

THE TEACHER'S MANUAL
AND
PUPIL'S TEXT BOOK ON

ANATOMY

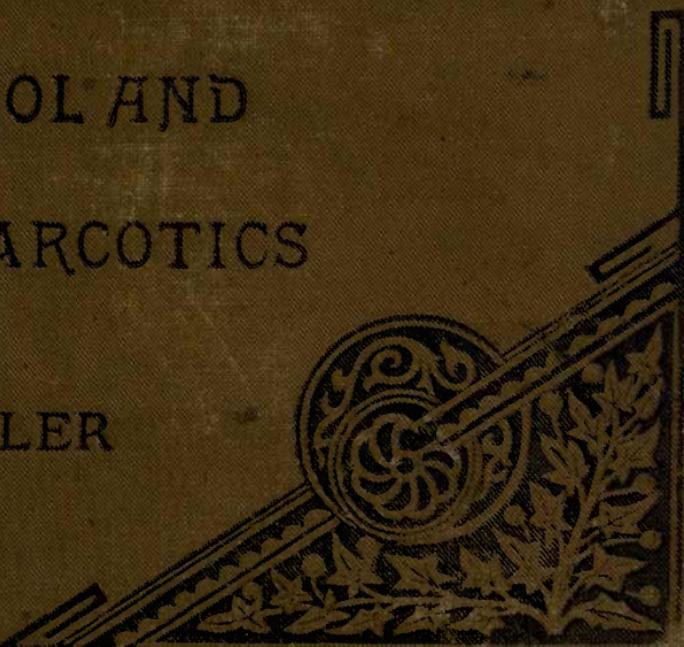
PHYSIOLOGY

AND EFFECTS OF HYGIENE

ALCOHOL AND

NARCOTICS

RASSWEILER



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THE TEACHERS' MANUAL

AND

PUPILS' TEXT BOOK

ON

Anatomy, Physiology and Hygiene.

INCLUDING THE EFFECTS OF

ALCOHOL AND NARCOTICS UPON
THE HUMAN SYSTEM,

DESIGNED TO ACCOMPANY

THE TEACHERS' ANATOMICAL AID

BY

PROF. J. K. RASSWEILER, A. M.



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PREFACE.

This book is intended to go into the schools of the country as a companion to the "TEACHERS' ANATOMICAL AID," which is supposed to be before the class during every exercise or recitation in Physiology, and to which the illustrative references, found throughout these pages, relate.

To the teacher who gives *oral lessons* in Physiology, by the use of the Aid, this volume offers assistance in presenting the truths of the science in proper order, plain language, and with many illustrations gathered within the range of the pupils' observation and experience. Thus, even inexperienced teachers are furnished with methods and material to conduct a well-arranged course of daily drills on a subject of surpassing importance and interest.

To the teacher who conducts a *recitation*, with the use of the Aid, this work offers guidance in pointing out, precisely, by its frequent references, those parts or features on the plates or manikin sections, which illustrate any topic in hand, as found in the current text-books on Physiology.

While this book is thus intended to be helpful to

teachers of all grades of experience, it is, at the same time, adapted for use as a text-book for elementary classes. The practical results which may be obtained from such a use of it, in connection with the Anatomical Aid, will be found to be more satisfactory than those which can be attained by any other method of instruction in the elements of Physiology.

When used as a text-book with the Aid, the latter should be made conveniently accessible to the pupils. This can easily be done in any school-room. The objection that the pupils will injure the charts by handling them, is a mischievous notion. They are entitled to such privileges. If well and kindly advised, they will handle them properly and will take pride in carefully preserving them from injury.

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THE SKELETON.

BONES.

Like the Framework of a House.

The framework of the body is composed of *bones* and *ligaments*. It is called the skeleton. What beams, joists and rafters are to a house, bones are to the body. As each timber in the framework of a building is fitted for its own particular place and purpose, so each one of the bones of the body has its own place and is in every way precisely adapted, in shape and strength, for a special use.

Number of Bones.

There are two hundred and eight bones in the skeleton. This does not include the teeth, for they are really not a part of the skeleton. Thirty-four of the bones of the body are single—only one of the same kind. Besides these, there are eighty-seven pairs, the two bones of each pair being alike—one on each side of the body.

Shape.

The skeleton plate shows that the bones are very different in shape. Some are long, like this (leg bone), for example. Others

are nearly round, like these bones of the wrist. Some are quite flat, like this large, spreading bone at the shoulder (16), or these broad bones in the lower part of the main body (3).

Structure. The bones are very hard and strong. "Hard as a bone" is a familiar comparison. We shall not be surprised at their hardness and strength when we shall have learned what important uses they serve in the body. There are two kinds of material in the structure of a bone. One part is called *animal matter* and the other is called *mineral matter*. If the bone were composed of animal matter alone, it would bear no pressure and keep no permanent shape. If it were made entirely of mineral matter it would be too brittle, and consequently would break very easily. So these two kinds of material are united together in such a way as to secure strength without too great brittleness. In childhood the bones are not easily broken. This is because in early life they contain about twice as much animal matter as mineral matter. What a wise protection against the "bumps" and "tumbles" of the little ones. In middle life the two kinds of material are more nearly equally divided. In old age, however, the bones are very brittle, because, then, there is about twice as much mineral matter as animal matter in their structure.

It is an easy and interesting experiment to separate these two kinds of bone material. Throw a flat bone, or piece of bone, into the fire. After a while

you will find a part of it, like a cinder, among the ashes. This is the mineral part. The fire has burned out the animal matter. Take the "drumstick" bone of a chicken and place it in a bottle containing a mixture made by filling the bottle half full of water and adding about half as much muriatic acid—a common drug which you can get for a trifle at the nearest drug store. This will take out the mineral matter from the bone and leave the animal matter. The mineral matter which you took from the fire was brittle or crumbling. The animal matter, when taken from the acid, is gluey and can be wound, like a cord, about the finger. The broad or flat bones, like those of the head, are not entirely solid. Between the two outside layers of such a bone there is a layer of spongy-like material. These three layers of structure in a flat bone can be clearly seen by looking at the edge of such a bone which has been sawed through.

The long bones are generally hollow and contain a substance called *marrow*. At the ends they are usually thicker and more spongy. This serves to break the force or shock of heavy stepping or jumping with the lower limbs, or a hard stroke with the arm. The ends of the long bones are also covered with a smooth, white substance called *cartilage*. This aids in giving the bone an easy motion at the joint where it is united to another bone.

How United. The bones are united to each other in different ways. Those which are quite movable are connected by joints. Some of these are called *hinge-joints* because they work like the hinge of a door. These (arm) bones which meet at the elbow are hinge-jointed. Raise and lower your forearm and notice particularly how the joint acts. The joints in the fingers and the knee are also hinge-joints. Another kind is called the *ball and socket joint*, where the round end of one bone moves in a hollow place of another. Here (*a*) at the hip is a good example of a ball and socket joint, where the round head of this large upper bone of the leg moves in a deep hollow of this lower bone of the main body. The bones of the head meet each other with jagged edges forming a seam-like junction called a *suture*. One of these is clearly shown on this skeleton (12). Between the bones of the back are placed cushions of *cartilage*. This is a substance softer than bone and quite elastic, like rubber. This cushion arrangement between the bones of the back, is nicely shown on this plate. (Refer to cartilages between lumbar vertebrae.)

Bound Together by Ligaments. The bones are bound to one another by *ligaments*. These are very strong and hold the bones firmly in position. Some of these stout bands or ligaments are shown on this plate. Here (XVI) are the ligaments which bind together the bones of the hip. These (XXV, XXVI) are the ligaments of the elbow joint.

**Uses of
the Bones.**

The bones of the body serve several important purposes. 1. They give the body its general shape. 2. They support the softer material of the body within and around them. 3. They protect delicate and important parts against injury from without, as, for example, the brain, lungs and heart. 4. They serve as levers, to be moved by the muscles in the various movements of the body, as we shall learn more clearly, somewhat later.

**Divisions
of the
Skeleton.**

By looking at the figure of the skeleton we perceive that the bones are grouped into four natural divisions, namely: 1. The bones of the *head*. 2. Those of the main body, or *trunk*. 3. Those of the *upper extremities*, or arms. 4. Those of the *lower extremities*, or legs.

We have now learned about the number, shapes, material, union, uses and groups of the bones of the skeleton. We are now ready to study the more important bones of each group more closely.

TABLE OF THE SKELETON.

Bones whose proper names are not given elsewhere are printed in *italics*. Letters and figures in parenthesis refer to the bones as shown in 'Anatomical Aid.'

BONES OF THE HEAD.

1 Frontal (forehead).....	(1)
2 Parietal (upper side of head).....	(2)
2 Temporal (lower side of head).....	(3)
1 Occipital (back of head).....	(4)
1 <i>Sphenoid</i> (base of skull).....	
1 <i>Ethmoid</i> (base of skull).....	
2 Nasal (bridge of nose).....	(6)
2 Malar (cheek bones).....	(4)
2 <i>Lachrymal</i> (part of eye socket).....	
2 <i>Palate</i> (roof of mouth).....	
2 <i>Turbinated</i> (in cavity of nose).....	
2 Upper Maxillary (upper jaw).....	(7)
1 Lower Maxillary (lower jaw).....	(8)
1 <i>Vomer</i> (partition between nostrils).....	

BONES OF UPPER EXTREMITIES.

2 <i>Clavicle</i> (collar-bone).....	(8)
2 <i>Scapula</i> (shoulder-blade).....	(16)
2 Humerus (upper arm).....	(1)
2 Radius (forearm).....	(2)
2 Ulna (forearm).....	(3)
16 <i>Carpal</i> (wrist bones).....	(4)
10 <i>Metacarpal</i> (middle hand).....	(5)
28 <i>Phalanges</i> (finger bones).....	(6-10)

BONES OF THE TRUNK.

7 Vertebrae of the neck.....	(1-3)
12 Vertebrae of the back.....	(4-5)
5 Vertebrae of the loins.....	(6-7)
14 True Ribs.....	(12-13)
10 False Ribs.....	(14-15)
1 Sternum (breast-bone).....	(10)
2 <i>Innominate</i> , or Hip Bones.....	(3)
1 Sacrum (between hip bones).....	(1)
1 <i>Coccyx</i> (cuckoo bone).....	

BONES OF LOWER EXTREMITIES.

2 Femur (thigh bone).....	(1)
2 <i>Patella</i> (knee-pan).....	(2)
2 Tibia (leg bone).....	(a)
2 Fibula (leg bone).....	(b)
14 <i>Tarsal</i> (heel and instep).....	
10 <i>Metatarsal</i> (middle foot).....	
28 <i>Phalanges</i> (toe bones).....	

The above, with the *Hyoïd* bone, and four bones in each ear, makes 208 bones.

BONES OF THE HEAD.

The Skull. There are twenty-two bones in the head. Eight of these are shaped and united in such a way as to form a sort of round box which is called the *skull*, or *cranium*. This is one of the most important parts of the skeleton, since it contains the brain, the most delicate organ of the body. The word *organ*, in physiology, means any single part of the body which serves a special purpose. Thus, the brain, heart, lungs and veins are organs. The skull, or brain-box, is placed, like a dome, at the top of the structure of the body. It is wonderfully fitted for the protection of its tender contents. It is shaped for strength as well as for beauty.

The front of the skull is formed by the *frontal* bone (1), or bone of the forehead. The two *parietal* bones (2) form the upper sides, and the two *temporal* bones (3) form the lower sides of the skull. At the back of the head (4, back view of skeleton) is the *occipital* bone. Two more of the skull bones form its lower part or base. These we will not name here; but you will find them named in the full table of the bones which has been given.

The Face. The remaining fourteen bones of the head give shape to the face. The two *nasal* bones (6) form the bridge of the nose, and the two *malar* bones (4) the prominence of the cheeks. The upper jaw is formed of the two *upper maxillary* bones (7). The lower jaw bone (8) is called the

lower maxillary. The teeth are set in sockets of these maxillary bones.

BONES OF THE TRUNK.

The main body is called the *trunk*. The upper part of the trunk is fitted to contain the lungs and the heart. Its lower part contains the stomach, liver and bowels.

The Spinal Column. The great pillar of the body is the *spinal column*. It bears aloft the head—the crowning part of the whole structure. It supports the great vital organs of the main body. It is most wonderfully constructed with reference to comfort and safety of life. Instead of being composed of but one or a few bones, it is built up of twenty-six pieces, which, while laid up one above the other, are separated from each other by very elastic cushions of cartilage. This does not only make the back-bone capable of bending forward, backward and sideways, but it makes the whole pillar springy, so that the delicate brain which rides at its summit is not affected by jarring from the heavy movements of the body.

Vertebræ. Twenty-four of the bones of the spinal column, or back, are called *vertebræ*. These are firmly bound together by ligaments and interlocked with each other by their own projecting parts. An opening runs through each vertebra. These openings form the *spinal canal* through which

the *spinal cord*, of which we shall learn hereafter, passes. The vertebræ are divided into three sets. The seven upper ones are in the neck. The next twelve are in the back proper; to these the twelve pairs of ribs are attached. The five lower vertebræ are in the region of the loins. They are very stout, as the figure shows, just as we would expect them to be, since they support a large part of the weight of the body.

The Chest. The upper part of the trunk, which contains the heart and lungs, is called the *chest*. The skeleton of the chest is formed behind, as you see, by the middle division of the spinal column; on the sides by the *ribs* (12, 13), and in front by the *sternum* (10) or breast-bone. Here, again, we find a wise provision for the protection of life. The breast-bone is not near so hard as most of the other bones. It is consequently more flexible. The ribs are not directly united to the sternum, but are joined to it by cartilages. By these means, a heavy blow on the breast, which otherwise would seriously injure the organs within, is made comparatively harmless.

The plate of the skeleton shows that the ribs are not all joined to the breast-bone in front. Seven pairs (12-13) are so joined. These are called *true ribs*. The remaining five pairs (14-15) are called *false ribs*.

The Pelvis. The bones of the lower part of the trunk are shaped and joined so as to form a large bowl-shaped cavity. This is called the *pelvis*.

Notice how broad and peculiarly formed these two (3) bones are. The *sacrum* (1) bone is wedged between these two bones at the back.

BONES OF THE UPPER EXTREMITIES.

The Shoulder. In examining the shoulder, we first notice these two collar-bones (8). Their use is to brace the shoulders properly apart; so one end rests against the breast-bone and the other against the shoulder. Next comes the shoulder-blade (16). These are so broad to allow the attachment of some very strong muscles of the upper part of the body.

The Arm. The upper arm has one large bone called the *humerus* (1). The *radius* (2) and the *ulna* (3) are the bones of the lower arm. There are eight roundish little bones in each wrist (4), five longer ones in the middle of each hand (5), three short bones in each finger (6, 9, 10) and two in each thumb (7, 8).

BONES OF THE LOWER EXTREMITIES.

The Thigh. Here we meet the largest bone of the skeleton (1). It is called the *femur*. Observe the round shape of its upper end (*a*). This is called the head of the femur. Moving in a hollow place of this large bone (3), it forms the ball and socket joint of the hip. Do not fail to notice how securely the lower limbs are bound to the main body by these numerous strong ligaments.

**Lower Leg
and Foot.**

The lower leg has two bones—the *tibia* (a), and the *fibula* (b). The knee-joint, between the thigh bone and the bones of the lower leg, is protected by a flat bone called the knee-pan (2). There are seven bones in each heel, five in the middle part of each foot, three in each of the larger toes, and two in each great toe.

Notice this peculiarity in the form of the foot. It is curved or arched from the heel to the front. Here is another arrangement for springiness, without which, walking would not only become clumsy but painful.

**Health of
the Bones.**

The bones of a grown person are so much hardened by the mineral matter which has increased in their structure, that they are not easily changed in shape. They are more easily broken than bent. Neither is the full-grown joint likely to change in shape and character during the active years of life. So the general carriage of the body in adult life, depends on the habits and circumstances which shaped it in youth. We have learned that in childhood the bones are quite flexible and disposed to bend, instead of breaking, under a strain. For this reason, children who begin to walk very early become more or less bow-legged. Pupils who are in the habit of leaning forward on the desk, in school, will certainly, more or less deform their bodies. If a boy, in walking, carries his body in a lazy, stoop-shouldered position, he will go bent and deformed through life. Avoid leaning the body

forward in sitting. When lying down, do not bolster up the head with high pillows. While standing or walking, hold the head erect, throw the shoulders back, and take in full breaths of air. If these positions in lying, sitting, standing or walking are carefully kept in youth, all the curvings and efforts of the body and limbs which come from ordinary labor, will not injure them, and the full-grown figure will be straight, graceful and strong.

OUTLINE.

THE BONES OF THE SKELETON.

- | | | |
|--------|---|--|
| WHAT? | { | <p>Framework of the body.
 208. Eighty-seven pairs. Thirty-four single.
 Shapes: Long, flat, round, irregular.
 Composed of animal and mineral matter.
 United by joints, sutures and cartilages.
 Bound together by ligaments.
 Arranged in four groups:
 Head, Trunk, Upper and Lower Extremities.</p> |
| WHERE? | { | <p>Twenty-two in the head.
 Fifty-four in the trunk.
 Sixty-four in the upper extremities.
 Sixty in the lower extremities.
 Eight in the ears.</p> |
| WHY? | { | <p>To give shape to the body.
 To support the softer parts of the body within and
 around them.
 To protect important organs.
 To serve as levers to be moved by the muscles.</p> |

SUGGESTIONS TO THE TEACHER.

Be sure that the acid and burning experiments on the *composition* of bones are performed either by yourself or by the pupils. Get a piece of flat bone sawed to show the *layers*. Get a leg joint at the butcher's; remove muscles and tendons, to show the *ligaments*; then sever the bones at the joint to show *cartilage*. Show a fresh piece of long bone containing *marrow*.

TEST QUESTIONS.

- Of what is the skeleton composed?
- To what parts of a house are the bones compared?
- How many bones in the skeleton?
- Do the teeth belong to the skeleton proper?
- How many single bones in the body?
- How many are in pairs?
- What variety of shapes have the bones?
- What two kinds of material in the bones?
- Which material makes the bone flexible?
- What is the effect of the mineral matter?
- How do these materials vary at different ages?
- What wise provision in this arrangement?
- Why are the ends of the long bones more spongy?
- Why are they covered with cartilage?
- In what ways are the bones united?
- Locate a hinge-joint of the body.
- Where is a ball and socket joint found?
- What bones are united by sutures?
- What bones are united by cartilages?
- How are the bones bound to each other?
- Name four uses of the bones.
- Into how many groups are the bones divided?
- What is the skull?
- Point out on the Aid, the frontal bone,—the parietal—temporal—occipital.
- How many bones form the face?
- What two form the bridge of the nose?
- Where are the malar bones?

- The upper maxillary? Lower maxillary?
What is meant by the trunk?
Where is the spinal column?
Why is it built so strong?
How is it made, elastic or springy?
What benefit in this arrangement?
How many vertebræ in the back-bone?
How many of these are in the neck?
How many have ribs attached to them?
How many are in the loins?
What bones make the frame of the chest?
Are the ribs united directly to the sternum?
Is the sternum as hard as other bones?
What benefit in these arrangements?
How is the lower part of the skeleton of the trunk shaped?
What is it called?
What three bones come together at the shoulder?
What two in the forearm?
How many in the wrist?
How many in the middle of the hand?
In each finger?
In each thumb?
Which is the longest bone in the skeleton?
What two bones in the lower leg?
How many heel bones in each foot?
Why is the foot arched instead of flat?

THE MUSCULAR SYSTEM.

MUSCLES.

We have studied the framework or skeleton of the body. We have seen from the figure of it in the Anatomical Aid, how it resembles the framework of a house before it is weather-boarded and shingled. The plate of the body which is now before us presents altogether a different view from that which we have been studying. We notice that it looks more like the full body, more like a house that is enclosed. The bones are here quite concealed by another division of organs—the muscular system. The word *system* in Physiology means the whole collection of parts or organs of the body, which perform similar work or which work together for some common purpose. We are already acquainted with the bony system. We will now study the muscular system.

The Muscles. The *muscles* form the lean flesh of the body. The meat which we eat for food is chiefly muscle. We are all familiar with the dark red color of beef when it is

raw. You have also undoubtedly noticed that the muscle or lean meat of pork is of a paler red, and the meat on the breast-bone of a chicken is quite white; so muscle is not always red; but it is *generally* red, and the plate shows us that the muscles of the human body are of a quite red color.

There are 527 muscles in your body. Each one of these is made up of many strands or string-like fibers. These are laid side by side in the muscle, sometimes making quite a thick bundle. Each fiber of a muscle bundle is, however, separated from the rest by a very delicate substance. If you will take a piece of cooked meat, when it is cold, you can pull the muscles apart into strands, and these strands can be separated into many finer fibers or threads of muscle. While this is being done, you can observe the breaking and crackling of the very thin layer of matter which separates the fibers. The muscles differ from each other in shape. Some are spread out much like a fan. Others are quite circular in form, like this (5) around the eye, or this (15) around the mouth. Some are quite long and of nearly even thickness. The largest muscle in the body is this (60), called the tailor muscle. It is nearly a yard long and does the work of crossing the legs.

Tendons. The ends of the muscles are attached to the bones by means of a hard white substance or cord, which is called a *tendon*. These

tendons are very strong. Besides binding the muscles very firmly at their ends to the bones, they are very useful in giving a graceful shape to many parts of the body. For instance, if these (39 and 40) muscles of the forearm, which must have a connection with the fingers, were all continued as muscular bundles, through the wrist, hand and finger-joints, the hand would have a very clumsy figure. But these muscles reach out to the finger-joints by means of their tendons, and these tendons are neatly bound down, to run snugly along the bones, by means of ligaments, like this (45), so that the hand is really a very shapely organ. This (63) shows the tendon of this (62) muscle of the leg, and here (68) is the tendon of this (66) large muscle of the thigh.

Use of the Muscles. The muscles have been very appropriately called "our servants," furnished us with "the house in which we live." They are indeed very faithful servants. It is their work to move, in many ways, the different parts of the body; or, as in walking, to move the body as a whole. There is no movement of any part of the body which is not produced by the action of one or more muscles. Every step we take, the slightest motion of a finger, the movement of the lips in speaking, the chest in breathing, or the eye in winking—all these movements are produced by the muscles. The rapidity with which these muscles work is quite astonishing. To be convinced of this,

we may observe the movements of the fingers of a skillful pianist or a rapid type-writer. To help you understand still better how very rapidly the muscles can act, you may remember that in saying the one word *muscle*, the mouth, tongue and voice organs must be put, in succession, into four different shapes or positions, all of which is done by the proper muscles. We must not get the idea that only the bones are moved by the muscles. Many other parts of the body are moved by their action. For instance, the lips in whistling, the eye-lids in winking, the skin in wrinkling the forehead, or the heart in its ceaseless beating. When a dog pricks up his ears, or a horse drives off the flies by shaking his skin, it is done by the action of the muscles.

Language of the Muscles. There is another use which the muscles serve, which is very interesting. It may be called the *language* of the muscles, and it is remarkable how often they speak for us. A frown on the face is purely the work of the muscles; yet everybody understands its meaning. The same is true of a smile. You see two men at a distance standing face to face and near together, with clenched fist and up-raised arm. You do not hear a word they say, but the action of their muscles, which you see, tells you how they feel. You pass near by a vicious horse, as he lays back his ears, or approach a dog whose hair on his neck is drawn up stiff and straight, you hear no sounds, but you understand the warning. It is the silent but expressive language of the muscles.

**Two Kinds
of Muscular
Action.**

Some of the muscles of the body act only when they are directed to do so by the mind or the will. These are called *voluntary* muscles. Others act without being controlled by the will. These are called *involuntary* muscles. The muscles of the arm, for example, are voluntary muscles. The muscles which produce the action of the heart are involuntary. Some muscles may act either with or without the action of our will. For instance, the muscles which produce winking usually "wait for no thinking." But we may will to wink, and wink whenever we please. On the other hand, the will usually controls the action of the motion of the jaws. But sometimes, as in the case of a chill, these muscles produce chattering of the teeth rather contrary to the direction of the will.

**How the
Muscles
Act.**

Motion is produced by the muscles, by the *contraction* of the fibers. A muscle shortens more or less according to the degree of motion which it is to produce. The shortening in length is caused by a swelling out of the muscles sideways. This swelling or bulging of a muscle can easily be perceived while it is contracted and pulling or holding the part which it moves. Grasp your arm between the elbow and shoulder firmly between your thumb and fingers. Now raise your forearm toward your shoulder; you feel the thickening of the muscle which raises your arm. This (34) is the muscle whose action you so plainly feel. It is called the *biceps* muscle of the arm. This

name means double-headed, and this muscle is so called because it has two upper tendons or starting places. Here (32) is the one, and here (33) is the other. The return of the muscle to its usual shape and length is called its *relaxation*. The relaxation of this (34) biceps must take place to permit the arm to straighten out; but, at the same time, some other muscle or muscles must contract to move it into the straight position. A muscle which bends a part is called a *flexor*. One which serves to straighten a part is called an *extensor*.

**Antagonists,
or Counter
Muscles.**

Most of the muscles of the body are paired off in their work. That is, the motion of a part produced by a certain muscle is reversed by the contraction of some other muscle. Such muscles are called antagonists, or counter muscles. Here again we refer to the chart for illustration. To raise the forearm, as we have seen, this (34) biceps must contract; but to straighten it out again requires the action of this muscle (36), the triceps. So the biceps and triceps are antagonists. These muscles (43 and 44) bend the fingers, while these (51 and 52) straighten or extend them—another illustration of counter muscles.

**Some Prominent
Muscles and
Their Names.**

The names of the muscles are very long and difficult to remember. It would be unwise and unreasonable to ask you now to learn many of them. But by studying a few of the more prominent ones you will learn something about their uses, and also how their

names are formed. This (1) muscle, which occupies a very prominent place, begins on the occipital or back bone of the head, and reaches forward to the skin of the forehead over the frontal bone. Its contraction raises the eyebrows and wrinkles the forehead. It is called the *occipito-frontalis*. It takes its name from the parts which it connects. This (15) curious muscle, when it contracts, puckers the lips. Physiologists call it *orbicularis oris*. *Orbicularis* means *circular*, and *oris* means *of the mouth*. So this muscle is named from its shape and position. Here (51) is a muscle which bears the name *extensor indicis*, which means the straightener of the index finger, this being precisely the work which the muscle performs. This muscle (22) takes its name from its position under the clavicle or collar-bone. So it is called the *sub-clavian* muscle. We see that some muscles are named after the parts which they connect; some from their shape and position; some from the work which they do, and others from their location. So the many long and difficult names of the muscles which you find on this plate (to which the figure seems to be pointing), and which are so meaningless to you now, are really very expressive and full of meaning, and may, some day, when you are more advanced in your studies, become very interesting to you.

**Health
of the
Muscles.**

The comfort of the body, its grace of form and the prompt activity of all its parts depend very largely on the healthy

and vigorous condition of all the muscles. To keep them all in that condition, each one must be used without being abused. A muscle which is not used loses its power of contraction, becomes weak and flabby, and finally altogether useless. On the other hand, if a muscle is overworked, it loses its power. If you were to tie up your arm in a sling, or bind it down to your side for a long time, you would lose the use of it entirely. If you should swing your arm for a long time, the muscles which produce its motion would cry out in painful protest against the abuse which they suffer; and were you to disregard their protest, they would "strike" and refuse, positively, to do the bidding of your will. The effect of the vigorous exercise of the muscles without overtaxing them, is to make them firm and strong; the stout arm of a blacksmith, and the strong limbs of a footman illustrate this. The difference between the robust figure and good health of a sturdy country boy and the slender body and feeble strength of his young friend in the city, lies mostly in the difference in amount of their general muscular exercise. But we must be careful not to mistake a bulky body, or thickness of the limbs, as a sign of stoutness and strength of muscle. It is true, indeed, that as the muscles grow stronger they grow thicker, and consequently increase the size of the limbs and trunk of the body. But the effect of the *fat* of the body is often mistaken for an "abundance of muscle."

OUTLINE.

THE MUSCLES.

- WHAT? { The lean flesh of the body.
Color, red. Number, 527.
Composed of many fibers.
Shapes : long, fan-shaped, flat and circular.
Bound to the bones by tendons.
Voluntary and involuntary.
Have power of contraction.
Swell out when they shorten.
Antagonists produce counter motion.
Flexors bend, extensors straighten.
Are kept healthy by exercise.
- WHERE? { Found distributed in all parts of the body.
- WHY? { To give motion to all parts of the body by the contraction and relaxation of their fibers.

SUGGESTIONS TO THE TEACHER.

In these lessons, whether you teach them by oral exercises or in recitation by the pupils, you can add much interest and practical instruction by bringing before your class illustrations of the real working of the parts or organs which are being studied. This can often be done very conveniently, and will contribute much to the pupils' knowledge of the *functions* or use of the organs (physiology), while the Anatomical Aid gives them a correct view of the *structure* (anatomy) of the parts. In studying the muscles, especially, such real examples of their work are very easily given. Name and point out on the plate a certain muscle. Make it serve your will as your pupils look on. Then let the class, in concert, join you in the performance. Wrinkle the forehead, close the eyes, pucker the mouth, swell the cheeks, raise the arm, etc. This will make the information which is imparted "stick," because it is stored in the mind among the *pleasures* of memory.

The "drum-stick" of a chicken—which some pupil may like to contribute—will, at this stage, furnish a very good object-

lesson. Show how the muscles are grouped about the upper part and gradually taper down to the bone. Below the muscle, lying along the bone, is a tendon. Separate the muscle. If the "drum-stick" has become cold, after having been cooked, you may hear the crackling of the delicate little sheaths which encase the fibers. When you have removed all the muscles, you have left two representatives of the bony system—the larger bone, the tibia, and the slender bone by its side, the fibula, corresponding, in position, to the same bones in the human body.

TEST QUESTIONS.

- What part of the body do the muscles form?
- What is the usual color of the muscles?
- How many muscles are in the body?
- What can you tell of the structure of a muscle?
- How do muscles differ in shape?
- What is the shape of the muscle which closes the eye?
- What and where is the longest muscle of the body?
- What is the use of the tendons?
- Can you explain how the tendons assist in giving a graceful shape to the body?
- What is the use of the muscles?
- What parts, besides the bones, are moved by the muscles?
- Can you give an illustration of the language of the muscles?
- What is meant by a voluntary muscle?
- What is an involuntary muscle?
- What is meant by the contraction of a muscle?
- What by relaxation?
- What is the difference between a flexor and extensor muscle?
- What are antagonists or counter muscles?
- How is a muscle affected by being unused?
- What is the result of too severe exercise?
- Is a bulky body always a strong body?
- What is likely to make the body bulky?

THE NERVOUS SYSTEM.

So far as we have now studied the body we have its framework and the muscles which are to give motion to its various parts. We have learned *how* the muscles act, and now comes the question: What causes them to act as they do? We have learned of the obedience of the voluntary muscles to the will. But how does the mind or will direct them *when, how much, and how long* to act? For the purpose of enabling the mind to control the action of the muscles, a very interesting system of organs is provided in the body, namely, *the nervous system*. This plate gives us an excellent view of it.

The Brain. The *brain* is, in many respects, the most important organ of the body. It occupies the loftiest chamber of the body house. (*Raise the face section and refer to the brain on plate.*) Here the mind—the invisible tenant or occupant of the body—seems to form its purposes and send out its orders to its hundreds of servants stationed at as many points, between top and toe. Here, also, it receives its messages of intelligence from the body and from the outside world. These messages may

bring it pleasure or pain; and they largely influence its decisions, its orders and its temper.

Structure. The brain is an exceedingly soft and delicate organ. If it were not enclosed in a triple sac and nicely fitted into its bony chamber it would fall apart from its own weight. It is composed of two kinds of substance, one of which is *gray* in color and the other *white*. The outer portion of the brain is composed of the *gray matter*. The white matter occupies the inside portion.

Protection to the Brain. The brain is surrounded by three coats or membranes. The one lying next to it is a delicate covering containing vessels which supply the brain with blood. This membrane takes its name from its purpose of careful protection; so it is called the *pia mater*—which means *a tender mother*. It lies very close to the surface, stretching over the little hills and dipping down into the little valleys, with which the outside of the brain is covered. Next to the *pia mater* lies a membrane so delicate that it was named after a spider's web—*arachnoid*. This membrane performs its work of protection by collecting from the blood a watery fluid to moisten the surface of the brain and prevent any possible friction. The outer coat is quite tough and substantial: so it is called the *dura mater*, or *hard mother*. It lies close to the inside surface of the skull bones. Now we can see how the brain is protected, for instance, against a blow on the head. The effect of such a blow would be diminished, first, by

the hair, then by the skin and muscles overlying the skull, then by the bone, next by the hard coat, then by the water coat, and finally by the soft coat—making no less than a half-dozen successive defenses against harm to the castle of the mind.

Divisions of the Brain.

The brain is divided into two parts, one of which is much larger than the other. These parts are shown here, in this section which represents the head as divided from top to bottom, close behind the ears. We will now refer to the manikin of the head, where we will get a very clear view of the size and position of these brain parts. (*Fourth section of the head.*) This (74) large upper brain is called the *cerebrum*. It fills the whole front and upper part of the brain-box. The small brain (75) is called the *cerebellum*. Notice that it lies behind and below the large division of the brain. When this small brain is cut through, its inner structure has this tree-like appearance (*shown on plate*), called the *arbor vitæ*.

Hemispheres.

Both the *cerebrum* and *cerebellum* are divided into two parts, called the right and left *hemispheres*. The lower parts of the two hemispheres are united by several small mysterious-looking organs, whose particular use has been a puzzle even to many wise heads, but which certainly have some special part to perform in the wonderful control of the mind over the body. The last section of the head (*turn to it*), which represents it as cut through from front to back, in the

middle, shows us the right hemisphere of both the larger and the smaller brain. The red vessels, in the figure, are *blood-vessels* which bring large quantities of the purest blood in the body to the brain, for a purpose of which we shall learn hereafter.

Work of the Cerebrum. From many observations and experiments which have been made by physiologists, it has been learned that the large brain is the *thinking organ* of the mind. It is here that impressions received from the outside world are translated into thought and feeling. Here the purposes of the will are formed, and from here all orders for the action of the voluntary muscles are issued.

Work of the Cerebellum. The work of the small brain seems to be to regulate the muscular movements which are directed to be made by the large brain. It has been discovered that when the cerebellum is injured, a person can not balance the body, as is required even in standing and much more in walking. A bird whose small brain is seriously injured or removed, can move its wings and its legs, but it can neither fly nor walk.

The Spinal Cord. The nervous matter of the brain is continued down through the back, passing through openings in the bones of the spinal column. This is called the *spinal cord*. Here (131, last section of the head) is where the spinal cord begins. This (124) upper part of the cord (*medulla oblongata*) is a very important part of the

nervous system, for the reason that it seems to have control of some of the most vital operations of the body. When it is injured, the breathing muscles fail to act, which, of course, means instant death. Here (150) we see the spinal cord continued downward. Now we will turn again to the nervous plate of the Aid, where the whole of this great nervous cord is shown with its numerous branches of nerves.

The Nerves. The nerves are composed of the same substance as the brain. They are silvery threads which branch out from the brain and spinal cord and are distributed to all parts of the body. Twelve pairs pass out through openings of the cranium. These are called *cranial nerves*. Thirty-one pairs pass out from the spinal cord through openings of the back-bone, as shown on the plate. These are called *spinal nerves*. The cranial nerves go to the eye, ear, nose, tongue and other important organs. The spinal nerves go to the arms, trunk and legs.

Besides the nerves which branch out from the brain and spinal cord, there is, on each side of the back-bone, a chain of nerve centers—little bits of brains, as it were—running down through the body. From these small nerve knots, delicate nerves run out, some to the heart, lungs and stomach, and others to the blood-vessels and to the cranial and spinal nerves. So all the important organs of the body are, in this way, connected with each other and with the brain. This figure (*The Sympathetic System*) shows,

beautifully, this wonderful nervous connection. The interesting object of this arrangement—which is called the *sympathetic nervous system*—we shall soon learn.

There are three kinds of nervous action. We will first consider the relation between mind, brain and nerve. The nervous system is very much like a telegraph system. The mind has been called the operator, the brain and spinal cord the sending or receiving offices or instruments, and the nerves the wires or lines running to all parts of the body. The comparison is very apt, indeed. One set of nerves runs *from* the brain or spinal cord to the muscles, so that every muscular fiber is in direct communication with headquarters. Now, wherever a muscle is to act, every fiber of it, in some mysterious way, gets a message over its nerve line, from the nervous capital, directing it precisely how much to contract or relax. For example, you make up your mind to close your eyes. The order is sent out over the nerve lines which go to the fibers of the circular muscle which we have found to lie around the eye, and promptly the eyelids close. The nerves which carry messages to the muscles are called nerves of *motion*. Another set of nerves are called nerves of *feeling*. They carry impressions from the body *to* the brain. These nerves are distributed so thickly near the surface of the body, in the skin, that it would be almost impossible to find a point on the body where the prick of

a pin would not be felt. If you touch your body on its skin surface anywhere, even with the fine point of a needle, you are sure to disturb one or more of the nerves of feeling. Quicker than thought they report the impression, according to the degree of its severity, to the brain, which, if the situation at the surface demands it, will promptly return an order, over the nerves of motion, to the muscles of the endangered part, to do their best to get it out of the way of harm. For instance, a mosquito may alight on your forehead so lightly as to make no impression on your nerves of feeling, and, consequently, you are not aware of it. But now he punctures the skin and touches a nerve with his wonderful little stiletto. The news of his attack has been received by the brain, and an order sent back for defense and protection. Quicker than thought your hand has come up and routed or crushed the little assassin.

But the impressions which the nerves of feeling carry to the brain and mind are not all alarming or painful. Many of them are impressions of comfort or pleasure. A gentle breeze fans your body on a hot summer day. Hundreds of nerves are telling it to the mind, which enjoys it as a pleasure. Light impresses the nerve of sight, and beautiful views of form and color are spread before the mind. Sound excites the nerve of hearing and the charms of music are enjoyed. Invisible particles from a rose come in contact with the nerve of smell and we are delighted with the fragrance of the flower.

**Reflex
Nervous
Action.**

If all the muscles were voluntary muscles, that is, if no movement of the organs of the body could be made without a special order from the mind, the continuance and enjoyment of life would be impossible. Every breath, every heart-beat, and many other operations of organs which can scarcely be dispensed with for even a few moments, would need to be constantly thought of and directed. Fortunately, the mind, and even the brain, is relieved from the ordinary control of the operations of organs upon whose regular and constant action our life depends. So the heart goes on beating, the lungs continue breathing and the stomach keeps on working, while the mind rests and the brain sleeps. Let us see how this is done.

The spinal cord may be regarded as a continuation of the brain. It is composed of the same two kinds of matter—white and gray. We may also look upon the spinal cord as a *deputy* brain. A deputy is appointed as a substitute for another, and empowered to act for him. An officer may have more duties to perform than he can personally attend to. So an assistant is given him, who is entrusted with certain lines of work for which he is held responsible. When serious questions or difficulties arise in the assistant's department of work, he appeals for special advice to the chief officer. So in the body, while the brain executes the orders of the mind, and controls the voluntary operations and movements of the body, the spinal cord is entrusted with the control of the

involuntary muscles which perform the work of the heart, lungs, stomach and other vital organs, *except in cases of emergency*. For example, when food comes into the stomach, certain movements of the walls of that organ are necessary. So the food makes an impression on the nerves which report its presence, not to the brain or to the mind, as a sensation, but to the origin center of those nerves, in the spinal cord. Here the cord exercises its authority and returns (reflects) an order over motor nerves to the muscles of the stomach to perform the needed service.

In the same way, the presence of impure air or the absence of air in the lungs causes impressions which are carried to the cord, which returns orders for the action of the breathing-out or breathing-in muscles, as the case may be. All these performances go on steadily, whether we are awake or asleep. But when an emergency arises, as, for instance, if the muscles of the chest are strongly resisted in their efforts to expand it, by outside compression, the news of the trouble is carried beyond the nerve centers of the cord up to the brain, where the mind quickly grasps the situation and promptly issues orders for the best possible measures of relief. A familiar illustration of reflex action is found in the flapping of a fowl whose head has been cut off. Its muscles which produce its violent motions are not in connection with the brain, and can not be controlled by it. Each fall to the ground produces an impres-

sion which starts from the cord a message for the repetition of these muscular movements. Even when it seems to have settled down quietly, if you touch its body the movements will be renewed.

Sympathetic Nervous Action. We have seen how the sympathetic nerves connect important organs with each other and each with the brain. So if one organ suffers, the others suffer more or less with it. When the stomach is distressed, the head aches. When the heart's action is excited, the stomach is affected. When the brain is impressed with the mind's sense of shame or modesty, the little blood-vessels in the skin of the cheeks swell out and are more than usually filled with blood, and we call this delicate expression of their *sympathy*, blushing.

Health of the Nervous System. We would naturally suppose that organs so delicately constructed, and yet so prominent in the operations of the body as those of the nervous system, would need the most proper care to prevent their derangement or injury. And so it is. The brain needs especial care. It needs rest at proper intervals; not only from severe application, but the complete rest of *sleep*. An overworked brain is a diseased brain. On the other hand, the brain must have a proper amount of exercise to keep it in vigor. Besides healthy and varied exercise, the brain needs pure blood regularly and in proper quantities. Too much or too little blood will paralyze it. Hence its dependence on the proper action of the *blood-circulating* system. Impure

blood will weaken its action. Hence its dependence on the blood-purifying system.

Severe excitement of the mind or long continued anxiety cripple the work of the brain, and finally result in insanity. A cheerful state of the mind is favorable to healthy nerves and long life. Consequently, all proper enjoyments, as the delights of music, pleasant changes of scenery, varied means of recreation and social pleasures, are like tonics to the nervous system first, and through it to the whole body.

There is no system of the body that is more severely outraged by the habit of drink and the use of narcotics than the nervous system. But this subject is so very important that it will be fully explained in a special chapter, after we are still better acquainted with the structure of the body.

OUTLINE.

THE NERVOUS SYSTEM.

- | | | |
|--------|---|--|
| WHAT? | { | <p>Consists of brain, spinal cord and nerves.
 Very soft and delicate in structure.
 Composed of white and gray matter.
 The large brain called the cerebrum.
 The smaller brain the cerebellum.
 Right and left halves of brain—called hemispheres.
 Nerves of two kinds, nerves of sensation or impression and nerves of motion.</p> |
| WHERE? | { | <p>Brain enclosed in cranium.
 Spinal cord extends from base of brain through the spinal canal of back-bone.
 Nerves branch out from the brain, spinal cord and the sympathetic nerve knots, and are distributed to all parts of the body.</p> |

- WHY? {
- To serve the mind in directing the voluntary movements of the body.
 - To control, by reflex action, the involuntary muscles.
 - To bring to the mind, from the body and from the outside world, impressions producing the sensations or feeling of touch, taste, light, sound, smell, pain or pleasure.

QUESTIONS.

- What are the organs of the nervous system?
- What position in the body does the brain occupy?
- Whose special instrument does the brain seem to be?
- What can you say of the brain's structure?
- What difference in the color of its substance?
- Describe how the brain is protected.
- What is the cerebrum?
- What is the cerebellum?
- What is the arbor vitæ?
- What is meant by the hemispheres of the brain?
- What can you tell of the work of the cerebrum?
- What seems to be the use of the cerebellum?
- Where is the spinal cord?
- What is its upper part called?
- What makes this part so very important?
- What are the nerves?
- From where do they start?
- Where do they go?
- How many pairs pass out from the skull?
- What are these nerves called?
- How many pairs branch off from the spinal cord?
- What are these called?
- Where do the cranial nerves chiefly go?
- To what part are the spinal nerves chiefly sent?
- What can you tell of the sympathetic nerves?
- To what have we compared the nervous system?
- Tell what you can of the comparison.
- Do all the nerves perform the same kind of work?
- Explain what is meant by the nerves of motion.

- What is meant by the nerves of feeling?
 Does the mind attend to all the movements of the body?
 If not, will you explain your answer?
 What kind of muscles are controlled by the nervous system independently of the mind?
 What is such nervous action called?
 Can you give an example of reflex action?
 What is sympathetic nervous action?
 Can you give an example of it?
 Why does the nervous system need special care?
 What kind of exercise is needed by the brain?
 By what habits are these organs especially injured?

THE SPECIAL SENSES.

Nerves of Common Sensation. All the sensory nerves except four, are nerves of common sensation. They are distributed everywhere throughout the body. They need no special organs to enable them to receive impressions. Near the surface of the body or in the skin, they end in little folds or loops called *papillæ*. All the nerves of the sense of touch are nerves of common sensation.

Nerves of Special Sensation. There are four nerves of special sensation. These are the nerves of sight, hearing, smell and taste. Each of these nerves has a special organ without which no impression can be received to be carried to the brain. These organs are very delicate and wonderful structures. They are really special instruments of the nervous system.

THE EYE.

(Third Section of Head Manikin.)

This (46) is one of the nerves of special sensation—the *optic nerve*, or nerve of sight. It connects with and terminates in the eye. This nerve is impressible only by light. Without the eye, the light would not impress it. The eye is an instrument to gather the light which is reflected to it from objects and to bring it to bear on the optic nerve in such a way that an impression is made and carried to the brain, where the mind receives the impression as a picture of the objects from which the light came. How all this is done is very mysterious. But the organs which are concerned in the process can be easily examined and studied.

Let us notice, first, that the eye is lodged in a deep socket of the bones of the head. Besides this feature of protection, there is placed behind and around the eye, quite a layer of fat, so that, even if the eye is struck, the force of the stroke is very much lessened by this fatty cushion. In front, it is guarded by the eyelids, eyebrows and eyelashes. The eyelids serve as a curtain. The eyebrows prevent the perspiration from running down from the forehead upon the lids. The eyelashes prevent dust from entering between the eyelids.

*(Manikin of the Eye.)***Tear Apparatus.**

Turning aside this outer section which represents the natural open eye, we see a gland lying in the outer corner above

the eye. This is called the *lachrymal* or tear gland. It secretes from the blood a watery fluid which it pours out upon the eyeball. By the act of winking the eyeball is entirely bathed by this fluid, which after it has flowed over the eye, collects in a little lake at the inner angle, from whence it is drained by two little channels (2) into the *tear duct* (1) which communicates with the nose. Shedding tears is simply an overflow of this eye-bathing fluid, when it is secreted in unusual quantity. At such times the little channels cannot carry it away sufficiently rapid; so it flows over upon the cheeks. This unusual activity of the tear gland may be produced by certain states of the mind, as sorrow or great joy; or by certain diseased conditions of the parts about the eye, as an inflammation or a severe cold.

The White Coat of the Eyeball.

The eyeball has three coats. The outer coat, or white of the eye, is called the *sclerotic*. It is a strong, tough membrane which forms quite a substantial case into which the *cornea* is set in front, like the glass or crystal of a watch. The sclerotic coat is not sensitive; that is, it has no nerves of feeling. But it is covered, in front, with a very delicate membrane which contains very fine blood-vessels and nerves. When these little blood-vessels become swollen with an unusual amount of blood, the eye is said to be "bloodshot;" and when a cinder or dust grain lodges on the eye and makes an impression on the delicate nerves of this fine protecting veil, the sen-

sation is very painful. No light passes through the sclerotic coat; but the cornea is very transparent.

The Black Coat. Next to the tough outside white coat lies the *choroid*. This is a soft black membrane. It prevents the reflection of strong light from the inner surface of the eyeball, and this serves an important part in making the sight sharp and clear. The front part of the choroid coat is arranged like a circular curtain. This is called the *iris*. This is what gives the eye its so-called color. The difference between a black eye and a blue eye is, that the cells of the iris of the one have a black coloring matter in them, while the cells of the iris of the other contain blue coloring matter. In the center of the iris is a circular opening called the *pupil* which you can see by looking directly into the eye of another person who stands close before you. Through this little circular window, surrounded by the curtains of the iris, the light must pass on its way to the back inner part of the eyeball. The amount of light which passes through the pupil is regulated by an interesting action of the iris. When the light is strong, the little muscles which are threaded through the curtain produce the effect of making the pupil smaller so as to pass less light. When we go from a light place into a dark, these same muscles bring about an opposite effect, that is, the pupil is made larger so as to admit more rays. This adjustment of the curtain of the eye is not instantly done. It requires some time. This you can

THE SPECIAL SENSES.

easily observe. For, in going from the dark into a very light room you can not see well until the change in the size of the pupil-window of your eye has been made. So, also, when going from a bright room into a dark place, at first it seems to be "pitch dark;" but, by and by, when your eye is adjusted to the change, you may be surprised to find that it is not so dark after all.

The third or inner coat of the eye is **The Nervous Coat.** *the retina.* This lies only over the back part of the inner eyeball. It is really the end of the optic nerve, or nerve of sight, spread out to receive the impression of the light in the eye. By turning to the last section of this eye-manikin, we find this clearly represented. Here is a small part of the white coat of the back part of the eyeball. It shows the opening (23) where the optic nerve enters through this coat. Turning down the section which lies just before this, we see the opening (21) for the nerve through (22) the choroid coat. Turning forward another section we come to the retina (15) into which the nerve is expanded and over which the blood-vessels (19, 20) which enter the eyeball with the nerve, are distributed. The retina is an exceedingly delicate nervous screen on which the action of the different parts of the eye makes a picture of the object we look at. How this picture is carried by the nerve to the brain and there grasped or perceived by the mind we do not understand.

(Sense of Sight.)

The Humors of the Eye. Between the cornea and the iris, in the front part of the eye, is a watery fluid called the *aqueous humor* (18). Back of the iris lies the *crystalline lens* (23). This is a beautiful gem-like little body—as clear as a crystal. Back of the lens, and between it and the retina, the eyeball is filled with another clear jelly-like substance called the *vitreous humor* (25). The effect of these three humors which are contained in the eye, and especially the effect of the lens, is to produce the image of things on the retina, as has already been mentioned.

(Third Section of Eye Manikin.)

These muscles, which are shown to be attached to the outer sclerotic coat, produce some of the principal movements of the eye—upward, downward, inward and outward. By the way, we also mention that the action of the muscles of the iris in regulating the size of the pupil, is an interesting example of what we have already learned to name reflex nervous action.

THE EAR.

The Nerve of Hearing. The nerve of special sensation which goes from the brain to the ear is called the *auditory nerve*. As the nerve of sight is sensitive only to light, this is sensitive only to sound. The ear is an instrument to collect sounds and bring them to bear on the auditory nerve in

such a way that an impression is made and carried to the brain to be recognized by the mind.

The ear is divided into the *outer, middle* and *inner* ear. The outer ear has a more or less cartilaginous frame. This allows motion, and, at the same time, keeps it in shape and position. It has also a few small muscles. But in the human ear these are nearly altogether useless, since men do not move or flop their ears. In animals which move their ears in various ways, these muscles are quite well developed.

(Sense of Hearing.)

The Middle Ear.

From the outer ear (1) a tube, a little over an inch long, called the *auditory canal* (2), leads in to the middle ear, where it is closed by a membrane called the *membrana tympani*, which means the membrane of the tympanum or drum (3). The middle ear is often called the "ear-drum," and the membrane just mentioned may be called the "drum-head," for it does, indeed, act very much like the head of a drum. Between this membrane of the drum and its inner, opposite side or end, there is stretched a very curious little suspension bridge of four small bones. The first of these is attached to the drum-head, and from its shape like a hammer is called the *malleus* (4). The next is called the *incus*, because it is shaped like an anvil (7). The third is a very small pebble of a bone called the *orbicular* or round bone (10). It

is followed by the *stapes* or stirrup bone (12), the last span in the little bridge. This rests against a small window-like membrane which is stretched over an opening in the inner side of the drum. At the bottom of the ear-drum or middle ear is an opening into a tube which leads from the ear to the throat. This is called the *Eustachian tube*. Its object is to supply the ear-drum with air, for without air inside to balance the pressure of the air on the outside of the drum-head, the action of the latter would be very imperfect and our hearing, in consequence, very dull. We frequently experience the truth of this statement; for whenever the *Eustachian tube* becomes clogged, as in the case of a very bad cold, our hearing is very much impaired.

The Inner Ear.

The inner ear is carefully hidden in a hollow place in the solid bone. In that part of it which lies next to the middle ear, is a little hall-way, or *vestibule*, about as large as a grain of wheat. This leads, on one side, into the arched or semi-circular hall-ways which are called the *semi-circular canals* (13, 14, 15). On the other side the vestibule opens into the *cochlea* (16, 17), which is shaped like a snail shell or a tiny winding stair. Here the auditory nerve, or nerve of hearing, takes up the impression of a sound and transmits it to the brain.

How We Hear.

All sounds are produced by the vibrations of bodies. To make this plainer, when a bell is struck its particles are

thrown into a violent trembling. By these tremblings or vibrations of the material of the bell the air is thrown into a wave-like motion all around it. When these trembling air waves reach the ear, the sensation of sound is produced and we say we hear the bell. When a person speaks to us the voice chords in his throat are set into rapid vibration. These vibrations produce waves of sound in the air; the air carries these waves to the ear, where, passing in through the auditory canal they tremblingly beat upon the drum-head; this carries the sounds to the bridge of little bones. Having passed over these, it enters the vestibule, then vibrates into the semi-circular canals and rebounds into the cochlea, where, as already stated, it is taken up by the nerve and carried to the brain where the mind interprets it as the voice and the language of the speaker.

THE SENSE OF SMELL.

The organ of smell is the nose and its cavities. The nerve of smell is called the *olfactory nerve*. This nerve is spread out in many branches over the delicate mucous membrane which lines the inside of the nose. To make the surface on which the nerve of smell is distributed as large as possible, there is set into the nostrils, against the outer walls, a pair of scroll-like bones. These are the *turbinated bones* of the face. Over their winding surfaces, covered with the mucous lining, the nerve of smell is spread. The two small nasal bones unite the nose to the

skull and keep it in shape. The lower part of the nose is shaped by a frame of cartilage, the advantage of which over a nose-frame of solid bone you can readily see.

**How We
Perceive
Odors.**

Things which have an odor, or smell, give out little particles of matter, altogether invisible. As these float in the air, they are drawn into the breathing passages of the nose and mouth at every breath. Of course those which pass with the air into the mouth can make no impression of smell, for there are no nerves there which are affected by odors. But those which pass into the nostrils strike upon the olfactory nerve branches which, as we have seen, have their special location there. The mind, receiving these impressions, recognizes the odor, which may be feeble or strong, agreeable or very unpleasant.

The sense of smell affords us protection in two important ways. Its organ, the nose, is set at the very gates of entrance of the air we breathe and the food we eat. So when the air is filled with putrid or offensive invisible matter, which, of course, would make it unfit to breathe, we are cautioned by the sense of smell, and instinctively turn away and seek a purer air to breathe. Likewise, we are often warned, just in time, against putting into the mouth, as food, substances whose odor betrays their unfitness to be eaten. Fortunately it is so provided in nature that poisonous and other harmful substances

have generally a strong and peculiar smell, although this is by no means always the case.

THE SENSE OF TASTE.

The special nerves of taste have their **The Tongue.** loop-like endings chiefly in the tongue, which is, consequently, usually spoken of as the organ of taste. But these papillæ, or end expansions of the nerve of taste are also distributed over the walls of the back part of the mouth. On account of the numerous little folds of nerve endings on the tongue, this organ has quite a velvety appearance. Besides serving as the chief organ of the sense of taste, the tongue also aids in the chewing of the food and in producing the sounds of speech.

How We Perceive Taste.

When substances which have a taste come in contact with the papillæ or nerve loops of the tongue, the impression is at once carried to the brain and mind. In order that such an impression can be made the substance to be tasted must be in a dissolved state. No dry or solid substance can be tasted. So the mouth is kept moist, and, as we shall learn later, during the process of eating, a large quantity of saliva is thrown into the mouth. This dissolves at least a portion of the food or substance which is in the mouth, so that its taste is well perceived. When the mouth is dry from disease, or from great thirst, food has but little taste and is very unpalatable. So when the nerves of the tongue

are covered with a strange coat, as in disease, our food does not taste natural.

OUTLINE.

ORGANS OF THE SPECIAL SENSES.

WHAT ?	{	Eye—the organ of sight. Ear—the organ of hearing. Nose—the organ of smell. Tongue—the organ of taste.
WHERE ?	{	Eye—under arch of frontal bone. Ear—in hollow of temporal bone. Nose—at entrance of air and food passages. Tongue—lies on the floor of the mouth.
WHY ?	{	Eye—to collect rays of light from objects and produce a picture or image of such objects on the expansion of the nerve of sight. Ear—to collect sound waves and convey them to the nerve of hearing. Nose—to bring odorous matter in contact with the nerve of smell. Tongue—to bring substances having taste in contact with the nerve of taste.

QUESTIONS.

- Where are the nerves of common sensation distributed ?
 How many nerves of special sensation are there ?
 Can these nerves receive impressions directly ?
 What is the special instrument of the nerve of sight ?
 What is the proper name of the nerve of sight ?
 By what only is it impressible ?
 What is the use of the eye ?
 How is the eye protected by its position ?
 What other means of protection are furnished it ?
 What is the use of the lachrymal or tear gland ?
 Where is this gland situated ?
 After bathing the eye, how is that fluid drained away ?
 What is meant by “shedding tears” ?
 What conditions of mind and body may cause this

- How many coats has the eyeball ?
What is the nature of the outer coat ?
What is the cornea ?
Is the white coat of the eye sensitive ?
How do you account for the pain felt when a cinder lodges
on the eye ?
What is meant by the eye being "bloodshot" ?
Does light enter the eye through the white coat ?
Through what does it enter ?
What is the color of the middle or choroid coat ?
What purpose does it serve in the eyeball ?
Where and what is the iris ?
What gives the eye its color ?
What is the pupil ?
How is the pupil regulated to admit more or less light ?
Where and what is the retina ?
What is formed by the eye on the screen of the retina ?
What humor lies between the cornea and iris ?
Where and what is the crystalline lens ?
What humor occupies the back part of the eye ?
Which of these parts is most effective in collecting the light
on the retina ?
-

- What is the nerve of hearing called ?
By what only is it impressible ?
What is the work of the ear ?
Into what parts is the ear divided ?
What tube leads from the outer ear to the "drum" ?
Describe the ear drum.
What is the use of the Eustachian tube ?
What are the parts of the inner ear ?
By what are all sounds produced ?
Describe the course of sound-waves from a sounding body
through the ear to the nerve of hearing.
-

- What is the organ of the sense of smell ?
What is the name of the nerve of smell ?
To what is this nerve sensitive ?
Against what does the nerve of smell afford us protection.

- Where are the extremities of the nerve of taste located ?
What gives the tongue its velvety appearance ?
Why are dry or solid substances tasteless ?
What provision is made to make food more perceptible to the taste ?
Why does food have no taste to us when we are sick ?
-

THE CIRCULATORY SYSTEM.

Besides the material which the body needs for its growth, during twenty years or more, it is constantly exposed to wear and tear, and, consequently, it must be supplied continually with material for repair. It is impossible altogether to avoid the wearing out of parts of the body. Some of the muscles, like those of the heart, for example, are on constant duty. Every contraction of a muscle destroys a part of its fiber. The nervous system is also constantly suffering wear. The slightest effort of body or mind produces damage which must be made good to maintain our strength. The simplest thought which occupies the mind lays a tax on the structure of the brain. Either a wink or a whisper destroys muscular fibers. If even these gentle movements are wearing, how great must be the destruction throughout the body, by labor which exercises vigorously the brain and many muscles.

So a system of organs is provided in the body, whose work it is to carry to all parts a supply of

material as may be needed for building or repairing. This is the *circulatory system*. The blood—a bright red fluid with which we are all familiar—floats the building material through the channels and reservoirs of the circulatory system. As the building of a house requires many kinds of material, such as wood, stone, iron, glass, lime, sand and putty, so the structure of the body calls for materials suitable for bone, muscle, nerve, hair, nails, and so on. All this variety of material is carried by the blood in its ceaseless rounds through the body.

Organs of the Circulatory System. The organs and vessels of this system are the *heart*, the *arteries*, the *veins*, and the *capillaries*. The plate before us shows the heart in its position, and gives us a very good idea of the manner in which the arteries and veins run to and from every part of the body. The figures of the right arm and right leg are so drawn by the artist as to show us chiefly the *veins* of these limbs, while the figures of the left arm and left leg show chiefly the *arteries*.

The Heart. The heart lies near the center of the chest, a little to the left of the middle line. A man's heart is about as large as his fist. It is a very strong muscular pump or engine and does an enormous amount of very important work, as we shall soon see. It has four chambers—two on each side. The upper chamber of the right side of the heart is called the *right auricle* (U); below this (W) is the

right ventricle. The *left auricle* (V) forms the upper chamber, and the *left ventricle* (X) the lower chamber of the left side of the heart. The upper and lower chambers—that is, the auricles and ventricles—are separated by valves, whose important use we will learn when we trace the course of the blood through the heart.

The Arteries. The *arteries* are the vessels which carry the blood in its course *from* the heart. All the arteries which distribute bright or pure blood from the heart for the nourishment of the body, are represented by red vessels on the plate. This large artery—the pulmonary artery (16)—carries dark or impure blood; so it is shown in blue. Of course the arteries near the heart are very much larger blood-channels than those farther out, where they divide as you see, into very many branches.

The Veins. The *veins* are the vessels which gather up the blood from all parts of the body and carry it to the heart. All the veins which bring dark, impure blood to the heart are represented by blue vessels in the figure. This (31) large vein—the pulmonary vein—carries pure blood; so it is shown in red. The veins near the heart are very much larger than those which are farther away. There are valves in the veins to prevent the blood from flowing or setting back in a wrong direction.

The Capillaries. The *capillaries* are very fine tubes connecting the arteries with the

veins. Their name comes from a Latin word which means *a hair*. It is difficult to imagine how numerous these little capillary blood-vessels are, and how well they are distributed to all parts of the body. You could scarcely prick your skin with a needle anywhere without bringing some blood to the surface; you are sure to pierce some capillary and cause it to leak.

**Blood Change
in the
Capillaries.**

In the capillaries are the landing places where the little cargoes of building material, which have been floated from the port of the heart through the arterial rivers, are unloaded and distributed to the thousands of little working cells, which are everywhere busy in building or repairing the body. At some places material for muscle is unloaded; at others material for bone, nerve or finger nail is wanted. In exchange for this new material which the capillaries distribute *to* the body, they take back *from* the body the material which has become old, worn out, and unfit for use. The consequence is that the blood which has come from the arteries into the capillaries red and pure, leaves them and gathers in the veins, dark and impure. It would be altogether unfit to make another round through the body without being purified; so the capillaries deliver it to the veins, and these carry it to the heart, which drives it to the lungs—one of the organs of another system—where its worn-out matter is unloaded, and it is again made fit to feed the body.

**The Course
of the Blood.**

We will now trace and learn the circulation or course of the blood in the body. This diagram* in the center of this plate will help us clearly to understand it. Here the heart (32) is laid open, showing its inner chambers and the valves between them. This large blood-vessel (16) is one of two great veins which empty the impure blood from the body into the right auricle of the heart. It is called the *ascending vena cava*, because it brings the blood from parts below the heart. Here (15) is the other of these large veins—the *descending vena cava*, bringing the impure blood from the upper parts. A valve prevents the blood from going back from the right ventricle into the auricle above. Here (21) is the *pulmonary artery*, which carries the blood from the right ventricle to the lungs. The blood is driven through this artery by the contraction of the muscle of the ventricle. Coming back from the lungs to the heart, the blood flows through this (23) *pulmonary vein*, which empties into the left auricle. From here it goes through a valve into the left ventricle. Now notice the thick muscle of the left ventricle. When this strong muscle contracts, the blood is forced out through this (24) great artery—the *aorta*, which branches out into many arteries and then into capillaries all through the body. It will be well for you to learn and trace the course of the blood in this way: Coming impure from the body, it flows into

* See plate showing "Formation and Circulation of the Blood."

the right auricle; then through the valve into the right ventricle; then through the pulmonary artery to the lungs; then through the pulmonary veins to the left auricle; then through the valve into the left ventricle; then through the aorta into many arteries; then into the capillaries; then into the veins, which return it to the heart.

Three Divisions of the Circulation. There are really three divisions of the circulatory system. The first is the course of the blood from the heart through the body *for building and repair*. The second is its course from the heart through the lungs *for its purification*. The third is a special course of a part of the blood through the liver. This is called the *portal circulation*. We see here (18) how several of these prominent veins gather the impure blood from these lower organs in the body, and, gathering into this (20) large vein, this blood is thrown into the liver, where it is partly purified, after which it is again collected by this upper (20) *hepatic vein*, which turns it, as you see, into the large (16) ascending vein, which goes to the heart.

Interesting Facts about the Circulation. The heart is, by far, the strongest muscular part of the body. No engine in the world, of its size, has so much strength. It beats about 100,000 times per day, 40,000,000 times per year, and in the life-time of an octogenarian 3,000,000,000 times without a stop! Its impulse is not only felt by its throbbing

on the walls of the chest; it may be easily felt at several other points quite remote from the heart itself, as, for instance, at the temples or at the wrists. These impulses, as felt at these places, are called the *pulse*. This index to the rate of the heart's action is very convenient to the physician, since it makes known to him at once any acceleration, retardation or irregularity of the blood's circulation.

**Health of the
Circulatory
System.**

The steady and thorough work of the organs of the circulatory system is very essential to life and health. Any cause which tends seriously to increase or diminish the normal rate of the heart's action is a thing to be avoided. The ordinary quickening of the flow of the blood, as in moderate exercise of the body, is not only harmless, but healthful. Here, again, exercise must be commended as a prime condition of a healthy circulation. Any part of the body which, from any cause whatever, remains comparatively unused, will not be supplied by the circulatory system with a sufficient quantity of pure blood to maintain its vigor. Such a part will therefore gradually wither and die. It follows that we need that kind of exercise regularly which will call into use all parts of the body, and thus prompt the flow of blood into every nook and corner of our physical structure.

OUTLINE.

THE CIRCULATORY SYSTEM.

WHAT? { Central organ, the heart.
 { Arteries, blood-vessels leading *from* the heart.

- WHAT? {
 Veins, blood-vessels leading to the heart.
 Capillaries, uniting arteries and veins.
 Three divisions of the circulation:
 From heart to lungs and back to heart, for purification—*pulmonary circulation*.
 From heart to body and back to heart, for nutrition—*systemic circulation*.
 From veins of digestive organs through liver, for partial purification—*portal circulation*.
- WHERE? {
 Heart in chest, near middle.
 Arteries, veins and capillaries distributed throughout the body.
- WHY? {
 To carry pure blood to all parts of the body.
 To gather up useless or waste material and carry it to the organs which remove it from the system.

QUESTIONS.

- What can you say of the "wear and tear" of the body?
 What is the object of the circulatory system?
 What is the use of the blood?
 What are the organs and vessels of the circulation?
 Where is the heart situated?
 About how large is the human heart?
 Tell what you can about its purpose.
 How many chambers has the heart?
 Where is the right auricle?
 Where is the right ventricle?
 Where is the left auricle?
 Where is the left ventricle?
 What are the arteries?
 What kind of blood do the arteries usually carry?
 What are the veins?
 Do they usually carry pure or impure blood?
 Why do the veins have valves?
 What are the capillaries?

- What changes in the blood take place in the capillaries?
By what large vein is the blood from the lower body brought to the heart?
By what large vein is the blood from the upper body brought to the heart?
What prevents the blood from flowing backward from the ventricle to the auricle?
What is the work of the pulmonary artery?
What of the pulmonary veins?
Why is the muscle of the left heart extra strong?
What is the aorta?
Now trace the course of the blood, beginning where it comes impure to the right auricle.
How many divisions of the circulatory system?
Why does the heart send the blood to the lungs?
Why through all parts of the body?
Why is a large part of the blood carried through the liver?
What is meant by the pulse?
What is the effect of exercise on the circulation?
May exercise become too violent?
How is the circulation affected in an unused part of the body?
What is the best kind of exercise?
-

THE RESPIRATORY SYSTEM.

We have learned that the blood in its course through the body is made quite impure and needs to be repeatedly purified. For this purpose the body is furnished with the *respiratory system*. The chief organs of this system are the *lungs*, which lie in the chest, close around the heart. Let us get a clear and accurate idea how these important organs are situated. (*Turn to the body manikin.*) Here is

a manikin of the body. We will remove the outer muscles of the chest. Now, the ribs are before us. Removing these, the contents of the chest are shown precisely in their natural places. These (8, 9,) are the lungs. The heart lies immediately under and between them.

Structure of the Lungs.

The lungs are very spongy and light, being composed largely of air-cells, whose walls are very delicate. These air-cells are all connected with tubes (*Turn to (25) third section of lungs*) and these tubes unite into this one large air-passage (24) called the *trachea* or wind-pipe. In the upper part of this wind-pipe, which comes close up to the mouth, the instrument of the voice, called the *larynx*, is situated. It is this (21, 22, 23), enlarged portion of the trachea. The exact structure of the larynx or voice-organ is shown by special sections above the lungs in the body manikin. This arrangement of these air-passages reminds one of an inverted tree. The larynx or voice-organ corresponds to the lower and thicker part of the trunk of the tree; the trachea to the trunk itself; the branching air-tubes in the lungs to the branches and twigs, and the air-cells to the leaves.

Use of the Lungs.

The pulmonary artery, which brings the impure blood from the heart into the lungs, branches out (18) into many small capillary tubes which wind among and around these numerous air-cells. When the cells of the

lungs are filled with air, the oxygen of the air, in a wonderful way, passes through the wall of the cell and the wall of the capillary and unites with the blood. At the same time, impurities from the blood pass through capillary wall and cell wall into the cells and out through the air-passages with the escaping breath. In this way the blood is renewed, purified and brightened by the life-giving oxygen, and starts vigorously off on another round through the body.

Breathing. Breathing is the act of the body by which the lungs are filled with air and emptied again at proper intervals. This operation is so important and essential to life, that it has been entrusted to the performance of muscles of the involuntary kind, that is, such as are not dependent on the direction of the mind. It is true, the will may interfere with the work of these muscles, so that we may suspend breathing to some extent. But it is Nature's plan that this work should be committed to faithful nerve-centers and muscles appointed for the purpose. It is well that this is so, for, otherwise, during sleep or other unconscious moments, when the mind gives no direction to the body, breathing would stop and life would end. Even when awake and in health, in this very busy age, we might *forget* to breathe.

**How we
Breathe.**

The scientific name for breathing is *respiration*. That act of respiration which brings air *into* the lungs is called

inspiration; that which drives the air *from* the lungs, *expiration*. There are quite a number of muscles concerned in these acts. When the lungs are to be filled, these muscles expand the walls of the chest so as to enlarge the space inside. The air rushes in through the mouth, nose and wind-pipe, and fills the cells. Then a reverse action is produced by the muscles. The chest contracts and the air is forced out from the lungs by the same way through which it entered, but robbed of its oxygen and mixed with gases discharged from the body.

Between the chest and abdomen is a broad partition muscle called the *diaphragm*. This muscle is chiefly concerned in ordinary, gentle breathing. When the lungs are to be filled, the diaphragm moves downward, pressing upon the contents of the abdomen and enlarging the cavity of the chest, giving the lungs room for full expansion, provided the act of inspiration is unrestricted and complete. In expiration, the diaphragm rises and diminishes the capacity of the chest, forcing the air out of the lungs. In forced breathing, the muscles between the ribs, called the *inter-costal muscles* (6, *rib section*), take a prominent part. These and other muscles also take more or less part in ordinary breathing.

Pleura. The inside of the chest is lined with a delicate web called the *pleura*. This is also spread as a covering over the lungs. It secretes a



watery fluid which keeps the walls of the chest and the surface of the lungs moist, and thus prevents friction which would otherwise be produced in the movement of breathing. The pleura is shown at (7 *on section of the ribs*). An inflammation of this membrane is called *pleurisy*. When both pleura and lungs are inflamed it is called *pleura-pneumonia*.

Health of the Respiratory Organs. From what we have learned of the structure of the chest and the action of the lungs in breathing, we can not fail to see that the healthy and natural action of the respiratory system requires perfect freedom of motion or expansion of every part concerned in the vital act of respiration. It is Nature's plan that every air cell in the lungs should perform its appointed part with all the rest, at every breath. If the habit of breathing, full and deep, while the chest is perfectly free to expand and the body is in erect or straight position, is well formed, every lung-cell will be filled at each inspiration. But if the chest is in any degree restricted and compressed, the lungs will be but partly filled, and many of the air-cells will lose their elasticity, and finally become utterly useless. Such an injurious interference with the natural expansion of the chest may be produced by habitual unnatural positions in sitting or walking, or by wearing the clothing too tight about the body.

Exercise. We have learned that the flow of blood through the vessels of the circulatory

organs is much quickened by exercise. So the rapidity of the flow of the blood through the lungs depends very much on the degree of our bodily activity. When we lie in bed, for instance, the circulation goes on very steadily, and our breathing is performed very moderately and quietly. But as soon as we arise and move about, both the circulation and respiration are quickened. The more vigorous the activity of the body the more air is drawn into the lungs to purify the greater quantity of flowing blood. The chest muscles act more strongly and every cell in the lungs is inflated. All this tends to produce pure blood and active lungs, and, consequently, good health.

Impurities of the Breath. The *quality* or *purity* of the air which we breathe is quite as important as the *quantity* which we inhale. We have learned that the oxygen, which is one of the elements or gases which compose the air, is taken from the lung-cells to unite with the blood. This alone would make the breath which is given out impure because of its having been robbed of its oxygen. But the air which is forced out from the lungs is made much more impure by the gases which come from the impure blood of the body. These gases escape from the lungs at every breath. It is plain that if we breathe in a close room or in a confined body of air, every breath adds to the degree of impurity of the air, so that the latter becomes more and more unfit to breathe. It becomes unfit to sustain life, not only

because it is robbed of the life supporting oxygen, but because one of the gases which are expelled from the body, by the breath, acts like a poison when it is inhaled (re-breathed) again.

Ventilation. Ventilation means the furnishing of the needed supply of pure air. Nothing is more important in the line of hygienic or health precepts than this, that we should avoid the breathing of air which has been made impure by the breath. To avoid this, it is necessary to have, at all times, a proper interchange between the air of a room and the pure, free air without. No person can remain long in a closed room without being injured by his own breath. There must be a place of escape for the impure air and a place of entrance for the pure air. Since impure air rises toward the top of a room, it escapes best from the opening of a window at the top, while pure air enters best through an opening lower down. But without attempting to describe any of the numerous plans of ventilation, let this precept suffice: Get from the abundance of pure air which God has provided, as much as you can at every breath, and avoid, as a poison, the inhalation of impure air.

THE VOICE.

The organs of the voice are so closely connected with the respiratory system that we will give a brief description of them here.

The chief organ of the voice is the *larynx*.

The Larynx. This is really an expansion of the upper end of the wind-pipe, as already seen. The prominent point on the front of the neck, commonly called "Adam's apple," is a part of the larynx. The cartilages of which the larynx is mainly composed form a sort of box, along whose two inner sides are stretched two membranous chords called the *vocal chords*. These come more or less closely together at the middle of the larynx, the slit or chink between them being called the *glottis*. Through this glottis every in-going and out-going breath ordinarily passes silently. But when the muscles which regulate the vocal chords tighten up these chords, while air is being expelled from the lungs, a sound is produced, either high or low, according to the degree of tension, or tightness, to which the vocal chords are drawn.

An Experiment. If you have learned to sing up and down the eight tones of the musical scale, you may easily perform an experiment on the action of the muscles which control the tension of the vocal chords. Sound slowly the syllables up and down the scale. You will feel a change in the contraction of the larynx muscles at every change of tone. Going up the scale, that is, to a higher and higher pitch, you will feel a tightening action of these muscles: coming down the scale to a lower and lower pitch, an opposite effect will be felt.

Speech. The action of the breath on the vocal chords which has just been described,

produces vocal sounds of different pitch. Their loudness depends upon the degree of force with which the breath is forced through the glottis. But this is not speech. To produce the articulate sounds of language, the sounds which are made by the vocal cords are very much modified and variously shaped by the changing position of tongue and mouth, which are produced in speaking. This is illustrated in every word we speak, and you will find it to be an interesting experiment to utter slowly the sounds which compose some word, while noticing the changes which you make in the position of your mouth and tongue.

OUTLINE.

THE RESPIRATORY SYSTEM.

WHAT ?	<ul style="list-style-type: none"> Lungs, very light and spongy, chiefly composed of air-cells. Trachea—commonly called wind-pipe. Larynx—upper part of trachea, and organ of the voice. Air-passages through mouth and nose. Chief respiratory muscles—the diaphragm and inter-costal muscles.
WHERE ?	<ul style="list-style-type: none"> Lungs—in middle of the chest. Trachea—between throat and lungs. Diaphragm—between chest and abdomen. Inter-costal muscles—between the ribs.
WHY ?	<ul style="list-style-type: none"> To furnish oxygen to the blood. To expel impurities which come from venous blood.

QUESTIONS.

- What is the use of the respiratory system ?
What are the chief organs of respiration ?
Where are the lungs located ?
Describe their structure ?
What is the trachea ?
What vessel brings the blood from the heart to the lungs ?
Tell what takes place in the lungs.
Is the act of breathing performed by voluntary or involuntary muscles ?
Why is this a wise provision ?
What is meant by *inspiration*? Describe the process.
What is meant by *expiration*? Describe the process.
What is the lining membrane of the chest called ?
What is the benefit of full and deep breathing ?
What are the consequences of cramping the chest ?
What is the effect of exercise on the lungs ?
How is the air made impure by breathing ?
Tell what you can of the necessity of ventilation.
Where are the vocal cords ?
How are the sounds of the voice produced ?
How is the pitch of the voice varied ?
How are the louder tones produced ?
What other organs assist in forming the sounds of speech ?

THE DIGESTIVE SYSTEM.

Where does the building and repairing material, which is delivered to all parts of the body by the blood, come from ? How is it prepared and how does it find its way into the blood-vessels of the circulatory system ? These are some of the physiological queries which come to us now.

The matter of the body all comes from our food. To provide our bodies with such material, of good quality and of proper quantity, ought to be the main object of our eating. Not all of the food matter which we eat is useful in the body. So the means of separating the useful from the useless is necessary. Then, again, the useful parts of our food must be very much changed before they can be used by the building cells of the body. So the means for its proper preparation must be furnished. The system whose organs prepare the needed elements of the food for the blood, and separate the useless from the useful portion, is called the *digestive system*.

The preparation of food material for the blood requires many operations. So the digestive system has a greater number of special organs than any other system of the body. We have seen how the movements and work of the circulatory organs depend upon the strength and prompt action of the muscles of the heart; also, how the respiratory system depends upon the muscular system in the steady and proper action of the breathing muscles. So, here, as we study the processes of the digestive system, we shall find how its work depends upon the muscles which are assigned to the duty of producing the necessary movements of its organs. Even the muscles of the arm and hand perform the very first act in the process of feeding the body, in properly bringing the food to the mouth.

Body-building from Blood.

Aid of the Muscular System.

The whole process of preparing food material for the blood is called digestion. The first step, that is, bringing the food into the mouth, is called *prehension*.

Work of the Teeth.

The second step in digestion is *mastication*. This is performed in the mouth by the *teeth*. The mouth and the teeth, as used in chewing or masticating the food, have been called the *mill of the body*. The grinding in this mill is done by the muscles which move the jaws so as to produce a cutting, crushing or grinding effect upon the food by the teeth.

Number of Teeth.

There are thirty-two teeth in the full set of a grown person. These are set in sockets of the upper and lower jaw-bones—sixteen in each jaw. Eight front teeth—four in each jaw—are called *incisors*, or cutting teeth. On each side of these incisors—above and below—is a *canine* tooth. The two upper canines are often called *eye-teeth*, and the lower canines, *stomach-teeth*. These twelve teeth—eight are incisors and four canines—separate or bite off a proper portion from the food which is brought to the mouth. Next to the canines are two *bicuspid*s, on both sides of each jaw. Bicuspid means having two roots. Then follow, as back teeth, three *molars* or grinders on both sides of each jaw. These twenty teeth—eight bicuspid and twelve molars—do the work of crushing or grinding the food to a proper degree of fineness.

As we have already learned, a tooth is not a bone. It does not belong to the skeleton. The teeth are instruments or organs of the digestive system. The structure of a tooth is an interesting study. To help us understand it, we are provided, in the Anatomical Aid, with the means of completely dissecting—that is, separating into its parts, the structure of a tooth. In the manikin of a tooth, the little projecting ridges at the top (1) are called *tubercles*. The portion above the gum (2) is called the *crown*. This is covered by a thin layer of *enamel*, the hardest material in the body. The tooth is mainly composed of a substance called *dentine*, or ivory (9). At (6) and (7) the roots of the tooth are shown. At (12) blood-vessels and nerves are seen to enter into the tooth. When an opening occurs in the body of the tooth, from decay, this nerve is exposed to the air and the action of food particles, and toothache is the result.

Work of the Salivary Glands.

The third step in digestion is *insalivation*. Really, mastication and insalivation are performed at the same time. While the food is being chewed by the teeth, a liquid is mixed with it in the mouth. This liquid is specially prepared for this purpose, from the blood, by a number of organs called *salivary glands*. By the way, let us not forget that all the substances of the body are prepared from the blood. A *gland* is an organ which *secretes*—which means *separates*—some

special or peculiar substance from the blood. So, one of the glands of the eye secretes *tears*, and the salivary glands secrete *saliva*. Three pairs of these glands are quite prominent. The largest pair is just below and in front of the ears. The second pair, in size, lies under the jaw-bone, and the third pair is under the tongue. These glands, between meals, furnish enough saliva to keep the mouth moist. But when food is taken into the mouth and chewed, or even at sight of something tempting to the taste, they furnish it in great abundance. It not only moistens the food so that it may be easily swallowed, but it also begins the process of changing the food material.

**Work of the
Pharynx and
Esophagus.**

The fourth step in digestion is swallowing. This is a much more familiar word than *deglutition*, which is the scientific name for the same act. When the food has been properly prepared in the "mill of the mouth," it is swallowed, or sent to the stomach. The cavity back of the mouth is called the *pharynx*. Between the pharynx and the stomach (*refer to body manikin*) is this tube (35) called the *oesophagus*. By the action of the muscles of the pharynx and the oesophagus, the food is moved into the stomach. This is *deglutition*.

**Work of the
Stomach.**

We have now traced the course of the food into the main organ of digestion—the *stomach*. Here its greatest change is to be produced. The position of the stomach

should be well understood. Observe it carefully in this manikin (31). The stomach has three coats or walls. The outer coat is thin and smooth, and fitted for the protection of this organ in its contact with other organs. The inner coat—called the mucous wall—contains many little glands or cells, which secrete a substance which is very important in the process of digestion. It is called the *gastric juice*.

When food comes into the stomach the gastric juice is mixed with it. This intermixing is made quite thorough by the action of the muscles which compose the middle coat of the stomach. As long as there is food within it, these muscles keep up a churning motion of the organ. The result of the action of the gastric juice is that the food is very much changed in its nature and appearance. It is now called *chyme*, and the change which has been produced in the stomach, *chymification*.

At the right end or discharging opening of the stomach is placed a muscular valve called the *pylorus*. This name means *gate-keeper*. The pylorus is a door-keeper of the stomach. Such portions of the contents of the stomach which have been properly changed into chyme, it allows to pass out, but refuses passage to other portions. Much depends upon the faithfulness of this pyloric muscle. When from any cause it loses its power, or refuses to act, the food escapes

**Use of the
Gastric Juice.**

**Work of the
Pylorus.**

from the stomach before it is prepared to enter the intestines, which is a form of indigestion which soon destroys life.

**Work of
the Liver.**

The *Liver*, as the manikin shows, is a very large organ overlying the stomach. It weighs from three to four pounds. It is both a blood-purifying and a secretory organ. As a secreting organ, it performs its part in the process of digestion by furnishing a substance called *bile*, which it sends through a duct or tube into the *duodenum*, or upper part of the small intestines, where it aids in further change of the chyme which has just passed into the intestines from the stomach.

**Work of the
Pancreas.**

Back of the stomach lies the *pancreas* (59). This organ furnishes a fluid called the *pancreatic juice*, which is also brought into the duodenum. The action of the bile, the pancreatic fluid and the intestinal juice, is to change the chyme into *chyle*, and to separate the useless or waste portion of the food. This waste portion is carried out of the body by way of the intestines, and the useful portion, having undergone all the processes of digestion, is now ready to be given to the circulatory system for transportation to every point of demand. How the chyle is transferred from the digestive organs into the blood will be shown in the next chapter.

Health of the Digestive System. Perhaps no system of the body is more carelessly or more frequently abused than the digestive system. No system of the body brings back upon the abusing offender a severer penalty of discomfort. Proper digestion is the very first condition of good health. Hence the hygienic principles referring to this system should be carefully learned and regarded.

Eating Too Fast. The injury resulting from eating too fast comes chiefly from this, that the processes of mastication and insalivation cannot be properly performed. Unless the food is properly chewed, and thoroughly mixed with saliva, its digestion in the stomach will be either much retarded or left incomplete.

Eating Too Much. The capacity of the stomach is limited. If it is overloaded, it can not thoroughly digest its contents. Besides, the gastric juice is also limited in quantity, and will not completely change into chyme more than a proper portion.

Eating Too Frequently. Between the digestive operations of the stomach, it needs intervals of rest. If food is taken too frequently, it loses its vigor, and soon fails to perform its work in a healthy manner.

Eating Indigestible Food. Some articles of food, though very tempting to the taste, are very "trying" to the stomach. It is plain, that, if



these are too frequently eaten, the stomach's action will be greatly impaired. If eaten at all, they should be sparingly mixed with more digestible food.

Exercise. Gentle exercise is very helpful to digestion. But violent exercise, either just before or after a meal, is quite as injurious. A cheerful state of mind is very helpful in keeping up a healthy action of all the digestive organs.

OUTLINE.

THE DIGESTIVE ORGANS.

- | | | |
|--------|---|--|
| WHAT? | { | Teeth—32 in full set.
Salivary Glands—three pairs.
Muscles of Pharynx and Œsophagus.
Stomach.
Liver.
Pancreas.
Intestines. |
| WHERE? | { | Teeth—in sockets of jaw-bones.
Salivary Glands—located about the mouth.
Pharynx and œsophagus—funnel and tube—
between mouth and stomach.
Stomach—under diaphragm in abdomen.
Liver—overlying the stomach.
Pancreas—lying back of the stomach.
Intestines—filling lower abdomen. |
| WHY? | { | Teeth—to masticate the food.
Salivary Glands—to furnish saliva.
Muscles of pharynx and œsophagus move the food
from mouth to stomach.
Stomach—to change food to chyme.
Liver—to furnish bile.
Pancreas—to furnish pancreatic juice.
Intestines—to complete the work of digestion and
separate the chyle from the waste matter. |

QUESTIONS.

- From what does all the body material come?
What processes are necessary to fit food for body nourishment?
What is the name of the system which performs these processes?
What is the first act in the process?
What steps take place in the mouth?
How many teeth in a full set?
Name the different kinds of teeth.
How is the food conveyed from the mouth to the stomach?
Describe the work of the stomach.
By what means is the gastric juice well mixed with the food?
What is the food, as it leaves the stomach, called?
Describe the action of the pylorus.
What does the liver furnish for the work of digestion?
What is furnished by the pancreas?
What is the chyle?
What are the consequences of eating too fast?
What results from over-eating?
What from eating too often?
What from eating indigestible food?
What are the effects of exercise on the digestion?
-

THE ABSORPTIVE SYSTEM.

In previous lessons we have learned how food is prepared by the organs of the *digestive system* and reduced to a fluid state. Let us also recall what we have learned of the *circulatory system*; how the blood is constantly making the circuit of the body, carrying food to every tissue.

The sixth plate of the Anatomical Aid shows most admirably all the organs and parts concerned in the

two processes just referred to, and a careful study of this plate will enable us to understand their relation to and connection with each other. How, then, does the digested food get into the circulation? What provision is made for transferring it from the *alimentary canal* to these blood-vessels? To answer these questions, we must first study how food is absorbed.

Absorption. The food in its liquid form must in the first place be removed from the stomach and the intestinal tube. This is accomplished by a process called *absorption*. This work may be more easily comprehended by first referring to a similar process constantly going on in vegetable growths. Planted in good soil and supplied with water, a plant will send out its small rootlets, whose little mouths will drink in (*absorb*) mineral substances from the soil dissolved by the water. This liquid plant-food is carried by the sap (*vegetable-blood*) up the trunk or stem to nourish the parts of the plant. There is a similar provision for taking up the liquid food from the alimentary canal. There are little rootlets provided for this work whose action resembles that of the root-fibers of the plant.

Intestinal Villi. The inner wall or coating of the small intestines has a velvety or plush-like appearance. This is due to the myriads of little hair-like projections, which hang down from the inner walls and point toward the center of the tube. These small cones or fingers are called *villi*.

They are very numerous, covering the intestinal membrane as with a coat of hair. The word signifies *hair-like bodies*. These villi, which dip into the liquid contents of the alimentary canal, are not themselves the absorbents; but they *contain* small rootlets which take up the food and start it on the way toward the heart.

In each villus (*singular of villi*) there are two kinds of little workers gathering up different kinds of food particles from the liquid mass in the intestines. These are known as *blood-vessels* and *lacteals*, and are the starting points of two different routes by which the food is carried to the heart and into the circulation.

The blood-vessels or veins are arranged around the center of the villus, forming a sort of net-work. They all unite and form one large vein, plainly shown here on the Aid (20). *This vein is called the portal vein.*

The route by which the blood and food carried by the *veins* reach the heart constitutes the *portal circulation*, which we will now consider a little more fully. The portal vein (20) empties its contents into the *liver* (33) from below, and divides and subdivides, finally forming the capillaries of the liver. The structure of the liver is shown by the Aid at (18) (*under microscopic structure of the textures*). In the liver an important

process takes place. The bile is secreted from the venous blood, and stored up in the gall-bladder, to be used when needed in the digestion of food. The blood, after being robbed of its bile and changed in other respects not well understood, is again collected and carried upward by the *hepatic vein* (20) and emptied into the lower *vena cava* (16), which in turn pours it into the heart, as shown here by the Aid. This completes the *portal circulation*.

The Second Route.

Now let us go back to the same starting point, and trace other portions of the digested food by *another route*; but which will ultimately lead to the same cavity of the heart.

At this point we should observe how nicely every organ of the body is adapted to perform its own specific work. The blood-vessels spoken of under a preceding head take up from the stomach and intestines only *certain portions* of their contents, to do which, they seem especially adapted. Other portions are absorbed by the *lacteals*, which seem to be particularly suited for *this* purpose.

Lacteals in the Villi.

Extending lengthwise through the center of each little villus, surrounded by the meshes of the small veins just described, is a single minute duct or rootlet called a *lacteal*. *Lac* means milk, and it is owing to the milk-like appearance of their contents that the term *lacteal* is applied to these vessels.

**Chyliferous
Vessels and
Lymphatic
Glands.**

As in the case of the blood-vessels, which are the beginnings of the *portal circulation*, so the lacteals unite and finally form the *thoracic duct* (10). Just as small creeks flow together and form larger streams, so the lacteals form *chyliferous vessels*, which are shown here at (7) on the Anatomical Aid. These vessels carry the chyle absorbed by the lacteals through numerous glands called *lymphatic glands* (6), and finally empty it into the *chyle receptacle*, which is seen here at (9).

**Thoracic
Duct.**

The chyle receptacle is a sac-like expansion of the lower end of the *thoracic duct*, which is about as large as a slate pencil or goose quill. The direction in which it carries the chyle is very plainly seen by referring to the Aid. It passes upward in front of the spinal column and behind the œsophagus (2). At its upper end it bends forward and downward, something like the crook of a walking cane, and pours its contents into the left subclavian vein. From this point the chyle passes into the *innominate vein* (14), and then through the upper *vena cava* (15) into the right auricle of the heart.

**What Has
Been Done.**

Thus we have traced the different substances of which the digestive food is composed by different routes to the same cavity of the heart, there to mingle with each other, and with the impure blood collected from all

5. Being fatty substance, it is absorbed chiefly by the lacteals.

6. The *chyliferous vessels* (7) carry it through the *lymphatic glands* (6) into the *chyle receptacle* (9).

7. The *thoracic duct* (10) empties it into the subclavian vein at 11, by which it reaches the right auricle of the heart.

8. From this point the two kinds of food travel together toward the outposts of the body, carrying nourishment wherever needed.

THE LYMPHATIC VESSELS.

Lymph.

Besides the blood which is found circulating in all parts of the body, there is another fluid, almost colorless in appearance, which is also found widely distributed throughout the system. This fluid is called *lymph*, which signifies *transparent fluid*. In composition the lymph closely resembles the plasma of the blood, and contains minute bodies or corpuscles resembling the white corpuscles of the blood; these are called *lymph globules* or *lymph corpuscles*.

Origin of Lymph.

This fluid is supposed to be mostly worn-out materials gathered from all parts of the body. It consists probably of portions of blood-ingredients which have oozed through the walls of the arteries, veins and blood-capillaries, together with certain products of the combustion which takes place in the body. These substances are gathered up by tiny vessels, and, after

being worked over in a manner not well understood, they are capable of further use in the body. Thus we see a wise economy in allowing nothing to go to waste which can in any way be put to further use. This reminds us of the economy practiced in sifting coal ashes taken from our stoves and furnaces, saving therefrom such partly burned coal as may be capable of giving off more heat if put into the fire again.

The Lymphatics. The vessels which carry the lymph just described are called *lymphatics*. They are more delicate in their structure than the veins and arteries and permeate every part of the body. Wherever blood capillaries are found, there *lymph capillaries* are also found, though on account of their minute size they can not be seen until injected with mercury or some colored fluid. They vary in number with the variation of the number of blood vessels.

The Lymphatics, a System of Drainage. The functions of the lymphatics of the system may be regarded as similar to those of tiles, or drain pipes, which farmers so frequently lay in wet, swampy lands for the purpose of carrying off the surplus water. The water soaks into these tiles, which carry it off under ground, thus drying the field. Likewise the surplus fluids which collect in all parts of the body are absorbed by the lymphatics—the drain pipes of the body—which unite, forming larger vessels, which empty into the thoracic duct, with the contents of which the lymph reaches the heart.

The Lymphatic Glands.

In all parts of the system the lymphatics pass through small bodies called *lymphatic glands*, which vary in size from that of a pin-head to an inch in diameter. It is not definitely known what the function of these glands is; but it is probable that they renovate or *work over* the waste and surplus material brought to them by the lymphatics, and that the *lymph globules* originate in them. Whether this is true or not, there can be no doubt that these glands are essential to health; because, when they become hardened or inflamed, as is often the case in persons of a scrofulous tendency, health fails and the patient grows thin and emaciated, even though his diet may be of the proper kind and quantity.

The Lacteals, a Part of the Lymphatics.

The *lacteals*, which we have considered in connection with the absorption of the food from the *alimentary canal*, are a part of the lymphatic system. They constitute that portion which begins in the villi of the intestines. When the process of digestion is completed, they serve as *drain-pipes*, like the lymphatics in the system at large. Their special work, however, is that in connection with the absorption of fatty food through the walls of the intestines.

The Lymphatics Compared With the Blood-Vessels.

We have learned how the blood "circulates;" how it starts from the heart and after making the complete circuit, is brought back to the heart again. We

have learned also that the blood-vessels both give off tissue-making substances and take on waste and worn-out material, which they carry away. In contrast with this the lymph does *not* "circulate." It is carried *toward* the heart, where it enters the life-giving stream—the blood. In the lymphatic system there are, therefore, no vessels to correspond with arteries. Again, the *lymphatics* collect worn-out tissues, etc., but give nothing in return.

Other Functions of the Lymphatics. The work of the lymphatics is not confined to the absorption of food from the intestines and collecting surplus and waste materials from the system in general. Certain other phenomena, all of which are of interest to us, are due to the absorbing power of these vessels. For instance, when a poisonous substance is placed upon the skin the lymphatics at once *absorb* it and carry it into the circulation. The lymphatics of the lungs take in the poison of disease and diffuse it throughout the system. When the appetite fails during long-continued illness, life is sustained by the unconscious consumption of one's own flesh, which is absorbed by the lymphatics and carried out into the circulation.

In a similar manner, as we will learn further on, the poisonous nicotine of tobacco is absorbed in the lungs and the system poisoned. Thus we see that these vessels, which are ever active, take up, indiscriminately, foods, poisons, medicines, or the waste of worn-out material.

**Suggestions
to the
Teacher.**

In concluding our consideration of the *absorptive system*, let it be suggested that the *Anatomical Aid* be constantly referred to. In all topics discussed, it will be an *Aid* indeed, and the work be made incomparably more effective.

OUTLINE.

WHAT?	{	Food is absorbed. It is conveyed to the circulation. Surplus and worn-out tissues are collected. They are renovated and prepared for use, and are again thrown into the blood to be used.
WHERE?	{	In the walls of the alimentary canal. In the system at large. In the tissue of the skin. In the cells of the lungs. Wherever blood-vessels are found.
WHY?	{	To collect and transfer material.

QUESTIONS.

- What is absorption?
 How do plants illustrate the manner in which food is taken from the intestines?
 What is there in plants to correspond with blood in animals?
 What gives the lining membrane of the intestines its smooth, velvet-like appearance?
 What do the intestinal villi contain?
 Describe their structure.
 What is the portal vein?
 Trace the food absorbed by the veins, from the intestines to the heart.
 How is the blood changed in its passage through the liver?
 Where is the hepatic vein? and what is its function?
 What are the lacteals? What is their function?
 Of what general system are they a part?

Through what glands do they pass? Into what do they empty?

What is chyle? Why are the lacteals so called?

What are the chyliferous vessels?

Describe the thoracic duct. Locate it.

What is the chyle receptacle? Describe it.

Explain assimilation. Where does it take place?

Trace a mouthful of food from the mouth to the tissue in the body.

What is lymph? What does it resemble?

What are lymph globules?

Explain the origin of lymph.

What vessels carry it? Describe fully the action of the lymphatics.

With what may they be compared?

In what respects do the lymphatics differ from the blood-vessels of the general circulation?

What is the difference between lymph and blood?

Explain how the lymph vessels constitute a drainage system of the body.

Whither is the lymph carried?

What are lymphatic glands? Describe them.

What effect have they upon the general health when they become diseased or hardened?

Why should we be careful not to touch poison ivy?

What danger is there in breathing the air of a sick chamber?

When a squirrel or other animal hibernates, on what does it subsist?

Why is medicine sometimes injected under the skin, and how is it rendered effective?

Name all the vessels which constitute parts of the absorptive system.

THE EXCRETORY SYSTEM.

It will be remembered that the material collected by the lymphatics is principally such as is capable of being *worked over* in the little workshops, the lymphatic glands, and used again as building material of the body.

There is, however, much waste matter which can not be thus elaborated for further use in tissue-building; and yet *some* of this material is taken from the blood by organs adapted to this particular purpose, and converted into substances essential to some of the vital processes. Other parts are fit for nothing whatever, and must be expelled from the system, because, if allowed to remain in the blood, they would not only be useless, but an actual poison to the system.

**The Excretory
Organs.**

The organs whose function it is to take from the blood such substances as can not be utilized again in the body-building process, but which must either be changed into some other substance, or expelled from the body, are the *lungs, liver, kidneys* and *skin*. Each of these is suited to take from the blood its own kind of impurities, and either elaborate them into some usable substance or start them in their course leading from the body.

THE LUNGS.

**Impurities
Thrown Off
by the Lungs.** The excretory functions of the lungs (*Turn to manikin of the body, 8, 9.*) have been referred to under *Respiration*, and their structure there explained. The pure air, taken into the lungs, gives up its life-giving oxygen, and in return becomes heavily loaded with *carbon dioxide*, or, as it is more commonly called, *carbonic acid gas*.

**Carbon
Dioxide.** The chief of the excretions from the lungs is *carbon dioxide*. It is a result of the union of the *oxygen* of the air inhaled, and *carbon* from the tissues of the body. This compound will not only fail to support life, but is an actual poison.

**Carbonic Acid
Test.** The destructive nature of this gas is illustrated in many ways. As for instance, if a man goes down into a well and is overcome, becomes unconscious and helpless, it is this gas which causes his condition. It is of the same kind as that which is thrown off by the lungs, is colorless, and is heavier than air, and consequently settles to the floor, or into cellars, wells, etc. Therefore it is safer to sleep on a bed than on the floor, since this deadly gas settles, during the night, on the floor.

As it will not support life in man and animals, so it will not support combustion, or burning. Hence, if it should become necessary to go down into a well,

it would be advisable to first lower into it a lighted candle. If the candle continues to burn, it may be concluded that the well is sufficiently free from carbon dioxide to enter it with safety.

**Test of the
Breath.**

That the lungs expel a gas which is identical with that which collects in wells may be illustrated by breathing into a glass jar, after having held the breath in the lungs for some time. If a lighted taper or wax candle be lowered into the jar containing this exhaled breath, it will go out, thus showing the absence of pure air and the presence of carbonic oxide. Again, to show that other substances, such as particles of animal matter, are contained in air once breathed, let the contents of the lungs after a full inspiration be breathed into a bottle and corked up. The effete matter excreted with the breath will decompose and soon give off an offensive odor. Thus we may understand the need of ventilation already mentioned. We can understand how the excretions from the lungs soon make the air in a closed room unfit for breathing, causing drowsiness and headache. The especial need of well-aired school-rooms is therefore urged for the consideration of teachers and pupils. Let pupils make the simple tests mentioned and see for themselves the importance of proper ventilation.

**Watery Vapor
Exhaled.**

Besides what has already been mentioned, the lungs take from the blood a watery vapor which is ordinarily not

visible, but in cold weather is condensed and collects on the windows, or can even be seen as it comes with the breath from the nostrils or mouth. It is chiefly the vapor of alcohol which is expelled from the lungs of a person who has used strong drinks, and his breath thus tells the tale of his indulgence. It has been carefully estimated that about one or one and one-fourth pounds of water is daily given off with the breath of a man.

THE LIVER.

As an Excretory Organ. The *liver*, and its connection with the process of digestion and also the portal circulation have been spoken of elsewhere. But it must also be considered as an *excretory organ*. Its function is not merely to secrete from the blood a fluid needed in the process of digestion, but by so doing it acts as a *blood purifier*. It is a well established fact, that, in case of a diseased liver, when that organ fails properly to perform its work of secreting the bile, which thus remains in the blood, a disease known as *jaundice* ensues, and, if this disease is not checked, the person dies with symptoms of poisoning.

THE KIDNEYS.

The kidneys are two bean-shaped bodies, a little more than half as large as the closed fist. They are located in the back part of the abdominal cavity, one on each side of the spinal column. Their shape, size, appearance, color and structure are very

plainly shown by the Anatomical Aid (*manikin of the body*). These dark-colored little glands have a very important function to perform. They cannot delegate their work to any other organ of the body, as is the case with some of the other glands. They alone can perform the work assigned them. Hence, when diseased, their work is not done, and sickness ensues.

Work of the Kidneys.

The particular and only work of the kidneys is to separate from the blood brought to them, a substance called *urea*. This is a very poisonous matter, which, if not removed from the body by the healthy action of the kidneys, will accumulate, and finally cause death.

The Kidneys at Work.

The *renal arteries* (g) constantly carry to the kidneys a portion of the blood, which passes through the capillaries of the kidneys, as seen by turning back the first section of the right kidney of the *manikin*. The blood is again collected by the veins, and conveyed through the *renal vein* (h) to the large veins leading to the heart. In the capillaries of the kidneys the blood loses its watery part, which carries, in solution, impurities called *urea*. This watery fluid soaks through the thin capillary walls, is collected and conveyed by two tubes (56), called *ureters*, to the bladder (57), whence it is expelled from the body.

Difference between Secretions of the Liver and Kidneys. As has been shown, the bile, secreted from the blood, is utilized in the digestive process. But the secretions of the kidneys are poisonous to the system, cannot be used in any process whatever, hence must be at once removed from the system. Thus the kidneys are *exclusively excretory organs*.

LESSONS FROM THE MICROSCOPE.

Its Purpose. There are about us myriads of wonderful creations which cannot be perceived by our unaided senses. Our sense of sight is not sufficiently acute to see the countless numbers of minute living bodies which throng every drop of water taken from a pond. We can not see the tiny corpuscles which float in the blood and give it its color, just as indigo dissolved in water will give it a blue color. Many persons know nothing of the wondrous beauty with which God has clothed the insects which swarm about us. With the unaided eye we see no beauty in the so-called dust which covers the wings of our moths and butterflies. But, when we call to our aid proper instruments, made for the purpose, the dust on the wings and body of the butterfly is at once transformed into beautifully formed scales, of brilliant rainbow colors and the most perfect shape and structure. The instrument

constructed to aid us in seeing things which are too small for us to see without this apparatus is the *microscope*. Its structure and principles upon which it operates, can not here be explained. Let it be sufficient to say that the microscope is a combination of glass lenses so arranged as to make things seen through it much larger. If you take your grandmother's spectacles and hold them just right, objects seen through the glasses will appear larger. In a similar way and for a similar purpose the glasses, or lenses, of a microscope are used, only that the microscope makes a much greater difference in the apparent and real size of objects seen through it.

MICROSCOPIC STRUCTURE OF THE TISSUES.

**The Micro-
scope as an
Aid in
Physiology.**

As the minute scales of the butterfly can not be satisfactorily examined without the microscope, so the proper and successful study of the different tissues of the body requires the aid of this instrument. And since it is not possible for all pupils to have access to a microscope, it is fortunate that those who have made physiology a careful study, and have examined the various structures and tissues with great care, have made drawings and sketches which we may study. Thus we have here on the *Aid* a series of marvelous paintings, true to nature, which we can study with even more satisfaction than if we were to prepare the specimens and look at them through the microscope ourselves. We have spoken of the body

as "the house in which we live." We may carry the comparison a little farther and consider the different tissues as the material used in the body-building, where they serve a purpose much like that of sand, stone, lime, glass, bricks and so on, in the construction of a building.

MICROSCOPIC STRUCTURE.

Of the Arteries (1).

Here (1) we see the three coats of the arteries. The outer layer is made up of a fibrous matter, more or less elastic. Next to it lies the middle coat, which consists of alternating layers of elastic tissue and muscular fibers, and the inner lining consists principally of a net-work of elastic tissue.

Of the Veins (2).

As in the arteries, the veins under the microscope show three distinct coats, but the entire vein wall is much thinner than that of the artery. Here at (2) the structure of the vein is shown. We see also the *valves*, mentioned under the *circulation*, which consists of pouch-like folds of the inner coat. Here we see *three valves*; but sometimes there are but two, and even one. From their shape and position you may see that they will allow blood to pass through them in one direction, but not in the other. Thus, blood can not flow backward, which, you will perceive, is a very wise provision. The shape of these valves as shown here will suggest the appropriateness of the name, *semilunar valves*.

Of Capillaries between Arteries and Veins (3). At (3) we have represented the network of capillaries which constitutes the connection between the arteries and veins. Here the outer and middle walls of the arteries have disappeared, and only the inner coat remains. The filtering process can thus take place with little difficulty.

Of Mucous Membrane (4). All cavities of the body which communicate directly or indirectly with the outside surface are lined with a soft, smooth membrane called the *mucous membrane*. This is a continuation of the skin. At the lips, for example, we may see that the skin merges into a softer and more sensitive coat, the mucous membrane. Here, at (4) you may notice its net-work of capillaries.

Looped Capillaries of the Skin (5). At (5) we see the capillary meshes of the skin. Through their folds are absorbed many substances which are then carried into the system, as we learned under *Absorption*. The activity of these capillaries as absorbents makes it possible for sailors to quench thirst by spraying their garments with sea water when their supply of fresh water is exhausted. The wet garments come in contact with the skin, and the moisture is absorbed.

Of the Intestinal Villi (6). This (6) gives the eye an opportunity to aid the mind in comprehending the outer structure of the villi. The vein capillaries which take up the digested food are here shown.

Air Cells of the Lungs (7). Number (7) gives us a view of the structure of the lungs. As you know, the lungs are composed chiefly of cells in which the impurities are exchanged for fresh supplies of life-giving oxygen. Here these cells and blood-capillaries are seen.

Capillaries of the Parotid Gland (8), Brain (9) and Cellular Tissue (10). The parotid, the principal one of the salivary glands, is also composed mostly of a capillary net-work, as shown here (8). At (9) we see the capillaries of the brain, with red and white corpuscles, or blood-discs, passing through them, carrying nourishment to the brain.

(10) shows how cells grow in length and then split into tissue-forming fibers. The cell, you will remember, is the smallest possible part of the body, and is the most important structure of the system, since all tissues and organs are made up of cells, just as sandstone is made up of millions of small grains of sand. But sand is lifeless, while, in the living body, life resides in the cell.

Elastic Tissues (11), Muscular Fiber (12), and Bone-Corpuscles (13). Under the microscope the muscular fiber has the appearance as shown at (12). It consists, of course, of many cells joined together, as will be seen

by carefully examining this cut. The structure of the bones, with their canals and little lakes, through which their nourishment is carried, is nicely shown at (13). Examine it carefully, and then procure, if possible, a bone cut crosswise, and compare.

Voluntary Muscles (14). We have seen that voluntary muscles are made up of bundles of fibers. This is beautifully shown here. We also see the cross-markings, or *strice*, which is a peculiarity of voluntary muscles. An examination of a piece of cooked beef will be helpful in connection with this view.

Glands of the Stomach (15). The all-important gastric juice, so much needed in a proper digestion of the food, is secreted by glands of the stomach wall. Such a gland is here represented in a very admirable manner. From the little mouths here seen, exudes the gastric fluid during the process of digestion.

Nerve-fibers of Brain (16), (17). At (16) and (17) are representations of nerve-fibers of the brain. Their healthy action, the abundance of their cells and their proper nourishment largely determine our mental capabilities.

Section through Hepatic Vein (18). The hepatic or liver vein, by which the blood is collected and carried from the liver toward the heart, is here shown as passing through the adjacent liver substance. The meshes of the liver capillaries are also seen. In these the bile is secreted.

Kidney Structure (19). The microscopic appearance of the structure of the kidneys is here represented (19). The peculiar little capsules or balls, called *Malpighian Corpuscles*, are a part of the mysterious organism provided for the secretion of the urea from the blood.

**Red Blood-
Corpuscles
(20).**

Fig. (20) shows the red corpuscles of the blood of different animals. Blood consists of a countless number of solid bodies floating in a liquid. Some of these solids are of a red color, while others are pale or white. These solids are called *corpuscles* or *blood-discs*. They vary also in shape in different animals. In man, the discs are usually nearly or quite circular, though, when seen in different positions, they present different appearances; just as a coin, looked at perpendicularly to its surface, looks circular, and, when we look at it edgewise, seems of an entirely different shape. These wonderful little bodies are so small that, of the red discs, 3,500, laid side by side, would measure only an inch, and, if placed one upon another, 18,000 would be required to make a column of that height. They usually arrange themselves in piles, and fit in each other like so many saucers or butter plates. It is the great number of these corpuscles which gives blood its color.

**Tendinous
fiber (21);
Adipose Tis-
sue (22).**

The structure of the strong tendons by which the muscles are attached to the bones, is shown very plainly at (21); As will be seen here they consist of many longitudinal fibers. Number (22) shows us how adipose cells appear under the microscope (23), and gives us another view of the structure of the bones. This is from the *ulna* of the forearm.

**Epithelial
Cells (24);
Cells of Epi-
dermis (25).**

The mucous membrane lining the mouth, nose and other cavities communicating with the outside, is covered with cells called *epithelial cells*. Here, at (24) we have a magnified view of these cells from the mouth; at (25) we see, as through a microscope, the cells of the epidermis. Though the worn-out particles of the cuticle can be seen with the naked eye, their peculiar structure can not be thus perceived.

**Pigment from
Choroid Coat
of Eye (26).**

The choroid coat of the eye is of a dark color, and absorbs the superfluous light brought into the eye. Its color is due to a dark pigment consisting of regularly formed six-sided cells. Their shape is seen at (26).

**Other Views
(27) to (31).**

The bile is secreted in the liver cells, a microscopic view of which is given us at (28).

Each of the thirty-one pairs of spinal nerves has two branches, as seen from (29). The posterior root has a ganglion of nerve matter which has the power of originating motion. (30 and (31) show us how the different nerve-cells appear when seen through the microscope.

Thus we have afforded us a series of views by a careful study of which we may be led to appreciate the fact that we are "fearfully and wonderfully made."

EFFECTS OF ALCOHOL.

Value of a Sound Body.

The principal organs of the body, and the functions of each, are now quite familiar to us. Let us now consider briefly the necessity of guarding against anything and everything which would in any way impair the health of these organs, or interfere with them in the performance of their work.

If a grain of sand should find its way into the eye, inflammation would at once result; sight, the function of the eye, would be interrupted. If, on account of some disease, the muscles of the heart should cease to contract and expand with their ordinary regularity, or stop their action entirely, the blood would cease to circulate and life would end. Thus, the well-being of the body, yea, life itself, depends upon the healthy action of the various organs which are our servants in our body-house.

Abuse of the Body.

Does it not seem strange, then, that so many thousands should still persist in abusing their bodies, which are made "in the image of their Creator"? Yet there are such who willfully take into their systems that which not only interferes with the healthy action of their bodily organs, but leads to certain death. More than this, they injure not only their bodies, but destroy their mental faculties, dethrone reason, bring misery and woe upon their families, and fail to accomplish life's ends.

What is strong drink? It is a liquid **Strong Drink.** which contains *alcohol* in large or small quantity; and, if taken into the system, will affect, more or less, all the organs and tissues of the body; and, if the quantity is sufficient, will cause what is called *drunkenness* or *intoxication*.

Alcohol, and What Is It? It is a liquid which in appearance can not be distinguished from water. If one vial be filled with water and another with alcohol, at a little distance it cannot be told which contains the water and which the alcohol. But the properties of the two are remarkably different. The alcohol has a strong odor, and a hot, biting taste. A small quantity may be placed in a shallow dish and a burning match held to it, when it will readily burn with a pale flame, but giving off much heat. If the white (albumen) of an egg be put in a cup, and alcohol poured on it, the albumen will soon become white, hard and tough, as if cooked. In all these and in many other particulars, it differs very much from water, which it so much resembles in appearance.

What Is Its Origin? Nearly all of the grains, as wheat, rye, barley, corn and rice, contain much starch. Corn-starch is made from corn, and sold by the grocer. The starch of these grains can, under certain circumstances, be converted into sugar, and this, in turn, can be changed into two very different substances, *carbonic acid gas* and

alcohol. Thus alcohol may be made from many substances. The juices of all fruits contain the sugar from which it may be produced. From the grape, currant, blackberry, elderberry and cherry, wine is made; from apples, cider is pressed; whisky is made from corn, barley, rye and other grains; rum is made from molasses and sugar cane. All of these contain alcohol in different quantities.

**How Is It
Done?**

If you take an apple and squeeze out of it the juice, you will have cider.

If this is allowed to stand in the warm open air, it will very soon begin to change its nature. If watched closely, small bubbles will be seen rising to the top and escaping. These are bubbles of carbonic acid gas, one of the products of the change of the fruit-sugar. The other is alcohol, which mixes with the liquid. The cider is now no longer sweet, but contains alcohol, is properly called "hard cider," and is a dangerous drink. It is the escaping gas that makes cider sparkle, and beer foam.

The change of the cider, from sweet to **Fermentation.** hard, or from the harmless juice of the apple to that containing alcohol, is called *fermentation*. All alcohol is the result of the fermentation of sugar, or some substance containing sugar. The apple juice, as soon as exposed to the warm atmosphere, absorbs from the air a peculiar substance called a *ferment*, which is something like yeast. It

at once begins to "work," that is, it begins to change the sugar to carbonic acid gas and alcohol. Thus wine is made from grapes, currants and other fruits. This kind of fermentation is called *vinous fermentation*.

Acetous Fermentation. If the process of fermentation is allowed to continue, the hard cider and the fermented wine will again change their nature. If a barrel containing cider is left in the warm sun, with an open bung (why), it first changes its sugar into alcohol. Additional ferment will change the alcohol of the hard cider to acetic acid, or cider-vinegar. This is called *acetous fermentation*.

Beer from Barley. Beer brewers add water to barley, and keep it sufficiently warm to cause it to sprout, when the starch it contains will change to sugar. More heat is added, and the germs or young sprouts are killed, and the water evaporated. This is now called *malt*, which is soaked in water, the sugar which it contains is dissolved and the sweet liquid drained off. Yeast is added to this liquid, to start the process of fermentation, or change of sugar to carbonic acid gas and alcohol. It is now called beer.

Distillation. If a cold cup be inverted and held over the spout of a tea-kettle from which steam is escaping, the steam will be condensed and gather in drops on the inner surface of the cup.

The water is first changed to vapor and this in turn is condensed to a liquid again. This is called distillation.

Now, if a quantity of wine or hard cider be placed in a vessel with an opening something like the spout of a tea-kettle, and heat applied, distillation will take place. But alcohol will boil, that is, change to vapor, at a temperature of 173° , while water requires 212° . Hence, the alcohol will be vaporized and pass off as steam before the watery portions will have reached a sufficient temperature. Thus, the vapor of alcohol can be condensed and collected as almost or quite pure alcohol. But sufficient heat may be applied to drive off some of the water with the alcohol. When about as much water is driven off as alcohol, the result of the process of distillation is *brandy, whisky or rum*.

**Two Classes
of Strong
Drink.**

Thus, we have seen that there are two kinds, or classes, of strong drink, the pernicious element in each being alcohol. One kind is called *fermented liquors*, such as wine, beer, ale and cider, and contain from three to twenty per cent. of alcohol. The other kind is known as *distilled liquors*, rum, whisky and brandy, containing as high as fifty-five per cent. of alcohol. An appetite for these liquors is the cause of more poverty, unhappiness, wickedness and crime than all other causes combined. We will now consider their effects upon the human system,

EFFECTS ON THE DIGESTIVE SYSTEM.

A Healthy Stomach. To possess a healthy digestion is a great blessing. It is essential to our physical well-being. Here we have a fine representation of a healthy stomach and liver. (See Aid.) The liver naturally lies across the stomach, but here it is turned up to show us the healthy appearance of a stomach which has never been abused by that terrible destroyer, alcohol.

Inflammation. If taken in an undiluted form, alcohol would burn the mouth and throat. The stomach would suffer in a similar way. But in its most diluted form it has an irritating effect upon the lining membrane of the stomach and intestines. Inflammation tells the story of the unnatural condition of things. The gastric juice becomes thick and unfit for its work in the digestive process. The constant inflammation indicates unnatural heat, and an unnatural thirst ensues, which is the probable reason for the fact that the more liquor a man drinks the more he wants. The quantity he drinks to-day will not satisfy him to-morrow, since more and more will be needed to counteract the ever-increasing inflammation.

This second cut shows us plainly the early stages of inflammation. It represents, perhaps, the stomach of one who has had his first experience with the deadly stuff; and yet how different in appearance from the stomach represented above.



At the bottom of this chart we see a **Ulceration.** more advanced stage of the difficulty. The blood-vessels are very much dilated, and indicate that extraordinary work has devolved upon this organ. The blood-vessels seem to have lost their power to contract sufficiently to expel the increased amount of blood brought hither. And here we see the results (first cut, next chart), of long continued distension of the blood-vessels. They have broken and sores or ulcers are the result. The stomach is now no longer able to perform its functions; the food is no longer properly digested, and as a consequence the blood is impoverished, and the general health has failed. All on account of the drink-habit which has now become so firmly fixed upon its victim that it is almost beyond human effort to break loose from it.

Last Stages of Alcohol Poisoning. The faithful servant of the body, the stomach, tries, from the first, to adapt itself to the derangements caused by the use of alcohol as a beverage. Just as the cuticle of the hand thickens and hardens, when we use an ax or shovel, so the stomach, if it is constantly being irritated by the presence of alcohol, becomes thick, tough and unnatural; and consequently becomes better adapted for the purpose of a whisky jug, but less for the purpose for which it was intended to digest food. The blood vessels of the stomach, having been dilated to their utmost, their diseased walls give way and ugly ulcers are formed.

These canker-like eruptions seen here, first eat through the inner coat, then the outer is attacked and the painful sores cause great suffering. Ultimately it can no longer accommodate itself to the condition of things. It gives up in despair. It can no longer retain and much less digest food. Its condition and appearance is shown here on the chart. A long and painful disease follows, and at last death relieves the poor slave to appetite.

Let us observe right here, how gradual is the process. How small and seemingly insignificant the beginning. And yet how certainly does the gratification of one thirst create the next. We would all do well to accept as our motto: "Touch not, taste not, handle not."

**Alcohol and
the Liver.**

We have just seen how alarming is the effect of alcohol on the stomach. But *the liver*, the healthy action of which we have found so necessary in the food-preparing and blood-purifying processes, suffers fully as much from the use of alcoholic drinks.

It is probable that most of the alcohol taken into the stomach is there absorbed and carried directly to the liver without passing into the intestines. A proper secretion of the bile in the liver demands that the cellular structure of that organ remain unchanged. Alcohol causes a change of these cells to fatty tissue, and an enlargement of the organ follows. Its tissues then become lumpy or knobbed, and produces what is known as "*gin, or hobnailed liver.*"

Let us compare its appearance under such conditions as we have it here represented, with its looks when in health, as seen on a previous plate.

Results. What is the result of a liver thus diseased? The answer is two-fold: First, the bile and liver sugar are not properly taken from the blood, and whatever poisonous matter may be contained in the blood which should be removed with the bile must remain in the system, and will certainly prove destructive to health. In the second place, the digestive process is not furnished with the needed bile, and the work of preparing the food will be imperfectly performed.

Alcohol and the Kidneys. The effect of a continued use of alcohol upon the kidneys is much like that upon the liver. In the kidneys the blood is constantly being filtered, and the poisonous urea is being taken from it and expelled from the body. If the blood carries alcohol into the cells of these organs they will be irritated, inflamed, and sometimes destroyed. This is known as *Bright's disease*, though other causes may lead to the same difficulties and terminate in the same disease. Here we have a view of a very common derangement with drinkers. It is an accumulation of fat about the kidneys, and may prove fatal.

EFFECTS ON THE NERVOUS SYSTEM.

On the Brain. Medical authorities tell us that after the death of a hard drinker, more alcohol is found in the tissues of the various parts of

the nervous system than any other part of the body. It has been found in sufficient quantities in the brain to distill it from the brain tissue. Its abundance in the nervous tissue is probably due to the amount of water which nerve tissue contains, and for which alcohol has a remarkable affinity or greed. As stated elsewhere, if alcohol is poured in a cup containing the white of an egg, it will harden or *coagulate* it. The tissue of the brain is similarly affected and made less sensitive. This loss of feeling is called *paralysis*. It also causes inflammation as seen here in the first plate of this chart. Compare the appearance of the two hemispheres of this important organ, one side represents the brain in health and the other as affected by strong drink.

THE BRAIN IS THE SEAT OF THE MIND.

Consequences. If alcohol effects its tissues as we have learned in the preceding topic, we may understand to some extent at least, how the habitual use of alcoholic drinks causes temporary insanity; and men are made silly in their actions, boastful in conversation and unmanly in every respect. That part of the brain which controls the voluntary muscles shows the effects of stimulants very promptly. The hand trembles and shakes "like a leaf." Walking soon becomes a difficult task. The control of the lips is lost and a quivering is the result. The tongue becomes ungovernable, and the poor toper becomes an object of pity, as he staggers through

the streets no longer a man, but a poor, degraded wretch, made so by his appetite for drink.

**Alcoholic
Softening of
the Brain.**

The effect of alcohol upon the brain sometimes manifests itself in a degeneration of the brain tissue. Fat accumulates as a result of frequent intoxications and the result is known as *alcoholic softening*, and the appearance of the brain in such condition is shown by the plate.

**Delirium
Tremens.**

The last cut of the stomach on the temperature charts gave us a view of that organ of a patient suffering from *delirium tremens*. The Aid furnishes us a corresponding view of *the brain* of such a patient. It is usually supposed that this condition is reached only after years of dissipation and drunkenness. Ordinarily this is true. But reliable medical authorities affirm that persons of a particularly nervous disposition are sometimes attacked by this terrible malady when but small quantities of intoxicants are taken. Those who indulge in strong drink are never absolutely safe. It may attack them at any time.

The victim of delirium tremens is in terrible fear and anxiety. His mind is so completely disturbed and his imagination so thoroughly aroused as to cause him to think his best friends enemies who would do him harm. He sees horrible sights and hears noises which alarm him. In his awful condition he raves and tears, cutting, tearing and biting himself like a madman; and not unfrequently dies

and thus escapes from his agony. Oh, that human beings should so abuse themselves as to bring themselves into such a condition!

Effect on the Nerves. The same paralyzing effect of alcohol on the brain of which we made mention in the preceding topics, is noticeable in the nerves. The alcohol takes up the moisture in the nerve tissues, leaving them more or less incapable of transmitting sensation. There is on record an account of a man, who, in his drunken stupor, burned his foot almost to a crisp without becoming conscious enough to remove it from the camp fire into which he had unconsciously placed it. The nerves were so thoroughly paralyzed by alcohol as to fail to transmit sensation to the brain, even if that organ had been in a fit condition to receive the intelligence. The brain and nerve tissues are among the first substances of the body to become affected by alcohol.

Different Effects of Intoxicants Upon the Heart. The effect of alcohol on the heart is more or less indirect. It is through the affected nerves that its effect upon the heart and circulation is brought about. The action of the heart is governed by the nerves, which act as a sort of brake, thus preventing a too violent action. Now when these nerves become affected and lose their control of the heart's action, it will beat more rapidly, and also with greater force. Thus the strain upon the heart is greatly increased, while the intervals of rest be-

tween the beats is diminished, which must be injurious to that important organ. With the increased activity of the heart, comes an increased rapidity of the flow of blood through the blood-vessels. The blood is forced to the surface, which becomes flushed, and, if long continued, the blood-capillaries at the surface lose their power of contraction, and the *drunkard's nose* is the result.

As in the kidneys, the tissue of the heart-walls will degenerate and change to fat. A fatty coat may run back from about it, and it is known as *fatty accumulation*. If the use of alcohol is continued, the heart will finally succumb; its fibers will become relaxed, its cavities become enlarged, it will entirely lose its power to contract, and death will ensue from *paralysis of the heart*.

Sometimes the heart continues its efforts to expel the blood, even when the cavities have increased their capacity, and the walls become thin and weak. *Alcoholic rupture* is then likely to occur. The effect on the appearance of the nerves, eye and blood-vessels is shown on the Aid.

Without going farther into the details
Synopsis. of alcohol, and other effects upon the human system just mentioned in these lessons, let us recall briefly what it *will not* do, and then resolve never to use it except as a medicine, and then only when directed to do so by a competent physician. Following are a few of the many facts concerning alcohol, which have so frequently been demonstrated

as to be no longer questioned:

WHAT IT WILL NOT DO.

1. Alcohol is not a food, hence—
2. It will not nourish the system.
3. It is not assimilated and made a part of the body tissue.
4. It will not fortify against cold.
5. It will not quench thirst.
6. It will not increase our powers of endurance.
7. It will not make the nerves more steady.
8. Its use will not make us more manly.
9. It will not increase our mental powers.
10. It will in no way benefit the system, except as a prescribed medicine.
11. It will not prolong life.
12. Its use can in no way add to our good name or reputation.

TOBACCO AND ITS EFFECTS.

The use of tobacco is so prevalent that all know what it is. Like alcohol, it does little or nothing for which its use can be recommended, while, on the other hand, there are many reasons for which its use should be entirely avoided.

Tobacco Is a Poison. It contains a substance called *nicotine*, which is a deadly poison. This poison can be extracted from the leaves of the tobacco plant, and is a dark-colored liquid of a sharp, biting taste. It has been found that a few

drops of this poison, placed on the tongue of a dog, will cause death. This *nicotine*, extracted from the tobacco and evaporated, forms large parts of the crust in the bowl of an old tobacco pipe.

**Its Effects
on the
Young.**

Its use is unnatural. When first attempted, it causes nausea and nervous and muscular weakness. It is a well-known fact that it exerts a very pernicious influence, particularly upon the young. It prevents their physical and mental development; it stunts their growth, and paves the way for disease in after years.

**Cigarette
Smoking.**

Injurious as tobacco smoking (in its common form) may be, smoking cigarettes is even more so. The poorest kind of tobacco is often used in making them, and poisonous substances are added to give them the proper strength and flavor. Opium, which is used in considerable quantities in this adulteration, is carried with the smoke to the lungs. Nicotine, that deadly poison found in tobacco, aids in the poisoning process. In view of the detrimental effect of cigarettes, it is not surprising that a number of States have enacted laws prohibiting the sale of cigarettes to young boys.

An Experiment.

To show you that the mucous lining of the mouth and air passages is subjected to a sort of tanning process, and thus has its ordinary functions impaired by cigarette smoking, a simple experiment may be per-

TOBACCO AND ITS EFFECTS.

formed. If we take a clean white cloth or handkerchief, two or three double, and inhale the smoke of a lighted cigarette, and then force it from the mouth through the cloth, a brownish yellow spot or stain will be found on it, which consists of the poisonous nicotine and other ingredients contained in the smoke, and mixed with the moisture of the mouth. Deposits of this kind are made upon the walls of the air passages when cigarettes are smoked, which *must be injurious.*

The respiratory organs suffer the most from cigarette smoking. We have here **The Respiratory Organs. How Affected.** (See Aid.) a series of views which will help us to understand the nature of the harm done, and, by a careful study of these, we may, perhaps, all be led to the resolve never to smoke cigarettes or cigars.

The trachea, or wind-pipe, in health has the appearance shown at 1 and 2; 4 shows us how it looks inside, and 3 outside, when it has become inflamed and irritated by the use of cigarettes. The inner structure of the lungs, with its subdivisions of the bronchial tubes and air-cells, in health, is nicely represented at 5. Here also we see the plump, full, well-formed lung before it has become shriveled up by the contents of the cigarette smoke. At 6 we see the effects. The air cells are filled up, and the bronchial subdivisions are almost wholly obstructed by nicotine deposits.

How, then, can the blood-purifying process be

successfully carried on in such a lung as is here represented?

Here in the lower right-hand corner of this plate we have a view of what is left of the lung after years of cigarette smoking. Nicotine has filled every air-cell. Nicotine had caused his death.

In the opposite lower corner on the Aid is seen a view of what is called *smoker's cancer*. It usually occurs in the throat and often proves fatal.

Conclusion. We have now briefly considered the essential features in the structure of the human body and the principal functions of the various organs. What is beneficial, as well as what is harmful, in its effects, has received attention. With the assistance of the Anatomical Aid, we have endeavored to impress the mind with some of the effects of alcohol and tobacco. If now, by the use of this little book in connection with the Aid, our young people may be induced to study the wonderful mechanism of their bodies, and try to avoid that which is injurious or in any way interferes with their physical or mental well-being, we shall have accomplished our purpose.

APPENDIX.

INDEX

TO THE

COMPLETE NERVOUS SYSTEM.

I. THE CRANIAL AND SPINAL SYSTEM.

No.	Common Name.	Latin or Professional Name.
1	Brain.	Cerebrum.
2	Small Brain.	Cerebellum.
3	Tree of Life.	Arbor vitæ.
4	Varol's Bridge.	Pons Varolii.
5	Three fold Nerve.	Nervus Trigemimus.
6	Abducent Nerve.	Nervus abducens.
7	Face and Sound Nerve.	Nervus facialis et acousticus.
8	Tongue and Pharynx Nerve.	Nervus glosso-pharyngeus, vagus et accessorius.
9	Willis' Accessory Nerve.	Nervus accessorius Willisii.
10	Loose cavity containing lung and stomach nerve ducts.	Nervus vagus pneumo-gastricus.
11	Lower tongue nerve.	Nervus hypoglossus.
12	Descending branches hypoglossal nerves.	Rami descendens nervi hypoglossi.
13	Cranial portion of the Spinal Cord.	Medulla oblongata.
14	Decussate pyramid.	Decussatio pyramidum.
15	Part of cervical spinal cord.	Pars cervicalis medullæ spinalis.

No.	Common Name.	Latin or Professional Name.
16	Part of thoracic spinal cord.	Pars thoracica medullæ spinalis.
17	Bulbous expansion at end of spinal cord.	
18	Terminal threads, spinal cord.	Filum terminale.
19	Neck nerves 1.	Nervus cervicalis 1.
20	Neck nerves 8.	Nervus cervicalis 8.
21	Network of neck nerves.	Plexus cervicalis.
22	Network of arm nerves.	Plexus brachialis.
23	Back bone nerve 1.	Nervus dorsalis 1.
24	Back bone nerve 2.	Nervus dorsalis 2.
25	Nerves between ribs.	Nervi intercostales.
26	Loin nerve 1.	Nervus lumbalis 1.
27	Loin nerve 5.	Nervus lumbalis 5.
28	Network of loin nerves.	Plexus lumbalis.
29	Anterior crural nerve.	Nervus cruralis anterior.
30	Hip—abdominal nerve.	Nervus ilio — hypogas tricus (ramus exterior et interior).
31	Hip—groin nerve.	Nervus ilio inguinalis.
32	Groin skin nerve.	Nervus inguino cutaneus.
33	Obturator nerve.	Nervus obturatorius.
34	Sacral nerve 1.	Nervus sacralis 1.
35	Sacral nerve 5.	Nervus sacralis 5.
36	Network of sacral nerves.	Plexus sacralis.
37	Coccyx nerves.	Nervi coccygei.
38	Sympathetic nerve.	Nervus sympathicus.
39	Upper cervical ganglion.	Ganglion cervicale superior.
40	Middle cervical ganglion.	Ganglion cervicale medium.
41	Lower cervical ganglion.	Ganglion cervicale inferior.
42	Thoracic ganglia.	Ganglia thoracica.
43	Loin ganglia.	Ganglia lumbalia.
44	Sacral ganglia.	Ganglia sacralia.
45	Coccyx ganglion.	Ganglion coccygeum.
46	Connecting branches between sacral and sympathetic nerves.	

No.	Common Name.	Latin or Professional Name.
47	<i>Sciatic nerve</i> (Hip nerve).	Nervus ischiadicus.
48	Groin nerve.	Nervus inguinalis.
49	Shoulder bone nerves.	Nervi supraclaviculares.
50	Branches of skin and axle nerves.	Rami cutaneus et nervi axillaris.
51	Arm skin nerves, internal posterior.	Nervi cutaneus brachii, internus posterior.
52	Arm skin nerve, small internal.	Nervi cutaneus brachii internus (minor).
53	Branches middle skin nerves (arm).	Ramus nervi cutanei medii.
54	Middle arm skin nerve.	Nervus cutaneus brachii medius v. internus major.
55	Branches skin palm nerves of middle skin nerve.	Ramus cutaneus palmaris, nerv. cutan. medii.
56	Branches of middle under skin nerve over ulna.	Ramus cutaneus ulnaris nerv. cutan. medii.
57	Branches under skin nerves, overlying cutaneous muscle.	Ramus cutaneus nerv. musculo cutanei.
58	Radial nerve branches.	Ramus nervi radiales.
59	Voluntary ulna nerve.	Nervus ulnaris volaris.
60	Voluntary finger nerves.	Nervus digitales volaris.
61	Network of arm pit nerves.	Plexus axillaris (brachialis).
62	Middle nerve, sending branches to thumb, index and middle finger and radial side of ring finger.	Nervus medianus.
63	Ulna nerve.	Nervus ulnaris.
64	Voluntary ulna nerve,	Nervus ulnaris volaris.
65	Spiral muscular nerve lying against radius.	Nervus musculo—spiralis v. radialis.
66	External elbow joint nerve.	Nervus interosseus externus.
67	Superficial radial nerve.	Nervus radialis superficialis.
68	Musculo cutaneus nerve.	Nervus musculo—cutaneus.
69	Anterior leg nerve.	Nervus cruralis anterior.
70	External anterior femoral nerve.	Nervus cutaneus femoris anterior externa.

No.	Common Name.	Latin or Professional Name.
71	Groin nerve.	Nervus inguinalis.
72	Groin skin nerve.	Nervus inguino cutaneus.
73	Large saphenic nerve.	Nervus saphenus major.
74	Middle anterior femoral nerve.	Nervus cutaneus femoris anterior medius.
75	Internal anterior femoral nerve lying against small saphenic.	Nervus cutaneus femoris anterior internus v. saphenus minor.
76	Branches of hip abdominal nerves.	Rami nervi ilio hipogastrici.
77	Branches hip groin nerves.	Rami nervi ilio inguinalis.
78	Branches muscular leg nerves.	Rami musculares nervi cruralis.
79	Superficial peroneal nerve fibular.	Nervus peronæus superficialis, con.
80	Internal foot skin nerve.	Nervus cutaneus dorsi pedis internus, et.
81	Middle foot skin nerve.	Nervus cutaneus dorsi pedis medius.
82	External leg skin nerve.	Nervus cutaneus cruris externus.
83	Deep peroneal or fibular nerve.	Nervus peronæus profundus.
84	Deep branch of peroneal nerve.	Ramus internus peronæus profundus.
85	External branch of peroneal nerve.	Ramus externus peronæus profundus.
86	Cervical or neck back bone joint.	Vertebra cervici (7).
87	Back bone joint (1).	Vertebra dorsi (1).
88	Back bone joint (12).	Vertebra dorsi (12).
89	Loin back bone joint (1).	Vertebra lumbalis (1).
90	Loin back bone joint (2).	Vertebra lumbalis (2).
91	Sacrum bone.	Os sacrum.
92	Coccyx bone.	Os coccygi.
93	First rib.	Costa prima.
94	Last rib.	Costa termina.
95	Crest of ilium bone.	Crista ossis ilii.

No.	Common Name.	Latin or Professional Name.
96	Underlying collar muscle connecting with sternum.	Musculus sterno — cleido mastoïdens.
97	Front scalene muscle.	Musculus scalenus anticus.
98	Middle scalene muscle.	Musculus scalenus medius.
99	Internal intercostal muscles.	Musculi intercostales interni.
100	External intercostal muscles.	Musculi intercostales externi.
101	Square loin muscle.	Musculus quadratus lumborum.
102	Large loin muscle.	Musculus psoas major.
103	Internal iliacal muscle.	Musculus iliacus internus.
104	Deltoid muscle (shoulder).	Musculus deltoideus.
105	Large breast muscle.	Musculus pectoralis major.
106	Flexible forearm muscle.	Musculus biceps flexor cubiti.
107	Fold in forearm.	Plica cubiti.
108	Head of ulna.	Caput ulnæ.
109	Aponeuroses of the palm.	Aponeurosis palmaris.
110	Fleshy ball of thumb.	
111	Short palm muscle.	Musculus palmaris brevis.
112	Cephalic vein (arm).	Vena cephalica brachii.
113	Basilical vein.	Vena basilica.
114	Middle basilical vein.	Vena mediana basilica.
115	Middle cephalic vein.	Vena mediana cephalica.
116	Head of humerus bone.	Caput ossis humeri.
117	Sharp process of scapula.	Processus coracoideus.
118	Deltoid muscle.	Musculus deltoideus.
119	See No. 105.	
120	Small breast muscle.	Musculus pectoralis minor.
121	Flexible muscle of biceps.	Musculus biceps flexor cubiti.
122	Short head of biceps muscle.	Caput breve, musculus bicipitis.
123	Long head of biceps muscle.	Caput longum, musculus bicipitis.
124	Coracoid arm muscle.	Musculus coraco-brachialis.
125	Internal arm muscle.	Musculus interna brachialis.

No.	Common Name.	Latin or Professional Name.
126	Internal head of extending triceps muscle.	Caput internum, m. tricipitis extensoris.
127	Long head of extending triceps muscle.	Caput longum m. tricipitis extensoris.
128	Muscle, serving to turn palm of hand upwards.	Musculus supinator longus.
129	Muscle, long, round extending wrist.	Musculus extensor carpi radialis longus.
130	Muscle, serving to turn palm of hand downward.	Musculus pronator teres.
131	Round wrist muscle bending or turning.	Musculus flexor carpi radialis.
132	Short, like functions as 128.	Musculus supinator brevis.
133	Common bending finger muscles.	Musculi flexores, digitorum communes.
134	One of the wrist bending muscles.	Musculus flexor carpi ulnaris.
135	Long bending striking muscle.	Musculus flexor pollicis longus.
136	Muscles serving thumb.	Musculus abductor et flexor brevis pollicis.
137	Drawing thumb to the index finger.	Musculus abductor pollicis.
138	Shoulder artery.	Arteria axillaris.
139	Arm arteries and veins.	Arteriæ et venæ brachialis.
140	} Arteries and veins of ulna.	Arteriæ et venæ ulnaris.
141		
142	Upper anterior spine of ilium.	Spina ilii anterior superior.
143	Tailor's muscle.	Musculus sartorius.
144	Middle gluteal muscle (serving to turn thigh in and outward).	Musculus glutæus medius.
145	Deep leg stretching muscle.	Musculus tensor faciæ latae.
146	Straight femoral muscle.	Musculus rectus femoris.
147	External vastus muscle.	Musculus vastus externus.
148	Muscle, serving to bring thigh together.	Musculus pectinæus.

No.	Common Name.	Latin or Professional Name.
149	Long drawing muscle.	Musculus abductor longus.
150	Large drawing muscle.	Musculus abductor magnus.
151	Leg muscle.	Musculus cruralis.
152	Internal vastus muscle.	Musculus vastus internus.
153	Tendon extending leg.	Tendo extensorius cruris.
154	Knee.	Patella.
155	Shin.	Tibia.
156	Internal } Ankle joint pro-	Malleolus internus.
157	External } jections.	Malleolus externus.
158	Transverse ligament.	Ligamentum transversum.
159	Foremost tibial muscle.	Musculus tibialis anticus.
160	Muscle, extending toes and foot.	Musculus extensor digitorum pedis longus.
161	Long peroneal muscle (Fibula).	Musculus peronæus longus.
162	Short peroneal muscle.	Musculus peronæus brevis.
163	Long extending striking foot muscle.	Musculus extensor pollicis pedis longus.
164	Counteracting on 160.	Musculus extensor digitorum pedis brevis.
165	Short striking foot muscle.	Musculus extensor pollicis pedis brevis.
166	Sole muscle.	Musculus soleus.
167	Femoral artery.	Arteria femoralis.
168	Femoral vein.	Vena femoralis.
169	Large saphenic vein.	Vena saphena magna.

II. THE SYMPATHETIC SYSTEM.

DISTRIBUTION OF FACIAL AND PNEUMOGASTRIC NERVES.

1	Descending thoracic aorta.	Aorta descendens thoracica.
2	Innominate artery.	Arteria innominata.
3	Right under-shoulder artery.	Arteria subclavia dextra.

No.	Common Name.	Latin or Professional Name.
4	Right carotid artery.	Arteria carotis communis dextra.
5	Internal carotid artery.	Arteria carotis interna.
6	External carotid artery.	Arteria carotis externa.
7	Upper thyroid artery.	Arteria thyroidea sup.
8	External jaw artery.	Arteria maxillaris externa (v. facialis).
9	Occipital artery.	Arteria occipitalis.
10	Upper ear artery.	Arteria auricularis superior.
11	Temporal artery.	Arteria temporalis.
12	Pulmonary arteries and veins.	Arteriæ et venæ pulmonales.
13	Intercostal arteries and veins.	Arteriæ et venæ intercostalis
14	Descending aorta (abdominal) with lower aortic plexus.	Aorta descendens abdominalis, con plexus aorticus inferior.
15	Cœliac artery and plexus.	Arteria cœliaca con plexus cœliacus.
16	Kidney artery and plexus.	Arteria renalis con plexus renalis.
17	Upper mesenteric artery with plexus.	Arteria mesenterica superior con plexus mesentericus sup.
18	Lower mesenteric artery with plexus.	Arteria mesenterica inferior con plexus mesentericus inferior.
19	Common iliacal artery.	Arteria iliaca communis.
20	Network of upper abdominal nerves.	Plexus hypogastricus superior.
21	Network of hæmorrhoidal nerves.	Plexus hæmorrhoidales.
22	Network of nerves surrounding bladder.	Plexus vesicalis.
23	Network of prostate nerves.	Plexus prostaticus.
24	Network of lower abdominal nerves.	Plexus hypogastricus inferior.
25	Lower phrenic arteries with network of phrenic nerves.	Arteriæ phrenicæ inferiores con plexus phrenicus.

No.	Common Name.	Latin or Professional Name.
26	Great network of stomach nerves.	Plexus gastricus magnus.
27	Splenic artery with network of splenic nerves.	Arteria splenica con plexus splenicus.
28	Liver artery with network of liver nerves.	Arteria hepatica con plexus hepaticus.
29	Upper network with semi-lunar ganglion.	Plexus solaris con ganglion semi-lunarius.
30	Loin ganglion.	Ganglion lum bale.
31	Sacral ganglion.	Ganglion sacrale.
32	Thoracic gland 1.	Ganglion thoracicum 1.
33	Thoracic gland 7.	Ganglion thoracicum 7.
34	Large splanchnic nerve.	Nervus splanchnicus major.
35	Small splanchnic nerve.	Nervus splanchnicus minor.
36	Upper network of thoracic nerves.	Plexus thoracicus superior.
37	Lower ganglion of neck nerves.	Ganglion cervicale inferior.
38	Middle ganglion of neck nerves.	Ganglion cervicale medina.
39	Upper ganglion of neck nerves.	Ganglion cervicale superior.
40	Network of nerve molles.	Plexus nervorum mollium.
41	Front ear nerve.	Nervus auricularis anterior.
42	Posterior ear nerve.	Nervus auricularis posterior.
43	Facial nerves and branches causing goose flesh on skin.	Nervus facialis et pes anserius.
44	Small occipital and upper ear nerve.	Nervus occipitalis minor et nervus auricularis superior.
45	Willis' accessory nerve.	Nervus accessorius Willisii.
46	Network of neck nerves.	Plexus cervicales.
47	Vagus nerve.	Nervus vagus.
48	Recurrent nerve.	Nervus recurrens.
49	Phrenic nerve.	Nervus phrenicus.
50	Network of arm nerves.	Plexus brachialis.
51	Network of loin nerves.	Plexus lumbalis.
52	Network of sacral nerves.	Plexus sacralis.

No.	Common Name.	Latin or Professional Name.
53	Nerves between ribs (intercostal).	Nervi intercostalis.
54	Network of nerves of the gullet (œsophagus.)	Plexus œsophagens.
55	Network of nerves of lungs.	Plexus pulmonalis.
56	Network of nerves of pharynx.	Plexus pharyngens.
57	Lower jawbone.	Os maxillare inferius.
58	Hyoid bone.	Os hyoides.
59	Shoulder bone or clavicle.	Clavicula.
60	First rib.	Costa I.
61	Second rib.	Costa II.
62	Eleventh rib.	Costa XI.
63	Transverse process of the loin backbone.	Processus transversus vertebræ lumbalis.
64	Sacrum bone.	Os sacrum.
65	Pubis bone	Os pubis (symphysis).
66	Large cheek muscle.	Musculus zygomaticus major.
67	Lower digastric jaw muscle.	Musculus digastricus maxillæ inferioris.
68	Chewing muscle.	Musculus masseter.
69	Salivary or parotid gland.	Glandula parotis.
70	Under jaw gland.	Glandula sub maxillaris.
71	Sterno-hyoid muscle.	Musculus sterno-hyoidens.
72	Foremost scalene muscle.	Musculus scalenus anticus.
73	Middle and posterior scalene muscle.	Musculus scalenus medius et posticus.
74	Midriff.	Diaphragm.
75	Square loin muscle.	Musculus quadratus lumborum.
76	Right bronchus.	Bronchus dexter.
77	Kidney.	Renes.
78	Upper kidney gland.	Glandula supra renalis.
79	Gullet.	Œsophagus.
80	Stomach.	Stomachus.
81	Jejunum intestine.	Intestinum jejunum.
82	Coloa intestine.	Intestinum colon.

No.	Common Name.	Latin or Professional Name.
83	Rectum intestine.	Intestinum rectum.
84	Bladder.	Vesica urinaria.
85	Ureter.	Ureter.
86	Procumbent gland.	Glandula prostratus.
87	Carrying vessel.	Vas deferens.
88	Spermatic cord.	Chorda spermatica.
89	Internal spermatic arteries and veins with network of internal spermatic nerves.	Arteria et vena spermatica con plexus spermaticus in- ternus.

III. THE SENSE OF SMELL.

VERTICAL SECTION OF NASAL CAVITY.

1	Cavity in frontal bone.	Sinus frontalis ossis frontis.
2	Nasal bone.	Os nasi.
3	Sphenoidal cavity.	Sinus sphenoidalis.
4	Cribiform plate of the eth- moidal bone.	Lamina cribrosa ossis eth- moidea.
5	Upper jawbone.	Os maxillare superioris.
6	Incisive canal.	Canalis incivious.
7	Hard palate.	Palatum durum.
8	Palate molles against soft palate.	Palatum molle v. velum palatinum.
9	Tongue.	Lingua.
10	Nasal partition.	Septum nasi.
11	Posterior nasal cavity.	Posterior nares.
12	Roof of mouth.	Pharynx.
13	Tonsils.	Tonsilla.
14	Pharyngeal palate arch.	Arcus pharyngo—palatinus.
15	Olfactory nerve.	Nervus olfactorius.
16	Nasal-palate nerve of scarpa.	Nervus naso-palatinus scar- pæ.
17	Incisive ganglion.	Ganglion incisivum.

IV. THE SENSE OF TASTE.

NERVES OF PALATE AND TONGUE.

No.	Common Name.	Latin or Professional Name.
1	Taste nerves.	Nervi palatini.
2	Tongue and pharynx nerve.	Nervus glosso-pharyngeus.
3	Branches of three-fold taste nerve.	Ramus gustatorius nervi trigemini.
4	Branches of No. 2.	Ramus nervi glosso-pharyngei (pro. m. glosso-palatino).
5	Upper lip.	Labium superioris.
6	Hard palate.	Palatum durum.
7	Soft palate.	Velum palatinum v. palatum molle.
8	Uvula.	Uvula.
9	Side nerve of tongue.	Arcus glosso-palatinus.
10	Arch of pharynx.	Arcus pharyngo-palatinus.
11	Tonsil.	Tonsilla.
12	Entrance to gullet.	Isthmus faucium.
13	Root of tongue.	Radix lingua.
14	Tongue.	Lingua.

V. THE SENSE OF SIGHT.

VERTICAL SECTION OF ORBIT AND GLOBE OF EYE.

1	Frontal bone.	Os frontis.
2	Upper jawbone.	Os maxillare superius.
3	Fatty matter.	Adipose tissue.
4	Frontal muscle.	Musculus frontalis.
5	Upper eyelid.	Palpebra superior.
6	Lower eyelid.	Palpebra inferior.
7	Lower oblique eye muscle.	Musculus obliquus oculi inferior.
8	Rectal eye muscle, lower.	Musculus rectus oculi inferior.

No.	Common Name.	Latin or Professional Name.
9	Rectal eye muscle, external.	Musculus rectus oculi, externus.
10	Rectal eye muscle, upper.	Musculus rectus oculi superior.
11	Upper eyelid muscle.	Musculus levator palpebræ superior.
12	Eye nerve.	Nervus opticus.
13	Conjunction of Eyelids.	Conjunctiva palpebræ.
14	Reflection of conjunction from inner surface of eyelids to globe.	
15	Conjunction of eyelids and white of eye.	Conjunctiva scleroticæ (bulbi.)
16	Conjunction of cornea.	Conjunctiva cornea.
17	Strong horny membrane forming outer part of eye.	Cornea.
18	Membrane of aqueous humor, lining anterior chamber.	
19	Anterior camera.	Camera oculi anterior.
20	Posterior camera.	Camera oculi posterior.
21	Sinus of iris.	Sinus venosis iridis.
22	Sclerotic tunic.	Tunica sclerotica.
23	Crystalline lens.	Lens crystallina.
24	Ciliary body.	Corpus ciliare.
25	Vitreous body, glassy matter.	Corpus vitreum.
26	Tunic of the retina.	Tunica retina.
27	Tunic of the choroid.	Tunica choroidea.

VI. THE SENSE OF HEARING.

THE INTERNAL ORGANS OF HEARING EXPOSED WITHOUT BONY STRUCTURES.

1	External ear.	Auricula externa.
2	Auditory canal.	Meatus auditor, externus.
3	Tympanum.	Membrana tympani.
4	Hammer.	Malleus.
5	Handle of same, long.	Processus longus mallei.

No.	Common Name.	Latin or Professional Name.
6	Mannubrium of hammer.	Mannubrium mallei.
7	Anvil.	Incus.
8	Short process of same.	Processus brevis incudis.
9	Long process of same.	Processus longus incudis.
10	Orbicular ossicle.	Ossiculum orbiculare Silvii.
11	Stapes.	Stapes.
12	Vestibule.	Vestibulum.
13	Upper semicircular canal.	Canalis semicircularis superior.
14	Posterior semicircular canal.	Canalis semicircularis posterior.
15	Lower semicircular canal.	Canalis semicircularis inferior.
16	Shell, spiral cavity.	Cochlea.
17	Cupolæ of shell.	Cupola cochleæ.





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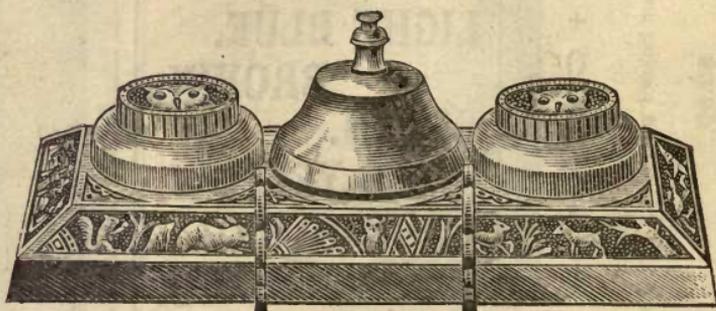
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CENTRAL SCHOOL SUPPLY HOUSE, - CHICAGO, ILL.



MERIDIAN.

FULL MOUNTED.

- No. 14. 12 inch, . \$25.00
 No. 16. 8 inch, . 15.00

MERIDIAN.

- No. 20. 12 inch, . 20.00
 No. 22. 8 inch, . 10.00

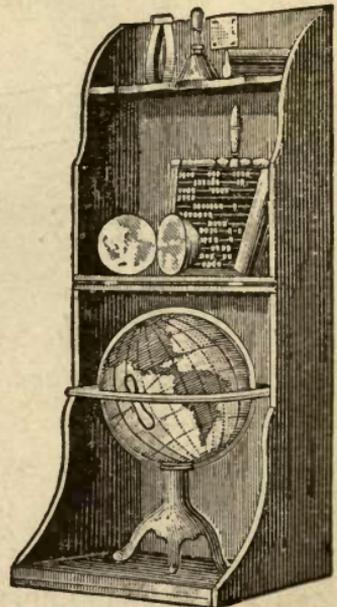
PLAIN.

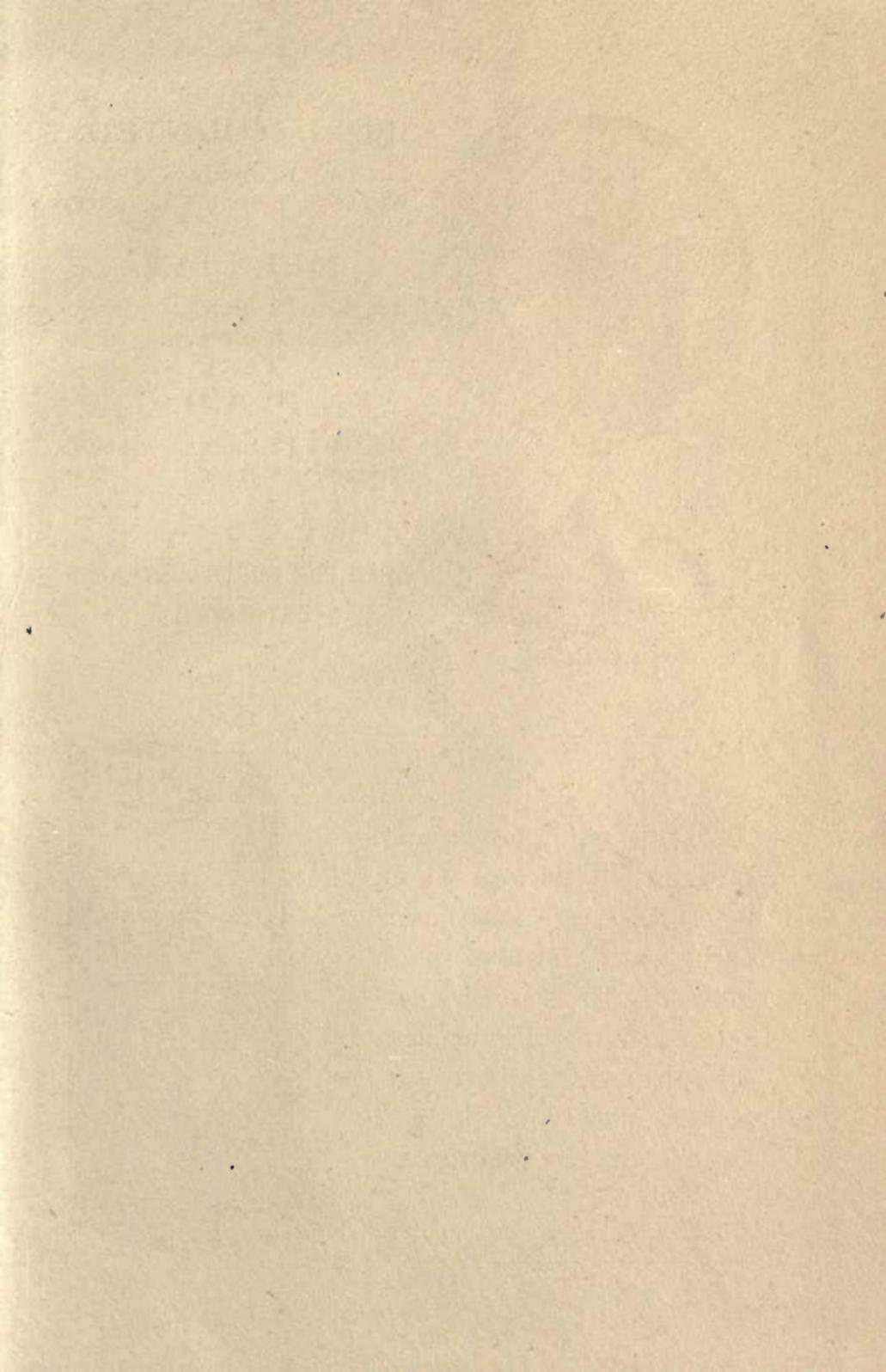
- No. 24. 12 inch, . 15.00
 No. 26. 8 inch, . 8.00

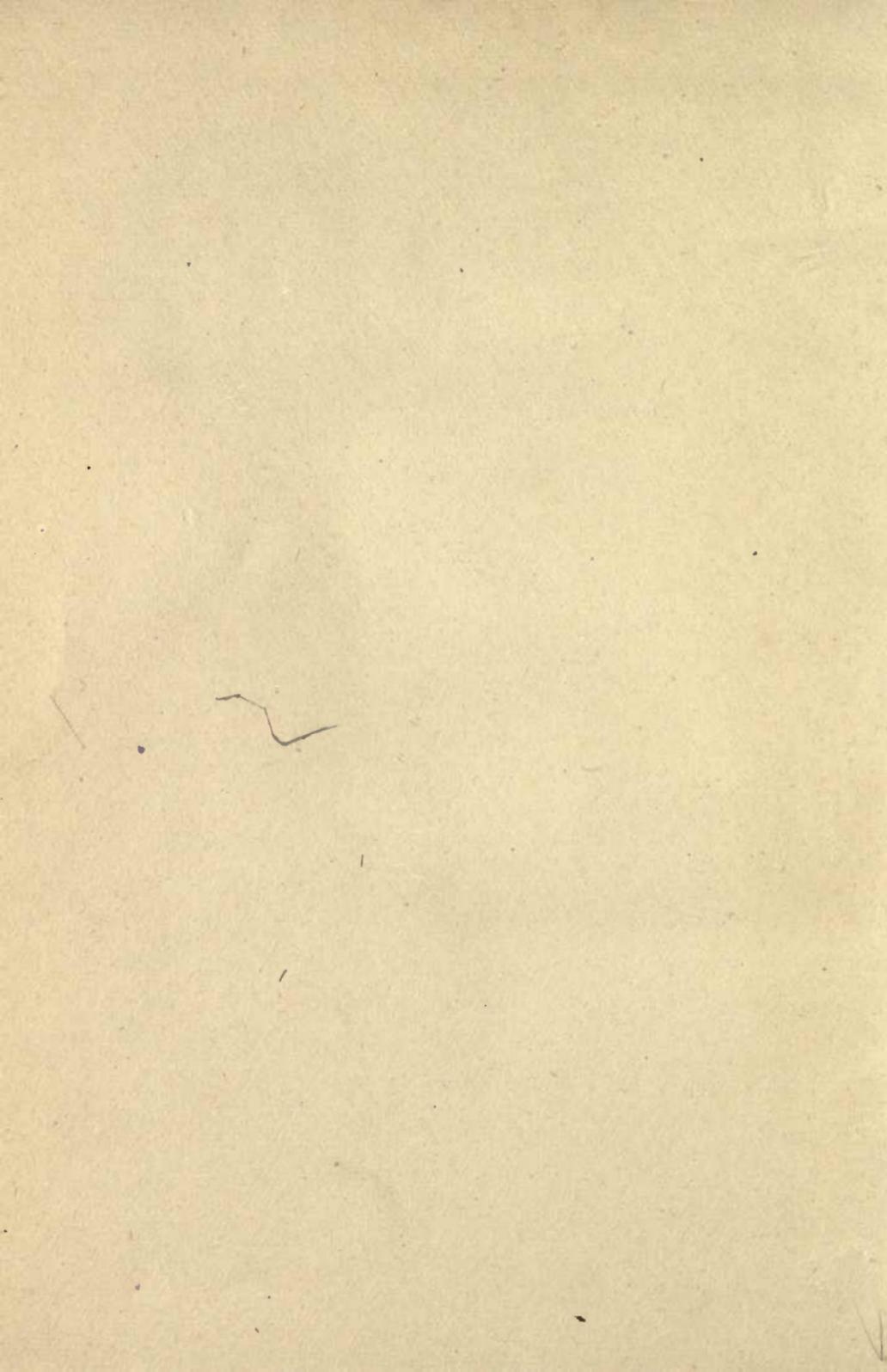


SEND FOR OUR ILLUSTRATED
 CATALOGUE.

This cut shows our Hinged Globe Case which is furnished with our eight and twelve-inch globes. It is easily arranged as a cabinet in a schoolroom, and is furnished with a lock and key to protect contents.







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