins in the neck; they contain lymph.

MAG'NI-FIED (Latin, *magnus*, great, and *facere*, to make). Made to appear larger than in reality.

MA'LAR (Latin, *mala*, the cheek). The bone which forms the prominence of the cheek.

MALT. Sprouting barley which has been dried by heat so as to change its starch into sugar; it is used in brewing beer.

MAR'ROW. A soft, fatty substance contained in the central cavity of bones.

ME-DUL'LA (Latin, *medulla*, marrow, pith). The portion of the brain which connects it with the spinal cord.

META-CAR'PUS (Greek, *meta*, beyond, and *karpos*, the wrist). That part of the skeleton of the hand between the wrist and the fingers.

META-TAR'SUS (Greek, *meta*, beyond, and *tarsos*, ankle). That part of the skeleton of the foot between the heel and the toes.

MI'CRO-SCOPE (Greek, *mikros*, small, and *skopein*, to view). An optical instrument, consisting of a combination of lenses, used to view objects which are too small to be seen by the naked eye.

MID'DLE FINGER. The finger placed midway between the thumb and little finger; the third finger.

MIN'ER-AL (Latin, *mina*, a mine). Derived from the inorganic or lifeless world; such as the rocks.

MO'LARS (Latin, *molere*, to grind in a mill). The three rear teeth in each jaw; they are used in grinding the food into small particles.

MOR'PHINE (Greek, *Morpheus*, the god of sleep). A white substance which constitutes the narcotic principle in opium.

Mu'cus (Latin, *mucus*, slime). A slippery substance secreted by the mucous membranes to keep them moist.

Mu'cous Mem'brane (Latin, *mucosus*, from *mucus*, slime, and *membrana*, a skin). The soft layer of tissue which lines the alimentary and breathing channels ; it secretes mucus.

Mus'cles (Latin, *musculus*, a muscle). The fleshy organs which move the various parts of the body.

Nar-cot'ic (Greek, *narke*, numbness). A drug which relieves pain and produces sleep ; when given in large quantity, produces insensibility and even death.

Na'sal (Latin, *nasus*, the nose). Pertaining to the nose.

Near'-sighted. A form of weak sight in which objects can only be seen clearly when held very close.

Nerves (Latin, *nervus*, a nerve). The thread-like bundles of fibres which run from the brain and spinal cord to different parts of the body and establish communication.

Ni'tro-gen (Latin, *nitrum*, nitre, and *genere*, to produce). The gas which forms four-fifths of the atmosphere ; it serves to dilute the oxygen.

Nos'tril. One of the two oval apertures at the front of the nose through which air is drawn.

Oc'ci-put (Latin, *oc*, back, and *caput*, the head). The hind part of the head or of the skull.

Oc-cip'i-tal (Latin, *oc*, back, and *caput*, the head). Referring to the back part of the head.

Oc'u-list (Latin, *oculus*, the eye). One who treats diseases of the eye.

Œ-soph'a-gus (Greek, *oiso* (future of), to carry, and *phagein*, to eat). The passage for food, leading from the throat to the stomach.

O'pi-um. A narcotic drug obtained from the fruit of the poppy plant.

Op'tic (Greek, *opticos*). Pertaining to sight. *Optic nerve*, the nerve of sight.

Orb'its (Latin, *orbis*, a circle). The cavities in which the eyes are placed.

Or'gan (Latin, *organum*, an organ). A part of the body which performs some special work ; the eye is the organ of sight.

Ox'y-gen (Greek, *oxus*, acid, and *genein*, to produce). An important gas which forms one-fifth of the atmosphere, and serves to sustain life.

PAN'CRE-AS (Greek, *pan*, all, and *kreas*, flesh). An important organ of digestion, situated in the abdominal cavity and pouring its secretion, the pancreatic fluid, into the small intestine.

PA-RAL'Y-SIS (Greek, *para*, beside, and *luein*, to loosen). Loss of the power of moving a greater or lesser number of muscles.

PAR'A-LYZED (Greek, *para*, beside, and *luein*, to loosen). Affected with loss of the power of moving a greater or lesser number of the muscles.

PA-RI'E-TAL (Latin, *paries*, a wall). A name given to the two bones which form the roof of the skull.

PA-ROT'ID (Greek, *para*, beside, and *ous*, the ear). A gland situated below and in front of the ear; it secretes part of the saliva.

PA-TEL'LA (Latin, *patina*, a pan). The knee-pan.

PEC'TO-RALIS (Latin, *pectus*, the breast). The triangular muscle on each side of the front of the chest which draws the arm inward.

PEL'VIS (Latin, *pelvis*, a basin). The bony basin at the lower part of the chest to which the thigh-bones are attached.

PEP'SIN (Greek, *pepsis*, digestion). A substance present in the gastric juice, which digests fleshy food.

PERI-CAR'DI-UM (Greek, *peri*, around, and *kardia*, the heart). The sac which surrounds the heart.

PERI-OS'TE-UM (Greek, *peri*, around, and *osteon*, a bone). A tough membrane closely covering the bones.

PERI-TO-NE'UM (Greek, *peri*, around, and *teinein*, to stretch). The smooth membrane which covers the abdominal organs and lines the cavity of the abdomen.

PER-SPI-RA'TION (Latin, *per*, through, and *spirare*, to breathe). The watery fluid given off from the skin; when visible it is called "*sensible;*" when invisible "*insensible.*" The sweat.

PHA-LAN'GES—Plural of phalanx (Greek, *phalanx*, a rank). The small bones forming the fingers and toes.

PHAR'YNX (Greek, *pharugx*, the throat). The cavity at the back of the mouth through which the food passes on its way to the œsophagus or gullet.

PHYSI-OL'O-GY (Greek, *phusis*, nature, and *logos*, a discourse). The study of how beings live.

PLAS'MA (Greek, *plassein*, to mold). The liquid part of the blood.

PLEU'RA (Greek, *pleura*, the side). The smooth membrane which covers the lungs and lines the cavity of the chest.

PORES (Latin, *porus*, a passage). The minute openings in the skin through which the perspiration escapes.

PUL'MO-NA-RY (Latin, *pulmo*, a lung). Pertaining to the lungs.

PULP (Latin, *pulpa*, pulp). The soft material which fills the central space in the teeth.

PULSE (Latin, *pulsus*, the pulse). The beating of the arteries.

PUPIL (Latin, *pupilla*, pupil). The opening in the iris through which light passes into the interior of the eye.

PY-LO'RUS (Greek, *puloros*, a gate-keeper). The opening in the stomach by which food passes into the intestines.

RA'DI-US (Latin, *radius*, a rod). The outer bone of the forearm.

REA'SON (Latin, *ratio*, reason). The power by which we distinguish right from wrong, and are able to employ proper means for the attainment of particular ends.

RE'FLEX ACTION (Latin, *re*, back, and *flectere*, to turn). Actions excited without our being conscious of them.

RE-SPIRE' (Latin, *re*, again, and *spirare*, to breathe). To breathe.

RESPI-RA'TION (Latin, *re*, again, and *spirare*, to breathe). The act of breathing.

RET'I-NA (Latin, *rete*, a net). The innermost or nervous layer of the eyeball which receives the impressions of sight.

RIB. One of the long, slender bones inclosing the chest.

RING FINGER. The finger next to the little finger, upon which rings are usually worn.

SAG'IT-TAL (Latin, *sagitta*, an arrow). Pertaining to an arrow ; a name given to the suture which unites the parietal bones, because it meets the coronal suture as an arrow meets the bow.

SA-LI'VA (Latin, *saliva*, spittle). The liquid secreted by the glands near the mouth, emptied into this cavity and serving to keep the mouth moist and to form a mass with the food ; the spittle.

SAL'I-VA-RY. Pertaining to saliva or spittle.

SCALP (Latin, *scalpere*, to carve). The skin covering the top of the head.

SCAP'U-LA (Latin). The shoulder-blade.

SCARF'-SKIN. The outer layer of the skin.

SCENT (Latin, *sentire*, to smell). Odor ; smell.

SCLER-OT'IC (Greek, *skleros*, hard). The firm, white, outer layer of the eyeball.

SEN-SA'TION (Latin, *sentire*, to feel). Feeling caused by external objects. *Nerves of sensation* are those which carry impressions of

touch, pain, heat, etc., from the various organs of the body to the brain.

SENSES (Latin, *sentire*, to feel). The faculty of obtaining information of the exterior world by means of certain organs; the five senses are, feeling, seeing, hearing, smelling, and tasting.

SEN'SI-TIVE (Latin, *sentire*, to feel). Having a high degree of feeling.

SKEL'E-TON (Greek, *skellein*, to dry up). The system of bones which constitutes the framework.

SKULL. The bones of the head taken collectively.

SOLE (Latin, *solea*). The under surface of the foot.

SOL'U-BLE (Latin, *solvere*, to dissolve). Capable of being dissolved in a fluid.

SPE'CIAL SENSES (Latin, *specialis*, a particular kind). The sense of taste, smell, sight, and hearing as distinguished from the *general* one of feeling.

SPI'NAL (Latin, *spina*, the spine). Relating to the spine or backbone. *Spinal canal*, the canal running through the back part of the backbone or *spine*, in which is contained the soft bar of nervous tissue called the *spinal cord*.

SPLEEN (Latin, *splen*). A large, flat body, composed largely of blood, placed on the left side of the abdominal cavity.

SQUINT. The condition of being cross-eyed.

STARCH. The white grains found in wheat, potatoes, and many other plants.

STER'NUM (Greek, *sternon*, the breast). The breast-bone.

STIM'U-LANT (Latin, *stimulare*, to incite). Anything which produces an increase of action in the system or any part of it.

STOM'ACH (Greek, *stoma*, an entrance). The receptacle for the food, placed between the lower end of the gullet and the beginning of the intestines.

SUB-LIN'GUAL (Latin, *sub*, under, and *lingua*, the tongue.) Situated under the tongue. *Sublingual glands*, two salivary glands placed underneath the tongue.

SUB-MAX'IL-LA-RY (Latin, *sub*, under, and *mala*, jaw). Situated beneath the jaw. *Submaxillary* glands, two salivary glands placed underneath the lower jaw.

SUT'URE (Latin, *suere*, to sew). The line of union between the bones of the skull.

SYN-O'VI-AL (Latin, *ovum*, an egg). Relating to the fluid found in joints. *Synovial fluid*, the fluid secreted in joints to permit of easy motion. It is formed by a sac known as the *synovial membrane*.

Sys'tem (Latin, *systema*). A collection of parts of the body performing the same function; for instance, all the arteries of the body taken collectively are known as "the arterial *system.*" Tne term *system* is also used to denote the body as a whole.

Tar'sus (Greek, *tarsos*, the ankle). The solid, hind part of the foot which is joined to the leg.

Tem'ple (Latin, *tempus*, time). A spot on the side of the head, just in front of the ear, so-called because the hair begins to turn gray in this situation, at the approach of age.

Tem'po-ral (Latin, *tempus*, time). Pertaining to the temple.

Ten'don (Latin, *tendere*, to stretch). The strong, fibrous part of a muscle by which it is attached to surrounding parts, especially bone.

Ther-mom'e-ter (Greek, *thermos*, hot, and *metron*, measure). An instrument used to measure the intensity of heat.

Thigh. The thick, fleshy portion of the lower extremity, between the lower end of the trunk and the knee.

Tho'rax (Greek, *thorax*, a breast-plate). The chest.

Thumb. The short, thick finger; the first from the outer side.

Tib'i-a (Latin). The inner bone of the leg.

Tis'sue (Latin, *texere*, to weave). A form of material of the body, composed of various elementary substances, such as cells, fibres, nerves, blood-vessels, etc., closely connected with each other.

To-bac'co (Indian, *tabaco*, the tube or pipe in which the Indians smoked tobacco). A plant much used for smoking, chewing, and snuffing.

Tra'che-a (Greek, *trachus*, rough). The windpipe; the canal which conveys air to the lungs.

Train (Latin, *trahere*, to draw). To prepare the body for extraordinary feats of strength or endurance.

Tri'ceps (Latin, *tria*, three, and *caput*, head). The large muscle on the back of the arm; so-called, because it is formed above of three portions.

Trunk (Latin, *truncus*, trunk). The central part of the body, to which head and limbs are attached.

Tu'bule (Latin, *tubus*, a pipe). A small tube.

Ul'na (Latin, *ulna*, elbow). The inner bone of the forearm.

Valve (Latin, *valva*, a folding-door). A lid or cover so formed as to open in one direction and close in the other.

Ve'ge-ta-ble (Latin, *vegetare*, to enliven). Relating to plants.

VEIN (Latin, *vena*, vein). One of the blood-vessels which receives blood from the capillaries and returns it to the heart.

VENTI-LA'TION (Latin, *ventulus*, a slight wind). The act of removal of impure air and admission of pure air.

VEN'TRI-CLES (Latin, *ventriculus*, dim. of *venter*, the belly). The two lower and larger cavities of the heart.

VER'TE-BRA (Latin, *vertere*, to turn). One of the bones which make up the spine or backbone.

VIT'RE-OUS (Latin, *vitrum*, glass). Like glass. *Vitreous humor*, the transparent, jelly-like substance which fills the eyeball, behind the lens.

VO'CAL (Latin, *vox*, voice). Relating to the voice-sounds; *vocal cords*, the bands of membrane existing in the larynx, which produce the voice-sounds by their vibration.

VOL'UN-TA-RY (Latin, *voluntas*, will). Produced by an act of the will.

WIND'PIPE. The passage by which air reaches the lungs. The trachea.

YEAST. A substance added to starchy or sugary liquids to produce fermentation.

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