PRIMER

OF

SCIENTIFIC KNOWLEDGE.

MAN.—ANIMALS.—PLANTS.—STONES.—THE THREE STATES OF BODIES.

READING-LESSONS.—SUMMARIES.—QUESTIONS.—SUBJECTS FOR COMPOSITION.

BY

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TRANSLATED AND ADAPTED FOR AMERICAN SCHOOLS.

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PREFACE.

The larger work of the lamented Bert was published in this country under the title of "First Steps in Scientific Knowledge," and at once met with the same remarkable success that had characterized it in France and Great Britain. Soon after its appearance in France it was officially assigned to the course for the second year in the French primary schools, and M. Bert was called upon to prepare the original of the present work for the first year's course.

The following from the author's preface gives the scope of the book and its relation to "First Steps in Scientific Knowledge":

"This new work is carried out in the same spirit as the former, and follows the same plan. The book is so arranged that the larger work becomes a review and extension of the subject. The method which consists in *presenting to the child during two or three consecutive years the same subjects, in the same order, following the same general arrangement, but with an increasing number of facts and a progressive elevation of ideas*, is an excellent one, and is now universally adopted.

"Special knowledge of things and the general development of the mind are attained by this method of repetition, if we but avoid monotony. I have tried to keep clear of this danger by giving to the present book a more elementary and at the same time more practical character.

"The reductions have naturally been largely in Physics, Chemistry, and Vegetable and Animal Physiology.

"Nevertheless, I have given a somewhat fuller development to the descriptive part of Natural History and to applications easy to comprehend.

"These two works, then, depend upon each other. They form a coherent whole. The first prepares for the second, the second completes the first; at the same time, each has its individuality and can be used without the other."

In the present translation only such changes and additions have been made as were necessary to Americanize the book and adapt it to the requirements of public and private schools of this country. The illustrations are for the most part entirely new. Those upon Natural History were drawn from life by some of our best artists.

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PRIMER

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I.—MAN.

1. Man.—We begin our study of living beings with the study of **Man**; that is to say, with the study of our own body.

Nothing is more useful, nothing more interesting, than to know how our body is formed, where our **heart, lungs, stomach, brain,** and other **organs** are placed, and of what use they are to us.

Ought we not, at the very least, to know ourselves?

2. The Principal Races of Men.—All men do not look like those of our own country. Thus, in Africa there are men called negroes (Fig. 1), with a skin more or less **black,** and with black woolly hair; in Asia live men (Fig. 2) with a **yellowish** skin, having black hair also, but straight and stiff; and in some parts of the United States and Canada we see men (Fig. 3) with a **reddish** skin and hair as black and straight as that of the Asiatics.

FIG. 1.—*Negro*, man with black skin and woolly hair (Africa. A young Zulu warrior).

FIG. 2.—Chinese, man with yellow skin and black, stiff hair (Asia).

FIG. 3.—American Indian, man with reddish skin and black, stiff hair (America).

FIG. 4.—European, American type, white-skinned (Europe and America).

Most of the people, however, of this country and of Europe have a **white** skin (Fig. 4), with soft hair

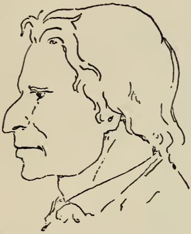


FIG. 5.—An American type, approaching the Indian in the proportions of the face (after Dr. Rimmer).

FIG. 6.—The same, refined to a higher type (after Dr. Rimmer).

of various colors, ranging from deep black to almost white.

In spite of these outward differences, and a few others which would not at present interest you, all man kind, whether black, yellow, red, or white, have the same **organization,**—that is, have the same organs or parts of the body placed and acting in the same way.

QUESTIONS.—MAN.

What are the principal races of men?
What is common to all the races?

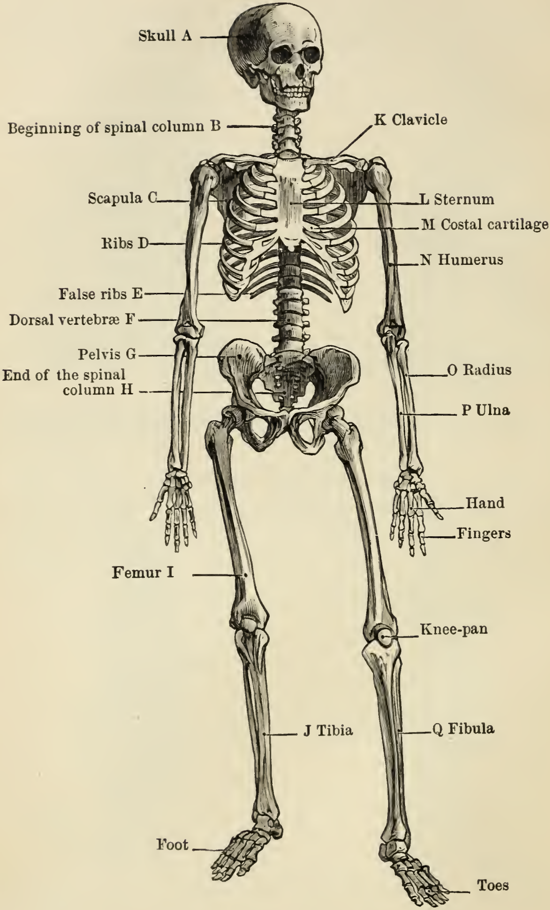


FIG. 7.—Skeleton of a man, front view.

1.—THE SKELETON.

3. Division of the Skeleton.—In the interior of our body is a framework which is designed to **support** the flesh, and without which we could not stand or sit upright: this framework. formed of **bones,** is called the **skeleton** (Fig. 7).

The skeleton of man is composed of—

1st. The **spinal column,** B to H.
2d. The **skull.** A.
3d. The **bones of the limbs.**

4. The Spinal Column.—The **spinal column,** or **backbone,** B H. is formed of a series of bones, called **vertebræ,** piled one upon another.

A vertebra is a kind of ring. These bony rings placed upon one another form a canal or tube called the **spinal canal,** which holds the spinal cord.

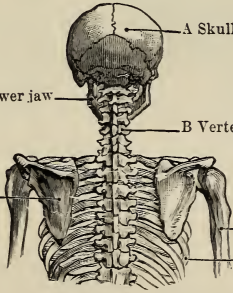


FIG. 8.—Thorax of a man, rear view.

In the region of the back each vertebra bears a bone or rib D, which is directed forward and is united to the opposite rib by the costal cartilages M (Fig. 7) and by a bone called the **sternum,** or breast-bone, which you can easily feel in front of the chest.

The dorsal vertebræ E (Fig. 8), the ribs D, the costal cartilages M (Fig. 7), and the sternum L, form a kind of open cage, larger at the bottom than at the top, commonly called the chest, and scientifically the **thorax.**

The remainder of the vertebræ have no ribs attached to them. They rest upon the bones G of the **pelvis.**

5. The Skull.—The **skull** A (Fig. 8) is placed at the upper end of the spinal column. It is a bony box (Fig. 9), which contains the brain, and whose cavity opens into that of the spinal canal.

FIG. 9.—Human skull.

The skull is formed of many bones. In front are the cavities, or **orbits,** B, B, in which the eyes are placed; below these are two other holes, C, called the **nasal openings;** and below these latter the **jaws** D, E, between which is the mouth.

The upper jaw D is fixed, being a part of the skull. The lower jaw E, on the contrary, is movable, as you all know.

On each side of the skull is an opening which leads to the organ of hearing. This organ communicates with the external world by means of the **auditory canal,** or tube, and the external ear.

6. Bones of the Limbs.—In the upper limbs (Fig. 7), the bone N of the arm is the **humerus;** the bones

O and P of the forearm are the **radius** and the **ulna.** The radius is on that side of the forearm where the thumb is.

The arm is attached to the body by two bones,—the **shoulder-blade** C (Figs. 7 and 8), which is directed backward and rests upon the thorax without being united to it, and the **clavicle** K, or collar-bone, which is placed like a cross-bar between the shoulder-blade C and the sternum L. We can feel the clavicle crosswise at the top of the chest.

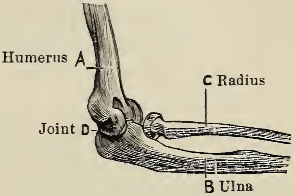


FIG. 10.—A joint of the arm and the forearm (elbow).

In the lower limbs, or legs (Fig. 7), the bone I of the thigh is the **femur,** and the two bones J, Q of the leg are the **tibia** and the **fibula.** The tibia is the large bone which we feel under the skin in the front of the leg.

The two femurs I (that of the right and that of the left thigh) are attached to a large and solid bony girdle, G, the **pelvis,** which at the back part is joined to the spinal column.

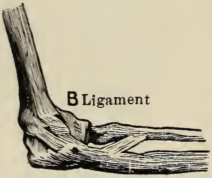


FIG. 11.—In the places where they play against each other the bones are held together by bands called ligaments.

The pelvis forms a solid base upon which the body rests upright.

7. Joints.—The bones move upon one another at certain places, D (Fig. 10), called **joints,** as the elbow, the wrist, the shoulder, etc.

At the joints the bones are held in place by ribbons and bands, called **ligaments.**

Alcoholics and Tobacco.—Tobacco, beer, cider, and wine, when used by the young, hinder the growth of bones; they also injure the health of the joints.

SUMMARY.—1. The Skeleton.

Races.—The principal **races** of men are: the **black** race, or negroes, of Africa; the **yellow** race of Asia; the **red** race of America; the **white** race of Europe.

Skeleton.—The human skeleton is composed of the **spinal column,** the **skull,** and the **bones of the limbs.**

Spinal Column.—The spinal column is formed by the **vertebræ,**—a species of bony rings, placed one upon the other, and forming, as a whole, the **spinal canal.**

The spinal column supports the skull, and upon the sides sustains the ribs. The latter, with the sternum (in front of the chest), form the cage of the **thorax** (chest). The spinal column rests on the bones of the **pelvis.**

The Skull.—The skull is a bony box which forms the head and contains the brain. We see in it the **orbits** for the eyes, the holes for the nose, or **nasal openings,** the **upper jaw,** which is fixed, the **lower jaw,** which is movable, and the openings which lead to the organs of **hearing** (the ears).

The Upper Limbs.—The bones of the upper limbs are the **humerus** (arm) and the **radius** and **ulna** (forearm). The humerus is attached to the thorax by two bones,—the **scapula** (shoulder-blade) and the **clavicle** (collar-bone).

The Lower Limbs.—The bones of the lower limbs are the **femur** (thigh) and the **tibia** and **fibula** (leg). The femur is attached to the spinal column by the bones of the **pelvis.**

Joints.—The place where two bones play upon each other is called a **joint.** At the joints the bones are held in place by a species of bands called **ligaments.**

QUESTIONS.—THE SKELETON.

What is the skeleton? What are the principal parts of the skeleton of man? How is the vertebral column formed? What name is given to the tube formed by the rings of the vertebræ? In what manner is each rib united to the rib opposite? What is the thorax, and by what bones is it formed?

Upon what does the vertebral column rest? What is at the top of the vertebral column? Of what is the skull formed, and what cavities are seen in it?

What difference is there between the two jaws? What are the two openings, one upon each side of the skull, called?

What name do we give to the bone of the arm? What to the bones of the forearm? What bones connect the arm with the body?

What is the bone of the thigh called? Name the bones of the leg.

To what bones are the femurs attached? What is a joint? How are the bones held in place at the joints? What is the effect of tobacco upon the bones? What upon the joints? What is the effect of beer, wine, and cider upon the bones? What upon the joints?

2.—ORGANS OF MOTION.

8. Muscles.—The bones of themselves would remain motionless. Something is necessary in order that they may move; and that something is what we call **a muscle.**

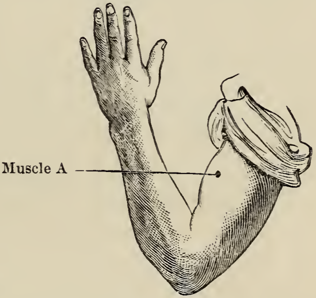


Fig. 12.—One of the muscles of the arm is in action: it hardens and enlarges.

Bend the right forearm upon the arm, and with the left hand grasp the arm in the middle during the movement. You can plainly feel at A (Fig. 12) something which grows harder and larger under your hand. It is the great **motor muscle** of the arm that is in action.

A muscle is a mass of red fibres, E (Fig. 13), placed side by side, and usually fastened at each end to a bone, B, D. Taken together, muscles form what is usually termed flesh. Muscles end almost always in a sort of white cords, or **tendons,** A, A, sometimes wrongly called nerves. This is a very incorrect expression, as it confounds tendons with true nerves, of which I shall speak in a few moments.

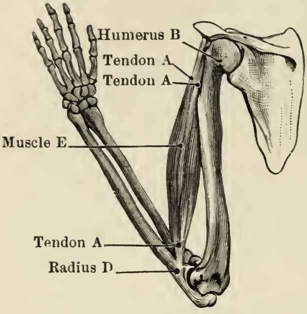


FIG. 13.—At each extremity the muscle is fastened to the bone by a species of white cords called tendons, A, A. When the muscle *contracts*, the forearm is brought towards the arm.

9. Muscular Contraction.—The fibres of muscles have a very remarkable property: they can **contract** of themselves; that is to say, they can shorten themselves.

Evidently, when they become shorter their ends are brought nearer together, and with them the bones to which they are fastened. That is what happened to your forearm a moment ago. There is a muscle that goes from the upper part of the arm to the beginning of the forearm D. When this muscle shortens, it pulls upon the radius, which is lifted up, carrying with it the hand. Naturally, the muscle cannot diminish in length without increasing in thickness; and this is why you felt it become larger and harder in your arm at E.

10. Number and Kind of Muscles.—There are a great many muscles. Some move the limbs, some bend or straighten the fingers; others turn or hold up the head, bend the back, raise the ribs, contract the stomach, etc.

It is by the **action of the muscles,** bones, and joints that we are able to remain seated or standing, that we walk. run, or jump.

Alcoholics, etc.—If a person uses beer or spirits for a long time, some of his muscles partly change to fat. Fat, unlike muscle, cannot contract. The beer-drinker often has large, flabby, weak limbs, and a weak heart. Alcoholics and tobacco are weakening to the young.

SUMMARY.—2. Organs of Motion.

Muscles.—The **muscles** which form the flesh are organs designed to move the bones.

Tendons.—Muscles are fastened to the bones by a species of white cords called **tendons.**

Contraction of Muscles.—Muscles have a special property,—the power to **contract**, or shorten. In contracting they compel the bones to which they are fastened to move upon each other, and we thus obtain the different movements.

QUESTIONS.—ORGANS OF MOTION.

What is it that moves the bones? What is the common name for muscle? Of what are the muscles made? By what are the muscles joined to the bones? What particular property have the muscles? What is the result of this shortening? Name some of the uses of the muscles, bones, and joints. What is the effect of beer or spirits on the muscles? What is the effect of alcoholics upon the young?

3.—THE NERVOUS SYSTEM.

11. **Brain.**—What is it that directs all the movements of the muscles? It is the **brain** A (Fig. 14), lodged in the skull, and its extension, **the spinal cord,** lodged in the vertebral canal.

Intelligence resides in the brain. When the brain is taken out or severely injured, no trace of intelligence, sensation, or will remains.

12. **Nerves.**—By what means does the brain send its orders to the muscles to set them in motion? By means

of the spinal cord B and the **nerves** C, C. The nerves are fine white fibres, often very long, which set out from

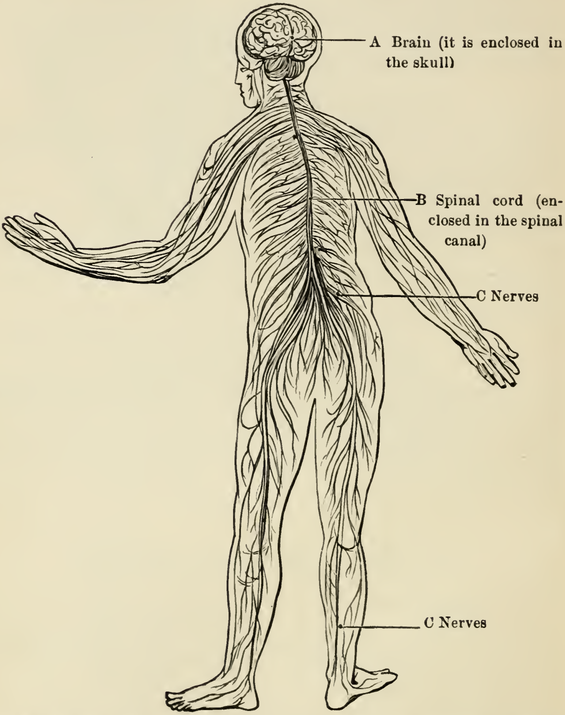


FIG 14.—In the skull is contained the brain A. From the brain proceeds the spinal cord B, which is enclosed in the spinal canal. From the spinal cord proceed the nerves C, C, which extend to every part of the body.

the spinal cord and the brain, and thence spread to every part of the body. The number of the nerves is countless.

The nerves which direct the movements are called **motor nerves.**

There are also **sensory nerves.** It is these that carry to the brain the impressions which come to them either from without or from any part of the body by means of the **senses.**

Touch a piece of marble: the sensation of cold that you feel is received by your skin and sent to your brain by the sensory nerves.

If you eat some salt, the salt taste is received by your tongue and sent to your brain in the same way by the sensory nerves. There are other sensory nerves which carry to the brain the sensations felt by your nose (odors), by your ears (sounds), by your eyes (form and color).

You will learn, when you are older, how the different **organs of sense** are constructed.

Alcohol causes a change in the structure of the brain and nerves. It causes the brain to work improperly. It causes the mind to make bad thoughts and the mouth to give forth bad and improper words. When beer or wine or spirits are taken in excess, silliness and drunkenness are the result.

Tobacco weakens the nerves. Cigarettes, as smoked by the young, cause trembling, dizziness, and even head-sickness. The young user of tobacco often cannot write or draw nicely and evenly. Alcohol and tobacco often lessen the sharpness of sight in the young.

13. The Skin.—The **skin** covers the whole body. Everywhere (except on the palms of the hands and on the soles of the feet) it is covered with **hairs**, the most of which are so small that we can scarcely see them.

When the beard grows, there are no more hairs on the chin than there were before: they have simply become larger.

The skin is made up of two layers: the under layer is called the **dermis,** and the upper layer the **epidermis.** The latter is all the time being destroyed and renewed. On the surface of the skin is found, especially in warm weather, a liquid called **sweat.**

There is also a kind of fatty varnish produced by little glands in the skin, which keeps it from being wetted when dipped in water.

Alcoholics and Tobacco.—Beer or spirits cause the toper to have a red, rough, and pimply skin. The smoking of cigarettes by young boys makes their skin appear old and yellow.

SUMMARY.—3. The Nervous System.

The Nervous System.—The principal organs of the nervous system are the **brain,** the **spinal cord,** and the **nerves.**

The Brain.—The **brain** is the seat of **intelligence.** It is the brain that directs the movements. It sends its orders to the muscles by means of the **spinal cord** and **motor nerves.**

The sensations (feeling, sight, hearing, etc.) experienced by different parts of the body are carried to the brain by the **sensory nerves.**

The Skin.—The skin is formed of two layers: that on the surface is the **epidermis,** the other, which touches the flesh, is the **dermis.**

The skin produces a liquid called **sweat,** and a kind of varnish which protects it from the wet.

QUESTIONS.—THE NERVOUS SYSTEM.

What is it that directs the movements? Where is the seat of intelligence? By what means does the brain send its orders to the muscles to put them in motion?

What are the nerves? What are the nerves that direct the movements called? How are the impressions made on our senses sent to the brain? Name some impressions sent by the sensory nerves.

What is the skin? Of what two layers is it formed? What does the skin produce?

What is the effect of alcohol on the brain and nerves? Of tobacco? What of cigarette-smoking? How does alcohol or tobacco affect the eyesight? How do spirits or beer affect the skin? How cigarettes?

4.—DIGESTION.

The part of this lesson which you all know, as with many other of your lessons, is the beginning. We take food and put it in our mouth; then, if it is small in bulk or is liquid, we swallow it at once; if it is too large for this, we chew it in order to break it up.

14. The Teeth.—The process of chewing, or mastication, is effected by the aid of the **teeth,** which cut and break the food, and of the **tongue,** a very movable mus-

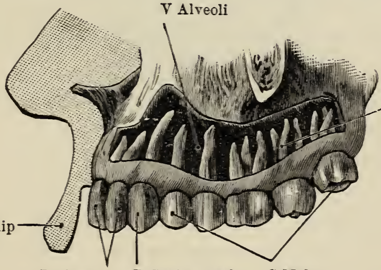


FIG. 15.—Human jaw in profile, and so cut as to show the teeth and their roots in the alveoli.

cular organ, which pushes the food under the teeth and rolls it into a sort of ball when ready to be swallowed.

The teeth are of very different shapes (Fig. 15). In front they are cutting, the *incisors,* A; on the sides they are pointed, the *canines*, B; farther back they are large and flat, the *molars*, C. I have, or rather I ought to have, in my mouth, in each jaw, four incisors, two canines, and ten molars,—thirty-two in all. You children, up to the age of about seven years, have only twenty teeth, called milk teeth, having only four molars in each jaw. After that age, one after another your first teeth, or milk teeth, fall out, and your second teeth, or permanent teeth, begin to appear. The teeth are planted by one or several roots in pits of the jaw called **alveoli.**

Tobacco hurts the teeth. It causes the user to spit very often. Frequent spitting weakens the digestive powers. Spitting is a bad habit. Tobacco fouls the mouth and makes the breath offensive.

Candy acts badly on the young. It hurries digestion. It aids in the decay of the teeth. Pure sugar does little harm when taken in small amounts with other food. All candies are bad for children.

15. Saliva.—The breaking up of the food is made easier by the action of the **saliva,** which comes into the mouth through several holes, two of which are under the tongue, near its root, and are easily seen.

16. Swallowing.—When the food is well broken and moistened with saliva and rolled into a sort of ball, the tongue pushes it into the throat; there it is at once seized by the muscles of the throat and carried away. This operation is **swallowing.**

17. The Digestive Canal.—The food then descends into a long tube, and, passing the neck and chest, reaches the **stomach** (Fig. 16).

The stomach is a kind of sack, holding, in man, two or three pints. From the stomach the food in time passes into the **small intestine,** a sort of tube a little larger in diameter than the thumb and coiled on itself

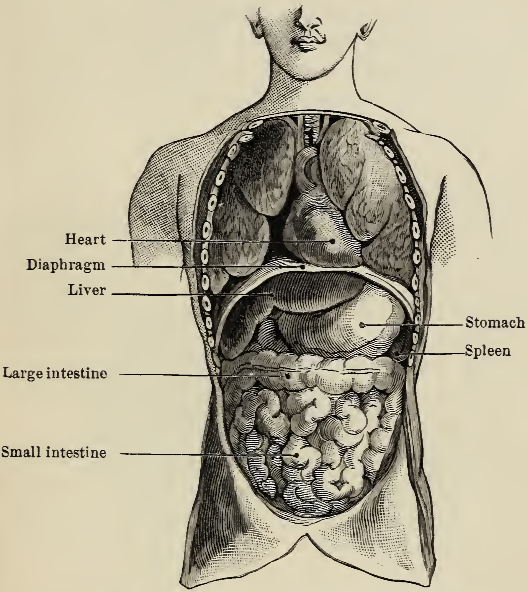


FIG. 16.—Position of the principal organs of digestion.

many times, and finally into the **large intestine,** which carries off the useless material and expels it. The stomach and intestines are contained in the **abdomen.**

The abdomen is separated from the chest, or thorax, by a thin partition called the **diaphragm.** This partition is a muscle, and plays an important part in breathing.

The tube of the throat, the stomach, and the intestines form what is called the **digestive canal.**

18. **Digestive Juices.**—The foods while passing along the alimentary canal are **changed** into new substances under the influence of certain liquids or **juices.** The first of these juices is the **saliva.** Who has not amused himself by chewing a bit of bread for some time? and why? Because after a short time the bread becomes of a sweet taste. This is because the **saliva** has changed some of the bread into **sugar**; some of the starchy part has become **sugar.**

In the stomach the foods receive the **gastric juices,** which dissolve meat and all animal matter except fat. There is also the **pancreatic juice,** which is poured into the small intestine by an organ called the pancreas. Finally the **bile,** a bitter, greenish-yellow fluid, is poured in by the liver. All these juices help to make the foods into fluids and permit them in this form to be mingled thoroughly with the blood.

Alcoholics.—Beer and wines, as commonly used, keep back digestion. They weaken the power of the digestive juices. Spirits, when used in excess for a long time, injure the digestive organs. When the organs are injured they fail to carry on perfect digestion.

When alcoholics are taken into the stomach they soon reach the blood. The blood takes them to all parts. Hence distant organs become affected. Beer and spirits, after a time, cause severe and lasting disease of the liver and kidneys.

5.—BREATHING.

19. Lungs, Windpipe, Larynx.—The air which we breathe goes into the chest, or, to speak more correctly, into the **lungs,** A (Fig. 17).

You know, of course, what the lungs are like. Butchers call them the lights, and give them to the cats to eat.

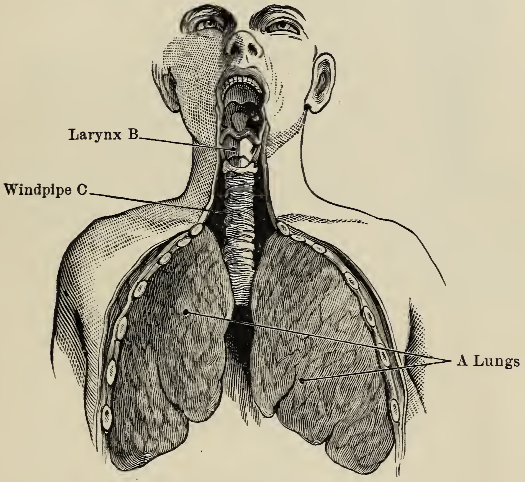


Fig. 17.—Principal organs of respiration.

We are told that cats like them, but I assure you they like meat better; and they have good reason, for the lights are a kind of tough sponge, difficult to chew; they are little else than air.

There are two lungs in the chest,—one on the right side, the other on the left side. These organs are hollow and very complicated. They are connected with the throat by a long tube, C, called the **windpipe.**

At the top of the windpipe is the **larynx,** B, in which the sounds of the **voice** are formed.

20. Respiratory Movements.—How does the air enter the lungs? Examine yourself (Fig. 18) by putting one hand on your chest and the other on your abdomen. You see, what you already knew, that regularly, about fifteen times a minute, you **breathe,**—you make respiratory movements. You also know that each of these movements is double: there being first **inspiration** (in which the air enters the lungs) and then **expiration** (in which the air goes out of the lungs).

FIG. 18.—During inspiration the air enters the lungs. During expiration the air goes out of the lungs.

During inspiration you feel that your ribs are raised, that your chest is enlarged, and that your abdomen swells out in front as the air goes into the lungs. During expiration the contrary takes place: the ribs sink, the abdomen flattens, the chest becomes smaller, and the air comes out as though driven by a bellows.

You will learn when you get older how all this takes place. You will also learn that the air that comes out of the lungs is very different from the air that goes into them, and that we should very soon be killed if we breathed the same air over and over again.

Alcoholics.—Some persons think that the use of wine or spirits will prevent consumption of the lungs. This is not true. Many drinkers of wine or spirits die of this disease. Smoking irritates the upper parts of the lung-tubes, and thus hastens lung-disease.

6.—CIRCULATION.

21. Blood.—The food made into a liquid by digestion then passes into the **blood.** The blood carries it to every part of the body, where it is used to repair the waste parts or tissues. In the lungs, where it takes up air, it acquires all the qualities needful to nourish the different parts of the body. You well know that there is blood everywhere in the body; for if you prick yourself with the finest needle, no matter where, you will bring out a drop of blood.

This morning we killed a rabbit at the house. I have brought some of the blood in a glass to show you. See, the blood has separated into two parts: a **yellowish liquid** and a dark red **clot** which floats in the liquid. This is because the blood, almost as soon as it comes from the body, curdles, **clots,** or **coagulates,** as it is called.

The blood is contained in small tubes or blood-vessels, the distribution of which in the body is very complicated.

22. Heart, Veins, Arteries, Capillary Tubes.—In the chest, a little to the left side, is the **heart** (Fig. 19), a sort of pouch, or hollow muscle which contracts at regular intervals, forcing out the blood that is in it.

The **veins** are the tubes by which the blood flows to the heart, and the **arteries** those in which the blood is sent out by the heart. At first there is only one large artery, C, setting out from the heart. This soon branches into smaller ones, which become more and more numerous and smaller the farther they are from

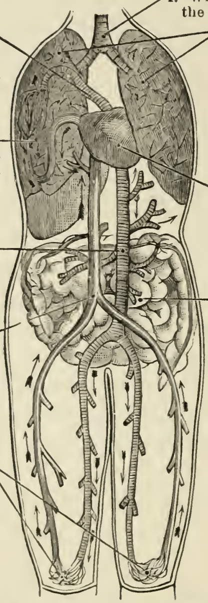


FIG. 19.—Figure showing how the blood circulates in our bodies. (Read in the order of the letters or the figures.)

the heart. They end in very fine tubes, E, called **capillaries** (from the Latin *capillus*, a hair), though they are smaller than the finest hair. These capillaries connect the arteries with the veins. The veins, at first very small, unite with one another, forming larger and larger veins, which grow less and less numerous, until there is only one, D, when very near the heart. You now see how the **circulation of the blood,** as it is called, is carried on.

The blood is forced with great rapidity from the heart into the arteries, and from the arteries into the capillaries, then from the capillaries it returns to the veins, and from the veins to the heart. The whole journey is made in half a minute. This is the **great journey** of the blood, which carries it to every part of the body.

There is another, a **short journey,** in which the blood goes only to the lungs, but it is, nevertheless, much the same thing; the blood passes from the heart into the pulmonary artery, A, then into the pulmonary capillaries, and finally into the pulmonary veins, B, which conduct it back to the heart. We shall learn by and by what qualities the blood acquires in the lungs.

Tobacco causes the heart of the young smoker to work improperly. When a young person smokes cigarettes or cigars, the hot smoke injures the lining of the mouth, throat, and air-tubes. The drugs of the tobacco penetrate into the blood. The blood takes these injurious drugs to all parts. The drugs do injury to the brain, the nerves, the glands, and the muscles. At an examination in 1887 of twenty young men who wanted to go to West Point Military Academy, ten out of the twenty were rejected. They were rejected because of "tobacco-heart," caused by smoking cigarettes. "Tobacco-heart" unfits young persons for hard good work.

Beer, when used largely for a long time, may cause "fatty heart." A fatty heart is a weak heart. It also causes a fatty change in the arteries. Fatty arteries are liable to crack open. When an artery in the brain cracks open, a dangerous condition, called apoplexy, results. In apoplexy a man falls as if he were struck with a club. It often results in sudden death.

SUMMARY.—4. Digestion. 5. Respiration. 6. Circulation.

Digestion.—Man has three kinds of **teeth**; *incisors,* which are cutting; *canine,* which are pointed; and *molars,* which are large and flat.

Until about seven years of age we have only twenty teeth (first, or milk, teeth). After the age of seven years the permanent, or second, teeth appear,—thirty-two in all.

The food is broken up by the teeth and moistened with the saliva. By the aid of the tongue it is passed into the throat, and descends by a long tube into the **stomach.** From there it passes into the **small intestine,** and finally into the **large intestine.**

In its passage through the different organs the food receives the *digestive juices,* which turn it into a **liquid** and prepare it to be thoroughly mingled with the blood.

Respiration.—The air we breathe passes through the larynx (organ of voice), then through a tube called the windpipe, and from there it is distributed to both **lungs.**

In the lungs the blood acquires properties needful to nourish the different parts of the body.

Circulation.—The blood, forced by the **heart,** passes from the heart to the **arteries,** from the arteries to the **capillaries,** from the capillaries to the **veins,** and from the veins back to the **heart.**

In the same manner the blood goes to the **lungs,** passing through first the **pulmonary arteries,** then the **pulmonary capillaries,** and finally the **pulmonary veins** back to the heart again.

QUESTIONS.—DIGESTION.

What is mastication? What are the different kinds of teeth? How many teeth ought a grown person to have? How many a child before seven years old? How are the teeth planted in the jaw? What effect has tobacco on the teeth and mouth? On digestion? How does candy affect the teeth? The digestion? What liquid aids the breaking up of the food? What is swallowing? Where do the foods go to when swallowed? What is the diaphragm? What are digestive juices? Name them. What are the effects of these juices on the food? What are the effects of beer and wines on the digestion? On the digestive organs? What effects have they upon the liver? The kidneys?

QUESTIONS.—RESPIRATION.

Where does the air we breathe go to? Describe the lungs. What connects the lungs with the throat? Where is the larynx? What is its use? By what does the air enter the lungs? Describe inspiration. Describe expiration. Is the air that comes out of the lungs similar to that which entered? What becomes of the food after being made liquid? Will wine or spirits prevent consumption of the lungs? How does smoking affect the lungs?

QUESTIONS.—CIRCULATION.

Of what is the blood composed? In what is it contained? What is the use of the heart? What is a vein? What is an artery? How are the arteries distributed? How do the veins and arteries communicate with one another? Where are they distributed? Sum up the circulation of the blood. Is there another smaller circulation? Describe it. What are the effects of smoking tobacco on the lungs? What does the blood do with the drugs of tobacco? What are the effects of smoking tobacco on the heart? Of beer?

READING-LESSONS.

1. Composition of Bones.—Here is a chicken-bone which I have put in the fire. It has burned and broken into pieces These pieces are white and brittle. There remains only the stony matter. The living or organic part has been destroyed by the fire.

Here is another piece of bone which I have left for several days in strong vinegar. The stony matter has been dissolved by the vinegar, and this time what remains is flexible and elastic. It is the organic matter of the bone. It is from organic matter that glue is sometimes made.

2. Nutrition of Young Children. Rickets.—It is the stony matter that makes the bones stiff and hard; without it they would be soft and flexible.

When quite young the bones contain only animal matter; the stony matter enters little by little and hardens them. This hardening proceeds regularly with children that are fed upon good milk, because they digest it well. It proceeds, on the contrary, very slowly and very imperfectly in young children fed too soon upon soup, meat, and vegetables. In consequence of this poorly-digested food the bones of the child remain in the flexible state too long. The backbone bends. The bones of the limbs, unable to bear up the weight of the body, are curved. The child has, as we say, the rickets, and there is a great chance, if it lives, of its being lame, hump-backed, or in some other way deformed.

But this is not the only bad effect of unsuitable food: it sometimes produces a terrible disease of the intestines—cholera infantum—which takes away every year a great number of children.

3. Fracture of Bones.—Sometimes a bone is broken by a fall or a blow. The surgeons then say it is fractured. They bring the ends of the broken bone together and fasten them with splints of wood and linen bandages. Then they wait until the bone mends itself (or grows together). This is how it is done: after some time there is formed between the ends of the bone a substance called callus, which becomes bone and holds the ends firmly together.

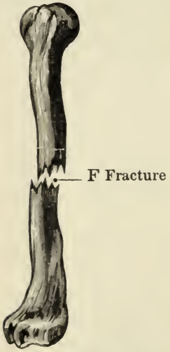


Fig. 20.—Broken bone.

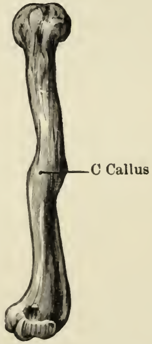


Fig. 21.—The same united by callus.

The way this callus is formed is very curious; but I have not time to tell you about it now, and I hope you will have no occasion to learn it at your own cost.

4. Distortion of the Spinal Column.—The chain of bones which forms the spinal column is very movable, and that is very fortunate, for, thanks to this mobility, we can turn our body almost as we wish.

But this mobility has also its dangers; for if you form the habit of twisting or bending over too much, leaning on one elbow, sitting badly, leaning on the desk,—in a word, doing those things which I tell you very often not to do,—you run the risk of having one shoulder higher than the other or twisting the spinal column so that it will not again become straight. (Figs. 23 and 25.) You

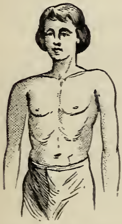


FIG. 22.—What follows from leaning too much on one elbow: high-shouldered.

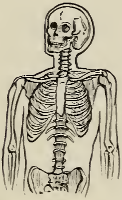


FIG. 23.—Skeleton of a high-shouldered child.

FIG. 24.—Stoop-shouldered.

FIG. 25.—Spinal column in stoop-shoulder.

then become more or less deformed. Think of this, and remember that it is not for the pleasure of seeing you all in a line at your desks that I so often reprimand you. You run a great risk in not obeying me.

5. Injuries to the Joints.—When the ligaments about a joint are stretched too far, or even a little torn, as sometimes happens when we make a false step, there results what is called a sprain. If the false step or movement has been such as to rupture nearly all the ligaments, the bones are no longer held end to end: they are put out of joint. This is what is called a dislocation.

Sprains get well of themselves with rest and time, but not so with dislocations. We should act quickly and pull upon the bones in order to get them into place. After a few days this is very difficult; and after a few weeks it becomes impossible, and the person is lame for life.

When you receive a sprain, you should call at once a good physician. It is not easy to tell a severe sprain from a dislocation or from a fracture. You need a physician to tell you that. Never let a quack treat you. You would not carry a watch or even a lock to a quack to be mended, since he has never learned how to mend watches or locks; would you then give him your body to repair, the most complicated thing in the world? Where has he studied medicine or surgery? The good physician, on the contrary, has studied for years in the medical college.

A broken bone may grow together crooked, or a joint become stiff; nor is this the worst that can happen. A badly-cared-for sprain, or, in general, a blow upon a joint, often endangers life itself. The joint may become inflamed and water form in it; then the bones become enlarged, and a terrible disease, called white swelling, is often the result.

Rarely is any one cured of this without becoming lame, and sometimes it is even necessary to cut off the limb; and those are fortunate who can survive this. These are some of the evils ensuing from not calling in a good physician in cases of injury to the joints.

FIG. 26.—The muscles that we bring into play become stronger: witness the arms of the blacksmith.

6. Gymnastic Exercise.—If we use our muscles they become larger, harder, and stronger. It is for this reason that bakers and blacksmiths have such large arms, since they work hard in kneading the dough or in striking upon the anvil with the heavy hammer. This makes their muscles large. For the same reason those who walk much have large muscles in the legs. You thus see the usefulness of exercise, and why after you have worked hard in school it is good for you to run and play. This exercises the muscles. People who pass their lives in-doors, with little or no moving about, as is the case with many living in cities, cannot be very strong. They need to take exercise; and the best way for them to do so would be by gymnastics, because the movements of the gymnasium have been so arranged as to bring into play all the muscles of the body.

7. Wounds.—The coagulation of the blood is of the greatest service to us. Without it, when we cut ourselves, the blood would flow out of our body so long as the heart beat, but now a clot is formed, which stops the flow of blood.

The *veins*, even when large enough to do so, can be opened without too great loss of blood. This is because they have thin walls, which fall in and thus aid in closing the opening made. The physician draws the blood from a vein in the arm when he bleeds a person.

With the *arteries* it is different. They have thick walls, and when we cut them the blood comes out with force and spurts several feet. There is then great danger, and a physician should be sent for. But while waiting, what should be done? Come, James, tell us. You do not know? Reason. Why does the blood spurt so? "Sir, it is because the heart beats." Good. Well, then, if an artery were opened in your hand and you should bind your arm tightly with a cord between the place and the heart, you would prevent the blood from passing and stop the bleeding.

Fig. 27.—Boy having an artery opened in the hand. We bind the arm with a cord and stop the flow of blood.

If, then, you find yourself with any one who has an artery opened, one of the hand, for example (Fig. 27), you must bind the forearm so tightly as to stop the flow of blood.

Hold up your arm. I will bind it, but only with a handkerchief, so as not to injure you. Look, your hand becomes first red, then purple; it is the blood which, no longer able to return to the heart, swells the veins of the skin. Is the blood stopped in the arteries? You do not know? Let us find out. I feel your wrist carefully near the root of the thumb. Ah, I feel your pulse, and I conclude from it that the blood still passes in the artery. For your pulse, which you feel plainly, is produced by the beats of the heart, which throws the blood into the arteries.

Do you wish for proof of this? Come here, Henry; hold James's pulse and put the other hand on his heart. What do you feel? "Sir, both beat at the same time." That is just what happens.

You see that simply a handkerchief is not sufficient to stop the flow of blood in the artery, and that it is necessary to bind it strongly *with a cord.*

8. Food may be a Cause of Disease.—Stale fish may cause pain, sickness at the stomach, vomiting, and diarrhœa. The flesh of the hog may contain a minute worm called the *Trichina* (tri-ki′na). This worm causes intense pain, as it crawls from the intestines through the muscles of man. Thorough cooking will kill such worms.

Ice-Cream.—Ice-cream should not be taken after a full meal. It cools the stomach. It slows digestion. It may cause pain, colic, and severe illness. Ice-water ought not to be freely taken, either with food or when the person is overheated. Ice-cream, when made from poor materials or when kept too long, develops a poisonous agent. This agent causes pain in the stomach, violent vomiting, and sometimes severe illness.

Improper eating, and especially *over-eating*, is a source of more ill health and disease than any other one thing, except bad air. *Improper habits of eating* do more harm to health than even the alcoholic drinking habit. This is the opinion of great doctors and of observing scientific men.

You should eat plain, simple food (milk, whole wheat, oatmeal, stale bread, fruits, etc.).

You should eat slowly.

You should chew the food thoroughly.

You should take only a moderate amount.

You should eat at regular hours.

You should rest after eating.

Children ought not to eat rich, spiced foods (rich sauces, puddings, pies), confectionery; pork, ham, and "gamey" food; unripe fruits; ice-cream; preserved fruits (raisins, citron, etc.).

FIG. 28.—Tobacco-plant.

Tobacco.—The different kinds of tobacco which are sold in the stores are made from the prepared leaves of the tobacco-plant (Fig. 28). This plant was found in Virginia by the early settlers. Its leaves contain a very powerful drug called *nicotine.* Nicotine is a poison which will cause death with lightning-like rapidity.

The Drugs of Tobacco (for nicotine is not the only drug in tobacco) hurt children very severely. They cause stomach-sickness, head-sickness, and muscle-weakness. *They stunt the growth of children who smoke, snuff, or chew tobacco.* They hinder the proper action of most of the essential parts of the growing body.

FIG. 29.—Opium-plant.

Tobacco is not a food. Children do not need it. They should not be allowed to learn to use it.

Morphia.—This is a powerful drug. It is derived from the opium-plant (Fig. 29). This plant is largely raised in Turkey, India, and China. The Chinese smoke prepared opium to get dreamy effects. The Americans take opium-preparations in the form of laudanum, "tonics," "cough-medicines," "soothing-syrups," "sleeping-draughts," and as morphia, under the skin.

Soothing-Syrups.—These are used to quiet babies and young children. Most of them contain morphia. They cause a deep, stupid sleep. They hurt the nerves and muscles worse than beer, or wine, or tobacco. We have learned some of the bad effects of these latter drugs. Mothers ought not to give soothing-syrups to their children.

Alcohol.—Beer contains alcohol (Fig. 30). Cider contains

FIG. 30.—The white space shows the proportion of alcohol in each of the measures.

alcohol. Wines contain alcohol. Spirits (rum, brandy, gin, whiskey) contain alcohol. Alcohol is a drug.

Uses.—Alcohol is useful for making drugs, and for preserving objects of natural history. It is needed in the making of rubber goods, varnishes, cooking-extracts, and cologne water. It is the active agent in most "tonics" and "bitters." About one-half the alcohol made is used in the arts.

Drugs are useful in disease. A healthy person needs no drugs. Most ailing people need simple food, pure water, warm, clean clothing, frequent bathing, plenty of fresh air, and daily exercise in the sunlight, *rather than drugs.* Hence healthy children, healthy men, healthy women, should not use beer, cider, wine, or spirits, which are drugs.

SUBJECTS FOR COMPOSITION.

MAN.

First Exercise (p. 10).—How is the flesh sustained? The vertebral column, thorax, skull, pelvis, bones of the limbs. Points where the bones play upon one another. Bands which unite the bones.

Second Exercise (p. 15).—The bones are motionless of themselves. What organs give to bones the power of motion? Explain, for example, the movement of the arm.

Third Exercise (p. 17).—The muscles, left to themselves, are motionless. What is the organ that directs their action? How is the transmission made?

Fourth Exercise (p. 21).—Through what do the foods pass? Under what influence are they transformed?

Fifth Exercise (p. 25).—How do we breathe?

Sixth Exercise (p. 27).—How does the blood circulate through the body?

Seventh Exercise (p. 32).—Little children often have crooked legs. How can this be avoided? Use of gymnastics for exercise for young people and for men.

Eighth Exercise (p. 33).—What should we do when we receive a sprain? When we are wounded?

Ninth Exercise (p. 37).—Bad effects of tobacco, and the drugs of tobacco. Soothing-syrups. Alcohol.

II.—ANIMALS.

23. Classification of Animals.—Having studied man, we are now going to pass to the study of animals, and I am sure there is no danger of my wearying you

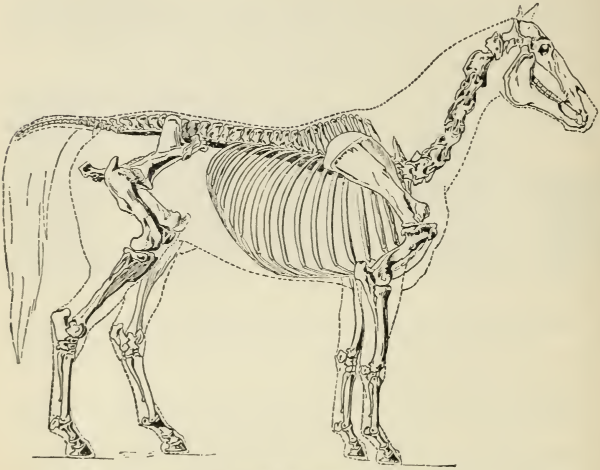


FIG. 31.—A horse has bones (vertebrate).

while upon this subject. Nothing is more interesting than the history of animals; and it would be very easy for me to amuse you during many of the lessons by describing to you their manner of life, the services they render us, and the dangers we have to fear from them.

But we must proceed in an orderly manner, and to do this we must not study animals one after another in a hap-hazard way; we must follow what naturalists call a **classification.** It is necessary to group together the ani-

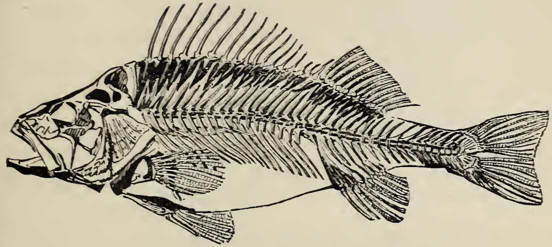


FIG. 32.—A fish has bones (vertebrate).

mals that are most alike, so as to avoid having to repeat for each of them that which is common to all. Thus, we shall put all the **birds** side by side and say once for all that they have a beak, wings, and feathers.

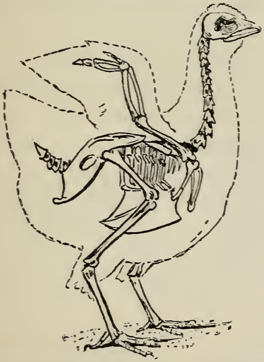


FIG. 33.—A chicken has bones (vertebrate).

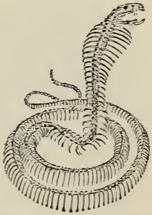


FIG. 34.—A serpent has bones (vertebrate).

24. Animals with Bones and Animals without Bones.—Yes, we must do as naturalists have done, and arrange all in order.

And, first of all, naturalists have noticed that a great many animals **have bones** inside the body, and that a great many others **have no bones.** Thus, a man, as we have already seen, has bones; so has a horse (Fig. 31), a fish (Fig. 32), a chicken (Fig. 33), and even a serpent (Fig. 34) or a frog (Fig. 35); but a slug (Fig. 36) has no bones, neither has a beetle (Fig. 37), nor a crayfish (Fig. 38), whose skin alone is hard.

FIG. 35.—A frog has bones (vertebrate).

There are, then, two great classes of animals: **animals with bones** and **animals without bones.** The whole of the bony framework is called the **skeleton.**

FIG. 36.—A slug has no bones (invertebrate).

25. Vertebrates and Invertebrates.—All animals that have bones have also, like man, a spinal or vertebral column. For this reason animals with bones are called **Vertebrates,** and those without bones **Invertebrates** (that is to say, not vertebrates).

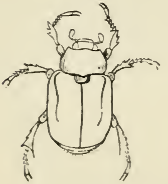


FIG. 37.—A beetle has no bones (invertebrate).

Another characteristic known for a long time, and a very important one, helps us to distinguish the vertebrates from the invertebrates. It is that none but vertebrates have **red blood** like our own in their bodies. You already

FIG. 38.—A crayfish has no bones (invertebrate).

know this to be true of our domestic animals. The same is true of serpents, frogs, and fishes: all have red blood. If, on the contrary, you were to prick a beetle, a slug, or a crayfish, a drop of **colorless** liquid would come from the wound.

SUMMARY.—Animals.

Classification of Animals.—There are two great classes of animals,—animals that **have bones** and animals that **have no bones.**

The name of **vertebrates** (having vertebræ) is given to animals having bones, and that of **invertebrates** (without vertebræ) to animals having no bones.

Vertebrates present this definite characteristic,—*they alone have red blood.*

1.—VERTEBRATES.

26. Division of Vertebrates.—I am about to tell you something which you must learn by heart.

Vertebrates are divided into the following classes:

FIG. 39.—A mammal (goat).

FIG. 40.—A bird (wild pigeon).

FIG. 41.—A reptile (water-snake).

1. **Mammalia** (Fig. 39), those that nourish their young with milk.
2. **Birds** (Fig. 40).
3. **Reptiles** (Fig. 41).

4. **Amphibians** (Fig. 42).
5. **Fishes** (Fig. 43)


FIG. 42.—An amphibian (frog).


FIG. 43.—A fish (salmon).

We shall now study the characteristics of these different groups.

VERTEBRATES.—I. Mammalia.

27. The Dog Jip.—You already know one mammal, —namely, man, whom we have just studied. I might now simply say to you, "The organs that you found in man you will find also in other mammals; the work that you have seen done by the organs of man you will see done by the organs of other mammals." I think, however, it will be useful to examine closely an ordinary mammal: we will take as an example my good dog Jip.

We see, first of all, that Jip's skin is all covered with hairs. These hairs grow constantly, and should we cut them off they would grow out again, just as do the hairs on the face after being shaved off.

The body of Jip is made up of several parts. There is the **head,** the **neck,** the **body proper,** and the **tail.**

In the fore part of the **head** is the mouth, having two jaws, furnished with sharp, white teeth. The lower jaw, F (Fig. 44), **moves** up and down; the upper jaw, G, is **fixed** to the rest of the head.

Above the mouth are two holes, H, the two nostrils, by means of which Jip breathes and smells. Still higher are two eyes, I, separated from each other, and each provided with two movable lids.

On the sides of the head are the ears, J, of which the exterior ear, or flap, is in almost constant motion. At

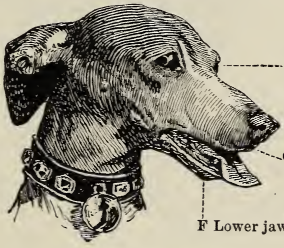


FIG. 44.—Dog's head.

the bottom of the exterior ear is the opening of the auditory canal.

Of the **neck** I need say nothing now, except that it is sufficiently flexible to allow the animal to turn his head in any direction.

Let us pass to the **body**. At first sight you will notice two parts. The first, C (Fig. 45), comprised between the ribs, solid and resistant to pressure, with bones under the skin, is the chest; the other, I, soft and flabby, is the abdomen.

On each side of the chest are the fore legs. You see they are entirely free, and I can even move the part B, which is concealed under the skin on the side of the chest. This latter part is the shoulder-blade; then comes the arm, D, then the forearm, E, and finally the hand, F, with the fingers, G, and the nails in the form of claws. Back of the abdomen are the hind legs. As in man, they are attached to the **pelvis,** K. Then follow

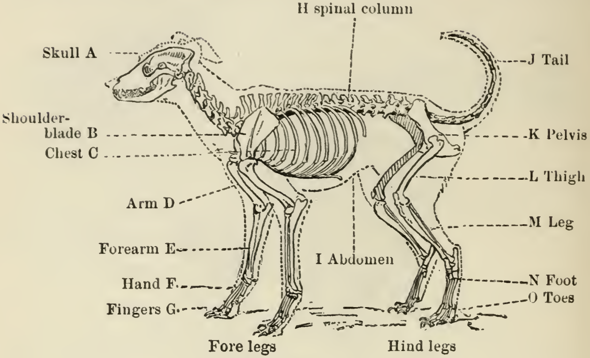


Fig. 45.—Skeleton of dog.

the thigh, L, and the leg, M, then the foot, N, which resembles the hand of the fore leg, as well as the big toes, O. Last of all comes the **tail,** J, long and flexible, having a series of vertebræ which you can easily feel.

All mammals resemble the dog more or less. But there are great differences among them, in the shape of the limbs, in the nature of the teeth, etc., according to the kind of life the animal is called upon to live.

An animal that climbs cannot be formed like an animal that swims; an animal that eats grass cannot be formed like an animal that eats meat.

28. The Sheep.—Let us examine closely this sheep (Fig. 46) which Farmer Jones has very kindly brought me for that purpose. Certainly it is in general like our dog. It has hair, a head, a body, four feet, and teeth. In these there is a general resemblance to the dog.

Let us look, however, at the feet (Fig. 47). Instead of nails in the form of claws, the sheep has what are

FIG. 46.—Sheep.

FIG. 47.—Leg of the sheep, ending in a hoof.

called **hoofs**. The animal walks on these hoofs, and they serve no other purpose; while in a dog, and still more in a cat, the claws are powerful weapons, as you have doubtless learned more than once, to your cost.

29. Division of Mammals into Carnivora and Herbivora.—Let me now call your attention to something very important. Open the sheep's mouth, James, while I hold open that of Jip. Both are furnished with teeth; but what a difference!

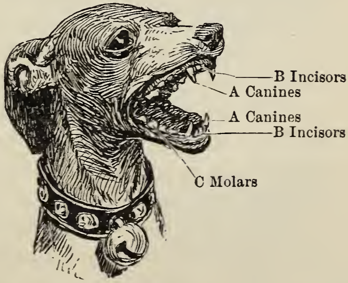


FIG. 48.—Jaws and teeth of the dog. (The skin has been cut away in order to show the teeth.)

See, on each side of the dog's mouth (Fig. 48), these four long, pointed teeth, A, the **canines**; those in front, cutting teeth, B, the **incisors,** which glide against each other like the blades of a pair of scissors when the dog shuts his mouth; finally, back of all, the **molars,** C, cutting teeth also.

The sheep (Fig. 49) has no **canines,** and has **incisors,** I, in the lower jaw only; back of these are **molars,** M, with crowns like the faces of millstones.

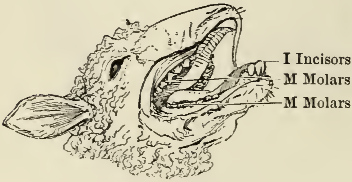


FIG. 49.—Teeth of the sheep.

With his sharp canine teeth Jip could strangle the sheep, and he could easily eat his flesh by cutting it to pieces with his back teeth.

On the contrary, the sheep cannot bite, but his large, flat molars completely grind up the hay or grain that he feeds upon. While eating, the sheep moves the lower jaw, as you see, **sideways,** from right to left and from left to right, and by so doing grinds the food under the "millstones" of his jaws. Jip moves his lower jaw but little in any direction except **up and down.**

Thus you see that the way in which the dog is formed permits him to run in order to catch his prey, to spring upon it with his claws, to strangle it with his front teeth, and to devour it with his back teeth. All this indicates that the dog is an animal that eats other animals,—an eater of flesh, a **carnivorous** animal.

The sheep can only crop the grass, grind it, and protect himself by running away on his hoofs in case of danger. He is an eater of grass,—an **herbivorous** animal.

We may thus divide mammals into two great classes, —**Carnivora,** or flesh-eaters, and **Herbivora,** or herb-eaters.

CARNIVORA.

FIG. 50.—Lion and lioness at home.

30. The Cat Family.—The true flesh-eaters are those that pursue and kill other mammals.

We must place the **cats** at the head of this division, since they are the best armed with teeth and

FIG. 51.—Jaguar (Central and South America). Nearly as large as the tiger, but not so ferocious.

FIG. 52.—Panthers live in the forests of Asia and Africa.—Attacking monkeys.

FIG. 53.—Hunting the tiger with the elephant (Asia).

claws. They also are the most **carnivorous.** Dogs, in fact, will eat bread, potatoes, etc., but cats for the most part despise vegetable food.

The **Cat Family** comprises the wild beasts that are terrible even to man,—the African lion (Fig. 50), the jaguar of America (Fig. 51), the panther (Fig. 52), and the tiger (Fig. 53). Many smaller kinds, among which is the wild-cat (Fig. 54), attack only small animals.

FIG. 54.—American wild-cat or lynx.

31. The Dog Family.—This is the family to which our good dog Jip belongs. It also is well provided with

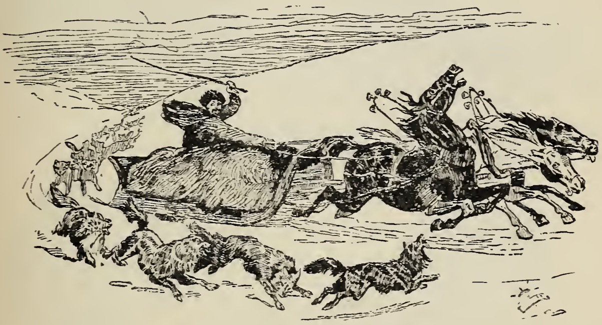


FIG. 55.—Chased by wolves.

teeth and claws, but the claws are not so well fitted for tearing the flesh of captured animals as are those of the cat family.

The wolves (Figs. 55 and 56), as a rule, attack man only when driven by hunger, or when assembled in packs. The foxes (Fig. 57) are harmful only to poultry. The jackals, a species of small wolves found in Africa, are harmless to man. So also are the hyenas (Fig. 58) of the same country, notwithstanding their height, their strength, and their love of flesh.

FIG. 56.—Head and teeth of wolf.

FIG. 57.—The fox hunts poultry and birds.

FIG. 58.—Hyena (Africa).

32. The Bear Family.—Certain bears, notably the

FIG. 59.—White bears attacking a canoe in the polar seas.

grizzly bear, found in the Western United States, and the white bear (Fig. 59), which lives in the polar regions of the north, unhesitatingly attack man. The brown bear (Fig. 60) of the Alps and Pyrenees in Europe is of a much more peaceful disposition.

FIG. 60.—Brown bear of the Pyrenees. Prefers fruits and honey to flocks and herds.

In addition to these there are numerous species of small carnivora which prey upon small mammals and upon birds. Among these are the marten, the weasel, the mink, the sable, the polecat, and the ermine,—the last-named much less common than the others.

33. Insect-Eaters (Insectivora).—Another class of small-sized flesh-eaters which feed upon weaker animals preys especially upon insects; for this reason they are called **Insectivora.**

Of these the best known are the mole (Fig. 61),

FIG. 61.—Mole. It eats white worms, or larvæ, and therefore should not be destroyed.

FIG. 62.—Hedgehog. Instead of hair it has spines. It sleeps through the winter.

which with its strong fore-feet digs under ground long galleries, heaping up the earth in the form of mole-hills, to the great annoyance of the farmer; the hedgehog of Europe (Fig. 62), which rolls itself completely into a ball, presenting an array of sharp quills to the jaws of the dog that molests it; the shrew, which resembles the mouse; and the bats (Fig. 63).

FIG. 63.—Bat (Mammal).—The bat has neither beak nor feathers, but has hair, ears, and teeth. Its wings are composed of the skin of the back and breast stretched out, and sustained by the prolongation of the finger-bones.—Nocturnal animals, useful to agriculture.

Yes, the bats!

I hear James saying that bats are birds, because they fly. No, my boy, they are not birds,—for they have no feathers, but hair on their skin, and they have jaws armed with teeth instead of a beak. Yes, that, I admit, is very curious.

34. Fish-Eaters (Piscivora).—There are some carnivorous animals that eat no flesh except that of fishes; on that account they have been termed **Piscivora** (from the Latin *piscis*, a fish).

Walrus. Killing fur-seals. Walrus-hunter.

FIG. 64.—Fish-eaters.

These mammals, living, as they do, nearly all the time in the water, have bodies well adapted for swimming and diving with the greatest ease.

They have under the skin a thick layer of fat, which protects them from the cold. Some of them come from time to time upon land to lie upon the ground, sleep, and digest their food. The bodies of some seals are covered with a thick fur; they all have four feet, which, although flattened and transformed into fins, permit of their dragging themselves along upon the sand.

The seals (Fig. 64) are the best known members of this family. They are found in great numbers in the polar regions. The walruses (Fig. 64), members of the seal family, and provided with enormous tusks, live also in the northern seas.

There is another kind of these mammals which never leave the water; these are called **Cetaceans** (sea-mammals). They have only two legs, the fore legs, and these are lengthened and flattened so as to form powerful fins. They have another fin at the tail, and frequently one upon the back. Many persons look upon these animals as fishes. I am sure that if I ask Henry if the whale (Fig. 65) is a fish he will answer yes: will you not, Henry? "Yes, sir." And why? "Because

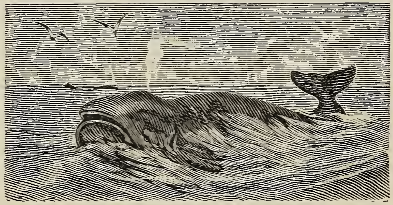


FIG. 65.—Whales. They have no scales. Fans, or whalebone, in the upper jaw. Warm-blooded. Give milk to their young (Mammalia). Come to the surface of the water to breathe (aërial). Sometimes are 107 feet long. Very narrow throat. Cetacean.

it lives in the water." Well, appearances are often deceptive. James just now took a bat for a bird, because it flies. He was wrong. Now Henry takes the whale for a fish, because it swims. He also is wrong, as I shall now prove to you.

The whale has no scales, it nourishes its young with its milk, and it does not live in the water in the same manner as a fish. If you were strong enough to hold it under water and not allow it to come to the surface to breathe, it would drown very quickly. The whale is therefore a mammal, and not a fish.

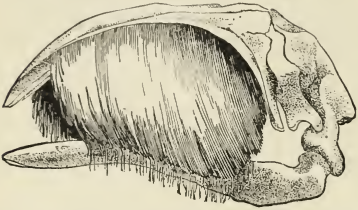


FIG. 66.—Skull of whale, showing the fans descending from the upper jaw.

Notwithstanding its enormous size, sometimes exceeding ninety feet in length, the whale feeds only upon very small animals. Its throat is so narrow that a herring could scarcely pass it.

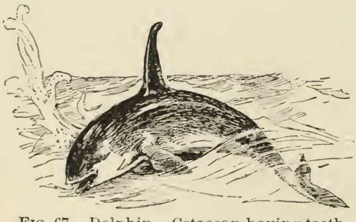


FIG. 67.—Dolphin. Cetacean having teeth.

It has no teeth. They would be of very little service in eating such small fishes. But from the upper jaw (Fig. 66) in the roof of the mouth descend long, elastic, horny growths, called fans, from which whalebone is made.

Some of the cetacea, as the **dolphins** (Fig. 67), found in all seas, and the sperm-whales, have **teeth,** and devour enormous quantities of fishes.

HERBIVORA,—GRASS-EATERS.

35. Monkeys.—The **monkeys** are herbivora, or, more correctly, eaters of vegetable substances, for they do not eat grass, but grain or fruits; for this reason they are often called fruit-eaters (**Frugivora**).

These mammals, living in the warm countries of both continents, are remarkable for their intelligence and for the rough resemblance which some species of them bear to mankind. For there are in some parts of Africa monkeys larger than a man, and that stand almost erect. The colonists of Algeria often have their orchards stripped of their fruit by magots (Fig. 68), monkeys with no tails. There are many species of monkeys, of various sizes.

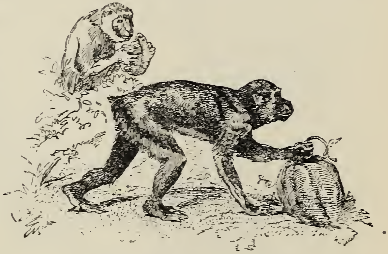


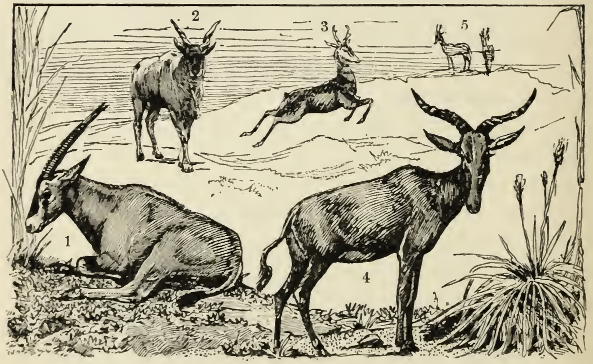
FIG. 68.—Magot of Algeria.

36. Cud-Chewers (Ruminants).—The most herbivorous of the grass-eaters, if I may so speak, are those animals that resemble sheep and cattle. They are called **Ruminants,** and for the following reason. If you will watch our sheep, without making any noise, when it has lain down and appears to sleep, you will see that it moves its jaws from time to time, sometimes in one direction and sometimes in another; this is what is called ruminating, or chewing the cud.

This is what happens. The ruminants, mostly timid animals, hastily fill their great stomachs with grass, which they do not take time to chew; then they lie down in a quiet place. There they bring back from the stomach into the mouth the grass in the form of balls (called the cud), chew it sufficiently, and then swallow it again, this time to digest it.

Fig. 69.—Skull of cow. The bone of the head is prolonged and covered with a sheath, called the horn.

The head of our sheep, which is a young male, has two horns (page 47) growing upon it. I have here the



1. Oryx, Africa; 2. Eland, Africa; 3. Prong-horned antelope, America; 4. Tetel, Africa; 5. Gazelle, Asia.

Fig. 70.—Herd of antelopes; ruminants with hollow horns; live in Asia, Africa, and America.

skull of a cow (Fig. 69), which will show you how the horns grow. The bone in front is prolonged and covered with a sort of sheath, which forms the horn.

These **hollow horns** are found upon the heads of cattle, sheep, goats, chamois, and some pretty ruminants, called antelopes (Fig. 70), that live in great herds in North America, Asia, and Africa.

Other ruminants **have solid horns,** as the Virginia deer, the moose, the wapiti, and the red deer (Fig. 71). Every

1. Moose; 2. Wapiti, or (so-called) American elk; 3. Virginia deer.

FIG. 71.—Deer: ruminants with solid horns.

year their horns fall off, and are renewed in a few weeks; and the same thing takes place with the horns of one species of American antelope.

Finally, there are ruminants **without horns.** The most important are the camel (Fig. 72), which lives in

Asia and Africa, and the llama (Fig. 73), which inhabits the mountains of South America.

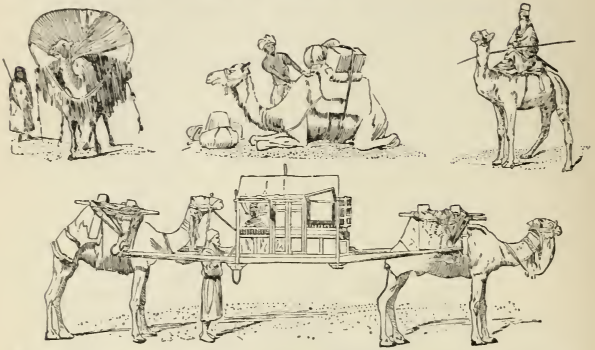


FIG. 72.—The camel transporting passengers and freight (Asia and Africa).

The giraffe (Fig. 74) has some bony bunches on the front of the head, but they are covered with skin.

FIG. 73.—The llama,—a kind of small camel,—loaded with ore from the mines (South America).

FIG. 74.—The giraffe grows sixteen feet high (Africa).

All ruminants have on each foot two toes, ending, except in the camel, in **two hoofs,** and appearing like a single hoof which has been cleft, as do those of our sheep (page 47).

37. Horses.—The animals comprised in the family of **horses** are distinguished in this, that they do not ruminate, and that they have only **one hoof** on each foot (Fig. 75).

FIG. 75.—Hoof.

You all know about the horse and the ass. I need only name them.

38. Thick-Skinned Animals (Pachyderms).—*Pachyderm* means thick-skinned. In this division there are some enormous animals.

The first are the elephants (Fig. 76), which attain

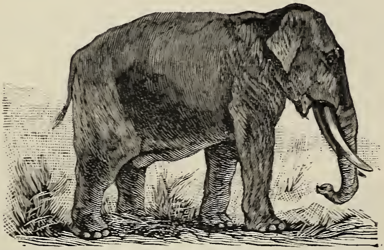


FIG. 76.—Elephant of India. Weight, 14,000 pounds. Height, 15 feet.

sometimes a height of more than fifteen feet. They are peculiarly remarkable for the nose, which is prolonged into the flexible trunk, and for the two long tusks of their upper jaw. The tusks furnish ivory. Elephants are found in Asia and Africa.

Next come the rhinoceroses (Fig. 77), which are also found in Asia and Africa. They have either one or two horns on the nose. Then comes the hippopotamus (Fig.

FIG. 77.—Hunting the rhinoceros. This animal is difficult to kill, on account of its thick skin.

78), a monstrous animal living in the large rivers of

FIG. 78.—Hippopotamus (rivers of Africa).

FIG. 79.—Wild boar.

Africa. It is in this group that we place the wild boar (Fig. 79) and the domestic hog.

39. Gnawers (Rodentia).—There are some eaters of vegetable substances that feed upon grain, fruit, or the tender roots of trees, in preference to plants and leaves.

You have all seen a rabbit eat a carrot; it **gnaws** the carrot with four long teeth, **incisors,** I (Fig. 80), set in

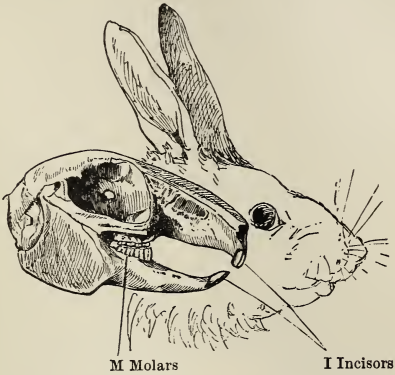


FIG. 80.—Head of a rabbit, with skull showing arrangement of teeth.

the fore part of the jaws, and then chews it with its molars, M.

You now understand why the name **gnawers** (Rodentia) is given to the rabbits, hares (Fig. 81), squirrels (Figs.

FIG. 81.—Hare. Rodent.

FIG. 82.—English squirrel. Rodent.

FIG. 83.—American squirrel. Rodent.

82 and 83), beavers, rats, and, in a word, to all those animals that have jaws formed like those of the rabbit.

40. Kangaroos.—I do not wish to close this subject of mammals without speaking to you of some animals that you will probably never see living in their native country of Australia, but which are common in menageries,—namely, the **kangaroos** (Fig. 84).

FIG. 84.—Kangaroos. Notice the little one in the pouch.

These herbivorous animals are curious, not only because of their strange form, their enormous hind legs, and their tail, but because they protect their little ones for a long time in a **pouch** placed under the abdomen. This peculiarity has given them, and also other animals having this pouch, the name of marsupials, because, in Latin, *marsupium* means a "pouch." Among the marsupials are both herbivora and carnivora.

SUMMARY.—I. Mammalia.

Division of Vertebrates.—We divide the vertebrates into five classes,—**mammals, birds, reptiles, amphibians,** and **fishes.**

Mammals are those animals that give milk to their young.

We divide mammals, from the food they eat, into **carnivora** (flesh-eaters) and **herbivora** (fruit- and plant-eaters).

The **carnivora** are known by their two long, pointed teeth, **canines**, in each jaw, by their **molar teeth**, which are shaped for *cutting food*, and by their feet, which are armed with **claws.**

The **herbivora** are known by the *absence or weakness* of their **canine teeth**, by their **molars**, which are adapted for *grinding* food, and by their feet, which end in **hoofs**, or in claws that are harmless.

Carnivora.—The carnivora are divided into **true flesh-eaters** (carnivora proper,—lion, wolf, etc.), the **insect-eaters** (insectivora,—shrew, mole, hedgehog, etc.), and the **fish-eaters** (piscivora,—seal, whale, etc.).

Among the **fish-eating** mammals, the most important are the **seals**, whose feet are transformed into oars, and the **cetacea** (whale, porpoise), which have only two feet, and are shaped like great fishes.

Herbivora.—The principal families of the herbivora are the **cud-chewers** (ruminants,—cattle, sheep), the **horses** (horse, ass), the **thick-skinned animals** (pachyderms,—elephant, wild boar), the **gnawers** (rodents,—squirrel, rabbit), and the **pouched mammals** (marsupials,—kangaroo, opossum).

Cud-chewers are those animals that chew their food twice. Their feet have *two hoofs.*

Horses are not cud-chewers. They have only a *single hoof* on each foot.

The **thick-skinned animals** are of great size (elephant, hippopotamus, rhinoceros).

The **gnawers** are distinguished by the *four long, strong incisors* in the front of the jaw. It is with these incisors that they gnaw.

The **pouched mammals** are the kangaroos and other similar animals that have **a pouch** (marsupium) under the abdomen, in which their little ones are protected during the first days of life.

QUESTIONS.—ANIMALS.

What is a classification? What have scholars noticed in regard to nearly all animals? What are the two great classes of animals? What are the vertebrates? The invertebrates? What are the several characteristics of the vertebrates? Into how many classes are the vertebrates divided?

QUESTIONS.—MAMMALS.

What is upon the skin of the dog? Name the principal exterior parts of the dog. Name the parts of the head. Name the different parts of the body. Of what are the fore limbs composed? Of what the hind limbs? Wherein do mammals differ? What is the difference between the foot of the dog and the foot of the sheep? Name the kinds of teeth the dog has. Name the kinds of teeth the sheep has. Show the difference in the way the dog and the sheep use their teeth. How do we divide mammals according to their teeth and food?

QUESTIONS.—CARNIVORA.

What is it that distinguishes the family of cats? What are the principal animals of this family? What distinguishes the family of dogs? Name some animals of this family. What do you know of bears? Do you know any small carnivora? What are the insectivora? Name some of the most common. Why are bats not birds? What can you say of the piscivora? What distinguishes the piscivorous mammals? Do the seals and their like remain all the time in the water? Where do they live? How are the cetacea made? Why are they not fishes? What is the food of the whale? What is remarkable in the upper jaw of the whale? Are any of the cetacea armed with teeth? What are the principal families of the carnivora?

QUESTIONS.—HERBIVORA.

Are the monkeys properly called herbivora? What do you know of monkeys? What does the word ruminate mean? Describe ruminating. How are the horns of sheep and cattle formed? Name some ruminants with hollow horns. What is singular about those with solid horns? Are there ruminants without horns? Name them. How many toes have ruminants on each foot? What are the characteristics common to the animals of the horse family? What are the two kinds of this family met with most often? What can you say of pachyderms? What distinguishes elephants? What other pachyderms are the best known? Name some of the rodents. Why are they named rodents? Name an animal of Australia. What is the peculiarity of the marsupials? From whence comes the name marsupial? What are the principal families of the herbivora?

VERTEBRATES.—II. Birds.

41. The Study of Birds.—Charles, go catch a chicken in the yard and bring it to me. We are going to study **birds** with it in the same manner as we have studied **mammals** with Jip.

We do not see hair upon the chicken, but feathers.

Each feather (Fig. 85) consists—first, of a hollow, horn-like portion, A, the quill; then, continuous with this portion, of a solid stem, B, on each side of which is a vane, C, having barbs with barbules, D. The quills of the large feathers of the goose were formerly used for pens.

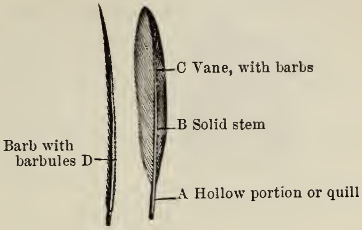


FIG. 85.—Parts of a feather.

There are also, here and there, some very small feathers, called down.

There are no feathers on the feet (Fig. 86), but instead they have a scaly skin, E, very similar to that of a snake.

The bird (Fig. 87), like the mammal, has a head, A, a neck, B, a body divided into a chest, C, and an abdomen, D, and a short tail, E, adorned with long feathers.

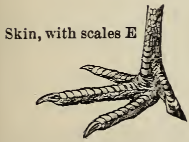


FIG. 86.—Foot of the hen.

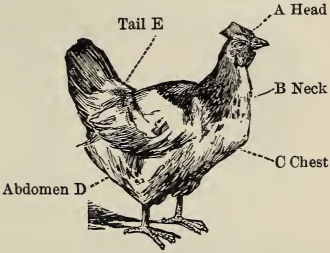


FIG. 87.—Hen.

Take first the head (Fig. 88). We find that the jaws have in place of teeth a horn-like sheath, A, or beak, and that the nostrils, B, are pierced near the base. Above them are the eyes, which, in addition to two horizontal eyelids, have a *third* white and vertical one, which you see pass over the eye from time to time. Birds appear to have no ears, or, more correctly, they have no external ear. But there is an auditory tube, C, as in mammals.

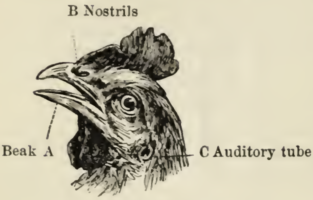


FIG. 88.—Head of the cock.

The fore limbs of the bird are used for flying; these are the wings (Fig. 89). You can feel here, in the back,

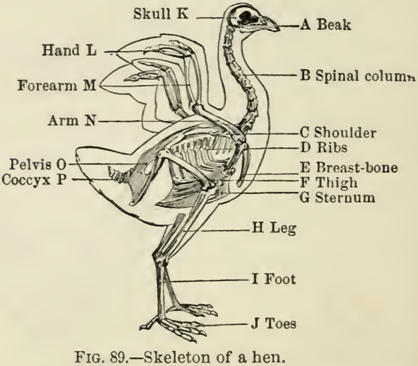


FIG. 89.—Skeleton of a hen.

the shoulder, C, movable, as in mammals. Then there is at N a part corresponding to the arm, beyond this, at M, the forearm, and finally the hand, L, very much reduced. The forearm and the hand bear the feathers which form the wing.

We find also in birds a spinal column, B, which is attached to the skull, K, and is prolonged to the coccyx, P. To this column are joined the ribs, D, which are united to the sternum, G, so as to form the chest, or thorax.

In the hind limbs we recognize the pelvis, O, which is fixed, and the movable parts, the thigh, F, and the leg, H, which you ordinarily call the drum-sticks; this is the calf of the leg: hence, you see, we are wrong in speaking of people who have slim legs to say they have "chicken legs." What we take for the leg is really the part I of the foot covered with false scales.

Then come the toes, J, also covered with scales. There are four toes. No bird has more, while some mammals have five (man).

We now see how a bird is formed exteriorly. All birds present the same parts, and otherwise they resemble one another much more than mammals do.

42. The Eggs and Nests of Birds.—You all know that birds lay eggs, and that these eggs are composed (Fig. 90) of a strong shell, A, a white, B, and a yolk, C. The shell is all white, like the hen's egg, or else colored or spotted, like that of the jay, blackbird, sparrow, or swallow.

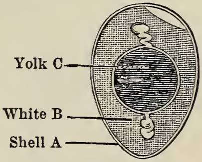


FIG. 90.—Egg, cut lengthwise.

The size of the egg naturally corresponds with the size of the bird that lays it. The shell of an ostrich can hold the contents of twenty-five hen's eggs.

The shape of the nests is still more varied than the color of the eggs. Sometimes they are built of earth, as those of swallows; sometimes of bits of moss, feathers, and refuse of all kinds, as those of the finches (Fig.

91); sometimes of twigs, as those of the magpie. Some are flat, others are long and round, like a bag. The nests of the titmouse and of the oriole are made with great skill.

FIG. 91.—Nest of the finch.

FIG. 92.—Nest of the lark.

Some birds are content with a hollow in the ground; such are the partridge and the lark (Fig. 92). There are some even that do not build any nest, but lay their eggs upon the bare ground.

43. Classes of Birds.—We have examined the hen carefully. It is a bird that feeds upon grain. The hen is a **grain-eater,**—a **granivorous** bird.

I will now show you the head and foot of a fish-hawk (Figs. 93 and 94).

FIG. 93.—Head of fish-hawk, showing bill for tearing flesh.

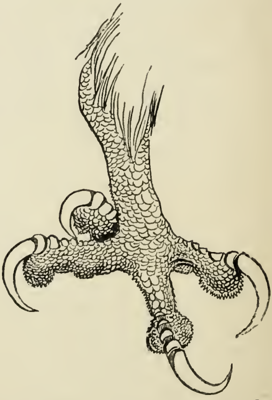


FIG. 94.—Foot of fish-hawk, with claws extended. A perfect grappling-machine for holding its slippery prey.

Notice the beak of this bird (Fig. 93): how strong and hooked it is by the side of that of the hen! And the claws of the feet (Fig. 94): how long and pointed they are! We can come to no other conclusion than that these *talons*, as they are called, are lengthened to seize a living prey, and that the beak is made strong to kill it and tear it to pieces.

Our fish-hawk is a **flesh-eater,**—a **carnivorous** bird.

We have, then, divided birds, as we have divided mammals, into **flesh-eaters,** or **carnivora,** and **grain-eaters,** or **granivora.**

FLESH-EATERS, OR CARNIVORA.

44. Birds of Prey.—At the head of **carnivorous birds** we must place **birds of prey,** which feed upon small mammals, birds, fishes, and reptiles.

We have in our country the eagle (Fig. 95), the hawk (Fig. 96), the falcon (Fig. 97), and the kite (Fig. 98).

FIG. 95.—Canada eagle—bird of prey.

FIG. 96.—Sparrow-hawk—bird of prey.

You may have often seen them turning in a circle and soaring with extended wings above their prey, upon which they finally fall like a stone.

The eagles (Fig. 95) and the bare-necked vultures

FIG. 97.—Falcon—bird of prey.

FIG. 98.—Kite—bird of prey.

(Fig. 99), eaters of carrion, are common on high mountains and in warm countries. Some of these measure

FIG. 99.—Vultures on a battle-field.

twelve feet from the tip of one extended wing to the tip of the other.

There are other birds of prey that sleep all day and come out only at nightfall. For this reason they are

FIG. 100.—Common owl.—Barn owl.—Great horned owl.

called **nocturnal**; such are the owls (Fig. 100).

45. Insect-Eaters (Insectivora).—The **insectivorous** birds are not so well armed by nature as the birds of prey. There are some, such as the shrike, which have the beak and claws well hooked. But it must be admitted that the last-named bird willingly eats his little brother birds and small mammals.

The woodpeckers (Fig. 101), the creepers (Fig. 102),

FIG. 101.—Woodpecker.

FIG. 102.—Creeper.

the magpies, the warblers, the mocking-birds, the swallows, the wrens, together with a great many other birds, feed upon insects.

46. Fish-Eaters (Piscivora).—There are also birds that eat fishes.

WEB-FOOTED BIRDS (Palmipeds).—Among the fish-eaters the principal ones are the swimmers and divers. They have feet formed like the foot of the duck (Fig.

103) that I show you. The toes have *palms*,—that is to say, they are united to one another by a kind of skin,

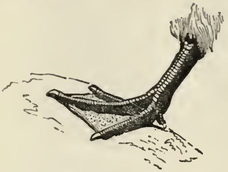


FIG. 103.—Duck's foot. The toes are united by a membrane or web.

FIG. 104.—Goose.

called a membrane or web. The bird pushes itself with its feet spread out as a man pushes a boat with the oars.

FIG. 105.—Heron—wading bird.

The duck, the swan, the sea-gull, and the goose (Fig. 104), all have webbed feet. We call these birds with palmed feet *palmipeds*.

WADING BIRDS (Grallatores).—Others live upon the banks of rivers, and are mounted on long, naked legs, with which they easily walk in the water. They have also a long

FIG. 106.—Water-hen.

FIG. 107.—Crane.

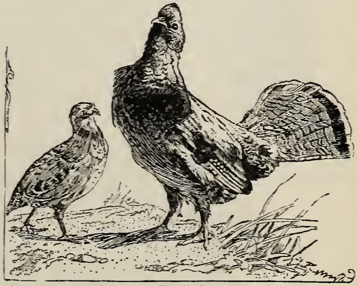
FIG. 108.—Stork.

neck and a long beak, with which they can seize their prey without being obliged to stoop down.

Such are the herons (Fig. 105), the water-hens (Fig. 106), the cranes (Fig. 107), and the storks (Fig. 108). All these birds, because of their long legs, look as if perched upon stilts, from which comes the name grallatores, or stilt-walkers, that is given them.

GRAIN-EATERS, OR GRANIVORA.

47. Scratchers (Gallinaceans).—The hen in Latin is called *gallina*. Those birds which are formed like the hen, with large and heavy body and short wings, and which feed upon grain, are hence called *gallinaceans*.



Quail—scratcher. Ruffed grouse—scratcher.
FIG. 109.—Grain-eaters.

1. Peacock; 2. Turkey; 3. Guinea-hen; 4, 6. Barn-yard fowls; 5. Pheasant.
FIG. 110.—Grain-eaters.

Such are the quails (Fig. 109), the partridges, the turkeys, the peacocks, and the hens (Fig. 110).

48. Pigeons.—The pigeons, beautiful in form and rapid in flight, are likewise grain-eaters.

49. Small Birds.—Many small birds, such as the sparrow, the finch (Fig. 111), and the linnet, have a large beak, which permits them to eat grains and even to crush them.

Fig. 111.—Finch.

Let us place side by side the short, thick beak of the finch (Fig. 112) and the long, slender beak of the mocking-bird (Fig. 113). You see at once that the finch can easily crush the hemp-seed, while the mocking-bird can only catch small insects or soft worms, like the caterpillar.

Fig. 112.—Large beak of the finch—granivorous.

Fig. 113.—Slender beak of the mocking-bird—insectivorous.

Fig. 114. — Parrot. Large beak for eating seeds.

50. Parrots.—Parrots (Fig. 114) are also grain-eaters. In our country these birds live only in cages and houses, where they become very tame and form exceedingly amusing pets, but in the very warm countries of both the Eastern and the Western continent they are found wild in great numbers in the forests.

Parrots are climbers; they use their beaks as well as their feet in climbing. The latter (Fig. 115) are remarkable in that they form a kind of hand, with which the bird takes its food.

FIG. 115.—Parrot's foot, in which it can hold its food.

51. Ostriches.—I must not leave the grain-eating birds without speaking of ostriches.

These are curious birds (Fig. 116) that cannot fly. But when we reflect that the ostriches of Africa are nine feet high and weigh ninety pounds, and think of the enormous

FIG. 116.—Ostrich-farming. In Africa and in some parts of America ostriches are raised for their feathers, which are used for ornamenting women's hats.

wings that would be necessary to lift such a body, we no longer wonder that they cannot raise themselves from the ground. However, to make up for its lack of power to fly, the ostrich is a very swift runner, being able to outstrip a fast racing-horse.

SUMMARY.—II. Birds.

Characteristics of Birds.—Birds have **feathers**, a **beak**, **three lids to each eye**, **two auditory canals**, without exterior ears, and **two feet**, with four **toes**.

They rear their little ones from **eggs**, which they generally lay in **nests**.

The egg consists of the **yolk** in the centre, the **white**, which envelops the yolk, and the **shell**, which encloses all.

Classes of Birds.—Birds are divided into: 1st. **Flesh-eaters**, or Carnivora, comprising the *birds of prey*, or true Carnivora, the *insect-eaters*, or Insectivora, and the *fish-eaters*, or Piscivora. 2d. **Grain-eaters**, or Granivora.

The **birds of prey** have a **hooked beak** to tear their prey in pieces, and feet armed with **talons** to seize it.

The **insect-eaters** have generally a **straight, slender beak.**

The **fish-eaters** are subdivided into **web-footed**, whose toes have palms, —that is, are joined by a membrane or web,—and **waders**, whose legs are long, like stilts.

Grain-eaters.—The grain-eaters have a **large beak**, which enables them to crush and eat grain.

QUESTIONS.—BIRDS.

What covers the bodies of birds? Name the different parts of a feather. What covers the feet of birds? Describe the exterior of a bird. Describe the head. What distinguishes birds that feed upon flesh? How are birds divided according to their food? Name some birds of prey. What are nocturnal birds? What is an insectivorous bird? Name some of the insectivora of our country. What is a piscivorous bird? How are the feet of palmipeds made? Relate what you can of the waders, and tell what their name comes from.

What are the characteristics of the scratchers? Name the principal ones. What distinguishes the pigeons? Name some of the little birds. What is the difference between the beak of a sparrow and the beak of a mocking-bird? What is remarkable of parrots? What distinguishes the ostriches?

What are the distinctive characteristics of birds? How do they produce their young? Name the principal parts of an egg. How are birds divided? What distinguishes a common bird? An insectivorous bird? A granivorous bird?

VERTEBRATES.—III. Reptiles.

52. I have here a lizard and a garter-snake. These are the only **reptiles** I have been able to procure. Let us examine them as we did the dog and the hen.

53. Lizards.—Let us begin with the **lizard** (Fig. 117). Its skin, you see, has neither hair, feathers, nor scales, but has little folds, which are very regular, like those on the foot of the hen; it is also hard and looks as if it were varnished.

FIG. 117.—Lizard. Its tail grows again after having been broken off.

The animal has a **head,** a **neck,** a **body,** and a **tail.** The jaws have **teeth,** the eyes have **three lids,** and there is **no external ear.** The lizard has **two fore legs** and **two hind legs,** in which we shall find the same parts as in those of the dog.

The lizard, also, like all reptiles, lays eggs similar to those of birds, except that the shell is not hard or stony. The lizards of this country are very small and perfectly harmless,—all except the "Gila monster," found in Arizona and New Mexico, which is venomous.

But their near relatives, the **crocodiles** (Fig. 118),

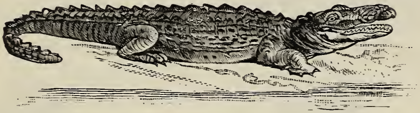


FIG. 118.—Crocodile. Some crocodiles are more than 20 feet long.

which live in America, Africa, and Asia, grow to be more than twenty feet long, and are, on the contrary, very much to be feared.

54. Serpents.—Let us now examine the **garter-snake,** —this pretty little snake with yellow stripes (Fig. 119). Who will take it in his hands in order to examine it? No one. You are afraid? You need not be. The garter-snake is a very gentle animal and never bites.

"But, sir, see, it runs out its sting: it is going to sting you."

Its sting, my boy? That is simply its tongue, which is smooth and soft and could not do any harm.

FIG. 119.—The garter-snake is harmless. That which people mistakenly call its sting is only its tongue, smooth and soft.

FIG. 120.—The head of the garter-snake is scarcely distinguishable from the neck.

Well, if you do not wish to touch it, let us look at it, at least.

See, this serpent is really a very long lizard which has no feet. But it has no movable eyelids, and it is this that gives to its eye (Fig. 120) the fixed look which causes so many people to fear it.

Even should the garter-snake bite you, it could do no more harm with its little teeth than a mouse.

FIG. 121.—Viper preserved in alcohol.

FIG. 122.—The head of the rattle-snake and of the viper is clearly distinguishable from the neck.

As for the **vipers**, like the one which is here in this bottle with alcohol (Fig. 121), it is a different thing. These are **venomous serpents.** Their bite causes fever, great swelling, and mortification; sometimes people even die from its effects, especially weak or old people or children.

In the warm countries there are enormous snakes, of great length, which can strangle an antelope or a wild hog (Fig. 123) by winding themselves around its body and then swallow it as our snakes swallow a toad. There are also venomous serpents, whose bite is always mortal.

Those warm countries are very beautiful, but they are the home of very many dangerous animals.

FIG. 123.—Boa (a large snake) winding itself about a wild hog in order to strangle and swallow it.

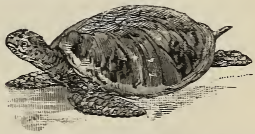


FIG. 124.—Tortoise. Its body is enveloped in a solid box, called a shell.

55. Tortoises.—Unfortunately, I have no tortoise, either living or dead, to show you.

But here is a picture (Fig. 124) which will give you a good idea of this strange animal, with his **beak** like that of a bird, and his **solid box,** which envelops his body and into which he draws his head and feet.

Some tortoises live on land, others in marshes. Very large ones are also found in the ocean.

SUMMARY.—III. Reptiles.

Reptiles.—The name reptile is given to those animals that seem to drag (*reptare*, in Latin) themselves along the ground, whether they have **short feet**, as lizards and tortoises, or **no feet at all**, as serpents.

Like mammals, the lizards and tortoises have a **head**, a **body**, a **tail**, **two fore legs**, and **two hind legs**.

Like birds, the lizards and tortoises have **auditory tubes, without external ears**, and **three eyelids**, and, like them, they lay **eggs**; moreover, tortoises have a **beak** similar to that of a bird.

The tortoise has a **body** enveloped in a **bony box**.

Serpents are divided into two great groups,—**venomous** and **non-venomous.**

QUESTIONS.—REPTILES.

Describe a lizard. Wherein are lizards like birds? Are the lizards of America dangerous? Name a great lizard dangerous to man. Is the garter-snake a dangerous animal? Has it a sting? Does the structure of a serpent differ much from that of a lizard? Is the viper harmless like the garter-snake? Are there in some countries dangerous snakes? Are these the only dangerous snakes of these countries? How are tortoises formed?

To what animals do we give the name reptile? What have the lizards and tortoises in common with mammals? What have they in common with birds? What is remarkable about a tortoise? Into how many groups are serpents divided?

VERTEBRATES.—IV. Amphibians (or Batrachians).

56. The Frog: its Metamorphoses.—Do you see these little animals that are swimming in this glass?

A, frogs' eggs; B, tadpole, first without feet; C, the two hind feet appear; D, the two fore feet appear; E, the animal has four feet and a tail; F, the tail disappears,—the animal is perfect.

Fig. 125.—Metamorphoses of the frog.

Their head and body (Fig. 125) are blended in a ball, and they have a long, fish-like tail. They have no feet. These are tadpoles. They live in water.

I will now show you a **frog** (Fig. 125, F): the head is distinct from the body; the animal has four feet, but not even a trace of a tail. The frog lives in air, and would be drowned if we held it too long under water.

Would you ever think, if you did not already know it, that these tadpoles are going to become frogs? Is it not wonderful? Legs will grow (Fig. 125, C, D); the tail will diminish (E), and finally disappear. In this last state the frogs will not live all the time in the water, and will not be eaters of plants. They will have undergone, as we say, their metamorphoses.

There is one thing that will not change: their skin will always remain soft, without hair or feathers, without scales, and without growing thick like that of reptiles.

With good reason we call these animals **amphibians,** since the word amphibian means "having a double life." In reality they have at first a wholly aquatic life, then an aerial life.

The toads and the tree-toads have a history like that of frogs.


FIG. 126.—Triton, or water-newt.

Some other amphibians have metamorphoses less complete. See this animal, which is called the triton, or water-newt (Fig. 126); this is also an **amphibian,** and it was a tadpole in its infancy. Its legs have grown, but it has retained its tail. It lives much of the time in the water, but if we prevent it from coming to the surface to breathe it will soon be drowned; in reality it is **aerial.**

The amphibians lay **soft eggs, without a shell.** You have certainly seen in the ponds in the spring-time floating masses of frogs' eggs, held together by a kind of gluey matter.

SUMMARY.—IV. Amphibians.

The Frog: its Metamorphoses.—The word Amphibians comes from two Greek words which signify **double life.**

This name is applied to frogs, toads, and water-lizards. These animals, during the first period of their life, are **aquatic,**—that is to say, live exclusively in water; after having undergone several changes, or metamorphoses, they become **aerial,**—that is to say, live in air.

The amphibians lay **eggs,** but these eggs are soft and without a shell.

QUESTIONS.—AMPHIBIANS.

Describe a tadpole and its mode of life. What differences are there between a tadpole and a frog? What metamorphoses does the tadpole pass through to become a frog? Why do we call toads and like animals amphibians? What does the word amphibian mean? Do all amphibians undergo the same metamorphoses as the frog? Do the amphibians lay eggs? What is the nature of these eggs?

VERTEBRATES.—V. Fishes.

57. The Goldfish.—We will now, proceeding in the same way, examine some fishes. Here is first a goldfish (Fig. 127); you see that its body is covered with **scales.** And these are true scales, which I can pull out one by one as I could pull out a hair or a feather. This could not be done with the false scales of reptiles.

The head, the body, and the tail are blended in one mass. Upon the sides you see two pairs of limbs, B, F, which are flattened and transformed into fins; we call them paired fins. Upon the back, at C, and at the beginning and the end of the tail, at D and at E, there are also fins, called unpaired fins.

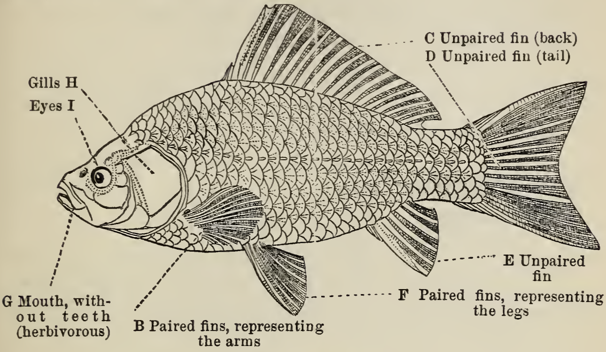


FIG. 127.—A goldfish.

On the sides of the head, at H, are two large slits, at the bottom of which are arches furnished with red fringes. These slits or openings are commonly called **gills**: by means of them the fish breathes. Fishes can breathe in water, but die quickly if exposed to the air.

58. Different Kinds of Fishes.—There are no teeth

FIG. 128.—Teeth of the pike (carnivorous).

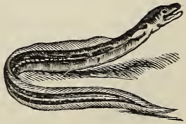


FIG. 129.—Eel. Goes to the sea to lay its eggs.

in the mouth of the goldfish, which is a **plant-eater**, or **herbivorous** animal.

On the contrary, this pike (Fig. 128) has his mouth full of teeth; carnivorous in the highest degree, he is the true tiger of the water.

Most fishes are **flesh-eaters,** or **carnivora.**

Let us examine the eel (Fig. 129). It resembles a serpent; but it has fins, gills, and scales. Sometimes the latter are so small that the magnifying glass is necessary in order to see them.

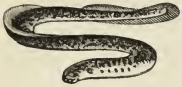


FIG. 130.—Lamprey.

Finally, I will show you a very strange fish, far less common than any of those of which I have just been speaking. It is the lamprey (Fig. 130), which is called lamper-eel by the fishermen of this country, and by the French fishermen "seven-eyes."

This strange animal has, in fact, on each side of the neck seven holes, instead of one, for gills. Its mouth, which it uses as a sucker, is round, like that of a leech. It has no paired fins, and no scales.

These different kinds of fishes live in rivers, lakes, ponds,—in a word, in **fresh water.** In the **salt water** of the sea there are many other kinds of fishes, of shapes the most unexpected and varied: round, flat——but why go on? It would require the whole of our remaining term for me to point out to you even their principal species.

Most fishes lay **soft eggs, without a shell,** as do the amphibians.

SUMMARY.—V. Fishes.

The Goldfish.—Fishes live exclusively **in water.** Their bodies are covered with **scales.** They move by means of **fins** and breathe in water by means of their **gills.**

The Different Kinds of Fishes.—Fishes are divided into **plant-**

eaters (herbivora), as the goldfish, and **flesh-eaters** (carnivora), as the pike. The latter has a mouth set with teeth.

We also divide them into **fresh-water fishes** (rivers, lakes) and **fishes of the sea** (salt-water). Fishes lay **soft eggs, without a shell.**

QUESTIONS.—FISHES.

Describe a goldfish. How do fishes breathe? How are fishes divided according to their food? What is remarkable about the eel? The lamprey? How are fishes divided according to the water in which they live? Describe the eggs of fishes.

What are the distinguishing characteristics of fishes? How are fishes reproduced?

2.—INVERTEBRATES.

59. Division of Invertebrates.—We now pass to those animals that have no bones, called **invertebrates** (without vertebræ), in order to distinguish them from those we have just studied.

The invertebrates are divided into:

1. The **Annulates** (animals with rings).
2. The **Mollusks** (animals with soft bodies).
3. The **Zoophytes** (animals that resemble some plants).

INVERTEBRATES.—I. Annulates.

60. The Annulates.—Peter, bring me that wood-louse (Fig. 131) that I see there, running into the corner. See, his body is made up of a sort of **rings** joined to one another.

FIG. 131.—Wood-louse. Body made up of rings (annulate).

Here is an earth-worm (Fig. 132), also a milleped (Fig. 133). Nothing is easier than to see the rings which form their body.

Let us catch a fly (Fig. 135) and examine it closely. Do you see any rings?

"Yes, sir; its abdomen is formed of rings."

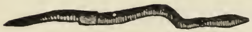


FIG. 132.—Earth-worm. You can see the rings (annulate).

FIG. 133.—Milleped, 20 pairs of feet; has rings (annulate).

The rest of the body is formed of rings also; but it is easier to see those upon the abdomen.

We give all such animals the name of **annulates,**—that is to say, animals with rings.

61. Division of Annulates.—The annulates are divided into secondary groups, which are **insects, spiders, millepeds, crustaceans,** and **worms.**

62. Insects.—Here is a butterfly (Fig. 134). Look at it closely. What do you see first, James? "I see its wings, sir." How many? "Four." Yes; and then? "Its feet." Tell me how many. "Six." Right.

Now the body: of how many parts is it composed? You should have begun with the body. "I see that the body is composed of two parts, without counting the head, which makes three." Very well; there is the head, A, the part B, or thorax, which holds the head, and the stomach, C, or abdomen.

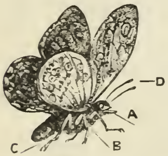


FIG. 134.—Butterfly. Four wings, six feet, three parts: head, A (distinct from body), thorax, B, abdomen, C, two antennæ, D.

Upon which part are the wings? "Upon the thorax." And the legs? "They are fixed to the same part." Examine the head. Do you see anything there to describe? "Yes, sir; I see two great eyes, and two horns, D." We call the horns antennæ. These parts are all easily seen.

Now take this fly (Fig. 135). What do you see? "I see that it has only two wings, D, instead of four." Well, and where are these two wings attached? "Upon the thorax, like those of the butterfly." And the other parts? "The other parts are similar to those of the butterfly: there are two antennæ, two eyes, and six feet." Very well. All **insects** are made in this way. The wings, it is true, vary in number, or even do not exist, as in

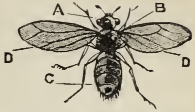


FIG. 135.—Fly. Two wings, six feet, three parts: head, A (distinct from body), thorax, B, abdomen, C, two antennæ.

FIG. 136.—Ant (magnified).

FIG. 137.—Dragon fly.

the flea (Fig. 145); but there are always a **head**, a **thorax**, an **abdomen**, and **six feet**. You will find these same parts in the beetle,

FIG. 138.—Gnat (magnified).

FIG. 139.—Bedbug (magnified).

the bee, the ant (Fig. 136), the dragon-fly (Fig. 137), the gnat (Fig. 138), the bedbug (Fig. 139), and many other insects.

The group of insects has the greatest number of species of any in the animal kingdom. There are more than **two hundred thousand** different species known.

63. Metamorphoses of Insects.—The history of insects presents a very curious peculiarity. Most of them undergo metamorphoses as complicated as those of the frog.

You all know, I suppose, the metamorphoses of the butterfly. The butterfly lays eggs; from each egg comes a caterpillar (Fig. 140), which grows, and which at a certain time appears to sleep and is changed into a chrysalis (Fig. 141). After a time the skin of the chrysalis is opened, and there comes out a **butterfly** (Fig. 142.)

FIG. 140.—From the egg comes a caterpillar.

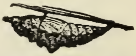


FIG. 141.—The caterpillar changes into a chrysalis.

FIG. 142.—From the chrysalis comes a butterfly.

FIG. 143.—Beetle.

FIG. 144.—Bee.

In many kinds the caterpillar before changing into a chrysalis spins a silky cocoon (page 98), in which it shuts itself up.

Flies (Fig. 135), beetles (Fig. 143), bees (Fig. 144,) and fleas (Fig. 145) have metamorphoses of the same

FIG. 145.—Flea. No wings (magnified).

FIG. 146.—Larva of the fly.

kind. Their caterpillars are called *larvæ* (Fig. 146); they never spin silk.

64. Spiders.—We will now examine a **spider** (Fig. 147). I caught one this morning in the cellar, and I have put it under this glass.

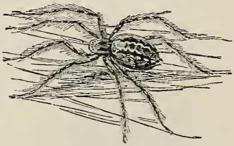


FIG. 147.—Spider. No wings; eight feet; two parts; head and thorax blended in one; abdomen; venomous fangs.

Let us see how the body of our prisoner is formed. Paul, what difference do you see from that of the fly?

"The spider has no wings, sir." That is true. No spider has wings. But what do you notice about the body?

"I do not see the head, sir." It does not seem, in fact, to have any. The body of the spider, instead of being composed of three parts, like that of insects, has **only two**: in front are the head and the thorax, united into one piece, which bears the feet; back of this is the abdomen. How many feet has it?

"I count **eight.**"

Yes; it has also two horns similar to antennæ.

Most spiders spin webs, sometimes very complicated, in the meshes of which flies and other small insects are entangled. As soon as an insect is caught, the spider rushes from his hiding-place and springs upon his victim in order to kill it and suck its blood.

And you must know that the spider is armed with a terrible weapon for this purpose. On each side of the mouth it has two venomous fangs, which with a little trouble we can distinguish upon the animal. A wound from these fangs is sufficient to paralyze a fly and force it to surrender to its enemy.

"If this were a man, sir, would the spider kill him?"

If it were a man, the bite would only raise a blotch like the bite of a gnat: for the fangs of a common spider are too weak to pierce the skin very deeply, and their supply of venom is too small to act dangerously. There are, however, some kinds of spiders whose bite is dangerous.

Fig. 148.—Milleped.

65. Millepeds. — The word "milleped" means "a thousand feet;" but the milleped does not have nearly so many feet. The one at the bottom of this bottle has only twenty pairs (Fig. 148),—quite enough, one might suppose.

66. Crustaceans.—The crayfish (Fig. 149) that I show you gives a good idea of the **crustacean.** It has five pairs of feet, one of which are pinchers, a bony shell on the back, and rings on the abdomen.

Fig. 149.—Crayfish (crustacean). Five pairs of feet, one of which are pinchers.

The crayfish lives in water, as do nearly all the crustaceans. The wood-louse belongs to a group of aerial crustaceans.

67. Worms.—By examining an earth-worm and this leech (Fig. 150) you will obtain a tolerable idea of the **worms.** A worm has no legs, and the body is of one piece and marked off by rings.

FIG. 150.—Leech (worm). No feet.

SUMMARY.—I. Annulates.

Divisions of the Invertebrates.—The **invertebrates** are animals that have no bones, no "vertebræ," and no red blood.

We divide the invertebrates into three groups: **Annulates, Mollusks,** and **Zoophytes.**

The Annulates.—The principal characteristic of the annulates is that the body is made up of a series of **rings.** Examples, the wood-louse, the earth-worm, the milleped, etc.

The **annulates** are divided into five secondary groups: **Insects, Spiders, Millepeds, Crustaceans,** and **Worms.**

Insects.—The bodies of insects are made up of three parts,—a **distinct head,** a **thorax** bearing six feet, and an **abdomen.** Certain insects have **four wings,** others have **two,** some have **none.**

Metamorphoses are the changes in form that an insect undergoes. The caterpillar passes to the state of a chrysalis, then to that of a butterfly.

Spiders.—The bodies of spiders are composed of two parts,—a **head,** which is blended with the thorax, and an **abdomen.** The thorax bears eight feet. Spiders **never have wings.**

Most spiders spin webs in which to catch insects, upon which they live.

Millepeds have a great number of feet, and numerous rings.

The Crustaceans have at least ten feet, and a **shell** on the back. The crustaceans are **aquatic,** with some rare exceptions, as the wood-louse.

Worms are distinguished by the **absence of feet.** Their bodies **are of one piece.**

QUESTIONS.—ANNULATES.

To what animals do we give the name invertebrates? How many groups of the invertebrates? What is the characteristic of annulates? Into what secondary groups are they divided? How many feet have insects? Of how many parts are their bodies formed? Upon which part of the body are the feet and wings? Are all insects made like the butterfly? What characteristics are common to all insects? Through what metamorphoses does the butterfly pass? Have all insects metamorphoses as complete as those of the butterfly? What are the differences between insects and spiders? How do spiders catch flies? What has the mouth of the spider that is peculiar? Is this dangerous to man? What annulates have a great number of feet? What distinguishes crustaceans? How are worms formed?

INVERTEBRATES.—II. Mollusks.

68. Snails.—Look carefully at this snail (Fig. 151), which has its head and horns out of its shell. Is it a vertebrate, James? "No, sir, for it has no bones." Well, then, is it an annulate? "No, sir: it has no rings."

FIG. 151.—Mollusk with a single shell.

Very well. This soft animal belongs to the group of **mollusks.**

69. Mussels.—Now let us examine this mussel (Fig. 152) that I have found in the river. It is dead, and is gaping,—that is to say, the two shells are not closed tightly against each other.

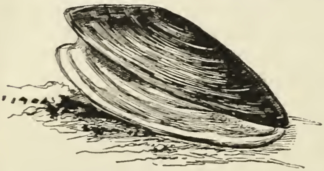


FIG. 152.—Fresh-water mussel (mollusk with two shells).

Its body is soft and without rings; when we look at it closely we see that it is in some things very much like the snail. The mussel is also a mollusk, but a mollusk with **two shells,** while the snail is a mollusk with **one shell.**

There are also mollusks with **no shell** at all, as the cuttle-fish.

INVERTEBRATES.—III. Zoophytes.

70. *Zoophytes*.—In order to finish our study of animals, it remains for me to tell you of some very curious ones, of which, however, I can only show you pictures.

They are called zoophytes,—that is to say, animal-plants,—because many of them resemble more or less some plants or flowers.

This is the case, for example, with the sea-anemone (Fig. 153), which spreads itself out in the water of the sea like a large flower decked in the richest colors.

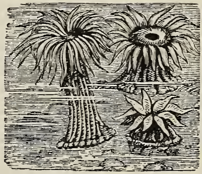


FIG. 153.—Sea-anemones. Zoophytes,—that is to say, animal-plants. The flower is formed of movable filaments, which seize small animals that pass near them.

It is also the case with very small animals, called polypi, which are soldered to one another in countless numbers. In this condition they make for themselves a sort of stony shell, which in time forms actual rocks, and even islands, in the warm seas where these little animals live. These rocks are called coral-reefs.

FIG. 154. — Star-fish. Zoophyte.

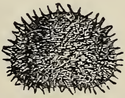


FIG. 155.—Sea-urchin. Zoophyte.

FIG. 156. — Sponge. The sponge, as we use it, is only the skeleton of the animal. While the animal is alive its flesh envelops the skeleton.

The star-fish (Fig. 154), with five branches, and the sea-urchin (Fig. 155), covered with short spines, and called for this reason the sea-chestnut, both of which are frequently met with on the sea-shore, are zoophytes.

The sponge (Fig. 156) is also a zoophyte, though it does not much resemble a flower.

SUMMARY.—II. Mollusks. III. Zoophytes.

Mollusks are distinguished by their **soft ringless bodies**. The soft body is protected in some cases by a **single shell** (snails); in other cases by **two shells** (mussels); in still other cases by **no shell.**

Zoophytes.—Certain of the invertebrates more or less resemble **some plants** or **flowers,**—viz., the sea-anemones, the corals, the star-fish, and sponges.

QUESTIONS.—MOLLUSKS.

To what animals do we give the name mollusks? What distinguishes a snail from a mollusk? Are there mollusks without a shell?

QUESTIONS.—ZOOPHYTES.

Name the best-known zoophytes. Why are they called zoophytes?

READING-LESSONS.

9. Injurious Insects.—Most insects are injurious, either when very young, as larvæ, or worms, or later as perfect animals, or even during their entire life.

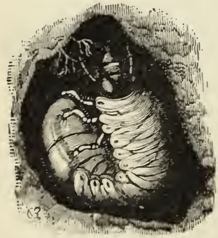


FIG. 157.—White-worm (larva of the May-bug), lives three years in the ground, and feeds upon the roots of plants.

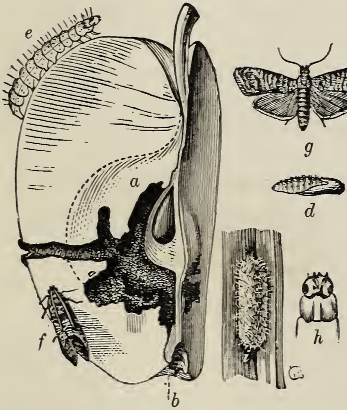
FIG. 158.—Certain caterpillars spin a kind of web or tent, in which they lay their eggs.

The **May-bug** is an example of an insect which is injurious in all its stages. The larva (Fig. 157), called also white-worm (white grub), lives in the ground and **eats the roots** of plants, doing great damage; the perfect animal, the May-bug, eats the **leaves of trees.**

The **caterpillars** (Fig. 158) also do great damage to plants; but the butterflies into which they change are harmless.

To tell of all the ravages of insects would take more time than we can spare at present.

There are some that bore into trees and kill them. Others



a, burrowings of larva; *b*, point where it entered; *e*, larva full grown; *h*, head; *d*, chrysalis; *i*, cocoon; *f*, moth with wings closed; *g*, moth with wings expanded.

FIG. 159.—The codling-moth.

make their way into fruit: you have all found worms in apples (Fig. 159), figs, nuts, etc.

All cultivated plants, and even the trees of the woods, have enemies among the insects. Farmers and gardeners are anxious to kill these insects; but their anxiety on this score does not prevent them from killing toads and bats and destroying birds' nests. Nevertheless, toads, bats, and small birds are among the best protectors of our fields and gardens.

The insects that are most to be feared are those which in great numbers attack cultivated plants.

10. Useful Insects.—The **silk-worm.** You should know the silk-worm, which is of great importance. It is the caterpillar (Fig. 160) of a kind of night-butterfly (Fig. 161), and came originally from China.

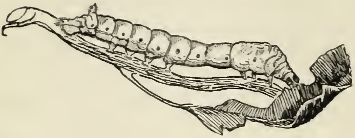


FIG. 160.—Silk-worm (caterpillar), feeds upon the leaves of the mulberry-tree.

In Central France these worms are raised in large numbers in houses built for the purpose. The worms feed upon the leaves of the mulberry-tree. Great care is needed to rear them successfully.

When the worm is a month old and has reached its full growth, it spins a cocoon of silk (Fig. 162), in the interior of which it is transformed into a chrysalis. This cocoon, when finished, is put into boiling water, in order to kill the animal; then the thread of silk, of which there is but one, is unwound. When the cocoon is of fine growth, this thread is fully one thousand feet long, and so fine that it would take nearly thirteen hundred of such threads placed side by side to make an inch.

FIG. 161.—Butterfly of the silk-worm. The caterpillars or worms come from the eggs it lays.

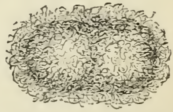


FIG. 162.—Cocoon of silk-worm. It is by unwinding this cocoon that the silk is obtained for cloth.

The silk-worm is subject to serious diseases; one of these, the pébrine, ruined many of the French silk-worm establishments some years ago, and a large number of growers gave up the cultivation of the insect.

A very learned Frenchman, Mr. Pasteur, found the cause of the disease and the way to prevent it. Thanks to him, millions are now saved each year. Let me say also, just here, that Mr. Pasteur has done much more. Formerly every year in France there died of a disease called charbon a great number of sheep, worth immense sums of money. Mr. Pasteur has shown how to protect the sheep from this disease.

11. Bees.—Among other useful insects are the **bees,** which furnish us with honey and wax. You know them very well. I have a few hives in my garden. Let us go out there: I will show you something very curious. I closed the hive last night by putting a card over the place where the bees enter, and they are shut in the hive. Do you hear the noise they are making? They are in a very bad humor.

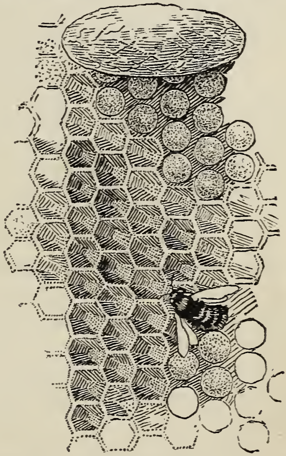


FIG. 163.—Fragment of honey-comb, showing empty six-sided cells, full cells with opening closed, and one large queen's cell.

Through the card I pass the nozzle of the fumigator, and I blow the smoke from some rags into the hive, thus stupefying the bees. Do you notice how the noise is diminishing? Finally it has ceased. I now lift off the top of the hive. Do not fear. They cannot move. See these beautiful wax cells arranged vertically, some of them full of honey. Take a piece of the comb (Fig. 163); now quickly replace the top of the hive, for the bees are beginning to revive.

You see how the comb is formed? It is double,—that is, there are two rows of little six-sided boxes. These are called cells. They are made of wax, and some contain honey and others eggs, or larvæ,—the brood, as we say. All this is manufactured by the working bees (Fig. 164), which are the common bees that we see every day in the fields.

There are in each hive about twenty thousand. The eggs are laid by a long bee, called the queen (or mother) (Fig. 165).

FIG. 164.—Worker. The workers collect the honey, with which they feed the larvæ. They also change a part of the honey into wax, with which to construct cells.

FIG. 165.—The queen lays the eggs from which come the larvæ. There is only one queen in each hive.

There is never more than one in a hive, except at and just before the swarming-time. I might spend hours in telling you about the habits of the bees, their swarming, their intelligence, but we have not time for that now.

There are patent hives in which the bees can be seen working. As for their products, they are well known to you. You also know as well as I that we eat the honey and use the wax for many purposes.

SUBJECTS FOR COMPOSITION.

ANIMALS.

Tenth Exercise (p. 40).—Animals with bones and animals without bones. What are they called? Principal divisions of animals with bones. Principal divisions of animals without bones.

Eleventh Exercise (p. 46).—Describe the skeleton of a dog. What differences are there between the teeth of an animal that feeds upon flesh and those of an animal that feeds upon grass or herbs?

Twelfth Exercise (p. 49).—Name—adding also some short descriptions of—the principal members of the cat family; the dog family; the bear family.

Thirteenth Exercise (p. 54).—Is the bat a bird? Is the whale a fish?

Fourteenth Exercise (p. 57).—What are ruminating animals? Hollow bones, solid bones, no bones.

Fifteenth Exercise (p. 60).—The two toes of ruminants. The single toe of horses. Thick-skinned animals. Incisors of the rabbit. Pouch of the kangaroo.

Sixteenth Exercise (p. 66).—What do we see upon a bird instead of the hair of mammals? Instead of teeth? Instead of arms? How many toes have birds?

Seventeenth Exercise (p. 70).—The beak of carnivorous birds. Their claws. Their principal kinds. The feet of palmipeds. Of waders.

Eighteenth Exercise (p. 76).—The beak of granivorous birds. Their principal kinds.

Nineteenth Exercise (p. 79).—Lizards and crocodiles. Vipers and serpents. Tortoises.

Twentieth Exercise (p. 82).—Metamorphoses of frogs.

Twenty-first Exercise (p. 84).—The scales of fishes. Their fins. Their gills. Fresh-water fishes and salt-water fishes.

Twenty-second Exercise (p. 87).—What do the words invertebrate, annulate, mollusk, and zoophyte, signify? How many feet have insects? Describe the metamorphoses of a butterfly. How many feet has a spider?

Twenty-third Exercise (p. 96).—Injurious insects.

Twenty-fourth Exercise (p. 98).—Useful insects.

III.—PLANTS.

71. After animals we will study vegetables, or plants. We will proceed in an orderly manner, just as we did with animals.

FIG. 166.—Herb, a plant having a soft stalk that dies to the root every year.

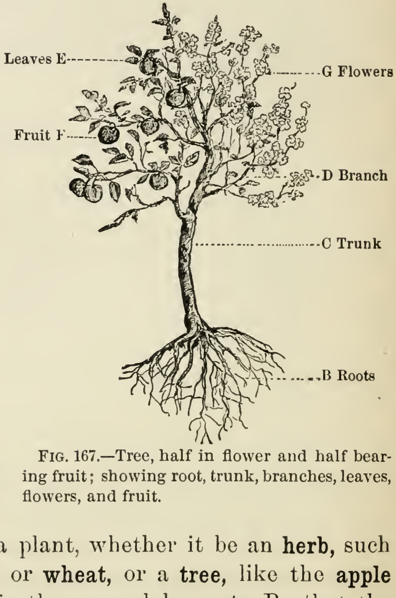


FIG. 167.—Tree, half in flower and half bearing fruit; showing root, trunk, branches, leaves, flowers, and fruit.

You know that a plant, whether it be an **herb,** such as **grass** (Fig. 166) or **wheat,** or a **tree,** like the **apple** (Fig. 167), is fixed in the ground by **roots,** B; that the stem, or **trunk,** C, grows upright and sends forth **branches,** D, covered with **leaves,** E. At a certain time the plant bears **flowers,** and then **fruit,** which contains the **seeds.**

You know also that in the stem or **trunk** of the tree, as well as in its branches, there are three parts (Fig. 168), —on the outside the **bark,** C; within, the **wood,** B; and in the centre the **pith,** A.

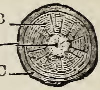


FIG. 168.—Trunk of tree.

You have had many chances to observe these facts in the gardens and fields.

I am teaching you nothing new, and yet Paul looks astonished. Why so, Paul?

"You say wheat has flowers, sir; but I have never seen flowers upon wheat."

Well, what flowers do you know?

"The violet, the daisy, the poppy, and the gillyflower."

Ah, I see. You know as flowers only such as are large, beautiful, and colored. There are many who think as you do.

But it is a mistake. Many plants have very small flowers, scarcely visible to the eye, and it is necessary to look closely in order to see them.

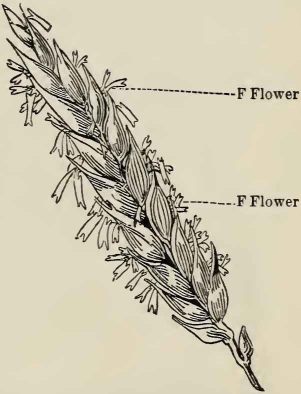


FIG. 169.—Head of wheat in blossom.

I have chosen the wheat because I have a good picture to show you, where you can see the flowers, F (Fig. 169), magnified. You still think that it does not look much like a flower? That does not surprise me: you do not really know what a flower is.

72. The Flower of the Buttercup.—Let us examine a flower carefully. I gathered a large bunch of buttercups this morning,—enough for each of you to have a flower in his hand. Distribute them among you. Now let each of you look closely at his flower.

The first thing that strikes your eye (Fig. 170) is the flower-cup, made up of these beautiful little yellow leaves, A; is it not? I am sure that many of you, like Paul, think these the whole flower. They are not even the important part. You shall see in a moment why.

These yellow leaves, A, are called **petals**; and, taken as a whole, they form the **corolla.**

FIG. 170.—Flower of buttercup, showing the upper side.

FIG. 171.—Flower of buttercup, showing the under side.

Turn the flower (Fig. 171) over and look at the under side. You see five little green leaves, B; these are the **sepals**, which, taken as a whole, form the **calyx** of the flower.

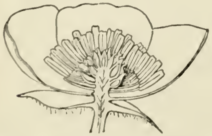


FIG. 172.—Cross-section of buttercup, showing the stamens and pistils.

Let us split the flower (Fig. 172) into halves. You see in the middle a number of little things like bristles, ending in tiny yellow balls. These are called the **stamens.** Finally, in the very centre of the flower, you notice some little greenish balls. These balls are the **pistils.** On ripening they will become the **fruit,** which will contain the **seeds.**

73. Stamens and Pistils.—I have told you that the petals and sepals are not the most important parts of the flower. The important parts are the **stamens** and **pistils,** as I shall prove to you in a few words.

Some days ago I went into the corner of the field where the buttercups grew very thickly, and I plucked away the calyx and corolla from a number that had just bloomed. I now show them to you. You see that the absence of the calyx and corolla has not stopped them from growing,—from **running to seed,** as we say. And that is the principal thing.

Upon some other buttercups, on the contrary, I cut away the stamens, without harming the rest of the flower. Patience was needed for this, but I succeeded. Well, look: not one of them has seeds. **No stamens, no seeds.** In like manner, there can be no seeds without pistils; for where could they be formed if there were no pistils?

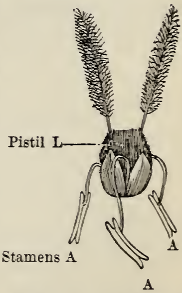


FIG. 173.—Flower of wheat separated from the head.

74. The Flower of Wheat.—Let us now examine the flower of wheat (page 103).

You see that there are a great many flowers, one below the other; these make up what is called an ear, or head.

Here there is no brilliant corolla, as in the buttercup, but three stamens, A (Fig. 173), very short, and a pistil, L, which will ripen into a grain of wheat.

The wheat, then, has flowers,—that is to say, **stamens** and **pistils.**

In the same way nearly all our cultivated plants, all our vines, all our trees, have flowers.

You see, I was right in telling you that the **stamens and pistils are the important fundamental parts of the flower.**

75. Plants without Flowers.—Yet there are some plants without flowers,—that is to say, without stamens and pistils. Thus, a mushroom or a toadstool has no flowers; neither has moss nor a fern. They have, it is true, a kind of seed, or something to take the place of seeds, for without seeds the species would soon perish. But these seeds are formed in a manner wholly different from those of the buttercup and the wheat.

There are, then, two great classes of plants, quite distinct,—**plants with flowers** and **plants without flowers.**

SUMMARY.—Plants.

In General.—The principal parts of a plant are the **roots**, which hold it in the ground; the **trunk** and **branches**, which bear the leaves; and the **flowers**, which yield the **fruit**. The fruit encloses the **seed**.

The trunk is made up of three parts,—**bark**, **wood**, and **pith**.

The Flower of the Buttercup.—The parts of a flower, such as the buttercup, are: 1st, the **corolla**, formed by the petals; 2d, the **calyx**, which surrounds the corolla and is formed by the **sepals**; 3d, the **stamens** and **pistils**, in the centre of the flower.

The most important parts of a plant are the **stamens** and **pistils.** They are indispensable in order that it may have **seeds**.

The Flower of Wheat.—Certain plants, as wheat, have neither calyx nor corolla; but they nevertheless bear seeds, because they have **stamens** and **pistils**.

Flowerless Plants.—There are some plants without stamens and pistils which nevertheless reproduce themselves. Such are ferns, mosses, toadstools, etc.

1.—PLANTS WITH FLOWERS.

76. The Plant Families.—Plants with flowers form an immense majority of those we know. They vary greatly in form and size. A tree and an herb, a violet and an apple-tree, are certainly very different.

In order to make a classification, the first idea that comes to one's mind is to put all the **trees** together into one class (poplar, apple, oak, linden, acacia, fir, etc.), then all the **shrubs** into another class (lilac, hawthorn, rose, wistaria, etc.), and finally all the **herbs**—that is, all the plants that have no wood (daisy, bean, potato, strawberry, wheat, etc.)—into still another class.

But more careful study has shown that it is better to put into the same group those plants whose **flowers, fruit,** and **seed** resemble one another. We have established upon this principle what are called **plant families.**

Thus, the bean (Fig. 174), the wistaria (Fig. 175), and

FIG. 174.—Flower of the bean (an herb).

FIG. 175.—Flower of the wistaria (a shrub).

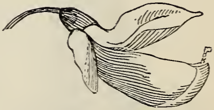


FIG. 176.—Flower of the acacia (a tree).

the acacia (Fig. 176) have flowers, fruit, and seeds which are much alike; and, although the bean is an herb, the wistaria a climbing shrub, and the acacia a tree, we place them in the same family,—the family of the Leguminosæ, or **pulse family.**

The flower of the apple-tree (Fig. 177), the wild rose (Fig. 178), and the strawberry (Fig. 179) are also very

FIG. 177.—Flower of the apple.

FIG. 178.—Flower of the wild rose.

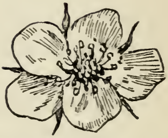


FIG. 179.—Flower of the strawberry.

much alike; we therefore place them in the same family, —the family of the Rosaceæ, or **rose family**; and so on.

77. Seed-Leaves.—We have now something very curious to notice.

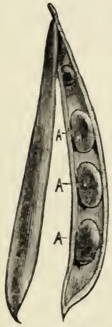


FIG. 180.—Pod of an open bean. A, seed (bean), containing the little plant and the two seed-leaves.

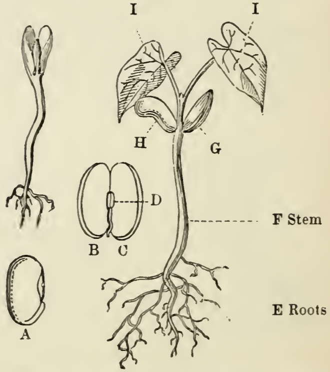


FIG. 181.—Sprouting of the bean from the germ to the young plant.

We were not able, a little while ago, to examine the seed of the buttercup thoroughly: it was too small.

But here is a bean, A (Fig. 180), quite large, as you know. Let us see how it is made. In the first place, it has a skin that envelops it. Removing this, we find (Fig. 181) two large lobes, B, C, which are named **seed-leaves,** and which are joined to each other at one point only. We will separate them at this point. Do you see a white body, D? It is this little body, called the **germ,** that will become a plant when the bean is put into the earth.

Here are some beans that I planted a few days ago (Fig. 181). You see how the little germ has grown, showing roots, E, a stem, F, and leaves, I.

The two lobes, H, G, the seed-leaves, which formed nearly the whole bean, are still there, but they are smaller in size and half withered.

That is because they have furnished the **food** that has nourished the young plant. Do you wish for proof of this? Notice the earth in the pot where I planted the bean: it is only **powdered brick, moistened.** Poor soil for a plant to grow in, is it not? In fact, the plant has found nothing there except a little water; and if it has developed, it is because of the nourishment it has drawn from the two seed-leaves.

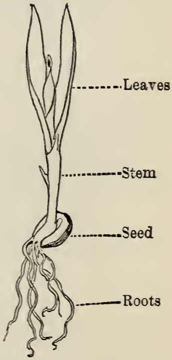


FIG. 182.—Germinating grain of Indian corn.

78. The Two Great Divisions of Flowering Plants.—We have just seen that the bean has **two seed-leaves,** or **cotyledons,** as they are called; for this reason it is named a **dicotyledonous** or **two-seed-leaved** plant (from the Greek word *dis*, meaning "two").

In some plants, as in the Indian corn (Fig. 182), the seed has only **one** seed-leaf. Such plants are called, for this reason, **monocotyledons** (from the Greek word *monos*, meaning "one").

There are vast differences between **dicotyledonous** and **monocotyledonous** plants.

I shall give you an example of this in telling you of the palm-tree (Fig. 183), which grows in warm countries. It is a **monocotyledon,** or one-seed-leaf plant.

This tree **has no branches,** but simply a tuft of leaves at the top, and its trunk, B, is **as large** at the top as at the bottom. On the contrary, the trunks of the trees of our country (Fig. 184), which are all **dicotyledons** (with the exception of the palmetto), are, as you know very well, **large** at the bottom and **small** at the top, and put forth branches and limbs.

FIG. 183.—Palm-tree (monocotyledon). The trunk, B, has no branches, but a large tuft of leaves at the top. It is as large at the top as at the bottom.

FIG. 184.—Oak (dicotyledon) has branches. The trunk is larger at the bottom than at the top.

There are, then, two great divisions of flowering plants,—**dicotyledonous** plants and **monocotyledonous** plants.

This will be of use to us in arranging for study some of the vegetable families. For I wish to make known to you some of the most common of these families by showing you the most interesting plants among them.

In our walks during the year I shall call your attention to the plants that we shall find by the road-side or in the fields, and shall explain to you the way in which they are formed, the peculiarities of their life, and of what use they are to us. But these lessons will be far more useful if you shall have previously learned in the class about some of these plants.

Here, however, I can show you only a very few living ones. We shall have to make use of pictures for the most part, and of my collection of dried plants.

SUMMARY.—I. Plants with Flowers.

Flowering Plants.—Plants are classed according to the **resemblance** of their **flowers**. Example: The bean (an herb), the wistaria (a shrub), and the acacia (a tree) are placed in the family of *Leguminosæ* because their flowers resemble one another.

The Cotyledons.—The seeds of many plants are formed of two lobes which enclose the germ. These lobes or seed-leaves are the **cotyledons**.

The **germ** is the plant on a small scale. It has a root, a stem, and leaves, all in miniature.

In a great number of seeds the cotyledons supply **food** to the germ until it is strong enough to draw it from the soil by the aid of its roots.

The Two Great Divisions of Flowering Plants.—All seeds do not have two cotyledons; many have but one.

Plants are divided on this account into **dicotyledonous** (two cotyledons) and **monocotyledonous** (one cotyledon) plants.

Plants with Two Seed-Leaves. (Dicotyledonous Plants.)

79. Crowfoot Family (Ranunculaceæ).—You already know the **buttercup** (Fig. 185). Be cautious with this pretty yellow flower: it is called in botany **Ranunculus acris** (*acris* meaning biting) because it contains a juice that bites the tongue. Do not put it in your mouth: it would burn your tongue.

FIG. 185.—Flower and stem of the buttercup (Ranunculaceæ).

This is a dangerous family: one of its plants—the clematis—has been named the "beggar's plant," because beggars formerly used it in order to make artificial sores. We have known children **to die** from eating the roots of another of these plants, called the wild turnip.

The roots of the aconite or monk's-hood are very poisonous. Notwithstanding the beauty of its flowers, we should banish this terrible plant from our gardens.

FIG. 186.—Pea (Leguminosæ). This family furnishes food for man, grass for animals, and medicines.

80. Pulse Family (Leguminosæ).—Here is a family which is as useful as the preceding is harmful.

It gives us the pea (Fig. 186) and the bean, excellent to eat when green and young, and very good when ripe and dry.

This family furnishes some of the **forage plants** of the fields that are necessary for the food of our grazing animals. You all know the **lucern** and the **clover.**

The yellow-flowered broom-plant, the thorny brown furze, and the locust-tree and the acacia, whose blossoms perfume the air in spring, all have flowers formed like those of the pea, and belong, therefore, to the pulse family.

There are some **medicinal plants** in this family. Cassia, or senna, is a well-known purgative. The licorice-plant, cultivated in France, yields the sweet black substance so well known to most boys.

The beautiful blue **indigo** is obtained from the leaves of certain plants of this family; but these plants grow only in warm countries.

The fruit of the Leguminosæ is called a **pod.**

81. Cress Family (Cruciferæ).—This is a family of wholesome plants (none are poisonous), whose flowers are composed of four petals in the form of a cross, from which the family gets the name **Cruciferæ** (cross-bearers, from the Latin *crux*, cross, and *ferre*, to bear). It produces not only flowers that smell sweet, like the gillyflower (Fig. 187), but also

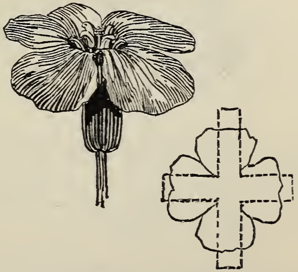


FIG. 187.—Gillyflower, with diagram of the top of the flower, showing the cross form.

plants that are **good for food,** as the cabbage, the turnip, the radish, etc.

Several plants of this family have leaves that are very wholesome when eaten raw, as the water-cress.

The seeds of the mustard, another of the cress family, when ground, give out a strong odor, and the flour thus produced, if applied to the skin, makes it turn red.

Mustard poultices, often used by physicians, are prepared from this flour, as well as the mustard that is upon our tables.

82. Rose Family (Rosaceæ).—The rose (Fig. 188), the queen of flowers, as it is often called, has given its name to the family of **Rosaceæ.** Our most important and most agreeable fruits, with the exception of the grape, are given us by this family.

FIG. 188.—American wild rose, showing bud, blossom, and fruit. Most of our fruit-trees belong to this family. A, blossom; B, bud; C, seed-pod; D, cross-section of bud; E, cross-section of seed-pod.

The blossoms of the apple, pear, prune, cherry, almond, blackberry, strawberry, are all arranged in nearly the same manner as those of the eglantine or wild rose.

But if the flowers of these various plants resemble one another, the fruits differ very much. In some the fruit has little **seeds** (pear, apple); in others it has **stones** (cherry, prune, plum); in some kinds it has **shells** (almond); in still others it is a kind of **berry** (strawberry, raspberry). Notice also that in the raspberry the true seed is enveloped by the flesh of the fruit, while in the strawberry the seeds are on the outside of the flesh and seem like little stones which are fixed on.

83. Parsley Family (Umbelliferæ).—Here is the flower of a **carrot** (Fig. 189). It is formed of a number of little flowers united into bouquets; then these bouquets are mounted upon little stems, side by side, so as to form one large bouquet. This is called an **umbel** (from the Latin *umbella*, parasol, umbrella), and certainly the bouquet of the carrot does look something like a parasol.

Fig. 189.—Flower of the carrot.

Nearly all the plants of this family have **odorous leaves**: crush the leaves of the fennel or parsley, and you quickly know it.

Some of them give us roots or stalks good to eat, as the carrot, celery, and parsnip. The fruits of the anise have a pleasant odor, and when steeped in sweet wine they produce anise cordial.

84. Poppy Family (Papaveraceæ).—This name comes from the Latin *papaver*, which means poppy. The corn-poppy (Fig. 190) and the common poppy are the principal representatives of this family.

If we prick the fruit of the poppy with a needle, there comes out a kind of milky juice, which on drying becomes brown and sticky. This juice has been used in medicine from time immemorial under the name of **opium**.

The seeds of the poppy contain an **oil** which is good to eat. It is in order to extract this oil, as well as the opium, that the poppy is cultivated. There is no opium in the seed: the shell of the fruit alone contains it.

FIG. 190.—Poppy, showing bud, blossom, and fruit, or seed-pod. From this plant opium is made.

We often see about old walls another plant of this family, with yellow leaves resembling those of the cress family. It is the great celandine. Do not put a stem of it in your mouth, or you will repent of it. Its yellow juice is so strong that it will destroy warts.

85. Nightshade Family (Solanaceæ).—Here is another terrible family. Nearly all the plants belonging to it are dangerous, and can poison by their roots, stems, leaves, flowers, fruit, and even seeds.

FIG. 191.—Flower of the potato.

These plants produce agitation, delirium, with unnatural actions of all kinds, and finally a heavy sleep which sometimes ends in death. The extracts of these dangerous plants (mandrake, belladonna, henbane, thorn-apple) were formerly used by people called sorcerers. Those to whom they gave them, or even the sorcerers themselves when they made use of them, became like crazy people, and took their dreams and imaginations for realities.

On the other hand, some of this family supply foods. We eat the fruit of the tomato and the egg-plant, and also the red pepper.

But we eat in far greater quantities the roots (or, to speak more correctly, tubers) which we call **potatoes** (Fig. 191).

Fig. 192.—Showing how the fruit of the potato-plant grows on the top of the stalk; the potato itself is not the fruit, but a modification of the root.

Nothing is more harmless and, at the same time, more useful than this admirable plant, which is a native of America. Nevertheless, when the potato sprouts in the light, when its eyes send out little branches, there is formed in these young green shoots a violent poison. We must therefore take care when using potatoes for the food of man, or even animals, and especially swine, which are very sensitive to their action, to break off the sprouts. Otherwise paralysis and death may come from their use.

Fig. 193.—Tobacco-plant.

For the same reason the fruit, or potato-ball (Fig. 192), must not be eaten.

There is another plant of this family which I must urge you not to use. I mean **tobacco**

(Fig. 193). In smoking, snuffing, or chewing tobacco we poison ourselves a little each day, for this plant contains a **fearful poison,**—nicotine; and we must attribute many grave diseases to its use, to say nothing of the weakening effect it has on the memory and the will.

FIG. 194.—Forget-me-not.

86. Borage Family (Boraginaceæ).—Here is a family in which there is no dangerous member; but there are no very useful ones in it. I shall mention only the borage, from which a drink is made; the alkanet, which is cultivated in France and other countries in order to extract from it a beautiful and harmless red coloring-matter, used for coloring candy; and the beautiful blue myosotis, which you all know under the name of "forget-me-not" (Fig. 194).

87. Sage or Mint Family (Labiatæ).—The other day I saw James boastingly holding the leaves of a nettle in his hands without being stung. But he well knew they were not the leaves of the true or stinging nettle. They were the leaves of the white nettle, or, as some people call it, the **dead-nettle** (Fig. 195), a plant very different from the true nettle, although the leaves of the two plants resemble each other. This stingless nettle belongs to the mint family.

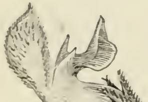


FIG. 195.—Flower of the dead-nettle. Family of sweet odors.

This is a family of **sweet odors.** The thyme, rosemary, lavender, summer-savory, sage, balm, mint, basil, are well known to you, and you have probably seen some of them put away with clothes to make them smell sweet.

Steeped in water or alcohol, some of them make an agreeable drink, useful to the stomach in some cases; mint, balm, sage, marjoram, and pennyroyal are especially worthy of notice.

This family has received the name of Labiatæ because in the plants which compose it the corolla of the flower (Fig. 195) grows in the form of lips (in Latin *labiæ*).

88. Mallow Family (Malvaceæ). — Among the best known plants used in making medicinal drinks are the mallow and the marshmallow.

FIG. 196.—Cotton-plant. A, full-blown flower; B, half-blown flower; C, seed-pod, or cotton-boll; D, ovary, with stigma; E, seed, with cotton attached.

The cotton-plant (Fig. 196), cultivated in the South and in other warm countries, belongs to the mallow family.

The seeds grow in pods, and are covered with long, white, silky hairs, which constitute the **cotton** of which cloth is made.

89. Madder Family (Rubiaceæ).—Here is a family in which are found three plants of very great importance,—madder, cinchona-trees (which yield Peruvian bark), and coffee.

Madder (Fig. 197) is cultivated for its roots, from which a beautiful red dye is made. Its culture has much diminished since chemistry has invented a coloring-matter almost identical.

Fig. 197.—Madder-plant. Coffee is a member of this family.

The bark of the cinchona is of great service to us in the **quinine** obtained from it. It cures the malarial fever which attacks those who live in damp places. The cinchona-trees are natives of South America.

The coffee-plant grows in the warm regions of Africa and Asia, and is also now cultivated in some parts of America. I need not tell you about the use of its seed, which, being dried, roasted, and coarsely ground, gives us, by infusion, an excellent drink.

Fig. 198.—Canada thistle.

The ipecacuanha, which also grows in warm countries, and the roots of which are used by physicians to cause vomiting, belongs to the madder family.

90. Sunflower Family (Compositæ).—1st. The Thistle. No plant is more common in summer than the thistle (Fig. 198). Let us examine very closely what we have supposed to be the flower.

Pull out what seems to be one of its petals. With your sharp eyes—but better still with my glass—you will see that it is really **a little flower, complete in itself,** having five petals.

Hence a flower of the thistle is made up of a number of little flowers collected together.

The flowers of the artichoke are thus formed; also those of the large-leaved burdock, whose burs in the autumn you often play with, and the absinthe, or wormwood, from which a liquor is made that weakens the nerves and even **destroys the reason** when taken to excess or as a habit. Believe what I say, and never drink this poison.

Fig. 199.—Dandelion, showing plant, root, seed, bud, and flower. A, dissection of flower; B, fruit, with all but one seed-flower blown off.

2d. Dandelion. The flower of the dandelion (Fig. 199) is also a collection of little flowers crowded together, one against the other. But these flowers, unlike those of the thistle, are flat and divided.

You can see that the head of the lettuce is, except in color, much like that of the dandelion.

3d. SUNFLOWER. Finally, the sunflower (Fig. 200), with its large yellow flowers, the daisy, and the chamomile, which has so strong a scent, have some flowers like those of the thistle, and other flowers, at the same time, like those of the dandelion.

FIG. 200.—Sunflower. The flowers in the centre are like those of the thistle; the flowers near the edge are like those of the dandelion.

91. Gourd Family (Cucurbitaceæ).—Here is a plant which will teach you something new.

Examine this yellow flower of the pumpkin (Fig. 201). You find five little sepals, A; five petals, B; within, some stamens; then nothing,—no pistil. Where will the fruit form? We see no trace of it

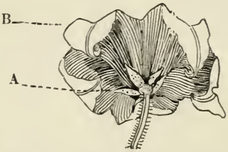


FIG. 201.—Pumpkin-flower with stamens, seen from below; five small separate sepals, A; five large petals, B, joined together at the bottom.

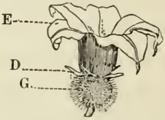


FIG. 202. — Pumpkin-flower with pistil; five sepals, with flower-cup, D, surrounding the pistil; five larger petals joined together.

in this flower. And yet the fruit of the pumpkin grows very large, sometimes even three feet long.

Be patient.

Now look at this other flower of the pumpkin (Fig. 202). Here are still five sepals, D, and five petals, E.

This time no stamens; but in the centre of the flower you see the end of the pistil, the lower part of which forms a ball, G. The pumpkin, then, has some flowers **with stamens only,** and other flowers **with pistils only.**

This does not prevent the fruit from setting and ripening. Many plants of this family are sought for the table: melons and cucumbers are eaten raw, pumpkins in pies, the citron-melon in preserves. Others are purgatives.

92. Catkin Family (Amentaceæ).—You all know the flowers of the hazel-tree (Fig. 203), forming green

FIG. 203.—Inflorescence of the hazel (Amentaceæ). Above, pistillated flowers; below, staminated flowers united into a catkin.

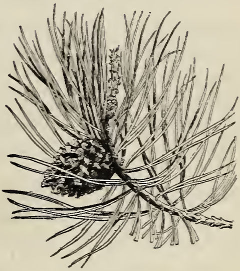


FIG. 204.—Pine branch bearing cones (Coniferæ).

clusters, called catkins, which look like large caterpillars. The flowers of the catkin family are nearly all formed in the same way.

This family is made up, almost without exception, of **large trees,** which furnish wood for the carpenter's use and for fuel (oak, chestnut, birch, etc.).

The bark of the oak is used by the tanner.

We eat the fruit of the chestnut, the sweet acorns of some oaks, and the nuts of beech- and hazel-trees; and from the beech-nut and hazel-nut we obtain oil.

93. Pine Family (Coniferæ).—This family, like the preceding, gives us woods for the carpenter's use and for commerce generally; these woods are white and not very hard, but the resin with which they are penetrated renders them **very resistant to moisture**: pine (Fig. 204), fir, etc.

We utilize also the **resin** and **tar** which are made from some of these trees, especially the pine and the fir.

SUMMARY.—Dicotyledons.

Crowfoot Family (Ranunculaceæ).—Nearly all the plants of this family contain an **acrid juice**, which is hurtful, at least when not used as a remedy by a physician.

Pulse Family (Leguminosæ).—With very few exceptions these plants are useful either as **foods** (beans, peas, etc.), as **pasture** or **forage plants** (lucern, clover, etc.), or as **medicines** (cassia or senna, licorice, etc.).

Cress Family (Cruciferæ).—This family furnishes us with **foods** (cabbage, radish, turnip, mustard, horseradish, etc.).

Rose Family (Rosaceæ).—This family furnishes fruits with **stones** (cherries, prunes), fruits with **seeds** (apples, pears), fruits with **shells** (almonds), and fruits with **berries** (strawberries, blackberries, etc.).

Parsley Family (Umbelliferæ).—One of the general characteristics of this family is its **odorous leaves** (parsley, anise, celery).

Poppy Family (Papaveraceæ).—The most useful member of this family is the poppy, from the seeds of which an **oil** is made, and whose juice furnishes **opium**.

Nightshade Family (Solanaceæ).—Nearly all these are **poisons**. Tobacco is one of the most violent. This family comprises, nevertheless, the **potato** and the **tomato**.

Borage Family (Boraginaceæ).—This family includes the heliotrope and the forget-me-not.

Sage or Mint Family (Labiatæ).—Among the best known are lavender, thyme, balm, sage, rosemary, all of which have a **sweet and pleasant odor**.

Mallow Family (Malvaceæ).—The most important is the **cotton,** of which **cloth** is made.

Madder Family (Rubiaceæ).—Among these we notice **madder,** which gives the beautiful **red color; cinchona (quinine),** which cures **fever;** and **coffee.**

Sunflower Family (Compositæ).—Thistle, dandelion, sunflower, daisy, etc. The remarkable fact in this family is that each flower is an **assemblage of little flowers** of various forms.

Gourd Family (Cucurbitaceæ).—In this family the same plant bears some **flowers with stamens only** and other **flowers with pistils only.**

Catkin Family (Amentaceæ) furnishes **wood** and **timber** (oak, walnut, poplar, etc.).

Pine Family (Coniferæ) also gives us **wood** (pine, fir, etc.).

Monocotyledons.

94. Lily Family (Liliaceæ).—This yellow tulip (Fig. 205) which I have pulled up to show you its structure, and all the other tulips cultivated in our gardens, are plants whose seeds have only a **single cotyledon.**

FIG. 205.—Tulip. Its root is a bulb.

You see what a singular root the tulip has, like the root or bulb of an onion. It is called a bulb.

The hyacinth, garlic, shallot, leek, and the beautiful white lily of our gardens, all have a bulb, flower, and fruit similar to those of the tulip; and the lily has given its name to the whole family.

Asparagus, the young shoots of which we eat, and the lily of the valley, with its white, fragrant flowers, are also of the lily family; but their fruits are fleshy, and in place of bulbs they have underground roots, called by some gardeners claws (Fig. 206).

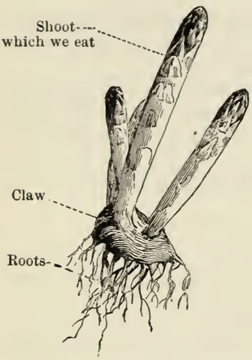


FIG. 206. — Asparagus. The claws branch under-ground; upon these branches are found eyes, from which spring other shoots.

FIG. 207.—Stalk of Indian corn. A, flowers with stamens; A′, single flower separated; B, flowers with pistils; C, stalk; D, roots.

95. Grass Family (Graminaceæ).—Wheat, as we have seen, and other plants of the grass family (oats, barley, rye, corn, sorghum, millet, sugar-corn, etc.), have only small flowers, with no beautiful colored petals.

But their flowers are none the less complete, with their three stamens and their pistil with a single seed, as I have explained to you. They are often arranged in ears.

Rice, which grows in the marshy lands of warm countries, belongs to this family; so also does Indian corn (Fig. 207), but in this the flowers with stamens are separated from the flowers with pistils.

Nearly all the plants of the grass family are herbs of medium height. Their name comes from the Latin word *gramen* (herb, grass).

Nevertheless, sugar-cane, sorghum, and bamboo grow to the height of thirty feet. Some bamboos are true trees.

SUMMARY.—Monocotyledons.

Lily Family (Liliaceæ).—Have an **underground root** (bulb or claws).

Grass Family (Graminaceæ).—This family includes wheat, oats, rice, barley, Indian corn, sugar-cane, etc.

2.—FLOWERLESS PLANTS.

96. Ferns.—I show you a stalk of **fern** (Fig. 208), to bring which here complete has given me no little trouble.

The stem, T, is concealed underground, like that of the asparagus, and from there sends out its leaves. The sprouts, A, are rolled up in a coil. As they grow they spread out on both sides equally.

Look at the under side of this leaf, B: notice these little yellow spots,—they are bunches of seeds which will reproduce the fern. They are not true seeds, and are called **spores.** The fern never had upon it either flowers, stamens, or pistils.

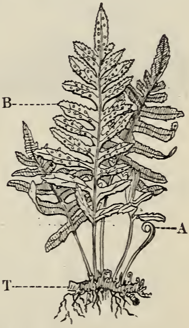


FIG. 208.—Stalk of fern. T, stem concealed underground; A, sprout rolled up in a coil; B, leaves bearing spores on the under side.

In warm countries some ferns, whose stems grow upright out of the ground, are true trees.

97. Mosses.—We must look at these pretty little plants (Fig. 209) with a magnifying-glass in order to see clearly their little stems and delicate leaves. There are many kinds of mosses, growing on the ground, upon walls, or upon the trunks of trees.

FIG. 209.—Moss.

Some of these stems send out a slender stalk, which bears a tiny ball. The seeds (spores) are in this ball.

98. Mushrooms.—Thus far all the plants that we have studied have been **green**, and have possessed roots, stem, and leaves.

With this white mushroom (Fig. 210), which has grown in a hollow in the hot-bed, it seems as if we look into a new world,—no roots, no leaves, no flowers, no green color.

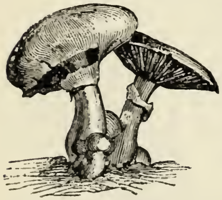


FIG. 210.—Mushrooms.

Many other kinds, of all sizes, and variously colored in red, yellow, violet, etc., are found, principally in the woods and in moist, shady places. The greater part of them are **poisonous**.

However, some mushrooms are good to eat.

The first of these is the truffle, which grows underground between the roots of the oak.

Among true mushrooms that we eat must be mentioned particularly the agarics, which have lamellæ, or "gills," under their caps; the boletuses, which have tubes; and the morels, whose heads are knobbed.

99. Moulds.—The moulds are mushrooms so small that one must look very closely in order to see their real structure. Most of them are not poisonous, but they are very disagreeable, and quickly spoil everything in damp weather.

Some kinds do much harm by attaching themselves to cultivated plants, upon which they live and which they exhaust. The **ergot** of rye and the **rust** of wheat are moulds. The **mildew,** that destructive disease of the vine, is a mould. Several diseases of the skin, scald-head among others, are the result of the development of certain vegetable growths (moulds) on the surface or in the thick skin.

Finally, there are some kinds of very small moulds which are the cause of fermentation. Wine, beer, and vinegar could not be made without them.

FIG. 211.—One of the higher algæ (coralline).

100. Algæ. — The long, green, thread-like substances which grow in the watering-trough are **algæ.**

In the water of the sea we find a number of kinds very pretty and very curious in form, many of which are of red color. These we call **sea-weeds.**

SUMMARY.—Flowerless Plants.

The flowerless plants include **ferns, mosses, mushrooms, algæ.**

QUESTIONS.—PLANTS.

Name the different parts of a plant. If we cut off the trunk of a tree, what three parts shall we see? Are all flowers beautiful and ornamented with bright colors? What first strikes the eye in a buttercup? What name is given to the yellow leaves of the buttercup? What name to the green leaves on the under side of the buttercup? What remains at the middle of the buttercup when the yellow petals are taken away? What do we find at the centre of the flower? What will the pistils become on growing? What are the important parts of a flower? What happens when we take away the stamens and pistils of a flower? How is the flower of wheat formed? Do you know some plants that have no flowers? How are these plants reproduced? In view of what has just been said, into how many classes can we divide plants?

QUESTIONS.—PLANTS WITH FLOWERS.

According to what characteristics are plants classed into vegetable families? Give examples. What is a cotyledon? What is the germ of a bean? How is the germ developed? Of what use are the cotyledons? What are plants with two cotyledons named? Have all plants two cotyledons? What are plants with a single cotyledon called? What are the differences between the palms and the trees of our forests?

Name two divisions of flowering plants. Why should you be cautious with the buttercup? Name some other dangerous plants of this family. Name some plants of the pulse family, and tell of what use they are to us. Name some useful plants of the cress family. Mention the useful plants of the rose family. What special quality has the parsley family? Do we make use of the plants of this family? To what family does the poppy belong? What do we get from the seed of the poppy? What from the flowers? What are the properties of the nightshade family? Name the plants we eat of this family. What of the potato? What does the use of tobacco produce? Name the most common of the borage family. Is the white nettle a true nettle? Name the principal plants of the mint family, and give the general qualities. What are the qualities of the mallow family? Where does cotton come from? What family furnishes madder? Quinine? Coffee? What is madder used for? Of what use is quinine? What countries grow coffee? How is the flower of the thistle formed? How the flower of the dandelion? How the daisy? What is the peculiarity of the pumpkin family? Name the plants of the pumpkin family used for food. How are the flowers of the catkin family formed? What is the importance of this family? Name the pine family and its products. What is the peculiarity of the tulip root? Name some of the lily family. What family produces the asparagus? Lily of the valley? What is peculiar about their roots? Have the plants of the grass family handsome flowers? Name the principal plants of the grass family.

QUESTIONS.—FLOWERLESS PLANTS.

Tell us about mosses. What is the peculiarity of mushrooms? Name some mushrooms good to eat. What class produces the fungi? Are they all disagreeable? Name the fungi injurious to plants. What is fermentation? What do you know of the algæ?

READING-LESSONS.

12. Dangerous Plants.—You must avoid fruits unknown to you which you find in the fields, near fences, or in the woods. The more showy, tempting, and sometimes even the more agreeable to the taste they are, the more necessary it is to be on guard against the temptation to gather them.

The black berries of the black nightshade and the red berries of the bitter-sweet cause vomiting, drowsiness, and other serious symptoms in children who eat them. But they are as nothing by the side of the fruits of the belladonna, or deadly nightshade, which are sweet to the taste and similar in color and size to small cherries. They have often caused dreadful poisoning, followed by death.

You run great risk of serious injury if you eat the fruit of the yew-tree or juniper, the black berries of the elder or the ivy, and especially the berries of the buckthorn. It is true that these last are horribly bad in taste, but this does not always stop children, especially very young children, from eating them. Last year a little child three years old died from eating the seeds of the stramonium, or "jimson weed," and there are few things less agreeable to eat than these.

The fruits and seeds are not the only dangerous parts. Many plants have in their stems or leaves an acrid juice capable of burning the tongue if put in the mouth. The flowers of certain other plants are true poisons. Finally, there are many fleshy roots which if you put them in the mouth will cause you to repent of it. In our country there are also several wild plants which are poisonous to the touch.

You see, then, you must be careful in going out for plants. In general, never put either the flowers or the leaves of unknown plants in your mouth, and especially distrust those that give a milky juice, either white or yellow. Recollect what I have said of fruit. As for roots, you probably have no great desire to dig them up; and, besides, those that are dangerous generally have a very bad taste.

13. Poisonous Mushrooms.—In each class of mushrooms there are some very poisonous ones that often look very much like the eatable ones.

Therefore it is exceedingly dangerous to eat mushrooms collected in the fields. Those who pretend to know them best run a great risk in eating them, and very often we read in the papers accounts of terrible cases of poisoning from mushrooms, sometimes destroying a whole family at a blow. Believe me, it is not safe to eat any except the white mushrooms that come from the green-house.

14. Buds and the Pruning of Trees.—I have a small branch that I cut this morning from one of my pear-trees. You see at the end of each branch and in the axilla of each leaf little hard bodies, covered with scales, and resembling a pine-bur in miniature. These are buds, or eyes (Fig. 212), as the gardener calls them. It is from the buds that the limbs grow. The buds are little branches in miniature.

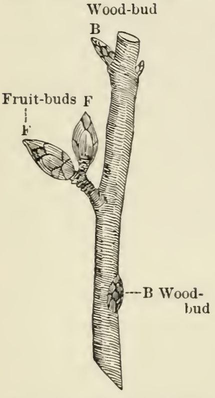


FIG. 212.—Branch of pear-tree, bearing fruit-buds, F, and wood-buds, B.

The buds are formed during the summer. They remain seemingly dead during the winter, and burst forth in the spring.

Some will produce branches and leaves, others flowers and fruit. The first are called **wood-buds,** and are known by their long form; the second are the **fruit-buds,** and are known by their round form.

In general the fruit-buds are quick to expand; they open before the others, and many trees are covered with flowers before the leaves are out. This is especially true of the apple-trees, which in the spring-time have the appearance of so many large bouquets.

But do not think that our pear-tree becomes covered with leaves and fruit without any care from me. It must have much care. Each year, before the spring opens, I **prune** the tree,—that is to say, I cut away the branches and the wood-buds which had grown too much during the preceding summer, and I try to save as many as possible of the fruit-buds.

The pruning of trees is really an art. I will explain the principles of it when you are more advanced.

15. Doubling of Flowers.—The beautiful varieties of roses that are cultivated differ much from the sweet-brier, or wild rose. Let us compare the wild rose with one of our cultivated, or double roses (Fig. 213).

FIG. 213.—Cultivated rose. E, colored petals originating from transformed stamens.

Instead of the five petals which you see in the sweet-brier, the cultivated rose presents a great number. But, on the other hand, there are neither stamens nor pistils. This is because by a very curious effect of the culture these have been transformed into **petals.**

This is what is called the doubling of flowers. It is the result of the transformation of stamens, and often also of pistils, into colored petals. You can now understand why the beautiful double flowers are those which when simple have many stamens and pistils. This is the case with roses and the crowfoots.

In double dahlias and double China asters, which are Compositæ, it is not the stamens that are transformed into petals, but the little flowers of the centre have become like the large flowers of the border.

16. Slips.—I see that James, our habitual questioner, wishes to ask me something; and we must listen to him, for his questions are nearly always very suggestive.

"If there are neither stamens nor pistils, sir, how are we able to obtain seeds of this rose-bush? How can we grow other rose-bushes of the beautiful variety you have just shown us?"

His question, you see, is a wise one. Well, my boy, there often remain a few stamens and pistils which are not transformed; the fruit sets in these, and we have seeds.

But in general we do not plant these seeds, and we preserve these beautiful varieties by another process.

Do you see upon this shoot of the rose-bush these little buds, or eyes, as gardeners call them? When they grow they will become branches, and upon them will be produced, naturally, roses similar to those on the rest of the bush.

FIG. 214.—Layering. B, branch covered with soil; A, new roots.

Now, if I put this shoot into moist soil and care for it well it will send out roots and will grow as though it had remained on the old bush.

I shall in this way obtain a new rose-bush from a slip.

17. Layering.—There is another way of doing this. Several persons have asked me to raise them young plants from this beautiful rose-bush which adorns the whole yard in front of the school. When the last of autumn comes I shall lay some of the branches in the soil, without detaching them from the bush (Fig. 214). The part A which is in the soil will send out roots, and when these are sufficiently large I shall cut the branch B, on the side next the bush. I shall in this way have a new rose-bush, which has been obtained by layering.

18. Grafting.—There is still another process. I could use a single bud (Fig. 215) without the branch, by placing it in fine, moist soil. That would require much care, but it is possible. To avoid all this care, we cautiously remove the little bud from its parent branch, and insert it as a slip upon the branch of the wild rose. To do this, we make a slit in the bark (Fig. 216), and set the bud in the moist place under the bark, closing the wound with a bandage (Fig. 217). The bud, being sealed in its place by wax, attaches itself to the limb, and, instead of sending

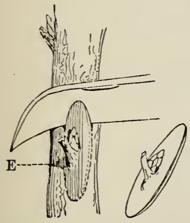


FIG. 215.—Budding. The bud, E, is cut from the limb with a small piece of the bark.

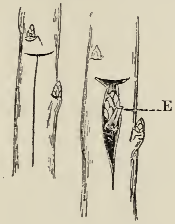


FIG. 216.—Budding. The bud, E, is put in a slit made in the bark of the bush we wish to graft.

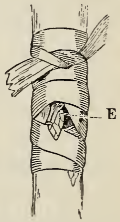


FIG. 217.—The bud, E, is bound and sealed in place with wax in order that the wound made in the bark may heal.

out roots and deriving its nourishment from the soil, takes up directly the sap of the rose-bush, just like the true buds of the rose-bush itself. This is what is called budding: it is a kind of grafting.

When spring comes I will show you how true grafting is done.

19. Varieties.—"But, sir, since we sometimes have seeds, why take the trouble to graft or use cuttings? Why do we not simply plant the seeds?"

We do this also, James; but, what is very curious, the seeds of double roses do not always produce roses of the same kind. Sometimes the roses obtained by planting the seeds are more beautiful, sometimes less beautiful, than the kind that produced the seed; and there are often changes in shape, size, and color. It is by planting the seeds that gardeners obtain **new varieties.** But in order to be sure of obtaining the same rose we must use cuttings, slips, buds, or grafts.

The same thing is true of many cultivated fruits. Thus, if we plant the seeds of pears and apples, or the stones of peaches or plums, we are by no means sure of obtaining the same kinds as we plant, or even good ones of any kind. This is why we slip or bud or graft these trees, just as we do with the rose.

SUBJECTS FOR COMPOSITION.

PLANTS.

Twenty-fifth Exercise (p. 102).—Name the principal parts of a plant. The parts or organs of a flower.

Twenty-sixth Exercise (p. 107).—What are some of our forage-plants? What family of plants gives us the pea? The bean? The radish? The turnip? The water-cress? Name the family that furnishes our principal fruits. Name those fruits, and describe them.

Twenty-seventh Exercise (p. 109).—Open a bean and describe the different parts that compose it. What are the two great divisions of plants?

Twenty-eighth Exercise (p. 115).—Explain the word "Umbelliferæ." What is peculiar to the leaves of this family? Name some esculent roots.

Twenty-ninth Exercise (p. 115).—What is opium? What product do we obtain from poppy-seed? What is the character of the nightshade family? Name an important plant of this family, and state what part of it is used for food. What danger is there in the sprouts of this plant? Name another plant of this family which is not good to use.

Thirtieth Exercise (p. 118).—What is the character of the mint family? Name the principal plants of this family. What of the mallow family?

Thirty-first Exercise (p. 119).—Why has madder lost its importance? What is the use of quinine in medicine? Where is coffee found? and for what is it used? Of what use is ipecac?

What is a composite flower? Name among the Compositæ a plant from which a very dangerous liquor is made.

Thirty-second Exercise (p. 123).—What is the importance of the Amentaceæ? What is used by the tanner? Name those plants whose seeds give us,—1st, oil to eat; 2d, oil to burn. Of what use is resin and tar?

Thirty-third Exercise (p. 125).—Name some plants that have only one cotyledon. What name is generally given to their roots? What are the claws of asparagus? Mention the importance of the grasses. Where does rice grow? What is Indian corn? Where does sugar-cane grow?

Thirty-fourth Exercise (p. 128).—What are mosses? To what is the disease called scald-head due? Give an example of fermentation.

Thirty-fifth Exercise (p. 132).—Describe buds, cuttings, layering, grafting.

IV.—STONES.

101. How we distinguish Stones from one another.—We have learned to tell animals from one another by their size, their shape, and the different organs that they have in the interior of their bodies.

But we cannot distinguish stones in the same way. In the first place, there are no organs within a stone; secondly, by a blow with a hammer we can always change the form of a stone and diminish its size. It remains, nevertheless, stone as before.

In order, therefore, to tell the different kinds of stones from one another we must search for other characteristics.

The first of these is **hardness,**—for you well know that all stones are not equally hard.

102. Hard Stones.—Here is a piece of stone, called **quartz,** which has a sharp edge. I draw it across this piece of **limestone,** of which buildings are made. You see that the limestone is easily scratched by the quartz. Moreover, the point of my knife, which cuts the limestone, glides off the quartz. The quartz is, then, very **hard,** and the limestone much less so.

103. Soft Stones.—Notice this piece of **gypsum** which was given me by the master-mason. It is scratched by the quartz and by the knife, and also by the limestone. Even my nail marks it. This is a very soft stone.

104. Clay.—Finally, here is a still softer stone. It is **clay,** upon which almost anything will make a mark.

It is so soft that it will take the imprint of any solid body pressed even lightly upon its surface.

Hence we see that **hardness** is one of the important differences between the various kinds of stones. But there are other and far greater differences.

105. The Action of Vinegar upon Stones.—I put into these four glasses a small piece of each of our four kinds of stone. Then I pour some strong vinegar into each glass. The **quartz** (Fig. 218), the **gypsum** (Fig. 219), and the **clay** (Fig. 220) remain perfectly quiet, and you notice nothing in particular.

FIG. 218.—Vinegar does not act upon quartz.

FIG. 219.—Neither does it act upon gypsum.

FIG. 220.—Nor upon clay.

FIG. 221.—On the other hand, bubbles of carbonic acid are set free from the limestone.

But see the **limestone** (Fig. 221): it gives out a great many little **bubbles of gas**, which form a froth on the surface. This gas is not air, but **carbonic acid**, which I will tell you about shortly. This bubbling of gas is called **effervescence.**

106. Action of Fire upon Stones.—There is still another difference, as I shall proceed to show you. I put a large iron spoon into the fire, and, as you see, it soon becomes red-hot.

Then I place a piece of **clay** in the spoon. The clay also becomes red in its turn. Take it out of the spoon and allow it to cool. A curious change has taken place:

from being soft and **malleable,** it has become as **hard** as brick, and is now, in fact, a piece of brick.

Now put the **gypsum** into the spoon. On being heated, this does not preserve its form well, but crackles and falls to pieces. It becomes quite **friable,**—that is to say, easy to make into powder. Add a little water to this powder that I have allowed to cool. What a curious change takes place! The paste becomes slightly warm, then hardens rapidly. You know this paste well, James, for you have often seen your father make it. "Oh, yes, sir: it is **plaster.**"

Now take the **limestone.** It acts almost like the gypsum, except that it remains harder and does not readily take the form of powder. Let us also wait until it cools, and put it into water. See what a **boiling!** The water has become so warm that we cannot touch it. Then all becomes quiet, and there is thus formed a kind of paste, but very different from that of the plaster. "It is **lime,**" says James. And he is right.

Finally, let us take our **quartz.** See: it does not change its appearance: it remains the same after having passed through the fire as it was before; but it burst into pieces with a loud noise. When I was watching it I took care to cover the spoon closely with the shovel, so that the fragments should not fly into your eyes. I also took the same precaution with the other experiments.

107. Characteristics of Different Stones.—Thus you see that we already know four kinds of stones:

1. **Quartz** (Silica).—Very hard, harder than steel, not altered by fire, cannot be scratched with a knife, and not acted upon by vinegar.

2. **Clay.**—Very soft, moulded in the hand, hardened by fire, and not attacked by vinegar.

3. **Gypsum.**—Very soft, marked by the finger-nail, changed into plaster by the action of heat, and, like both the preceding, not acted upon by vinegar.

4. **Limestone.**—Harder than clay or gypsum, but can be scratched with the knife; vinegar brings out from it carbonic acid, and on being heated it is changed into lime. We call this stone calcareous (from a Latin word which means lime).

108. Other Mineral Products.—But these are not the only mineral products found in the soil. There are others, such as **slate, marl, sandstone, granite,** of which I shall speak more fully next year. We also find **coal,** and the minerals, such as **iron, lead, silver,** etc.

109. Precious Stones.—We likewise find in the earth the **diamond,** which is a kind of coal, and the **precious stones,**—the ruby and the emerald, for example,—which are a kind of silica.

SUMMARY.—Stones.

Hardness.—We distinguish stones by their **hardness.** **Very hard stones,** as **quartz;** **hard stones,** as **limestone;** **soft stones,** as **gypsum;** **very soft stones,** as **clay.**

Action of Vinegar upon Stones.—Vinegar has no action upon quartz, plaster, or clay; but upon **limestone** it produces **effervescence,**—that is to say, the setting free of bubbles of **carbonic acid gas.**

Action of Fire upon Stones.—In fire **clay** becomes hard, like brick; **gypsum** is reduced to a powder; **limestone** becomes **lime;** **quartz** is not changed in appearance, but breaks into fragments.

Other Mineral Products.—We also find in the earth **slate, marl, sandstone, granite, coal,** and the **metals** (iron, lead, etc.); also the **precious stones** (the diamond, the ruby, etc.).

QUESTIONS.—STONES.

How are stones distinguished from one another? Limestone? Clay? What is the action of vinegar upon stones? What is the action of fire upon clay? Upon gypsum? Upon limestone? Upon quartz? Give the characteristics of different stones. Do you know any mineral products besides stones? What is meant by precious stones?

READING-LESSONS.

20. The Use of Stones.—The silicious stones are sought on account of their great hardness. Thus, millstones are silicious stones. Ask the miller if they are hard to pick. He uses a steel chisel for this purpose, and the sparks from it have tattooed the skin of his hands.

Granite, also very hard, of which such solid stone-work is made, is a silicious stone.

The hardness of **calcareous** stones varies greatly. Masons say that there are among them some hard and some soft stones; and they are right. Of the first foundation-walls are built, and of the second the walls themselves.

Many calcareous stones become much harder in the air; therefore they are cut as soon as possible, while they are still wet from the quarry. The hardest calcareous stones take a beautiful polish when rubbed with fine sand; such are the marbles.

The softness of the **gypsums** permits of their being easily cut. From a variety called alabaster we make ornaments of many kinds, which are very cheap; but this is of no great importance.

The malleability of the **clays** is made use of in order to give them any shape desired. They are then hardened by burning in a kiln. From the ease with which the clays are moulded and their hardening when burned have come the great industries of the tile-maker, the brick-maker, and the potter. Crockery and porcelain are made in the same way from very fine white clay.

21. Plaster.—The stone called gypsum, from which plaster is made, is somewhat rare.

There are many very large gypsum-quarries near Paris,—whence the name plaster of Paris. The stone is placed in great kilns (Fig. 222), where it is burned, and then it is ground and put into bags, which must be kept in a dry place. You know, of course, how plasterers use the plaster: they "temper" it with water, then use it immediately to cover walls, ceilings, etc.

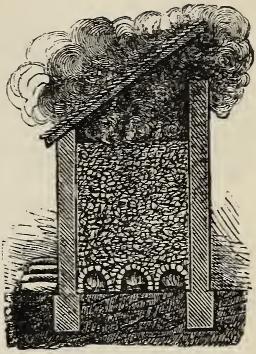


FIG. 222.—An oven for burning plaster. Gypsum subjected to a great heat becomes plaster.

22. Lime and Cements.—Limestone is also burned in kilns (Fig. 223). The lime that is just taken from the kiln is called **quick-lime.** It cannot be kept very long, for the air soon causes it to become limestone again as it was at first.

You have seen masons put it into water in a little basin made of sand. It swells, gets very hot, and finally becomes a smooth white paste. It is then slacked lime. On being mixed with fine sand it forms the mortar which is used to bind together the stones or bricks of walls.

FIG. 223.—A lime-kiln. When calcareous stones are subjected to a very high temperature they are transformed into lime.

There is still another kind of lime, called **hydraulic** lime, which on being mixed with fine sand forms a mortar that has the remarkable property of **hardening under water.** It is called **mortar of hydraulic lime,** or cement.

The **natural cements** are stones in which clay and limestone are found mixed. Reduced to powder and mixed with water, they become, on drying, **as hard as stone.**

We can with care make similar mixtures, which are called **artificial cements.**

FIG. 224.—A fragment of slate from a coal-mine bearing the impression of a fern-leaf.

Hydraulic lime is a kind of cement.

23. Coal.—Coal is found in large quantities in the United States. It is used for fuel and for making gas.

This coal is the remains of immense forests which covered the earth millions of ages ago and which have been buried we know not in what way.

You ask, How do we know that coal comes from these ancient forests?

In the simplest and surest way. In coal-mines they sometimes discover whole trees whose trunks and branches can be distinguished, and very often the imprints of the leaves (Fig. 224), most of which must have been like our ferns.

SUBJECTS FOR COMPOSITION.

STONES.

Thirty-sixth Exercise (p. 138).—Name the different kinds of stones. What is the action of vinegar upon calcareous stones? The action of air upon stones? Where are the metals found? The precious stones?

Thirty-seventh Exercise (p. 142).—What is the character of granite? What materials for building do we obtain from clay? What household utensils? What is modelling?

Thirty-eighth Exercise (p. 142).—What is plaster? Its use? What is quick-lime? Slacked lime? Mortar? Cement? What is coal?

V.—THE THREE STATES OF BODIES.

I.—Solids, Liquids, and Gases.

110. Solids.—Here (Fig. 225) are a piece of wood, A, a ball of lead, B, and a stone, C. These **bodies,** as we term them in science, have a **definite shape:** they remain there motionless and each by itself upon the table where I have placed them. They are hard, and I cannot dent them with my finger. We call them **solid bodies.**

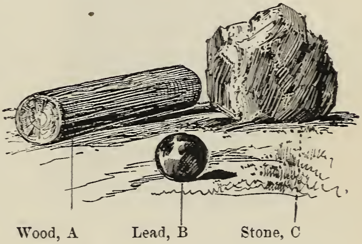


FIG 225.—Wood, lead, and stone are solid bodies.

111. Liquids.—On the other hand, here is some water (Fig. 226). I cannot show this by itself, as I can the stone. I must put it into a glass or a bottle. Without that it would flow and spread over the table. It has **no shape of its own.** I can push my finger into it without its offering any resistance. It is a **liquid body.**

FIG. 226.—Glass of water. Water is a liquid body.

112. Gases.—Finally, I plunge this empty bottle (Fig. 227) under water. As the water enters the bottle, do you see those bubbles that are escaping at A?

What is it that makes these bubbles, Paul? "It is the air that filled the bottle, sir." Very well. Now, this air, which **has no shape** of its own, any more than the liquid has, but which escapes and rises, while the liquid falls, is what is called a **gas,** or a **gaseous body.**

Bubbles A

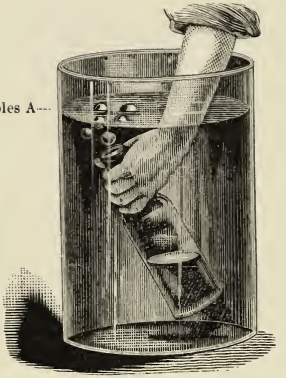


FIG. 227.—The air which escapes at A is a gaseous body.

Bodies, then, present themselves to us under three aspects, or, as it is termed, **three states,**— the **solid** state, the **liquid** state, and the **gaseous** state.

113. Differences between Solid Bodies.—You must know that there are degrees in the **solidity** of bodies.

Hardness.—In the first place, they are more or less **hard,** or more or less **soft.** Thus, there is a great difference between the hardness of a stone and the hardness of a ball of butter; and yet these are two solid bodies.

FIG. 228.—The nail scratches the stone. The iron is harder than the stone.

I scratch this stone with a nail. The nail makes a mark upon it. That is to say, the iron is harder than the stone.

In the same way the nail easily marks the lead ball. Lead is not so hard as iron.

If I scratch the head of my hammer, which is iron, with the edge of this quartz, I mark the iron. Quartz is harder than iron.

But if I strike the piece of quartz a good blow with my iron hammer (Fig. 229), the quartz is broken into pieces. This is because the quartz, although harder than iron, is more **brittle** than that metal.

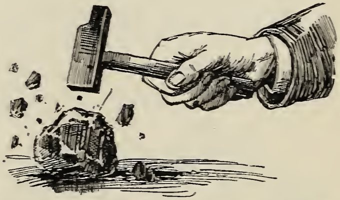


FIG. 229.—A blow of the hammer breaks the quartz. Quartz is brittle.

The hardest of all bodies,—that is to say, the one that scratches all others,—the **diamond,** can be broken in the same way by a blow from the hammer, or even simply between two stones; but this is too costly an experiment for us to make.

If I put my lead ball upon this stone (Fig. 230) and strike it with the hammer, it will be flattened or crushed. With a little patience I can make it almost as thin as a leaf.

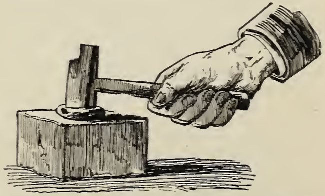


FIG. 230.—Lead is flattened under a blow of the hammer. Lead is malleable.

We express this quality by saying that the lead is **malleable** (a word that comes from the Latin word *malleus*, which means a hammer).

Here are a slate-pencil and a piece of leaden pipe of the same size. Nothing is easier than to twist the latter in all directions (Fig. 231). But it is impossible to bend the slate-pencil: it would break at once. We say that the lead is **flexible.**

FIG. 231.—The lead pipe can be twisted in all directions. Lead is flexible.

Finally, compare this iron wire with this knitting-needle, which is of steel. They are of the same size. The iron wire I can twist almost as easily as the lead pipe; and, once bent, it remains bent, without attempting to straighten itself. On the contrary, the steel needle, when bent (Fig. 232), straightens quickly as soon as I leave it to itself. It is because it is not only flexible, but **elastic.**

FIG. 232.—The steel needle straightens when released. It is elastic.

114. Differences between Liquid Bodies.—Liquid bodies also present differences. See: this oil does not flow as easily as water. We say it is **viscid,** while water is **fluid.** Syrups, and molasses, are still more viscid. A piece of melting butter is so viscid that it is hard to say when it ceases to be a solid and becomes a liquid.

SUMMARY.—I. The Three States of Bodies.

Solids, Liquids, and Gases.—Bodies exist in the **solid** state (stone), in the **liquid** state (water), and in the **gaseous** state (air).

Differences between Solid Bodies.—A solid is **hard** (marble) or **soft** (butter); it is **malleable,**—that is, it may be hammered out with the hammer (lead),—or **brittle**,—that is, it may be reduced to a powder under the hammer (quartz).

A solid can be **flexible**,—that is, can be bent (as a lead wire),—or it can be **stiff** and break (as a slate-pencil).

Some flexible bodies are also **elastic**,—that is, straighten themselves after having been bent.

Differences between Liquid Bodies.—Some liquids are **fluid**, —that is, flow easily, as water; others are **viscid**, as oil and syrups.

QUESTIONS.—THE THREE STATES OF BODIES.

How do we tell a liquid body? How a solid? What experiment shows the existence of a gas? Name the three states of bodies. Are all solid bodies equally hard? Give examples. When is a body said to be brittle? When malleable? When flexible? When elastic? Are there differences between liquids?

II.—The Changes in the State of Bodies.

115. Ice, Water, Vapor.—Water is a liquid body. But you also know that in winter, when it is very cold, it changes into **ice** (Fig. 233), and ice is a solid body. Then, when the heat comes again, the

FIG. 233.—Cold changes water to a solid (solid state).

FIG. 234.—Water, on being heated, is changed into a vapor (gaseous state).

ice returns to the state of water, of a liquid,—is **liquefied**.

I put some water over the fire in this kettle (Fig. 234). You see that the water, in heating, is changed to **vapor,** or steam, and you know that if we leave it long enough it will boil and finally disappear, leaving the kettle completely dry.

Fig. 235.—Steam becomes a liquid on coming in contact with a cold plate (liquid state).

Now, vapor is the same thing as gas. While the water is evaporating I place above the kettle a cold body,—this plate, for example (Fig. 235). You see **drops of water** appear upon it. It is the vapor, which, on cooling, becomes a liquid.

Therefore the **solid, liquid,** or **gaseous** state is a question of **heat.**

116. All Bodies can exist under each of these Three States.—It is very easy to show this of water. But we can show it also more or less easily of all other bodies.

Thus, I put my lead **ball** into the shovel over the fire (Fig. 236): it soon melts, is **liquefied;** and, if I had a fire hot enough, the lead would be changed into a vapor, or gas.

Fig. 236.—Under the influence of heat the lead ball is melted,—is liquefied.

This piece of **tallow** is a solid body,—not very hard, it is true, but solid all the same. having a shape of its own. To bring it near the fire will be sufficient to melt it, to have it become a **liquid.**

I could also make a **gas** of it; but if I put it into the fire-shovel, as I did the lead ball, I should run the risk of setting it on fire before it turned into gas.

I pour some **wine** upon this plate. It **evaporates** and changes very quickly into **gas,** or vapor, if I bring the plate near the fire. We can, on the other hand, **solidify** it by placing it in extreme cold.

We can even do more than that: we can **liquefy** and **solidify the air.** But for this purpose very complicated machines are required.

Thus, by heating a **solid** we make a **liquid** of it; by heating a **liquid** we make a **gas** of it. By cooling a **gas** we make it a **liquid**; by cooling a **liquid** we make it a **solid.**

117. Evaporation, Boiling.—The more we heat a liquid the faster it is changed into gas.

Here are two plates upon which I have poured the same quantity of water. I leave one upon the table (Fig. 237); it will hardly be dry in two hours, at the close of school. I put the other near the fire; it will be dry in less than a quarter of an hour.

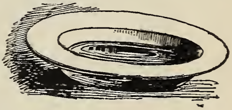


FIG. 237.—Water can be changed into vapor slowly,—*evaporation*. When the change takes place briskly it is *boiling*.

I return to the kettle, which has remained on the fire (Fig. 234, page 149). The water in it now boils; the change to a vapor is going on briskly, with much bubbling, and in a few moments the kettle will be dry.

A liquid, then, can be changed into a gas in two ways,—by **evaporation,** which is slow, and by **boiling,** which is brisk and rapid.

118. Change in Volume.—Nearly all bodies in passing from a solid state to a liquid state occupy a little more space,—that is, **increase a little in volume or size.**

When they pass from a liquid state to a gaseous state there is an **enormous increase** in volume. Thus, when we boil water, the steam occupies seventeen hundred times as much space as the water that produces it.

To occupy more space is to expand.

Inversely, most liquid bodies on becoming solid occupy less space,—that is, **diminish** in volume.

To occupy less space is to contract.

119. Force of the Vapor of Boiling Water.—Here is a very important use that is made of the enormous increase in volume which water undergoes in becoming a vapor.

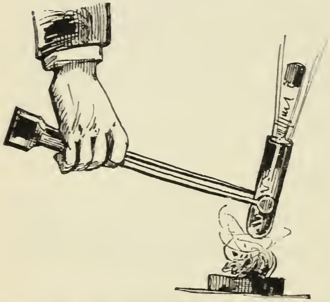


Fig. 238.—The vapor that is formed in the tube forces out the cork.

I introduce some water into this iron tube (Fig. 238), which is closed at the bottom, and cork it tight. I then place it over the fire. Wait a little. Pop! there goes the cork, blown out with a loud noise. What has happened? It is all very simple. The water has boiled, has become a vapor. And, as I have just told you, the vapor of water (steam) occupies seventeen hundred times more space than the water. Can the tube hold all that? The cork must blow out. If it had held too strongly the tube would have burst to pieces.

Denis Papin, a Frenchman, first made use of this great force of the vapor of boiling water, which is the moving power of the steam-engine.

Certainly between this little tube and the powerful **locomotive** that runs on our railroads there is a great difference; nevertheless, it is the same force in each. In place of pushing a cork, the steam in the locomotive pushes a piston, which turns the wheels.

SUMMARY.—II. The Changes in the State of Bodies.

Ice, Water, and Steam.—The changes in the state of bodies are caused by **heat.** Example: Water, when frozen, is in the solid state (ice); at ordinary temperatures it is in the liquid state (water); heated, it passes into the gaseous state (steam).

All Bodies can exist under the Three States.—All bodies can pass through the three states,—solid, liquid, and gaseous,—provided we have heat sufficient to **melt** and **vaporize** them, or a cold intense enough to **solidify** them.

Change in Volume.—In passing from the solid state to the liquid state, and from the liquid state to the gaseous state, bodies occupy more space,—they **expand.** On the contrary, bodies occupy less space, or **contract,** in passing from the gaseous state to the liquid state, and from the liquid state to the solid state.

Application of the Force of Vapor.—By confining vapor in a machine, the different parts of which are set in motion by its expansive force (as in the steam-engine).

QUESTIONS.—THE CHANGES IN THE STATE OF BODIES.

What is water? What is the effect of cold upon water? What is the effect of heat upon ice? What happens when we put a vessel of water on the fire? What is the effect of cold upon steam? Whence come the three states of bodies? Do all bodies assume the three states? Give the summary of the changes in the state of bodies. What is the difference between evaporation and boiling? What happens when a body passes from a solid to a liquid state? What happens when a body passes from a liquid to a gaseous state? What happens when a liquid body returns to a solid state? Show by an experiment the force of steam. What takes place? What application has been made of steam? How does the steam propel the locomotive?

III.—The Weight and Density of Bodies.

120. The Balance.—Henry, bring me the balance (Fig. 239) and weigh this lead ball with it. I wish, however, to ask you a question beforehand: Which is the heavier, wood or lead?

"Oh, sir, lead."

Very well. We shall see as to that presently. Now weigh the ball.

"I put the ball of lead into one of the pans of the balance." Do you do anything before placing the body to be weighed in the pan? "No, sir." That is wrong. You ought first to notice whether the beam, D, of the balance plays readily upon the knife-edged pivot, E, which supports it, and then whether the needle, F, placed at the middle of the beam, points to the zero-mark of the scale, which proves whether the needle is vertical and the beam horizontal. Without these conditions the balance would not weigh correctly. Proceed.

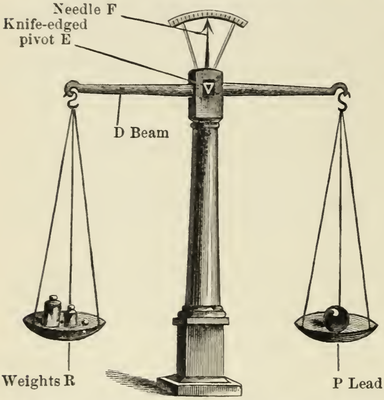


FIG. 239.—The body is weighed when the needle marks 0 on the scale.

"I place the lead ball, P, in one pan. The pan sinks. Then I put weights, R, into the other pan until the beam is horizontal and the needle points to zero." Well, how much is it? "Four ounces—two ounces—one ounce: seven ounces." Your ball of lead, then, weighs seven ounces.

121. Lead is Denser than Wood.—Now take out the weights and put in their place this piece of wood, B, which I have prepared (Fig. 240).

"It weighs just the same as the lead ball, sir."

Then the piece of wood is as heavy as the lead ball?

"Yes, sir."

You told me, however, a moment ago, that lead is heavier than wood.

"So it is, sir; but the piece of wood is much larger than the lead ball."

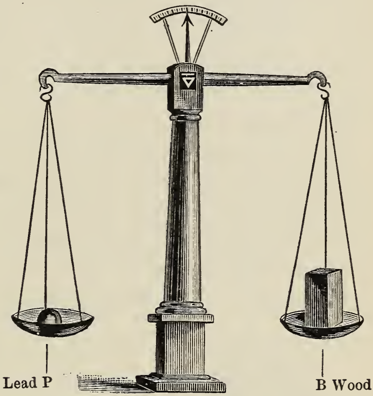


Fig. 240.—Lead is denser than wood.

And if you weigh this other piece of wood, which is just the same size as the ball of lead!

"Oh, it is not worth while, sir. The piece of wood is lighter."

You see that there is a want of exactness here. We must not say, lead is heavier than wood, since a piece of wood sufficiently large is as heavy as a small piece of lead. We must say, for an **equal volume, lead is heavier than wood.** We express this in a word by saying,—lead is **denser** than wood.

122. Bodies are of Different Densities.—Similarly we must say, water is **denser** than oil, illuminating gas is **less dense** than air, cork is **less dense** than water, and a feather is **less dense** than lead.

You smile, Henry, and understand now why you were the one questioned. You will be no longer unable to answer the question James jestingly asked you yesterday,—"Is a pound of lead heavier than a pound of feathers?" It is just as heavy, of course, since it weighs the same. But the feathers have a much greater volume, because they are **less dense.**

123. Comparative Density of Solids, Liquids, and Gases.—Solids or liquids are always much **denser** than gases. Thus, a pint of water weighs seven hundred and seventy-three times as much as a pint of air.

Most solid bodies are **denser** than water, and sink when placed in it. This is true of the lead ball, B (Fig.

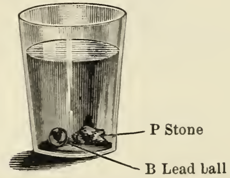


FIG. 241.—Stone and lead are denser than water.

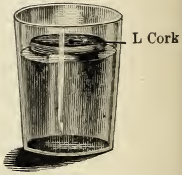


FIG. 242.—Cork and dry wood are not so dense as water.

241); of the stone, P; and, generally, of all metals and stones.

On the contrary, almost all kinds of dry wood are **less dense** than water, and float on its surface. Cork, L (Fig. 242), is especially remarkable in this respect.

You have learned that all solid bodies are not equally dense; the same is true of liquids. See (Fig. 243), the oil that I have poured upon the water **floats** upon its **surface**, H,—which means that it is lighter, **less dense**, than water.

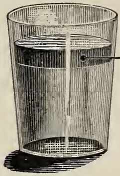


FIG. 243.—Oil is not so dense as water.

On the contrary, this drop of a liquid called **mercury**, or quicksilver, goes to the bottom at once. By the way, mercury is **denser** than most solids.

Gases also are of different densities. Air is **denser** than illuminating gas.

SUMMARY.—III. The Weight and Density of Bodies.

Lead is Denser than Wood.—This means that for **equal volumes** lead **weighs more** than wood. A cubic inch of lead weighs much more than a cubic inch of wood.

Solids and liquids are always **denser** than gases.

Generally solids are **denser** than water; dry wood and some other solid bodies are exceptions,—they **float** upon water.

All bodies in the same state are not equally dense: lead is denser than wood (solids), water is denser than oil (liquids), air is denser than illuminating gas (gases).

QUESTIONS.—THE WEIGHT AND DENSITY OF BODIES.

Describe the process of weighing a body in a balance. What is density? Name some bodies of different densities. Are gases, liquids, and solids of the same density? Is the density of all solids the same? Is it the same for all liquids? For all gases?

IV.—Expansion of Bodies by Heat.

124. The Thermometer.—You all know this instrument which you see me look at now and then during school-hours. It is a **thermometer** (Fig. 244), a word which means **measurer of heat** (from two Greek words, *thermos*, heat, and *metron*, measure).

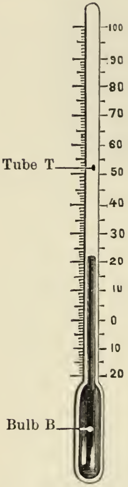


FIG. 244.—The thermometer is used for measuring temperature. It consists of a glass tube, T, closed at both ends, the lower end of which, B, is filled with alcohol or mercury.

In fact, we measure heat, or rather **temperature,** with a thermometer. How is that done, John?

"When the weather grows warm, the thermometer **rises**; when it grows cold, it **falls.**"

What falls?

"The liquid in the tube."

Right. The liquid in the tube is alcohol, colored red.

We also make thermometers of other liquids. Here is one that I put aside lest it should be broken. It is made of **mercury,** that dense liquid of which I have told you.

Now, when the weather grows warm the mercury ascends in the glass tube in which it is confined. Why does it do that? Why does the level of the mercury rise? Can no one answer? Tell us, James.

"It rises because it occupies more space, sir."

Very good. When heated, the liquid occupies more space,—that is to say, **expands,**—and as the bulb, B, at the end is full, it must **rise** in the tube, T. On the contrary, when it grows colder (in other words, when there is less heat), the liquid occupies less space,—that is to say, **contracts,**—and its level **falls** in the tube.

125. Graduation of the Centigrade Thermometer.—In order to know how warm the air is, or, as we say, the **temperature** of the air, we look at the figures which are marked at the end of the lines by the side of the tube. When the level of the liquid is opposite the figure 20, we say it stands at twenty degrees, and write 20° ; when the level is at the figure 10, we say it stands at ten degrees, and write 10° ; when it is opposite 0, we say it stands at zero, and write 0°.

You are aware that these figures are not marked at random on thermometers: if they were we should not know what temperature was meant when we read in the paper that on such a day, at such an hour, at such a place, the thermometer indicated so many degrees of heat.

All thermometers must be compared, and the same figures must signify the same thing upon all.

In order to reach this result we proceed as follows. We have in this saucepan (Fig. 245) some boiling water. I plunge into it the bulb of my mercurial thermometer, which has figures marked on the tube. See how the mercury rises, quickly at first, then more slowly.

FIG. 245.—The temperature of boiling water is called the temperature of 100 degrees.

Now it has stopped. Opposite what number? "The number **100**." Yes; and as long as the water boils it will mark 100; the level will not change.

Therefore the temperature of **boiling water** is called the temperature of **one hundred degrees.**

Now, if I had some ice in a glass it would melt very quickly. If I were to plunge the thermometer into the water from this **melting ice** (Fig. 246) the mercury would **fall,** and would stop at the point A, which is marked **zero.**

Fig. 246.—The temperature of melting ice is called the temperature of zero (0°).

Hence the temperature of **melting ice,** or the **freezing-point** of water, is called the temperature of **zero.**

The rest is very simple. The length of the tube between the point 0 and the point 100 is divided into **one hundred equal parts,** and marked with figures as you see. This scale is called centigrade, which means divided into one hundred grades or degrees.

For the coldest weather, or, rather, for very low temperatures, the graduation is continued on the tube below the zero-point, and the figures 1, 2, 3 are marked, beginning at zero. Therefore, when we say it is ten degrees below zero (which we write —10°), every one knows that it is very cold.

The alcohol thermometer is graduated like the mercurial thermometer. Its zero and other figures have the same value, of course. But we cannot mark it up to 100°, because alcohol boils at a temperature below one hundred degrees, and boiling would break the tube.

Not all thermometers are marked—or, as we say, **graduated**—in this way.*

126. Expansion of Solids and Gases.—Liquids are

* The Fahrenheit scale is very commonly used. In this scale the space between the boiling-point and the freezing-point of water is divided into one hundred and eighty equal parts. The **boiling-point** is marked 212°, and the **freezing-point** 32° (212 — 180 = 32). The zero of the scale is 32° below the freezing-point.

not the only bodies that expand by heat. Solids also expand. The metals, for example, increase in size when heated.

It is the same with gases. Here is a rubber balloon (Fig. 247) that I have half filled with air and then

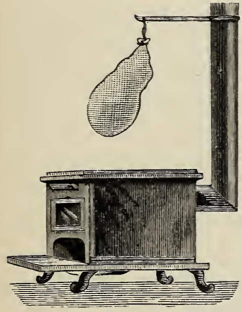


FIG. 247.—Balloon half filled with air.

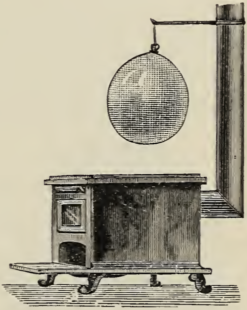


FIG. 248.—The heat of the stove expands the air in the balloon, and the latter is inflated.

sealed. I hang it over the stove (Fig. 247). See: the air which it contains, on being heated, expands (Fig. 248), and the balloon is distended in a very short time.

SUMMARY.—IV. Expansion of Bodies by Heat.

The Thermometer.—When a thermometer is heated, the alcohol or mercury that it contains expands and **rises in the tube**, and continues to rise so long as the heat increases.

Graduation of the Centigrade Thermometer.—If a mercurial thermometer, we place it in melting ice, and the point where the mercury stops we mark **0**; we then place the thermometer in boiling water, and mark **100** at the point to which the mercury rises. The space between these two points we then divide into **one hundred equal parts**; each division is called a **degree**.

We proceed in the same way with an alcohol thermometer, except that we cannot go up to one hundred degrees, because alcohol boils at a lower temperature.

Expansion of Solids and Gases.—Solids and gases, like liquids, **expand** when heated.

QUESTIONS.—EXPANSION OF BODIES BY HEAT.

What is the thermometer? Explain the movement of the liquid in a thermometer. How do we know the quantity of heat there is in the air? How do we fix the 100-degree mark of a thermometer? How do we fix the 0-degree? Into how many parts do we divide the tube between 0 and 100? What have we done in order to measure the temperature below 0°? Show by an experiment that gases expand.

V.—Air, Combustion, and Respiration.

127. Use of the Air.—Of what use is the air to us? Who will answer? Do you, James.

"To breathe, sir. If I should put my head under water I should soon be drowned."

Quite correct. The air serves us for **breathing.** That is a use of the first importance. But do you know another use of air? No? Well, air is necessary in order not only to **support life,** but also to produce **heat** in our stoves and **light** in our lamps.

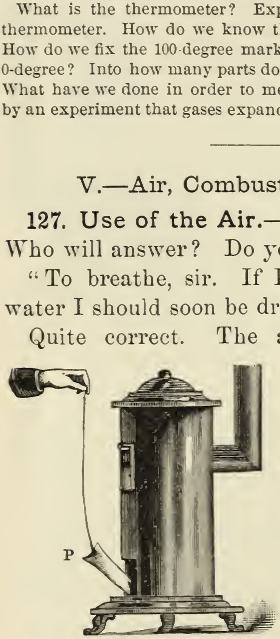


Fig. 249.—The exterior air drawn into the stove carries with it the paper, P. Air is necessary to combustion.

Our stove has just been lighted, and is roaring loudly. Fix a piece of paper, P (Fig. 249), to the end of a thread and place it in front of the draught. Notice how the paper is drawn towards the draught. It is carried along by the air which is drawn into the stove. If we were to close this draught, and thus prevent the air from passing in, the fire would go out.

Air, then, is necessary in order to produce fire, or, to speak more exactly, in order to support **combustion,** which gives more or less light and heat.

128. Air is composed of Oxygen and Nitrogen. —I light this candle, which I have fixed in a plate of cork. I place the plate upon the water in this pan and cover the whole carefully with this large glass jar (Fig. 250).

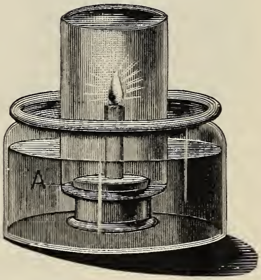


FIG. 250.—The heat of the candle *expands* the air in the jar and forces the level of the water to A.

Watch closely. What do you see, Paul?

"The candle burns, sir."

Yes; but your discovery is not very extraordinary. Do you notice nothing else?

"Yes, sir: I notice that the surface of the water in the jar sinks to A. Ah, now it rises again."

That's right. Continue to watch, and tell us what you see.

"The candle is going out, sir. There it goes! What made it do that? There is still much air in the jar."

Not so fast. Let us look into this matter closely. Why did the water fall to A at first? Can no one tell? You ought to have been able to answer that at once. Well, it fell because the candle heated the air in the jar; that is—— ?

"The air expanded, sir, and in expanding it forced some of the water from the jar."

That explains the first action. But what followed this? We saw the water rise to B (Fig. 251), which showed that the quantity of air in the interior had diminished; then the candle went out. At this moment the air is cooling, is contracting, and the water is still rising a little.

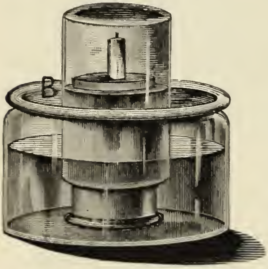


FIG. 251.—The candle in burning has consumed one of the elements of the air in the jar (oxygen). The water has risen to B.

The fact is, the flame of the candle has taken, has used up, has **consumed** one of the elements of the air; when this element failed, it went out.

Notice carefully that it is not **all** the air that has been consumed: **it is only one of the elements of the air, that one which supports combustion.**

There are, in fact, two elements in the air, **two gases.** One **supports heat and light,** the other **does not support them.**

The first is **oxygen** (we shall learn by and by why that name has been given it), the second is **nitrogen.**

One-fifth of the air is oxygen, four-fifths are nitrogen.

The nitrogen is what has remained in the jar. There is still a little oxygen left, because the candle went out before having used it all up.

129. The Production of Oxygen by Green Plants.—I am sure you all desire very much to see **oxygen.** Well, I am about to show it to you, and we are going to learn something very curious at the same time.

Do you see these green plants (Fig. 252) that I gathered yesterday from the river, and which, after having placed them in this glass full of water, I have exposed to the sun?

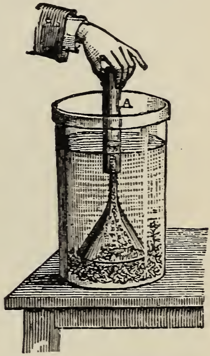


FIG. 252.—Little bubbles of gas come from the green plants exposed to the sun. This is oxygen gas.

Look at them carefully. From the green plants come little bubbles of gas, which I cause to rise to the surface by jarring the glass slightly. **This is oxygen, produced by the green plants exposed to the sun.**

I have left the jar in the sun since yesterday. I covered the plants with a small funnel, at the end of which I placed a glass tube, A, closed at one end (a test-tube); all were full of water. Now, the plants have produced so much oxygen that my little tube is nearly full of gas.

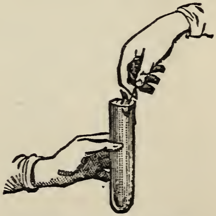


FIG. 253.—The match is relighted in the oxygen.

Wait a little. I place my finger upon the mouth of the glass tube and take it out of the water and then invert it.

Paul, light a match. Now blow it out, and give it to me quickly while the end is still red. I plunge it into my little tube (Fig. 253). Wonderful! The **match is relighted at once** and burns with a flame as before. That is what **oxygen** does. It increases and rekindles fire, it **supports combustion.** It is oxygen that causes our fires to blaze, our lamps to give light.

130. Combustion.—You wish to ask me a question, James? Go on.

"How do the plants manufacture the oxygen, sir? They must get it somewhere."

That is a very sensible question; but before answering it I shall have to tell you of a gas that you do not yet know about: **carbonic acid gas.**

The principal part of wood is carbon, which is the base of charcoal. When wood burns it is changed into red coals. These in being consumed leave nothing but a few ashes. What has taken place? The carbon has united with the oxygen of the air and given birth to two gaseous bodies, **carbonic acid** and **carbonic oxide.**

These two gases are **poisons,** the carbonic oxide especially.

Now, since fires in burning produce **carbonic acid,** it is not strange that there should be a little in the air, and consequently also in water.

131. Green Plants decompose Carbonic Acid.—I can now reply to your question, James, and tell you how the plants manufacture oxygen. They take it from the **carbonic acid** that they find in the air or in the water; it is this they attack. They absorb the carbon from it and allow the oxygen to escape into the air.

What is done with the carbon? The use is a very happy one. **They store it up.** It forms the greater part of their wood.

132. Animals consume Oxygen.—Here is something which, while it is no more wonderful than what we have just seen, is still more interesting for us.

If instead of the candle I had placed upon my piece of cork a small cage, with a mouse or a bird in it (Fig. 254), the animal, after a certain time, would have died, and the water would have risen in the jar nearly to the same height as it did when the candle was used.

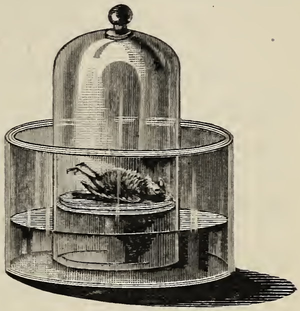


FIG. 254.—Air is a mixture of oxygen, which supports life, and nitrogen, which does not support it. The bird died when it had used up the oxygen.

That proves that **it is one of the elements of the air that supports life.**

This element is **oxygen.** It is oxygen that serves **in respiration**; many experiments have proved this.

The other element, which can no more sustain respiration than it can support combustion, is **nitrogen,** or, as it is sometimes called, **azote**; this last name comes from two Greek words, and means **not sustaining life.**

What has the animal done with the oxygen? It has made **carbonic acid,** just as the candle did.

Yes, **the oxygen of the air is taken up by animals; they slowly burn the carbon of their bodies with it.** For there is carbon in the bodies of animals. In order to assure yourself of this you have only to look at a chop broiling.

133. The Purity of the Air.—Fires that burn and **animals that breathe** are constantly throwing into the air carbonic **acid** and constantly drawing from it oxygen.

Of course there is a great deal of air about the earth, and consequently much oxygen. Nevertheless, if fires and animals continued indefinitely to absorb the oxygen and give none back, there would come a time in the course of centuries when all the oxygen would be exhausted and when man and animals must perish from **asphyxia.**

Fortunately, the **green plants** take the carbonic acid from the air, store up the **carbon,** and give out the **oxygen.**

In this way the purity of the air necessary to animal life is preserved.

Then the animals, which continually use the carbon of their bodies in forming carbonic acid, eat the plants, and absorb from them the carbon which they need in order to repair their loss.

SUMMARY.—V. Air, Combustion, and Respiration.

Use of the Air.—Air is necessary in order to sustain the **respiration** of animals and the **combustion** of bodies.

Elements of the Air.—The air is composed of **oxygen** and **nitrogen.**

Oxygen.—It is the oxygen that sustains **combustion** and **respiration.**

Combustion.—When wood or a candle, etc., burns, the oxygen of the air **combines** with the **carbon** which exists in the burning body and produces poisonous gases, **carbonic acid** and **carbonic oxide.**

Green Plants and Carbonic Acid.—In the sun green plants **decompose the carbonic acid** of the air; they allow the **oxygen** to escape, and store up the **carbon.**

Respiration.—When an animal breathes, the **oxygen** of the air unites with the **carbon** which is contained in its body, and **forms carbonic acid,** which is then breathed out.

Renewal of the Air.—If we prevent the air about a lighted candle or a living animal from being renewed, the oxygen is **consumed,** the candle goes out, and the **animal dies,**—is asphyxiated.

Purity of the Air.—The air is continually vitiated by the burning of fires and the breathing of animals. They **take away its oxygen** and **give back carbonic acid.** But the green plants in the sun **decompose this acid** and **give back its oxygen** to the air.

QUESTIONS.—AIR, COMBUSTION, AND RESPIRATION.

Of what use is the air to us? Show by an experiment that fire consumes air. Is all the air consumed? What is the composition of the air? What gas is produced by green plants? What is the principal property of oxygen? Show by an experiment that carbonic acid is produced when a body burns. Is there carbonic acid in both air and water? How do plants make oxygen? Show by an experiment that oxygen also supports animal life. What is nitrogen? How do animals use the nitrogen of the air? What would happen if the oxygen of the air were not renewed? Where do animals find the carbon necessary to them?

VI.—Water.

134. Water.—We already know many things about **water.** We know that it is frozen and changed into **solid ice** at the temperature of 0°, and that it passes quickly to the gaseous state, the state of **vapor,** when it reaches the temperature of 100° by the centigrade thermometer.

I have told you (page 152) that nearly all bodies **diminish** a little in volume in passing from the **liquid** to the **solid** state.

Water is an exception to this rule: **it increases in volume in solidifying,** in changing to ice.

This increase in volume takes place with such force that should we fill a bomb-shell with water, seal it, and then freeze the water, the shell would be burst into pieces. For this reason we should never in winter leave water standing in tanks or vessels: if the water were to freeze, it would burst them.

When we add sugar or salt to water they disappear, are **dissolved.** Water dissolves many solids, and also many liquids,—alcohol, for example.

It also dissolves gases. Carbonic acid, among others, is soluble in it in large quantities. A gallon of water will absorb a gallon of carbonic acid gas.

135. Decomposition of Water.—For a long time water was regarded as an **element,**—that is to say, as a body that cannot be decomposed. It was the same with air, in which we have found oxygen and nitrogen. Well, it has been proved that water is composed of **two gases.**

The composition of water is something that always appears very wonderful. Yes, this beautiful, clear liquid is in reality composed of two gases.

"What!" you will say, "a **liquid** composed of **two gases?**" Yes, and you will see many other examples of the same kind when you come to study **chemistry.**

Moreover, you know already that carbonic acid is formed of a **gas,** oxygen, and a **solid,** carbon.

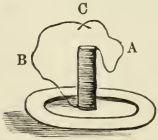


FIG. 255.—Electric pile, formed of copper pennies, disks of zinc, and disks of cloth. A, brass wire, in contact with a disk of copper. B, another, in contact with a disk of zinc.

The two gases which compose water are **oxygen,** which we know about already, and a gas called **hydrogen** (a word which means **giving birth to water**).

I am now going to prove what I have said. Here is an instrument of which you will learn more next year. We call it an **electric pile** (Fig. 255). I have made a very simple one out of some copper pennies, disks of zinc, and disks of cloth: these I placed one above the other, alternately, and then dipped the whole in strong vinegar.

This costs but little, and answers our purpose just as well as a more expensive one.

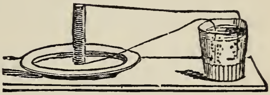


FIG. 256.—The water is decomposed into two gases, *oxygen* and *hydrogen.*

I place the two brass wires which are fastened to the ends of the pile in this glass full of water (Fig. 256). You see, after a few moments, bubbles of gas forming at the **end of each wire** and rising to the surface of the water. The gas at the end of one wire is **oxygen,** and that at the end of the other is **hydrogen.**

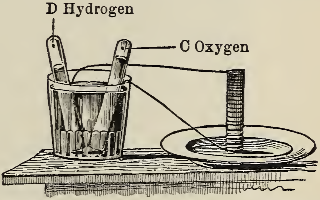


FIG. 257.—By the aid of closed tubes we collect the hydrogen at D and the oxygen at C.

Let us try to collect them. For this purpose I take two little glass tubes, C, D, closed at one end. I fill them with water and place them over the wires (Fig. 257). The gas rises into each of them. These gases are produced by the **decomposition of the water.**

136. Hydrogen.—While we were speaking our little tubes were filling, especially the **hydrogen** tube, which contains, you see, twice as much gas as the oxygen tube. I withdraw it from the water, closing the open end with my finger and

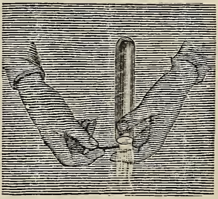


FIG. 258.—Puff! a slight noise and a pretty little flame. Hydrogen is, then, an *inflammable* and *explosive* gas.

holding it downward. Paul, light a match. Watch, now, all of you. I bring the match to the mouth of the tube and take away my finger (Fig. 258). Puff! a slight noise and a pretty little flame with a very faint light, so faint that we scarcely saw it.

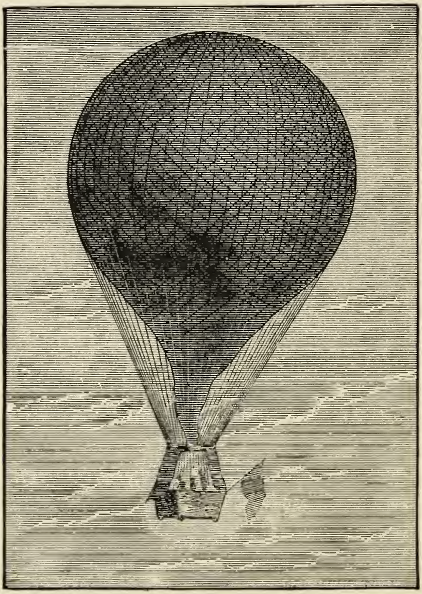


FIG. 259.—Balloons used to be filled with hydrogen, which is fourteen times lighter than air. They are now filled with coal-gas, because it is much cheaper.

Hydrogen is, then, you see, an **inflammable** and explosive gas. If instead of a small tube we had had a large jar of it, we should have caused a **real explosion.**

Hydrogen has another remarkable quality. It is extremely light, weighing **only one-fourteenth as much as air.** For this reason it was once used to fill balloons; but, as it is expensive to prepare, they are now generally filled with **coal-gas** (Fig. 259), which costs much less.

137. Oxygen.—That is sufficient for hydrogen. Let us now take our other tube, C (Fig. 260), which in its turn is nearly full; it contains **oxygen,** we said. You can readily recognize it. How?

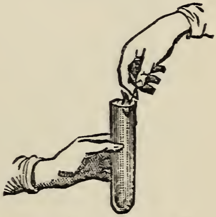


FIG. 260.—The match is rekindled in the oxygen.

"Because it **rekindles a match when nearly out.** You showed us this the other day, sir." (See page 165.)

Very well, James; you may make the same experiment. Be very careful, now, and invert the tube holding it with the **opening at the top,** because oxygen is **heavier** than air and will fall out if the opening is below. That's right. See, the match is rekindled.

138. Recomposition of Water.—You are now quite sure that there are **hydrogen** and **oxygen** in water. But are these two gases all that it is composed of?

Yes; for if we burn hydrogen (which is the same thing as combining it with oxygen) we have **water,** as a moment ago we had carbonic acid from burning carbon,—that is to say, by combining it with oxygen.

It is a somewhat delicate experiment to perform. But as there is hydrogen in nearly all bodies that we burn, **water is formed** when they burn, and I can show you this water.

I light my alcohol lamp and hold a cold plate over it (Fig. 261). You see there are drops formed on it; these are not from the alcohol's being distilled: taste them. No, they are drops of water, formed by the **burning** of the hydrogen contained in the alcohol.

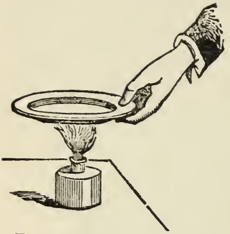


FIG. 261.—There are drops of water formed. This water is due to the combination of the hydrogen of the alcohol with the oxygen of the air.

You see that **hydrogen** is well named, since its name signifies **giving birth to water.**

We know, then, positively the composition of water in two ways: first, because by means of the electric pile we can **decompose it** into two gases, hydrogen and oxygen; secondly, because we can **recompose it** by uniting oxygen and hydrogen by the aid of heat or by some other means.

I have proved beyond a doubt all my statements, just as I promised you. This is what we should always be ready to do.

SUMMARY.—VI. Water.

Water.—**Water** is an exception to the common law. It **increases in volume** in passing from a liquid to a solid state (ice).

Dissolution.—Such bodies as salt and sugar disappear in water,—**dissolve.** Water also dissolves some gases, notably carbonic acid.

Composition of Water.—Water is composed of two gases,—**oxygen** and **hydrogen.**

Hydrogen.—**Hydrogen** is **inflammable,** and is **lighter** than air.

Oxygen.—**Oxygen** will not burn, but **rekindles** bodies that are plunged into it. It is **heavier than** air.

We **decompose** water into two gases by means of the **electric pile.**

We **recompose** it by burning hydrogen.

QUESTIONS.—WATER.

Sum up what you know of water. Does water, like other bodies, diminish in volume in passing from a liquid to a solid state? What happens when we add certain bodies, such as sugar and salt, to water? Does water dissolve only solids and liquids? Of what is water composed? What are the two gases? By what means can we decompose water? What do you know of hydrogen? What do you know of oxygen? Prove by an experiment that there is only oxygen and hydrogen in water. By how many ways do we know the composition of water?

LIGHT, SOUND, ELECTRICITY, AND MAGNETISM.

139. Just here I think it advisable to say a few words on a number of physical phenomena which present themselves to our observation every day.

I.—Light.

140. Light moves in a Straight Line.—I close the blinds of one of the windows of the class-room by which the sun enters. You see that through each of the little holes that I have left a ray of the sun passes (Fig. 262).

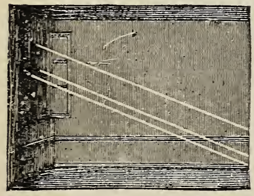


FIG. 262.—Light travels in a *straight line.*

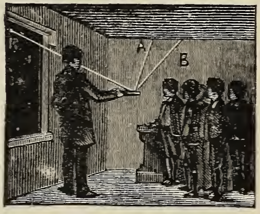


FIG. 263.—Light is reflected from polished surfaces (reflection).

These rays light up on their way numbers of little particles of dust which are in the air. Notice **that these rays move in a straight line.**

141. Light is reflected from Polished Surfaces.—In the line of a ray of light I place a small mirror.

Yonder on the wall (Fig. 263), at A, appears a bright spot. It is the image of the hole in the shutter which is **reflected** from the glass.

Fig. 264.—The straw appears *broken* (refraction).

When I move the mirror, the spot moves from A to B. You see, moreover, that the reflected ray lights up the particles of dust **in a straight line.**

142. Light is turned from its Course in passing from Water into Air.—If I plunge this straw into this glass of water (Fig. 264), it will appear broken into two pieces, one of which is in the air, the other in the water.

This effect is called the **refraction** of light,—in Latin *refractio* means breaking.

II.—Sound.

143. Sound is produced by Vibrations.—Paul, come here to me. I strike the edge of this glass with a rod (Fig. 265): it gives a clear, strong sound. Put your finger on the edge. What happens? "The sound stops, sir." Yes; but what do you feel with your finger? Wait: I will begin again. "I can feel **the glass tremble while it sounds,** sir; **when I**

Fig. 265.—The sound is transmitted to us by the air. It is produced by the vibrations of the air.

stop the trembling I stop the sound." Precisely. We say the glass **vibrates;** and these **vibrations are what produce the sound.**

144. Sound is transmitted by the Air.—But the glass does not touch our ear. How, then, do we hear the vibrations? We hear them because they are **communicated to the air, which vibrates in its turn into the interior of our ear.**

145. Sound is transmitted by Solids and by Liquids.—The sonorous vibrations can be transmitted to us by **solids** and by **liquids.** Place your ear at the

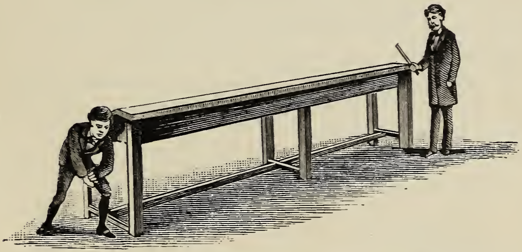


FIG. 266.—Sounds are also transmitted by solids and liquids.

end of this long table (Fig. 266). I touch the other end lightly: you hear the noise very plainly.

III.—Electricity. IV.—Magnets.

146. Friction develops Electricity on the Surface of Certain Bodies.—I take a stick of **sealing-wax.** I bring it near these little bits of paper on the table. As you see, they remain perfectly still.

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Now I rub the wax briskly on my sleeve (Fig. 267), and present it again to the bits of paper. See, the bits of paper **fly** to the stick and collect upon it (Fig. 268).

FIG. 267.—I rub the sealing-wax upon my sleeve.

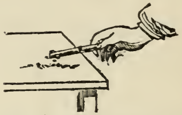

FIG. 268.—It then attracts the bits of paper (electricity).

I make the same experiment with the same result by rubbing this glass tube upon my sleeve. I could repeat it with other bodies, though not so easily.

This **force** which is thus developed on the surface of bodies by friction, this **force** which **attracts** light bodies, is called **electricity.**

As the air is very dry to-day, and there is a thunder-storm threatening, I am going to show you something new to most of you.

I shall make the experiment upon my cat, although he will not relish it very much. I pass my hand along his back (Fig. 269). Do you see how the hairs stand up and follow my hand? **The rubbing has developed electricity.**

FIG. 269.—When cats are rubbed in dry weather they give out electric sparks.

Keep very quiet now, and listen while I stroke the cat once more. Do you hear a series of sharp little noises? If it were dark, we should see little sparks spring out from the hair.

Now, bear in mind: these sharp little noises are

little claps of thunder; these little sparks are miniature **flashes of lightning.**

When two clouds approach within a short distance from each other, there is produced between them the same effect as was produced between my hand and the cat, but in very different proportions. **Flashes of lightning** are nothing but enormous **sparks**, and **thunder** is the noise produced by the discharge of these sparks.

We obtain electricity in large quantities and for use either with **electrical machines** or with **electrical piles** more or less like that which I used when I showed you how to decompose water.

FIG. 270.—The horseshoe magnet.

147. Magnets attract Iron and Steel. —You see this little piece of steel, bent like a horseshoe (Fig. 270). In its appearance there is nothing extraordinary. But, look: I present both its ends to a steel needle (Fig. 271). When it is about half an inch from it, **the needle rises, flies to the magnet, and clings there.** A hard shake is necessary in order to detach it. The same thing will occur if instead of the needle we use an iron wire.

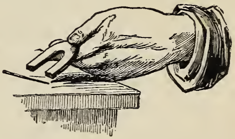

FIG. 271.—The needle flies to the magnet and clings there.

This piece of steel which attracts iron and steel is called a **magnet.**

148. The Magnet attracts only Iron and Steel.—Here, mixed together, are iron- and copper-filings, saw-dust, cinders, coal-ashes, and sand. I spread these upon a plate (Fig. 272). Above the plate I hold the ends of my magnet. See, **all the iron-filings are drawn to it and fix themselves upon it.** The copper and other bodies do not move.

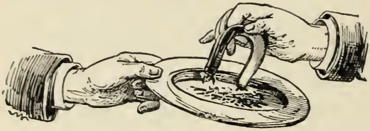

FIG. 272.—The magnet attracts only iron and steel.

The **magnet attracts only iron and steel.**

149. What is the Magnet?—There are some **natural magnets.** The natural magnet is a kind of **iron-ore.** But the magnets which we use are made by a process which you will learn about later on.

SUMMARY.—Light, Sound, Electricity, and Magnets.

Light moves in a **straight line.**

When a ray of light falls upon a polished surface, it is **reflected,**—that is to say, it continues its course after making an angle.

Refraction means Breaking.—When a ray of light passes from air into water, instead of **moving on in a straight line, it changes its direction.** This is what makes a straw plunged into water appear broken.

Sound is produced by the trembling of all the parts of a body. These tremblings are called **vibrations.**

Sound is **transmitted** to the ear by the **vibrations of the air.** Sound is also transmitted by **solids** and **liquids.**

Electricity is a **force** which is developed upon the surface of bodies when rubbed. It shows itself by **attracting** light bodies and by **sparks.**

We produce electricity by **machines** and **electric piles,** or batteries.

It is electricity accumulated in great quantities in the clouds that produces **lightning** and **thunder.**

A Magnet is a piece of steel which has the property of attracting iron and steel.

QUESTIONS.—LIGHT.

How does light move? How is light reflected? What is refraction of light?

QUESTIONS.—SOUND.

By what is sound produced? By what is it transmitted to the ear? Can it be transmitted by solids and liquids?

QUESTIONS.—ELECTRICITY. MAGNETS.

What is produced when we rub a stick of sealing-wax upon a woollen cloth and bring it near some bits of paper? What is the name of this force that thus attracts bits of paper? What happens when we rub the back of a cat in a dark place? What do these little phenomena represent? What is lightning? What is thunder? How do we obtain electricity in large quantities?

SUBJECTS FOR COMPOSITION.

THE THREE STATES OF BODIES.

Thirty-ninth Exercise (p. 145).—Define solids, liquids, gases. When is a body brittle? When malleable? When flexible?

Fortieth Exercise (p. 149).—Name the three states of water. Can all bodies exist in any one of the three states? Under what influence? The change of liquids slowly into gas. Rapidly.

Forty-first Exercise (p. 152).—Expansion. Contraction. To what is the force of vapor due? The important application of this force.

Forty-second Exercise (p. 154).—Weight of bodies. Compare lead and wood. Water and oil. Air and illuminating gas. Density.

Forty-third Exercise (p. 157).—The thermometer. Its construction. Its uses.

Forty-fourth Exercise (p. 162).—Composition of air. Properties of oxygen. How can we make oxygen?

Forty-fifth Exercise (p. 166).—What takes place when wood burns? Why is it beneficial to renew the air of rooms?

Forty-sixth Exercise (p. 169).—Of what is water composed? Describe the experiment which proves the composition of water. Hydrogen and its use. Difference between oxygen and hydrogen.

LIGHT, SOUND, ELECTRICITY, AND MAGNETS.

Forty-seventh Exercise (p. 175).—How does light move?

Explain what is meant by reflection of light, also by refraction. How is it that we hear the sound of a clock striking? Is air the only conductor of sound?

Forty-eighth Exercise (p. 177).—What happens when we rub a piece of sealing-wax upon the sleeve? What is electricity? What is lightning? What is thunder? What is the property of a magnet?

GLOSSARY.

Abscess, a cavity in the human or animal body containing pus, or the liquid products of inflammation.

Absinthe, a bitter cordial, made by steeping the leaves of wormwood in alcohol.

Acid, a sour substance, solid, liquid, or gaseous, which has the property of attacking certain metals and stones.

Adjust, to fit together; to put in proper order.

Aerial, living in the air, as opposed to *aquatic*, which means living in water.

Alcohol, a very strong liquor, obtained by the distillation of grains that contain starch or sugar.

Amphibians (double life), a group of animals that live in the water when young and in the air after having undergone certain metamorphoses or changes of form (frogs).

Anterior, forward; situated toward the front.

Aquatic, living in the water, in opposition to *aerial*, or living in the air.

Artificial, produced by the aid of man: used in distinction from *natural*, or produced by nature alone.

Asphyxia, the sudden suspension of all outward signs of life; suffocation.

Axilla, the armpit; also the angle formed by a leaf with a branch.

Basement, the under part of a building.

Blister, a substance which makes the skin sore and causes water to collect under it; or a place to which such a substance has been applied.

Carapace, the upper part of the bony box that encloses certain animals, as the turtles or tortoises.

Carrion, the flesh or the dead body of an animal when in a state of decay.

Cartilage, the white part found at the extremities of the bones and in other parts of the body.

Catkin, an arrangement of the flowers of a shrub or plant in a form suggesting the tail of a cat,—as seen in the hazel, willow, or poplar.

Cerebral, pertaining to the brain.

Chloroform, a liquid substance whose vapor when inhaled produces, after a certain time, insensibility to pain and a heavy stupor resembling sleep.

Classification, the distribution of objects (as animals, plants, and stones) into groups or classes.

Clot, a small mass of blood thickened.

Coagulation, the partially hardened or clotted state into which certain liquids (as blood or milk) may pass in certain conditions; also a clot or hardened mass derived from a liquid.

Column, a pillar such as is sometimes seen in a building. *Vertebral column*, the succession of *vertebræ* in the animal body; popularly called the *backbone*.

Congestion, an abnormal or undue

accumulation of blood in any part of the body.

Contraction, a shortening; a diminishing of length.

Cotyledon, a seed-lobe; the part of the seed in which food for the young plant is generally stored.

Crystal, a body having a more or less regular outline and bounded by planes or faces arranged according to a definite law. Certain substances, when they pass from a liquid to a solid state, naturally assume the form of crystals.

Crystallize, to bring, or to be brought, into the form of crystals.

Cutaneous, pertaining to the skin.

Cutting, a part of a plant separated from it and planted in the earth.

Diamond, the hardest and most brilliant of precious stones. It consists of pure carbon crystallized

Dilatation, expansion; increase of size or volume.

Ergot, spurred rye; a kind of spur-shaped fungus which grows among the grains of rye. It has injurious qualities when eaten, but it is used as a medicine.

Explosion, a violent bursting, often accompanied by a loud noise. Gunpowder when fired makes an explosion.

Fermentation, a process of slow decomposition which takes place in certain moist substances when they are exposed to the action of air at a moderate heat.

Filament, a long thread-like or hair-like slip of any material.

Forage-plants, plants suitable for the food of domestic animals.

Fracture, a break: a broken place; the state of being broken.

Friable, easily broken into small pieces.

Fundamental, lying at the foundation; necessary to the very existence of anything; playing a very important part.

Fusion, the state of being melted.

Germination, sprouting; growth of a plant from a seed.

Glutinous, sticky; like glue or paste.

Graduation, division into degrees.

Hemorrhage, a flow or discharge of blood.

Horizontal, parallel to the plane of the horizon; at right angles with a perpendicular.

Infantile, pertaining to infancy or to very early life.

Inflammable, capable of being burned; easily burned.

Inflammation, a condition in which some part of a living animal body becomes swollen, heated, and painful.

Intelligence, the faculty of understanding; the ability or power to receive knowledge.

Intermittent, ceasing at intervals. An intermittent fever is one in which there are (at more or less regular intervals) times when no fever is perceptible.

Isolated, separated from every other thing or person; separated from every other thing of the same kind; detached.

Lamella, a thin, flat piece or plate.

Ligature, a knot or tie; the string or fine wire with which blood-vessels in wounds are tied to prevent bleeding.

Lobe, a division or main part, as the *lobe* of a leaf. A cotyledon is a seed-*lobe*.

Malleable, capable of being beaten out or extended by hammering.

Marl, a name for various kinds of

earth; often a calcareous (limy or chalky) earth mixed with clay. Some kinds of marl make an excellent dressing for farm-lands.

Masticate, to chew, as food; to reduce to pulp by aid of the teeth.

Menagerie, a collection of living wild animals of many species, whether for study or to amuse visitors.

Mercury, quicksilver, a metal which at ordinary temperatures is in a liquid state.

Metamorphosis, a change of form or structure which takes place during life. Such changes are seen in insects, frogs, and other animals.

Mildew, a kind of blight or disease which attacks wheat and other plants.

Miniature, a painting of small size.

Motor, taking part in motion; that which causes motion.

Muscular, having muscles or muscle-fibre; having well-developed muscles.

Naturalist, a person who studies natural objects, especially plants or animals.

Neutralize, to render inactive or harmless.

Nocturnal, pertaining to the night. A nocturnal animal is one that is active by night.

Opium, the dried juice of the poppy, used as a medicine to relieve pain and to procure sleep.

Organ, a part in any plant or animal which performs any work serviceable to the life or health of the plant or animal of which it is a part.

Organic, having organs; produced by organs or by an organized structure; pertaining to organs or to a structure with organs, like a plant or an animal.

Orifice, an opening; a hole serving as an exit or entrance to any cavity or hollow organ.

Pacific, peaceful; having a peaceable disposition.

Perfect insect, one which has passed through all the stages of its development.

Piston, a piece fitted to the inside of a cylinder, and capable of being moved to and fro, or up and down, as the piston of a pump or of a steam-engine.

Pitchy, abounding in pitch; very sticky, like pitch.

Posterior, towards the back; in the rear.

Pulse, the beating or throbbing of the arteries, as is seen upon the wrist.

Race (of men), a stock, or number of tribes or nations, the people of which much resemble one another.

Reflection (of light), the turning back or changing of the course, as by means of a mirror.

Reptile, an animal which either has no feet and legs (like a serpent) or has such short legs that it creeps upon the ground.

Residue, or **Residuum**, that which is left after any process which separates or removes a part of any substance.

Rigidity, stiffness; resistance to a bending force.

Scarlatina, the scarlet fever; a contagious fever, in which the skin becomes very red.

Science, human knowledge; knowledge reduced to systems.

Sensitive, receiving sensations; capable of being impressed through the senses.

Solidify, to render solid; to become solid; to change from a liquid or a gaseous state to that of a solid.

Solution, the state of being dissolved or diffused through a liquid; also a liquid in which any substance has been dissolved.

Sorghum, a large plant of the grass family, from the juice of which sugar and molasses are made.

Spirits, a popular or commercial name for alcohol and alcoholic liquors.

Steel, iron combined with carbon and rendered very hard by tempering.

Subdivision, a further division of the parts of something which has been already divided.

Surgery, that part of medical practice which employs instruments or mechanical devices in operations upon the human or animal body. It includes amputations, the dressing and care of broken bones, the opening of abscesses, etc.

Swarming, the action of the bees when they forsake the hive in large numbers looking for a new home.

Tanning, the changing of hides or skins into leather. This is often done by means of the bark of the oak-tree or of the hemlock-tree.

Tattooing, the tracing of figures or designs upon the skin (often on the face or arms) by means of a black pigment introduced by pricking through the skin. Tattooing cannot be effaced. It is much practised by savages, and sometimes by sailors.

Transverse, crosswise; from side to side.

Vaporize, to change from a solid or a liquid state to one of vapor.

Varnish, a liquid substance which when applied to the surface of a body becomes hard and makes the surface smooth and shining.

Vegetation, the vegetable kingdom. All plants, including trees, shrubs, herbs, grasses, fungi, toadstools, moulds, and sea-weeds, belong to the vegetable kingdom.

Venomous, poisonous; poisoning by means of a substance introduced into the blood through a wound in the skin.

Vertical, perpendicular to the horizon; standing straight up, or falling straight down like a plumb-line.

Volume, size; bulk; largeness of body.

Wart, a rough and generally dry growth often seen upon the hands of young persons. Another kind of wart is sometimes seen on the face, generally of grown persons.

THE END.