INTRODUCTORY STEPS IN SCIENCE

PARTS

I, II, III

ANIMALS
PLANTS
MINERALS
&
ROCK
FORMATIONS

PARTS I, II, III

INTRODUCTORY STEPS IN SCIENCE

FOR THE USE OF SCHOOLS

BY

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PREFACE.

It is a well-recognized fact that the cultivation of the sense-perceptions lies at the foundation of all knowledge. These sense-perceptions are converted into knowledge under two conditions: **first,** by *observing differences;* **second,** by *observing likeness* or *similarity.* Upon these distinctions all classification depends, for where no differences can be observed the objects must be classed together and receive the same name.

Throughout the book, minute technical classification—not being of prime importance—has not been introduced. The broad outlines of generalization, however, have not been overlooked. By a few observations pupils are led to group all objects into the three **Kingdoms of Nature**—*Animal, Vegetable,* and *Mineral.* Again, by observing differences, the Animal Kingdom is readily divided into five **Sub-Kingdoms**—*Vertebrates, Annulates, Mollusks, Radiates,* and *Protozoans.* Each sub-kingdom is still further divided into **Classes.** Thus the sub-kingdom Vertebrates consists of five classes — *Mammals, Birds, Reptiles, Amphibians, Fishes.* The term *class* in this sense becomes a technical zoölogical term; so, again, the division of a *class* into several *orders.*

By *easy steps* the learner is led to group together the rodents, ruminants, and the carnivorous animals, etc. ; yet the technical terms, class and order, have been avoided. There has been no attempt whatever to still further subdivide into *genera* and *species.*

In all departments of the book the subjects have been treated in a manner to cause the learner to *observe, think,* and then *express* the result of the observations in suitable language. The pernicious practice of *memorizing* the textbook, or of requiring the student to *listen, recollect,* and then *repeat* the formulated statement of the instructor, can not be too strongly condemned.

Over half a million copies of the original book, by M. Paul Bert, were sold in France within three years, and in the preparation of this volume only such changes have been made as were required to adapt it to the wants of the youth of America ; and, to beginners in science, it is offered with confidence that it will meet with commendation.

The translator has endeavored to make his text clear and intelligible to the young mind, always adhering to the language of the author when possible to do so ; making little additions here and there to suit the age and country, and putting in the mouths of the pupils just such questions as his long experience in the school-room has taught him would naturally be asked by the grade of children for whom this work is intended. Where unfamiliar words or expressions occur, the meaning is annexed in brackets, to economize time for the teacher. The style is simply conversational, nothing more.

The illustrations in the original were so very small as to make some of them of little value. Great care has been bestowed upon the illustrations in this volume, and their usefulness to the student will be acknowledged. In the Natural History, so far as possible, American species have been substituted for foreign ones; and in the chapter on Rock Formations, that portion which treats of the continental development of North America has been substituted for the author's geological history of France.

In short, such corrections and changes have been made as would materially enhance the value of the book in the hands of beginners in science in America.

The complete work of M. Paul Bert consists of seven parts: I. Animals; II. Plants; III. Minerals and Rock Formations; IV. Physics; V. Chemistry; VI. Animal Physiology; VII. Vegetable Physiology.

J. M.
M. C. V.

Brooklyn, New York,
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PART I.

NATURAL HISTORY OF ANIMALS.

NATURAL HISTORY.

ANIMALS.

DIVISIONS OF THE ANIMAL KINGDOM.

1. **Classification.**—We are going to enter upon the study of *Natural History*, and we shall begin with **animals,** as it is that part which is most entertaining, and which you know something about already.

Animals interest you more than *plants* and much more than *stones*. An *animal* grows, feels, and moves at will ; it lives and dies. A *plant* also lives and grows and dies ; but it does not move out of its place, and it feels neither blows nor caresses. [This is true of all the higher forms of animal life. But many of the lower animals do not possess a nervous system ; and the microscope shows us lower forms of plants that move freely from place to place.] As for *stones*, not only do they not move about, but they do not die, and they never change unless something disturbs or breaks them.

On the other hand, you know that *animals* are very different in shape and size. A whale, a fly, an elephant, a sparrow, a tiger, a snail, a beetle, a spider, and an earth-worm, are animals very different from one another, and about which you already know many things.

This is not all : you know very well that we resemble animals, especially in the internal (inner) arrangement of our bodies. You know you have a *heart* that beats in your breast, *lungs* with which you breathe, a *stomach* and *intestines* that digest your food, *eyes* that see, and *ears* that hear. Now, however carelessly you may have glanced at a butcher's stall, or noticed your mother preparing a chicken for cooking, you have learned that the ox, the sheep, the pig, the rabbit, and many other animals, have an internal conformation more or less like our own. Hence, in studying animals somewhat closely, we are making a study of ourselves.

But where shall we begin our study, with so many useful and interesting subjects before us? Now, this is what I think. While you were little children, you learned a great many things about the history of animals, in your school-readers and story-books, and in looking at pictures and having them explained to you.

You know, among other things, that the *tiger* is a fierce animal belonging to Asia and Africa; that he eats cattle and men. You know, too, that the *ostrich* is a large bird that roams over the wilds of Africa; and you have some ideas about the *shark*, the *rattlesnake*, *humming-birds*, *alligators*, *camels*, etc. And, now that you have grown older and larger, we are not going to tell you all these things over again in a confused manner. On the contrary, we are going to arrange these animals in their proper order, so as to enable you to get a true idea of what you are learning, and we shall complete this knowledge step by step.

To do this we must not take up animals one after another, without order. We must follow what *naturalists* (those who teach natural history) call a *classification* or arrangement in groups. We must bring together those animals which are most alike, so as not to be obliged to repeat about each one what is common to all of them. Thus, in placing birds side by side, we can say, once for all, that they have a beak, wings, and feathers.

But, it is not so easy to make a correct classification. We must know exactly in what respects different animals are like one another, and in what they are not. To find this out, we must examine them very closely, both internally and externally.

2. Animals that have Bones and Animals that have no Bones.—"Come, John, what is the difference between a fly and a horse? You laugh, but that's no answer; try to tell me."

"A horse, sir, is a very large animal, and a fly is very small."

"Yes, but here is a picture in which the fly has been enlarged and the horse made very small. Of course, you would never mistake one for the other, in spite of the size ; but, do you see nothing else ?"

"Oh, yes, sir; a fly has wings, and a horse has none."

"Ah ! that is very well ; but, suppose I were to pull off the fly's wings ? There must be something else. What do you say, Paul ?"

"A horse, sir, is covered with hair, and a fly has no hair."

"Are you quite sure about that ? Catch a fly, and let us look at it through my little magnifying-glass. See, it is all covered with hairs ! They are very small, it is true, but they are there. James, have you anything to say ?"

"Sir, a horse has *four* legs, and a fly has *six.*"

"Ah ! that's a good observation, and we shall make use of it. But suppose we take two legs away from the fly, what then ? Do you see no other difference ? No ? And, yet, there are many, and great ones at that."

"Can we crush a fly ?"

"Oh, yes, very easily, and nothing would be left but the outer parts—the skin, the legs, and the wings."

"But, could we crush a horse ?"

"I know very well that we have not enough strength in ourselves to do so."

"But, if a house were to fall on it, would it crush the horse and reduce it to a pulp, as would have been the case with the fly ?"

"No ? Why not ?"

"Because *the horse has inside its body hard parts*—**bones** —*that can not be crushed, while not even the smallest bones are to be found in the fly.* The horse, then, is an **animal that has bones,** or, as is also said, that has a **skeleton,** as the whole bony frame is called ; and the fly is **an animal that has no bones.**"

Another difference, and a no less important one : Stick this fly with a pin, and a drop of *colorless liquid* will ooze out of the wound. Now, if you were to do the same to a horse, what would come out of the wound ? "Ah !" you all cry out, "*blood !*" Yes, blood, a red liquid, very curious to examine, and of which we shall speak later on. Now, *real blood, red blood, is to be found only in animals that have bones—that have a skeleton.* This is another great point.

3. Vertebrates.—"Besides the horse, do you know any other animals having a skeleton and red blood, Paul?"

"Oh, yes, sir; the *cat*, the *chicken*, the *pig*, the *ox*, the *rat*, the *hare*."

"And what about yourself?"

"Oh, sir!"

"Are you offended because I tell you that you are an animal, that we are all animals? It is true, for all that. We eat, we breathe, we are born, and we die, just like an animal, and

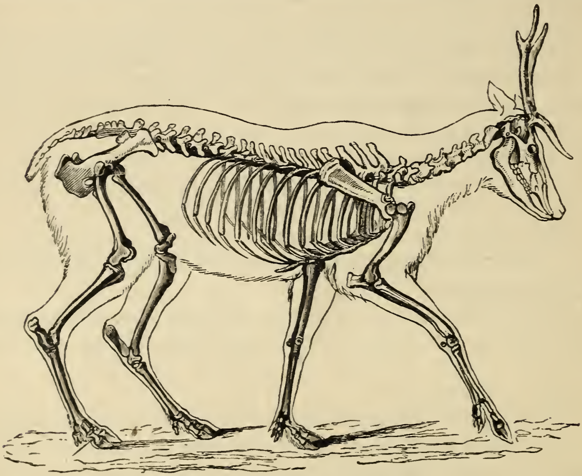


FIG. 1.—Skeleton of the deer.

we are formed just like animals, having bones and blood. This does not in any way take from our moral superiority, and, if we do not digest our food any better than they do, we think much more and far better than they. There is, then, nothing to be offended at in this fact, but, on the contrary, much to be proud of.

"But, let us return to animals. You have not, so far, shown a very lively imagination. All the animals you have named are very much like one another, since they are all four-footed and covered with hair. They are hairy *quadrupeds*. Do you know any others that have also bones and blood ?"

"Yes, sir. *Birds*."

"Very well. Any others ?"

"*Fishes*."

"Any others ?"

"Yes; there are frogs, toads, newts."

[Since these creatures not only possess lungs for breathing, but they also have gills during a part or the whole of life, they are called amphibians, which means *double* life.]

Fig. 2.—Skeleton of a sparrow.

"What others ?"

"Serpents and lizards."

"Very good. And what are serpents and lizards generally called ?"

"*Reptiles*."

"Right again; and we shall come back to this in a little while."

Thus, **Quadrupeds** (having hair) (Fig. 1), **Birds** (Fig. 2), **Reptiles** (Fig. 3), **Amphibians** (Fig. 4), **Fishes** (Fig. 5), *may be classified together as having bones and blood.* They are known

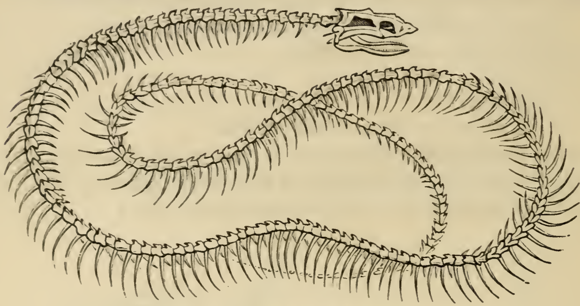


Fig. 3.—Skeleton of a snake.

under the general name of **Vertebrates**, because among these bones there are a certain number called the *vertebræ*, which form the spine, or backbone, and from this comes the name of

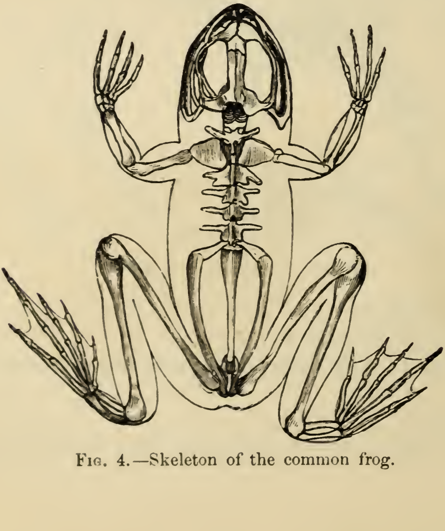


Fig. 4.—Skeleton of the common frog.

vertebral (*spinal*) *column*, given to the whole set of these bones. You can easily feel them under the skin, down your back. In some vertebrates having no *limbs*, such as serpents, this vertebral (spinal) column constitutes, with the head (or

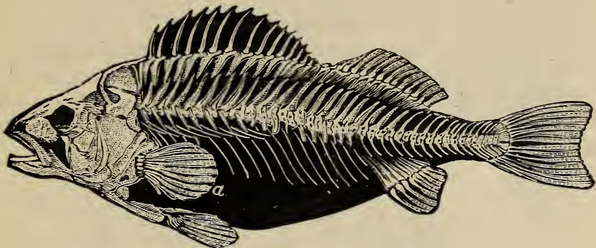


FIG. 5.—Skeleton of the perch.

rather the *skull*, as the bones of the head, taken together, are called), the entire skeleton; but most vertebrates have bones in their limbs, as you well know. We shall tell you more about this further on.

4. Annulates.—"Let us now pass on to animals that *have neither bones nor red blood*, and which are called *Invertebrates* (without *vertebrœ*), to distinguish them from the others.

FIG. 6.—Beetle.

FIG. 7.—Butterfly.

"We have already seen that the *fly* has two wings and *six* feet. Now, do you know any other creatures that are very much like it ? What do you say to a *beetle* (Fig. 6) ? How many wings has a beetle ?"

"*Four.*"

"How many feet has it ?"

"*Six.*".

"Very well. Now, mention some others."

"A *butterfly* (Fig. 7) has also four wings and six feet."

"A *dragon-fly* (Fig. 8) has four wings and six feet, too."

"Very good. That will do for the present. Now, bear in mind that *all these creatures having six feet are called* **Insects.**"

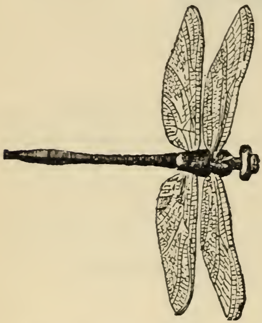


Fig. 8.—Dragon-fly.

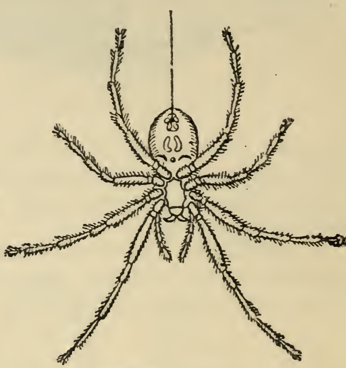


Fig. 9.—Spider.

Now, let us catch a *spider* (Fig. 9). It looks very much like an insect, but it runs upon *eight* feet.

Fig. 10.—Milliped.

This *milleped* (Fig. 10), as it is called, has a great many pairs of feet. Now, look at these animals closely, and you will see that they are formed by a succession of *rings*, joined together and working upon one another, *articulated* (as it is called) one upon the other. The *wood-louse* is composed of a succes-

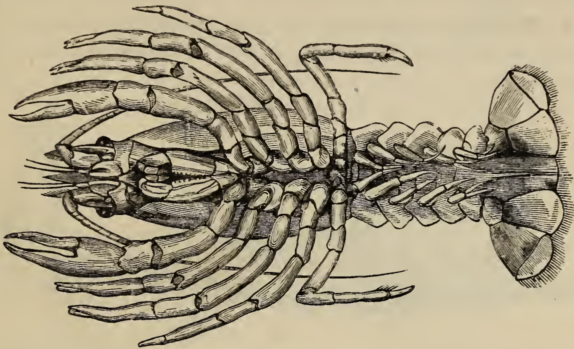


Fig. 11.—Common crayfish.

sion of rings. The *crayfish*, or *crawfish* (Fig. 11), has two hard rings, to form the front part of the body, and for this reason it is called a **Crustacean** (from the Latin *crusta*, a crust).

Now, here is an *earth-worm* (Fig. 12), and here is a *leech* (Fig. 13). These, likewise, have rings, but the head is not separate from the body, and they have no feet; the skin is

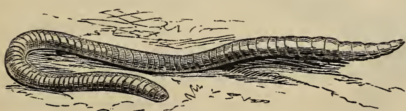


Fig 12.—Earth-worm.

not tough, like that of insects, nor crusted, as in the crayfish. These are known as **worms.**

Insects, *spiders*, *millepeds*, *crustaceans*, and *worms*, are often classi-

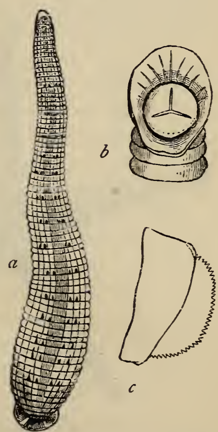


Fig. 13.—*a*, Leech. *b*, Magnified view of mouth. *c*, Saw-like jaw.

fied together, under the common name of **annulates,** because the bodies of all the animals of this group seem to be composed of *rings*.

5. **Mollusks.**—Look at the slug, so naked and so soft ; and at this *snail* (Fig. 14), which is just as naked and soft, although it has been smart enough to build itself a *shell* to protect and shelter it.

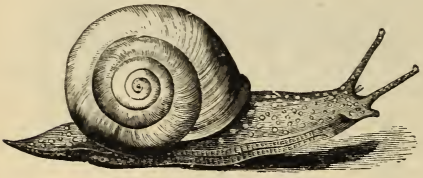


Fig. 14.—Snail ; a univalve.

Fig. 15.—Mussel ; a bivalve.

Let us add this *mussel* (Fig. 15), soft like the others, but protected by *two* shells. *In these animals you will find no signs of their being divided into rings. They are not, therefore, annulates. They have neither bones nor red blood*, therefore they are not *vertebrates.* They are known under the name of **mollusks** (from the Latin *mollis*, soft).

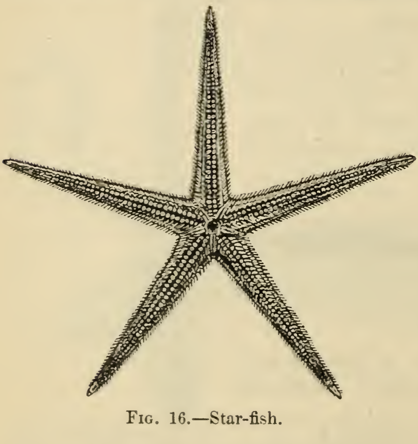


Fig. 16.—Star-fish.

6. **Radiates.**—Finally, I show you two pictures. One represents an animal very common along the sea-shore, and known under the characteristic name of *star-fish* (Fig. 16). The other is an enlarged picture of a tiny creature that lives in colonies

of innumerable little creatures like itself. These little creatures, called *polyps* (Fig. 17), build around themselves a sort of stony cell, and the union of all these cells forms what is called a *polypary.* These polyparies often reach a very large size, forming rocks, reefs, and islands. Look ! the star-fish and the polyp are not unlike each other; they are composed of *rays*, which start from a sort of center. The star-fish has *five*, the polyp has *eight*, but they are both arranged in the same way. You now understand why the name of *radiate* (from the Latin *radius*, a ray) has been given to these animals. The name *radiata*, or *radiates*, is often preferred to that of *zoophytes*, which means *plant-like animals* (from two Greek words, one meaning *animal* and the other *plant*), because the *polyps*, when they spread out their eight little white arms, have been mistaken for little flowers growing out of the rock.

FIG. 17.—Polyp. Red coral (magnified).

[7. **Protozoans.**—We must now study some strange little animals. Look at that sponge, with which you clean your slate. Sponges were for many years considered plants; but we know they are animals. That piece of sponge in your hand can be pressed together, and because it is elastic it takes again its first shape. What you see is only the skeleton or hard part of a colony of jelly-like particles, which make up the *sponge-flesh.* In the living state the whole skeleton, or what you call sponge, is covered inside and out with this soft material, or sponge-flesh. Then, if you should examine the water of a pond, you would see a number of minute creatures in it. By the aid of the microscope you would see a wonderful variety of animals in a drop of this water. Some of these are simple particles of jelly, without a skeleton, without eyes—yes, without nerves. These forms of life are the lowest, or first division of the animal kingdom, and are called protozoans, which means first life (Greek *protos*, first; and *zoon*, an animal).]

This, then, is the basis of the classification of what is called the *animal kingdom*. There are five great groups: **1. Vertebrates; 2. Annulates; 3. Mollusks; 4. Radiates; 5. Protozoans.** The best thing for us to do now is to study these different groups of animals, one after the other, giving special attention to the most interesting among them.

SUMMARY.—Divisions of the Animal Kingdom.

1. **Generalities** (page 4).—An *animal* grows, moves, feels, lives, and dies.

2. A *plant* grows, lives, and dies, and generally does not move or feel.

3. A *mineral* remains unchanged, if not displaced or broken.

4. The *animal kingdom* comprises five great groups: **Vertebrates, Annulates, Mollusks, Radiates,** and **Protozoans.**

5. **Vertebrates** (page 6).—Under this common name are classified all *animals that have bones*, or what is also called *a skeleton*. A horse is a *vertebrate.*

6. The name *vertebrate* comes from the fact that among the bones of these animals those forming the backbone are called *vertebræ.*

7. Among animals, the vertebrates are the *only* ones that have **red blood.**

8. **Annulates** (page 9).—The *annulates* (insects, spiders, millepeds, crustaceans, and worms) are animals that have neither *bones* nor *red blood*, and are formed by a species of **rings,** joined together and working upon one another. A *house-fly* is an *annulate.*

9. **Mollusks** (page 13).—*Mollusks* have neither *bones* nor *red blood*, nor *rings.* They are *soft*, and often hidden in shells. A *snail* is a *mollusk.*

10. **Radiates** (page 12).—*Radiates* are animals with rays springing from a sort of center (forming its body). A *star-fish* is a *radiate.*

11. **Protozoans** (page 12).—These are the lowest forms of animal life. The body may be a single mass of jelly, or several of these masses together, as in the sponge. Very few of them can be seen without the microscope. By steeping old hay or some sage in water, many of these minute creatures will be found in the infusion, and the name Infusoria is given to these little animals.

(Simple subjects for Composition will be found on page 99.)

I.—VERTEBRATES.

Vertebrates, as has been said already, are animals that have **bones** and **red blood**. We know, too, that they are divided into several great classes : *Mammals*, *Birds*, *Reptiles*, *Amphibians*, and *Fishes*.

8. **Mammals.**—There are in the first place *Quadrupeds* (four-footed animals), covered with hair. As they suckle their young, they are called **Mammals**, from the Latin *mamma*, an *udder* or *milk-bag*.

9. **Birds.**—"Now, Paul, tell me what belongs to *birds;* what is there that all birds have in common ?"

"You have already told us, sir. Birds have a beak, wings, feathers, and only two feet."

"Very good."

10. **Warm-blooded Animals and Cold-blooded Animals**— "What is there common to all **Reptiles**? What is their nature ? Ah ! you seem puzzled. Now, think ; the *lizard* has four feet, the *snake* has none, and the *turtle* lives shut up in a box, or, as it is called, a *carapace* (shield over the back). All these animals bear little likeness to one another, yet they are called by the general name **Reptiles**. We must find a reason for this, and I am going to try to find it for you.

"Peter, when you put your hand on a dog or a horse, does it feel warm or cold to you ?"

"*Warm*, sir."

"Right. And when you lay hold of a bird or a chicken, for example, does it feel warm or cold to you ?"

"*Very warm*, sir."

"Right, again ; but, if you take a *lizard* or a snake in your hand, how would it feel to you ?"

"Oh, sir, a snake ! I should never dare to do such a thing ; it would bite me, and people die of such bites."

"I should not advise you to touch a *rattlesnake*, but you might handle this little *garter-snake*, so playful and harmless. Put your hand on it without fear, there's no danger. How does it feel ?"

"Sir, **it is quite cold.**"

"Right. And this frog?"

"That's **cold,** too."

"And this *gold-fish*, which I shall take out of the globe on purpose for you to feel it?"

"**Cold,** *like the snake and the frog.*"

Here, then, is a new and very great difference we have found among animals. There are *warm-blooded animals*, such as mammals and birds. There are *cold-blooded animals*, such as reptiles, amphibians, which we are going to talk about presently; fishes, and, with them, all animals without bones and without vertebræ (Annulates, Mollusks, Radiates, Protozoans)—the **Invertebrates,** as they are often called.

11. Reptiles, Amphibians, Fishes.—*Reptiles*, as we have seen, *have cold blood*, and this is enough to distinguish them from mammals and birds. It remains now to distinguish them from **fishes.** "What difference do you see between them, James?"

"*Fishes live in the water*, sir, and *reptiles live on land.*"

"Very well said, my boy. We would express this in scientific terms by saying that reptiles are *aërial* animals, or animals that breathe the air; and fishes are *aquatic* animals, from the Latin word *aqua*, which means water.—What are you laughing at, over there? What's the matter?"

"Please, sir, what are you going to do with the *frog* (Fig. 18), which lives both in the air and in the water? Is it half fish and half reptile?"

"Yes and no, and your question is a very good one; but you have made a mistake! 1. The frog does not live partly in the air and partly in the water; *it lives in air only.* It is true that, at the least noise, it jumps into the water and hides itself; *but if it did not rise to the surface*, or *did not, at least, put the end of its nose up out of the water so as to breathe air, it would be drowned.* There are men who can stay under water for two minutes without being asphyxiated (suffocated); the frog can remain under water an hour, but no more, except in winter, when the creature becomes torpid, as if it were dead. The frog is, after all, an *aërial* animal, like the lizard or the snake. But the frog has not always been in this state. 2. When young, it was a *tadpole that lived in the water all the time;* it was an *aquatic* animal. Now, here is an animal which, when it was quite young, was an *aquatic*, and which, after its change of life (or metamorphosis, as scientific men call it), became an *aërial*. A classification

Fig. 18.—Metamorphosis of the frog. *e*, Eggs. 1, Tadpoles just out of the egg. 2, With outside gills. 3, With gills hidden, and beak-like mouth. 4, Hind legs appearing. 5, All legs grown, but fish-tail remaining. 6, Putting on frog appearance; tail being absorbed. 7, Young perfect frog.

has been made of animals of this kind, like the toad, the salamander, etc., called the **Amphibians** (having *double life*), to distinguish them from *true* **Reptiles**.

"There is still another difference between Amphibians and Reptiles. Observe the skin of this frog; it is *moist* and *smooth.* Is it like the skin of the snake, John?"

"No, sir : the snake's is *covered with scales.*"

"Like a fish's ?"

"Yes, sir."

"You have made a mistake. Look closer. Look at this gold-fish. Now, I could pull out one of those scales just as easily as I could pull a hair out of your head, or pluck a feather from a bird. This could not be done with the scales on a snake ; what you see there are merely *folds* of the skin, regular ridges ; they are called *false scales.*

Let us review. 1. **Reptiles** are *aërials;* their skin is covered with *false scales.* 2. **Amphibians** are *aquatic* in their primary state, and *aërial* when they have reached their full development ; their skin is bare. 3. **Fishes** are *aquatic;* their skin is covered with real separate scales.

SUMMARY.—Vertebrates.

1. **Division of Vertebrates** (page 15).—**Vertebrates** are divided into several great classes, viz.: *Mammals, Birds, Reptiles, Amphibians, Fishes.*

2. **Warm-blooded Animals** (page 15).—**Mammals,** or hair-covered animals which suckle their young.

3. **Birds** have a beak, wings, feathers, and two feet.

4. Mammals and birds have *warm blood.*

5. **Cold-blooded Animals** (page 16).—**Reptiles** have *cold blood,* and their skin is covered with *false scales.*

6. **Amphibians** have cold blood and a bare skin. In their primary state they live in the water, and are *aquatic.* When they reach their full development, they are obliged to rise to the surface of the water for air, and become *aërial.*

7. From this *double existence* comes their name of *Amphibians,* meaning *double life.*

8. **Fishes,** cold-blooded animals, are *aquatic.* Their skin is covered with real, separate scales.

(Simple subjects for Composition will be found on page 99.)

VERTEBRATES.—1. **Mammals.**

12. Mankind.—"Honor to whom honor is due," says an old proverb. We shall begin the study of mammals with *mankind*, because man is a mammal.

I am fully aware that he deserves a separate classification, all to himself, so far does he stand above all the others ; but let us for a moment lay aside our powers of mind and look only at our body, and in doing so we can not but own that we look very much like monkeys.

And yet we walk erect on two legs, which they can not do ; we have strong and shapely hands, with which, with the help of the thumb, we can grasp and feel. Our body has but few hairs upon it, except on the head and the lower part of the face.

All men are not exactly like those of our own country. Here, in our own town or city, there are fair complexions and dark complexions—people who are very unlike one another. A native of the north of Europe, a Norwegian or a German, is large and fair, and very unlike a native of the south of Europe, a Spaniard or an Italian, who is dark and generally small in stature. In America, too, the same differences are to be seen : the Esquimau is short and thick-set, while the white

Fig. 19.—White race.

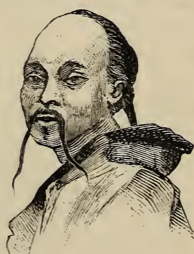


Fig. 20.—Yellow race.

race is generally fair and tall. Now, all the people of *Europe* have a **whitish** skin (Fig. 19), regular features, a straight nose, well-poised jaws, and smooth but soft and sometimes wavy hair. On the other hand, *Chinese* (Fig. 20) have a **yellowish** skin; their hair is smooth, hard, and black; their eyes are set obliquely, and their teeth are projecting. *Negroes* (Fig. 21) have a **black** skin, tight-curling and woolly hair, prominent jaws, and a flat nose; they are not so intelligent as the Chinese, and far less so than the whites. [The author evidently refers to the uncivilized tribes of Africa.] In *America* (Fig. 22) there is another race somewhat allied

Fig. 21.—Negro race.

Fig. 22.—Red race (American Indian).

to the yellow race, but more robust, and having a **reddish** skin. There are also many other tribes, less populous, and not so easily defined. Let us confine ourselves for the present to the *white* Europeans, the *yellow* Asiatics, the *black* Africans, and the *red* American Indians. Only, you must bear in mind that the whites, being more intelligent, more industrious, and more courageous than the others, have spread over the whole world, bringing under their yoke all inferior races.

Now, there are some races vastly inferior to others. Thus, aboriginal or native Australians are of low stature, with darkish skin, straight, black hair, and very small heads. In their natural state they live in little groups or bands, do not cultivate the soil, have no domestic animals except a species of dog, and their intelligence is of a very low order. There are some tribes of savages who do not even know how to make a fire.

13. Monkeys.—At the head of the *Monkey* species must be reckoned three that have much more intelligence than the others, and that really bear a very strong resemblance to man. The most anciently known of these large monkeys is the *orang-outang* which lives in the forests of Borneo, and the largest of which have reached a height of four feet and over. On the Gaboon coast and in Guinea is to be found the enormous *gorilla* (Fig. 23), which has been known to attain the height of six feet, and the *chimpanzee*, which is rarely more than three feet high.

Fig. 23.—Gorilla.

These animals have no tail; they walk resting on the knuckles of their hands and the outer sides of their feet, the

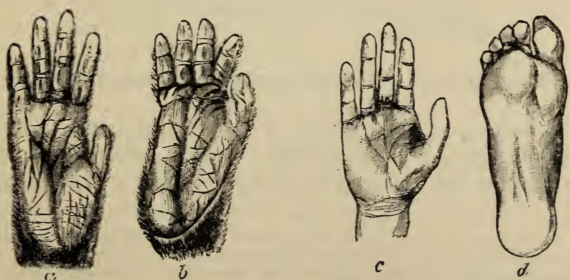


Fig. 24.—*a*, hand, *b*, foot, of chimpanzee; *c*, hand, *d*, foot, of man.

soles of the latter being turned mainly inward, and they often stand almost erect like a man. But, like all other monkeys, they have a great-toe, or thumb, separated from the other toes, like the thumb on our hands (Fig. 24). This enables them to hold on to the branches of trees. For this reason you will often find that monkeys are described under the name of *Quadrumana* (animals having four hands), and man under that of *Bimana* (having two hands).

These large monkeys live in small families, are very intelligent (for animals), are easily tamed when caught young, and may then, on account of their size and their almost erect gait, be taught to do all manner of household service.*

Fig. 25.—Quadrumana. A Catarhine monkey, one seventh of the natural size.

The other species of monkeys are very numerous (Fig. 25). They live in the warm climates of both continents, and in countless troops, gay, noisy, always leaping, climbing, gam-

* We remember, in our youth, seeing one of these creatures dressed in livery and performing the duties of porter. He would take the visitor's card on a salver to the mistress, and, returning, bow the visitor into the reception-room, with all possible dignity.—Translator.

boling, and teasing one another in the forests, where they feed on fruits.

14. Bats.—Let us now pass on to *bats*. It surprises you somewhat, does it not, to hear me class bats among the *mammals?* They fly, and this fact would lead you to look upon them as *birds*.

As I expected your objection, I caught one last night, by placing a light in my class-room and leaving the window open. Here it is, under this glass globe, and it is not injured in the least. Let us examine it together (Fig. 26).

Fig. 26.—Bat.

In the first place, we see that it is *covered with hair*, and not with feathers ; then it has *long ears*, which you have never seen on a bird. Wait a moment ; I am going to seize it with this pair of pincers, but without hurting it.

"Why do you use those pincers, sir ?"

"Because it would bite me. Look at all these *little teeth*. Did you ever hear of a bird having teeth ? Now, the bat has neither beak nor feathers, but it has teeth. It can not, therefore, be a bird."

"But, what about its wings ?"

"Ah ! We must examine them more closely. Holding the creature firmly in this way, I spread out its wing. See how different it is from a bird's ! We see no feathers ; it is simply a *thin membrane* sustained by bones and opening out like a fan. The bones are those of the fingers, which are here very much lengthened out. The membrane is double; it is *the skin of the back and breast* stretched out and quite thin. Finally, this membrane extends from the arm to the tail, embracing both the arm and the tail. This is a very odd kind of wing, is it not ?"

Now let us set our bat free. See how heavily and awkwardly it flies. It does not seem to know where to go. This is because of the strong sunlight, and the poor creature, which dreads the light, which comes out only at twilight, and which is what is called a nocturnal (Latin *nox*, *noctis*, night) animal, is dazzled by the glare. Ah ! at last it has found the window, and will now be able to find refuge in some cave or dark recess. There it will hang by its hind-claws, head downward, and sleep all the day long This evening it will wake up again and go in search of insects, which it will devour in quantities. You see by this that *the bat is useful to tillers of the soil, and should, therefore, be protected.*

In winter, bats remain in their holes inert (without power to move), and sleep the whole time without eating or drinking. This is what scientific men call *hibernating* (from the Latin *hibernare*, to winter).

15. Insectivorous Animals.—Other mammals, wingless this time, are *insect-eaters*, hence their name *Insectivores*, or *Insectivora.* They are generally small in size, as you can easily understand that such food could not satisfy large animals.

The *hedgehog* (Fig. 27), whose hair is mixed with prickles or spines, is endowed with the power of rolling itself into a ball so as to present the spines outwardly in every direction. It is a hibernating animal and nocturnal in its habits.

Fig. 27.—Mole and hedgehog.

The *mole* (Fig. 27), which by the aid of its large, powerful fore-feet, that work like a mattock, is able to burrow long galleries under the ground, has such very small eyes that they can hardly be seen, and, like the funnel of its ear, are hidden under its soft, silky fur. *It is wrong to destroy the mole, as is often done*, because it never eats the roots of trees, but lives on *white worms* (*larvæ*) and other destructive insects concealed under the earth.

The *shrew-mole* is another insectivore, and looks like those mice with long noses and sharp-pointed teeth, to enable them to crush the carapace (upper shell) of insects.

16. Carnivorous Animals.—We shall now take up animals that eat flesh, that devour mammals and live birds. These are called *carnivorous animals*, or carnivores (from the Latin words *caro*, *carnis*, flesh, and *vorare*, to devour).

The most prominent type and the most expert hunter is the **Cat**. Let us examine our good *puss*, if she will be kind enough to let us do so. In the first place, look at her paw: notice those sharp, cutting claws; there is no danger of their wearing out, for when resting pussy draws them into her paw, so that the points never even touch the ground. This point of the claw never comes out of its covering except when the animal stretches out its toes, to climb or to strike its prey.

Fig. 28.—Cat's mouth. Four long pointed teeth.

Now look at its mouth (Fig. 28), but do so quickly; see on each side those long, strong, pointed teeth that seize the prey, and behind them those other cutting teeth that work on one another like a pair of scissors and will cut up the flesh. What weapons! When a mere cat can do so much harm with them, what must it be when a lion or a tiger uses them?

Now, the *lion and the tiger are simply enormous cats*, able to handle a man as a cat would a mouse.

Fig. 29.—Tiger.

The *tiger* (Fig. 29), which is the most to be feared, has a beautiful orange skin, striped with black, and inhabits the warmer parts of Asia, chiefly India and the Indian islands. It is very daring, and will attack man with such ferocity that in 1875 in British India alone no less than 917 men were devoured by tigers.

Fig. 30.—Lion.

The *lion* (Fig. 30), which is a

native of Africa and Southern Asia, is less aggressive, but what havoc he plays among wild and domestic animals! It is estimated that each lion in Algeria costs the colonists some four thousand dollars a year.

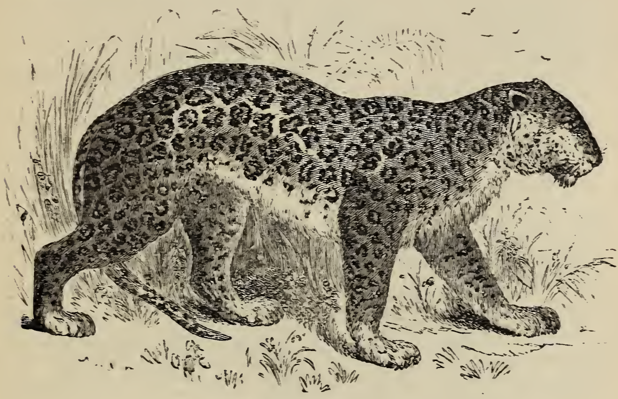


FIG. 31.—Leopard.

The *leopard* has a spotted skin, rarely attacks man, and is to be found, in a variety of species, in Africa and Asia. The American panther is a ferocious feline mammal of several species—as the catamount, jaguar, and puma.

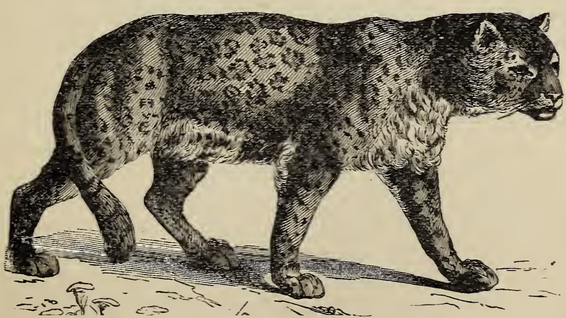


FIG. 32.—Jaguar.

The *jaguar* (Fig. 32) is found in America, where it grows almost as large as the tiger, but it is not nearly so dangerous to man. It is of a brown-yellowish color above, faintly marked with stripes or rings along the sides, and whitish below. It is found from Brazil to Texas.

The *cougar*, or *puma*, is of a brownish-yellow color, without spots, and is the second largest American tiger. It is found from Texas to Patagonia. It has sometimes been called the *American lion*, a name that is justified neither by its courage nor by its strength.

Fig. 33.—Lynx.

In Europe the only animals of the cat kind (*felines*) are the *wild cat* of the forests, from which comes the ordinary domestic cat, and the *lynx* (Fig. 33), which is still to be found in high mountain-regions. The lynx looks very much like the common cat, but has longer ears and a shorter tail. The *Canada lynx* is a native of North America, and is remarkable for its gait. Its method of moving is by bounds from all four feet at once, with the back arched. Its length is about three feet, and it feeds principally on the American hare. It will not attack larger quadrupeds.

After *cats*, come *dogs*, whose teeth are somewhat like those of cats, but whose claws are fixed and can not be drawn in, like the cats'. *Wolves*, which are not very dangerous in America and in western Europe, live in numerous packs in eastern Europe and Asia, and there is scarcely a year in which they do not devour twelve million dollars' worth of cattle and the like in Russia alone. The *fox* (Fig. 34) burrows in the earth, and is remarkable for its cunning. It preys on lambs, geese, hens, or other small animals. It is found in all the northern

Fig. 34.—A group of fur-bearing animals. 1, Arctic fox. 2, Silver fox. 3, Sable. 4, Otter. 5, Mink. 6, Ermine.

and temperate regions of the globe. The red fox belongs to America.

In Algeria and in other parts of Africa, on the Asiatic shores of the Mediterranean, and in Greece, lives a sort of little wolf called the *jackal*. It preys on game and fowl, is of a yellowish-gray color mixed with tawny, and has a very pointed muzzle and rather short tail.

The *hyena* (Fig. 35) is an inhabitant of Asiatic Turkey, Syria, Barbary, and many other parts of Africa. It is large and strong, and prefers dead bodies to live flesh. It never attacks man. The striped hyena belongs to Algeria. You may see specimens of some of these and other animals in the Central Park Museum in New York, and in the Zoölogical Gardens of Philadelphia and other cities of the Union.

The *bear* is to be found all over the world, except in Africa and Australia. In Europe is found the *brown bear*, which

FIG. 35.—Hyena.

inhabits the Alps and the Pyrenees, and is not to be feared by man, as, like most other bears, he prefers fruits and honey to the flesh of herds. The *black bear* (Fig. 36) is found in considerable numbers in the northern districts of America. He leads a solitary life in the forests and uncultivated regions, and lives on fruits and on young shoots and roots of vegetables. He is exceedingly fond of honey, and, as he is an expert climber, he scales the loftiest trees in search of it. The *white* or *polar bear*, which is an inhabitant of Spitzbergen, Greenland, and of all the icy regions of the North (Fig. 37), is noted for its great ferocity. It is sometimes to be found many miles out at sea, floating on

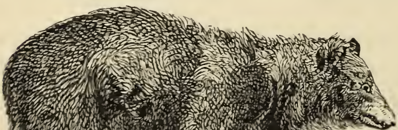


FIG. 36.—Black bear.

blocks of ice. It suffers exceedingly when taken to a warm temperature. It sometimes reaches a length of twelve feet. The large *grizzly bear* of North America is not so particular about his diet as the others, and regards human flesh as the most desirable food, and it is sometimes difficult to escape from his attacks. He is, perhaps, the most formidable of all bears in size and ferocity, being nearly twice the bulk of the black bear. He is well adapted for digging in the ground, but is not able to climb trees. He is to be found principally in the Rocky Mountains.


Fig. 37.—Polar bear.

[The *raccoon* (Fig. 38) is found throughout the United States. It is about twice the size of a large cat. Its color is grayish brown, with many black-tipped hairs, and the tail is ornamented with five black rings.]


Fig. 38.—Raccoon.

The *badger*, of the European forests, is in many respects like the bear; it is very fond of grapes, and will not turn up its nose at a chicken or a rabbit. It is a clumsy animal, with short, thick legs, and long claws on the fore-feet.

The greatest enemies of fowl and of small game are the *ferret*, the *marten*, the *weasel*, the *ermine* (Fig. 34), and the *polecat* (so called either for *Polish cat* or for *poultry-cat*, because it feeds on poultry. The American polecat is often called *mink*) (Fig. 34).* All these animals are slender creatures, and abound in the woods and hedges of Europe and America. In revenge for their depredations, they are hunted for their *skins*, but the finest *furs* are to be found in the coldest countries. In Siberia and British America, millions of dollars' worth of the furs of ermine, marten, and sable are sold every year.

Fig. 39.—Sea-otter.

The *otter* (Fig. 39), having also a long body, pursues and destroys fishes in our rivers and ponds. It is found in Europe and America, and is hunted for its fur.

17. Edentates.—The *Edentates*, or toothless animals, are so called from the absence of the incisive (fore) teeth, and sometimes of the canine or pointed teeth, and grinding teeth. They are a curious species of mammals, and are unknown in Europe. They feed on small insects, and have very little disposition to move about. The sloth and armadillo, natives of

* The American *skunk* is a different animal from the *polecat* here mentioned.

South America, are edentates. The most interesting member of this family is the *great ant-eater*, also a native of South America (Fig. 40). The ordinary length of this animal is about three feet seven inches, exclusive of the tail, which is about two feet six inches long, and the tongue, some fifteen inches long, which it sticks out of its mouth like a long, slime-covered worm, with which it entraps all the ants that come within its reach.

FIG. 40.—Ant-eater.

18. Rodents.—We are now through with the flesh-eaters, or, at least, the most interesting among them, and pass on to herb-eaters, or *Herbivores* (Latin *herba*, herb, and *vorare*, to devour).

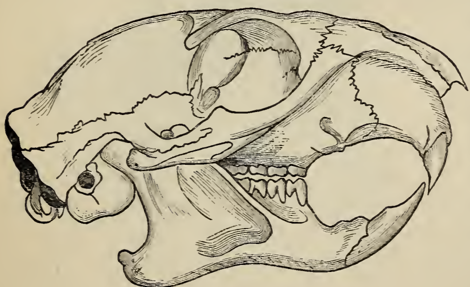


FIG. 41.—Side-view of the skull of a rodent.

The first species I will call your attention to are the *Rodents* (Fig. 41), or gnawing animals (from Latin *rodere*, to gnaw). Look at the head of a *rabbit*. In each jaw are two long teeth, which work upon each other by rubbing, in such a way as to *gnaw* whatever may come between them; the lower jaw works backward and forward so as to produce this gnawing.

Fig. 42.—Squirrel.

"Does not this constant rubbing wear out the teeth?" asked Paul.

"Yes, but they grow as fast as they wear away, and so always remain of the same length."

The principal *Rodents* that inhabit our country are the *squirrel* (Fig. 42), as quick in his movements as a monkey, so gay, so pretty, and so lively, in summer at least, for he sleeps in his nest during the whole winter, feeding upon the supply of nuts he has been provident enough to lay up for himself during the autumn. Then we have the *dormouse*, smaller but not less pretty than the squirrel, but more *hibernating* (or dormant) than he; the *rat*, the *field-mouse*, and the ordinary *mouse*, whose propensity for stealing has given them all such a bad reputation; the *hare* (Fig. 43) and the *rabbit*, so well known to everybody; the *marmot*, common to the Alps and

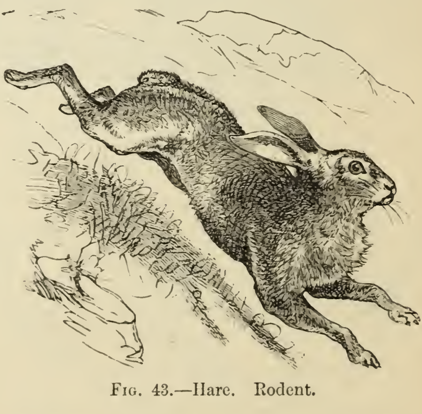


Fig. 43.—Hare. Rodent.

higher Pyrenees, and remarkable for its torpidity. The American marmot is the *woodchuck* (Fig. 44). [The *prairie-dogs* (Fig. 45) are burrowing rodents, and are found on the Western prairies of the United States. They live together in what are termed villages, and are quite neighborly with the burrowing-owl and the rattlesnake, both of which frequently share the same burrows with the prairie-dog. They get the name *dog* from the chirp or bark which they utter.]

Fig. 44.—Woodchuck.

The woodchuck, as well as the prairie-dog, bears a close resemblance to the marmot. The woodchuck is about twice the size of the common rabbit.

Fig. 45.—Prairie-dog, and the owl and snake that live in its burrow.

We must not forget the *beaver* (Fig. 46), which may be seen in Europe along the Rhône and the Danube, and on the Euphrates; but it is principally in North America that this large rodent is to be found. Here it lives in colonies, builds its dams upon rivers, puts up its lodges, cutting trees and wood with its strong teeth. The mud and stones used by beavers in their embankments are not carried on their tails, as has been supposed, nor do they use their tails as trowels for laying on the mud. The fact is, that the stones and mud are carried between their chin and

Fig. 46.—Beaver.

fore-paws, and the mistake respecting the tail is evidently caused by the slap that beavers give with it when they dive. They are valued for their fur, and for the material called *castor* obtained from two small bags in the groin of the animal. Its fur, which is mostly of a chestnut brown, is the material of which the best hats are made.

The *porcupine* is found in Africa, Tartary, Persia, India, and in Italy. It sometimes weighs as much as thirty pounds. Its body is covered with sharp prickles, or quills, some of which are twelve inches long, and capable of being erected at pleasure, and are used as weapons of defense. The American Indians use the quills extracted from the *Canada porcupine*, a species living on trees, for ornamenting various parts of their dress, especially their moccasins or shoes.

19. Horses.—*Horses* are true herbivores (grass- or herb-eating animals), as you well know; this can be readily ascertained by examining their back teeth. Instead of having sharp-pointed teeth like the insectivores, or incisors (or cutting teeth) like the carnivores (flesh-eaters), theirs are *flattened out*, which permits them to act as *grinders* (from their name *molars*, grinding-teeth), and to crush the grain and grasses (herbs) on which they feed.

What is especially common to horses is that each foot has but one *toe* (Fig. 47), ending in a sort of *horny substance*, which entirely covers the extremity, and is called a *hoof*.

FIG. 47.—Fore-foot of the horse.

FIG. 48.—Zebra.

The principal varieties of the horse family are: the horse, properly so called, the *ass*, the *quagga*, the *wild ass*, and the *zebra* (Fig. 48).

20. Ruminants.—You have, no doubt, all seen a cow or a sheep *ruminating* (chewing the cud, from *rumen*, the upper stomach of animals which chew the cud), that is to say, chewing without appearing to have anything to eat. Now, this is what is going on: These animals eat very fast and chew their food very imperfectly while doing so. When they are at rest, *they bring up from the stomach to the mouth little pellets of imperfectly chewed grass*, which they proceed to chew again at their leisure, until this thorough mastication has fitted it for digestion.

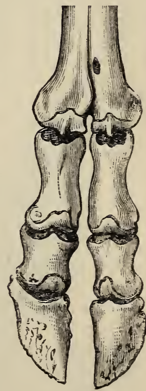


FIG. 49.—Fore-leg of the ox.

Nearly all the *Ruminants* are rather large in size ; some are even enormous. Their molars (grinding-teeth) are flat-

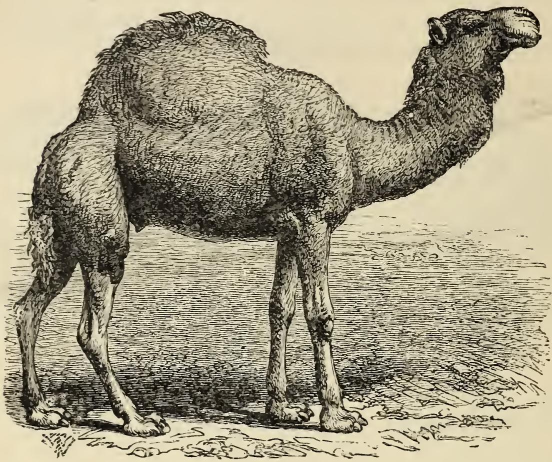


Fig. 50.—True camel.

tened like those of the horse ; their stomach is composed of several pouches (four stomachs), and it is this fact that enables them to *ruminate.* They have two toes on each foot, terminating in hoofs (the cloven hoof),(Fig. 49).

Fig. 51.—Llama.

I shall tell you first about the *camel*, of which two domesticated species are known — the *camel with one hump*, or *dromedary*, of Africa (Fig. 50), and the *camel with two humps*, which belongs to

Asia. Both of these animals are equally serviceable to man because of their strength and docility, and also because they are furnished with a bag formed as a reservoir to contain a larger quantity of water than is necessary for immediate use, and thus adapts them for crossing deserts, where a supply of water is rarely to be found.

Fig. 52.—Giraffe.

In South America may be found veritable little camels without hunches, one species of which, the *llama* (Fig. 51), has been domesticated and made very useful by the Indians.

The *giraffe* (Fig. 52) sometimes reaches a height of twenty feet from the hoofs to the top of the head. It is found only in Africa, and but one species is known.

The *deer* family, on the contrary, has a great variety of species, and may be found in Europe, Asia, and America. Their principal characteristic is that the males have *solid branched horns* (antlers), *which are shed and renewed every year.* Among the principal species may be mentioned the *red deer*, the *roe deer*, the *fallow deer*, of Europe (Fig. 53); the *elk* (Fig. 54), of the northern regions of

Fig. 53.—Fallow deer.

FIG. 54.—Elk, or Waipiti.

Europe and of the United States and Canada, which is as large as a horse; and the *reindeer*, the draught-horse of the icy regions, and the female of which, like the male, has branched horns. The *American moose* (Fig. 55) is the largest deer of America. It is found from the northern part of the United States to the Arctic Ocean, and is distinct from, though resembling, the *elk*.

FIG. 55.—Moose.

See, here is a cow's horn; it is a sort of *hollow sheath.* On the animal this *sheath* covers a bony protuberance of the forehead which fits into it exactly. *This protuberance and its sheath are never shed.* All ruminants having horns of this kind are called *hollow-horned ruminants.*


Fig. 56.—Bison.

Oxen are the largest animals of this kind, and the most interesting to know and to study. In Europe, Asia, Africa, and here in America, many species have been domesticated. There is still found in a wild state, even in Europe, a sort of big-headed, humpbacked variety roaming through the vast forests of Poland. This animal is very much like the *bison* (Fig. 56), sometimes erroneously called *buffalo.* The American *bison* is a very ferocious animal, with thick body and stout legs, short black horns rapidly tapering, and with hair much more thick and shaggy in winter than in summer. It is to be found especially in the neighborhood of the Rocky Mountains.


Fig. 57.—Chamois.

Sheep and *goats* are also

domestic animals. The former are prized for their wool and flesh. Goats are found wild in mountainous countries, as the Alps and Pyrenees, and wild sheep are to be found in Corsica.

Finally, the general name of *antelopes* is applied to other ruminants with hollow horns, very numerous and of various sizes, dwelling in countless herds in Africa, Asia, and North America. The African *gazelles* are celebrated. One species, belonging to southern Africa, travels in herds of twenty thousand head. The only species to be found in Europe is the *chamois* (Fig. 57) of the Alps and Pyrenees. The *prong-horn antelope* is found across the western part of North America, from the Rocky Mountains to the Pacific coast. The horns of the antelope are almost always rounded and annulated or ringed.

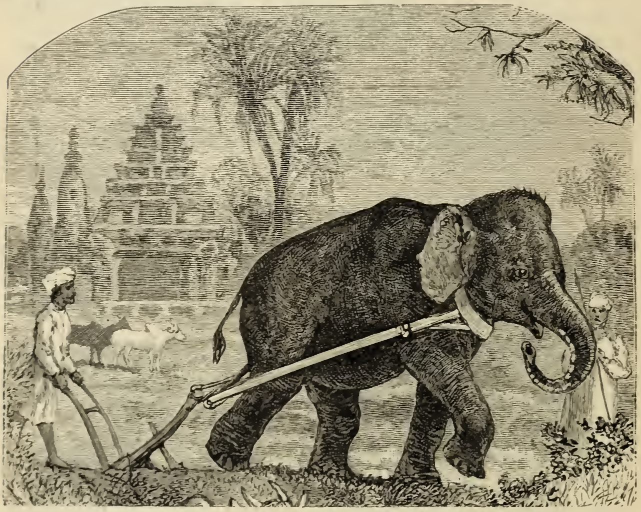


Fig. 58.—The elephant, showing how used by man.

21. Pachyderms.—The name of *pachyderms*, which means *thick-skinned*, is applied to mammals which have hoofs, but do not *ruminate*, and which are distinguished for the *thick-*

ness of their skins, and include the elephant, mastodon, hippopotamus, rhinoceros, hog, etc.

The *elephant* (Fig. 58) is the largest of terrestrial animals now living, and belongs to the tribe of *pachyderms*. It attains a weight of over 14,000 pounds, and when full grown is from seventeen to twenty feet high. Everything is strange in this enormous animal : the proboscis, or nose, is prolonged into a movable trunk, which it can stretch out from one to five feet, and with which it carries food and water to its mouth ; the two enormous teeth, or *tusks*, of the upper jaws, and which make such beautiful ivory ; its intelligence ; the facility with which it is tamed, the service it renders in carrying burdens, and the assistance it affords in the chase and in war, all combine to make it a most extraordinary animal. But two living species are known : one belongs to India and Ceylon, and is the only one domesticated up to this time ; the other, which has larger ears and an arched forehead, is a native of Africa. The negroes have never utilized it, but it was used by the Greeks and Romans, and could just as easily be used again.

Fig. 59.—Hippopotamus and young.

The *rhinoceros* is a pachydermatous mammal, closely allied to the elephant and the hippopotamus. It is characterized by having one and sometimes two very strong horns upon the nose. It is of great size, very powerful, and its skin is so thick that a rifle-ball will hardly pass through it.

The *hippopotamus* (Fig. 59) is also a very huge animal, larger and heavier than the rhinoceros, and moves very awkwardly on land. In the water, where it delights to be, it is quite agile and formidable. It has an enormous mouth, full of large teeth, which are used for ivory. The *hippopotamus* inhabits nearly all the large rivers of Africa, and in some cases has been found to measure seventeen feet.

22. Marsupials.—The continent of Australia, with the exception of the dog and a few varieties of the bat, produces no mammals resembling those of other parts of the world, except the opossum of America. *The mammals existing there have quite peculiar characteristics.*

Fig. 60.—Kangaroo.

As in most cases the young, immediately after birth, take refuge in a pouch (*marsupium* in Latin), situated under the mother's abdomen (belly), the name of *marsupials* is given to this group of animals.

Marsupials may be *carnivores*, or *flesh-eaters ; insectivores*, or *insect-eaters ;* and *herbivores*, or *herb-* or *grass-eaters.*

Among the latter the best known is the *kangaroo* (Fig. 60), a curious creature that, with the help of its long tail and enormous hind-legs, is enabled to make prodigious bounds, sometimes a rod at a time. The great *kangaroo* is nearly as tall as a man.

Another very peculiar mammal is the *ornithorhynchus*

(Fig. 61), sometimes called the *water-mole.* It is shaped like an otter, with a horny, flattened beak resembling that of a duck, and its paws are webbed and formed for swimming. The *ornithorhynchus* is not a marsupial. [It is the connecting

Fig. 61.—Duck-bill, or ornithorhynchus.

link between mammals and lower vertebrates, and is closely related to birds. It has been proved that this *mammal lays eggs*, two at a time, and which are about three fourths of an inch in length, and incased in a white shell.]

Only one of the marsupial group is to be found outside of Australia ; it is the *opossum*, a native of North America, and to be found nearly all over the United States. This little animal is *carnivorous*, and has a great fondness for chickens. It uses its tail in climbing and swinging from tree to tree, something after the manner of monkeys. It also makes its tail a support for its young, who sit on its back and wind their tails round their mother's to prevent them from falling off. The *opossum* is hunted for its flesh. When closely pursued it will be still and pretend to be dead (hence the expression "playing 'possum"), or, if the opportunity presents itself, it will drop among the herbage and creep silently away. Another species of the *opossum* is to be found in South America (Fig. 62).

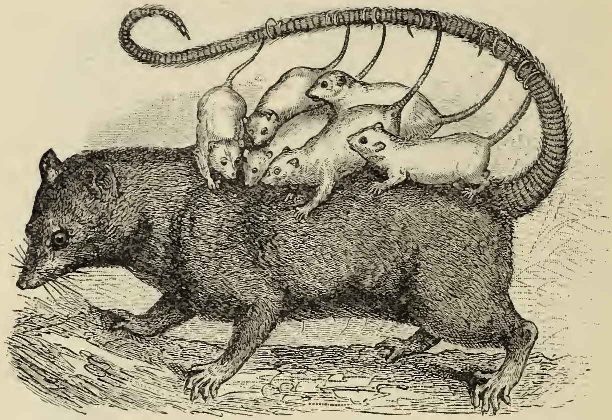


Fig. 62.—South American opossums. The female carrying its young upon its back.

23. Seals.—All the mammals that I have told you about up to this time live on land. True, the *otter* preys on fish ; the *hippopotamus*, as we have seen, passes a great part of its time

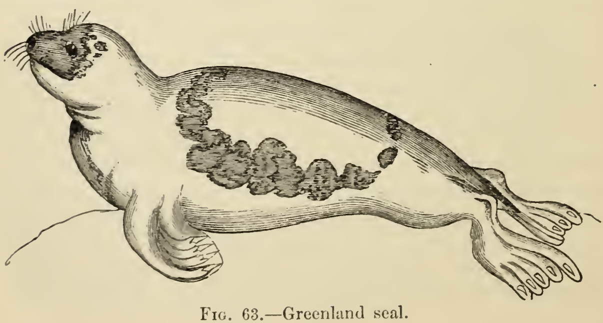


Fig. 63.—Greenland seal.

in the water; but, if they *are* fond of bathing, they all come ashore to walk and run about.

Such is not the case with the *seal* (Fig. 63), whose fore-feet are flattened out and serve as fins, and whose two hind-feet are used almost as the tail of a fish, to assist and direct its course; and it is with great difficulty that it can drag itself along the sand for a few feet from the water. Seals spend nearly their entire time in the water, and swim and dive with wonderful agility. They live on fish, are properly classed with carnivorous animals, and are to be found principally in the higher latitudes of both hemispheres, where they are caught in large numbers. In 1870 the fishermen on the Scottish coast killed 90,000 of these animals. The fat or oil of the seal is utilized, and the skin is manufactured into beautiful furs. Some seals reach a length of twenty-five or thirty feet.

In the northern seas are to be found, in herds, animals akin to the seal; these are known as the *walrus* (Fig. 64). They are especially noted for the two enormous *tusks* that project from the upper jaw and which extend downward for nearly two feet, and resemble the tusks of the elephant. *Walruses* are very formidable animals, are from fifteen to sixteen feet in length, and yield from twenty to thirty gallons of excellent oil. They are hunted for the sake of their skin and tusks, and, when attacked in the water, will gather in numbers, turn upon the boats, and sometimes, with the aid of their tusks, succeed in overturning them.

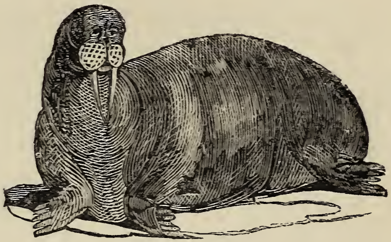


Fig. 64.—Walrus.

24. Cetaceans.—We have now come to the study of a class of mammals that can not stay on land even for the shortest time, and, if they should happen to be washed ashore by a storm, would soon die. These are called *Cetaceans* (Latin, *cetus*, a whale), and are divided into two groups, the *whales* (Fig. 65) and the *porpoises* (Latin, *porcus*, hog; *piscis*, fish).

"Many persons regard whales as fishes; now, if I were to tell you that the whale is a fish, what would you say, Paul?"

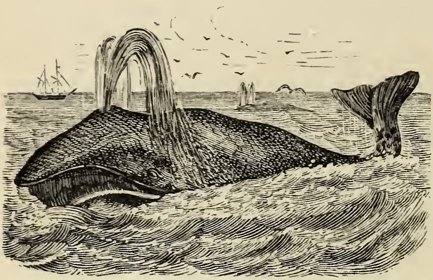


Fig. 65.—Right whale.

"I would say, sir, that *whales have no scales, but fishes have.*"

"That will do; but what else could you say?"

"Ah, sir! I can't tell whether the whale has warm or cold blood."

"*It has warm blood.*"

"Then, it is not a fish, which I certainly thought it was."

"No, it is not. Besides, *whales suckle their young*, and *are obliged to rise to the surface of the water to breathe.* They would be drowned if they stayed under water more than half an hour. The whale is, then, an *aërial* animal and a *mammal.*"

But the cetaceans are a very curious set of mammals. They have the form of a fish, the tail is flattened into a fin, but it is a horizontal fin and not a vertical one like the fish's. Their fore-feet form regular oars or fins, and they have no hind-legs.

Among *cetaceans* some have teeth and devour large quan-

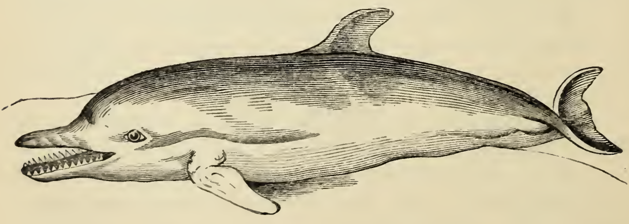


Fig. 66.—Common dolphin. Cetacea.

tities of fish. *Porpoises* and *dolphins* (Fig. 66) belong to this class. You may see the porpoise at any time along the coast.

A large cetacean, the *cachalot* or *spermaceti whale* (Fig. 67), has teeth on the lower jaw, and has a large, almost triangular, cavity in the right side of the nose, adapted for secret-

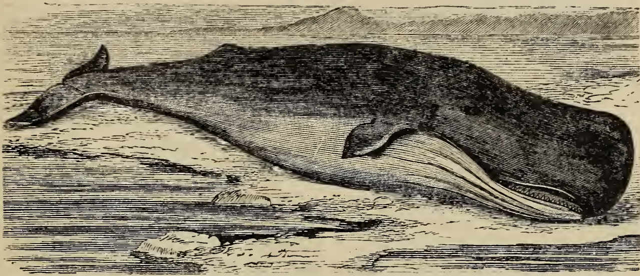


Fig. 67.—Spermaceti whale.

ing and containing an oily fluid which, after death, becomes a sort of granulated substance of a yellowish color, called spermaceti.

It sometimes reaches a length of from seventy to seventy-five feet, and is very dangerous. The fin-backed whale is probably the longest animal in creation, sometimes exceeding one hundred feet in length. Whales have been known to yield as much as twenty tons of pure oil.

Whales really have no teeth, only the upper jaw is furnished with barbs, long, flat, and flexible, called *fans*. These compose the *whalebone*, the longest spars of which are found to be not less than eighteen feet. Whales have been known to weigh 500,000 pounds, or about as much as forty elephants.

Huge as these animals are, they feed on very tiny little creatures that float in countless shoals on the surface of the ocean.

"But, please, sir, why don't the whale eat fishes?"

"Because its throat is so narrow that a herring could scarcely pass through it."

Whales are hunted for their whalebone and for the oily grease (blubber) that lines their skin and protects them from the cold.

SUMMARY.—Mammals.

1. **Mankind** (page 19).—**Man** is a mammal.

2. There are four principal races of men: the *white* Europeans, the *yellow* Asiatics, the *black* Africans, and the *red* American Indians.

3. There are also some *inferior races.*

4. **Monkeys** (page 21).—At the head of the **Monkey** family are three great species: the Asiatic *orang-outang*, and the African *gorilla* and *chimpanzee.*

5. The other kinds of monkeys are extremely numerous.

6. The large as well as the small species inhabit warm climates.

7. **Bats** (page 23).—**Bats** are mammals and not birds. They are covered with hair and not feathers; they have ears and teeth; the wings consist of a thin membrane, a prolongation of the skin of the back and breast sustained by the elongated bones of the fingers.

8. Bats sleep during the day. At night they leave their dark hiding-places and prey upon insects. Being useful in this way to farmers, they ought to be protected.

9. **Insectivores** (page 24).—Other *Insectivores*, that have no wings, feed on insects; they are small in size, such as the *hedgehog*, which is covered with bristles; the *field-mouse*, with its sharp nose; and the *mole*, which does not destroy the roots of plants, but devours large quantities of white worms.

10. **Carnivores** (page 25).—**Carnivores** (from the Latin *carno, carnis*, flesh) feed on flesh.

11. They have strong paws armed with sharp and piercing nails; their mouth is set with long, strong, and pointed teeth.

12. The most prominent type of hunters is the genus **Cat** (page 25). The *tiger*, the most formidable of fierce animals; the *lion*, the *panther*, and the *jaguar*—all three less dangerous to man than the tiger—are nothing but large cats.

13. After cats come **Dogs** (page 28), akin to which are the *wolf*, to be feared in Asia and Russia; the *fox*, and the *jackal*, well-known poachers on the hen-roost.

14. **Hyenas** (page 29) prefer dead to live flesh.

15. The **brown bear** (page 29), of the Alps and the Pyrenees, prefers fruit and honey to human or animal flesh. The *bear* of the polar regions and the *grizzly bear* of North America, on the contrary, regard man as a choice morsel.

16. **Edentates** (page 32), which have few or no teeth, are unknown in Europe. The most interesting of these is the *great ant-eater*, whose

long, worm-like, and slime-covered tongue entraps all ants that come near it.

17. **Herbivores** (page 33) are herb- or grass-eaters.

18. **Rodents.**—The most prominent among these (page 33) are *rabbits, squirrels, rats, mice, marmots, beavers*, etc.

19. The **Horse** (page 36) tribe, to which belongs the ass, have *flat back teeth;* they have but one *toe* on each foot, which ends in a sort of horny substance which entirely covers the extremity and which is called a *hoof.*

20. **Ruminants** (page 37) are so called because they *ruminate*, that is, chew without appearing to have anything to eat; this is chewing the cud.

21. The molar teeth of ruminants are flattened like those of the horse; they have four stomachs or pouches; they have *two toes* on each foot, terminating in hoofs.

22. Ruminants comprise: the *camel with one hump*, or dromedary of Africa; and the *camel with two humps*, which belongs to Asia; they do the same work there as horses do here; the *llama*, of South America, domesticated by the Indians; the *giraffe*, of Africa, that stands twenty feet high; the *deer*, *roe-deer*, *fallow deer*, *elk*, *moose*, and *reindeer*, the latter belonging to the polar regions, all of which have *solid branched horns* (*antlers*), *shed and renewed every year; oxen; bisons*, to be found in the Rocky Mountain regions of North America; *sheep* and *goats; antelopes;* the *chamois*, of the Alps and of the Pyrenees; all have hollow, permanent horns (that are not renewed).

23. **Elephants** (page 42) are the largest terrestrial animals now living. They are very useful for carrying burdens. The African species is wild, and the Asiatic species has been domesticated.

24. **Pachyderms** (page 42), thick-skinned animals, include the *wild boar*, from which springs the domestic hog; the *rhinoceros* and the *hippopotamus*, of Africa, and others.

25. **Marsupials** (page 44), nearly all found in Australia, have a pouch (*marsupium*) under the belly, in which they protect their young. The best known is the *kangaroo.* The *opossum*, which belongs to this group, is a native of America.

26. **Seals** (page 46) live almost entirely in the water. They live in herds along northern shores, and are hunted for their oil and fur. The *morse*, or *walrus*, with its two long tusks, is classed with the seal.

27. **Cetaceans** (page 47) comprise *porpoises*, *dolphins*, *spermaceti whales*, and *whales* in general.

28. *Whales* are not fishes. They have no scales, fishes have; they are *warm-blooded*, fishes are not; they suckle their young, and would

drown if they were to stay under water more than half an hour; they are *mammals* and *aërial* animals.

29. *Whales* have no teeth; their upper jaw is filled with long, flat, flexible barbs, called *fans*, and commonly known as *whalebone;* their throats are exceedingly narrow. Other cetaceans have teeth.

(Simple subjects for COMPOSITION will be found on page 99.)

VERTEBRATES.—2. **Birds.**

25. Birds.—Birds, as I have already told you, are easily recognized; they have a beak, feathers, two wings, and two feet.

The *beak*, which you can readily see by examining a chicken's head, is simply a sort of horny sheath which covers the two jaws.

The *feathers*, when fully developed, have a long, narrow barrel by which they are imbedded in the skin, and a stalk, each side of which bears a *vane* or web consisting of a number of little *barbs*, which frequently, in their turn, as in this goose's feather, have other smaller barbs or barbules. All these barbs are strongly interwoven together. But feathers are not always so complete.

The wings are ordinarily strong enough to allow the bird to fly. Some birds, however, such as ostriches, have such short wings that they can not rise from the ground. Others use them as fins for swimming under water.

All birds lay eggs, and most of them build *nests*. Eggs are composed principally of a *stony* (*calcareous*, *limy*) *shell*, of a *white* part and of a *yellow* part. Here are two hen's eggs. I break the raw one, and, as you see, the contents are spread all over this plate. Do you notice that little white speck in the yellow? Now, that is the *germ*, and it would have become a little chicken had we allowed it to be hatched. This other egg is boiled *hard*. I take off the shell and cut it in two; you see the position of the yellow or *yolk*, and the white or *albumen* (from Latin *albus*, white).

When an egg is kept in a warm place for some weeks, a little bird is formed in the *germ;* it grows, gradually absorbs the *yolk* and the *white*, and finally fills the egg and breaks the shell (pierces it with its beak). Sometimes it comes out of this shell blind and almost motionless, like the little *pigeon;* at other times it comes out full of life, seeking for food and able to move about like the chick (Fig. 68), or to swim like the duck.

Fig. 68.—Coming out into the world.

Ordinarily the mother-bird furnishes the heat necessary for the hatching of the eggs ; she sits upon them, and builds the nest in which the eggs and little ones will be warm and sheltered. The greatest variety is to be found in the size and shape of these nests. But you must know that eggs can also be hatched by artificial means, in a particular kind of *box* sometimes called the *eccaleobion-machine* (from Greek *ékkaleo*, I call, and *bios*, life). The Egyptians called these boxes *mammals.* They are now called *incubators.*

I have something more to tell you about birds. There are some that *travel*, or *migrate*, regularly every year. Thus, *swallows* come to us every spring to lay their eggs, and when winter comes and insects become scarce, they go off to a warmer climate. The *bluebird*, the *nightingale*, the *robin*, *bobolink*, and many others do the same. There are others again that never visit us except in winter, when the excessive cold drives them from the North ; wild ducks and wild geese belong to this class. Let us now take up the principal groups of birds.

26. Birds of Prey.—There are birds that live entirely upon the *flesh* of other birds, mammals, and reptiles ; and for this reason they are called *birds of prey.* They are admirably equipped for their work of destruction, having hooked and sharp *beaks*, long and sharp claws, called *talons*, and long, pointed *wings* (Fig. 69). They can fly so long and so rapidly that a falcon, lost one day in the forest of Fontainebleau, near

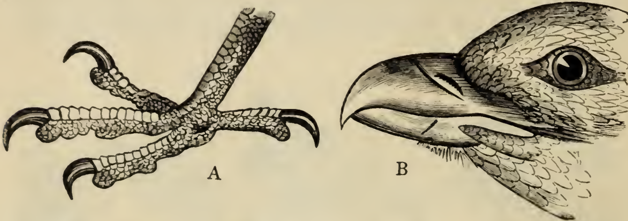


Fig. 69.—Raptores. A, Foot of Peregrine falcon. B, Head of buzzard.

Paris, was found on the following day at Malta, more than a thousand miles away.

There are birds of prey that hunt for their food in the daytime, and they are, for this reason, called *diurnal* (from *dies*, day); others that hunt for it at night, and these are called *nocturnal* (from *nox*, *noctis*, night).

Fig. 70.—Bald eagle.

Among the *diurnal* birds may be mentioned the *vulture*, that feeds on the flesh of dead animals. Very large varieties of these birds are to be found in the mountainous regions of Europe. In warm countries they do good service in removing carrion that would otherwise poison the air. The *condor* of South America is the largest of birds that fly, measuring sometimes as much as

Fig. 71.—Peregrine falcon.

Fig. 72.—Night-hawk, feeding on the wing.

from twelve to fourteen feet from tip to tip of its outspread wings. The *gypætos* or *lammergeyer* of the Alps is almost as large. *Eagles* (Fig. 70) have stronger beaks and talons than vultures, and are bolder; they feed on live prey. The *bald* or *white-headed eagle* is found in various parts of North America, and was at one time very common in the vicinity of Niagara Falls. It will often steal young pigs and carry them alive to its nest. *Falcons* (Fig. 71), in proportion to their size, are stronger and more courageous

Fig. 73.—Turkey buzzard of America.

than eagles. In days gone by, they were trained for the chase, and they are still used for this purpose in Algeria and in the East. The *hawk* (Fig. 72), the *buzzard* (Fig. 73)—the scavenger of some of our Southern cities—the *sparrow-hawk*, and the *kite*, are not so strong as the birds of this family already mentioned.

Fig. 74.—Horned owl.

Nocturnal birds of prey have very soft plumage, which allows them to fly without noise. The openings of their ears are very large, their eyes full and round, and directed toward the front. These come under the generic name of *owl.* Some species have erectile tufts on the head, and are called *horned owls* (Fig. 74). The *screech-* or *barn-owl* is of a rusty-red color mottled with white. Owls feed on rats, mice, and other destructive little mammals; they should, therefore, be protected, and not nailed up on barn-doors, as is sometimes foolishly done.

27. Parrots.—Parrots (Fig. 75) are characterized by their short, hooked bill, and fleshy tongue, which is capable of uttering words. Their toes, two of which are turned forward,

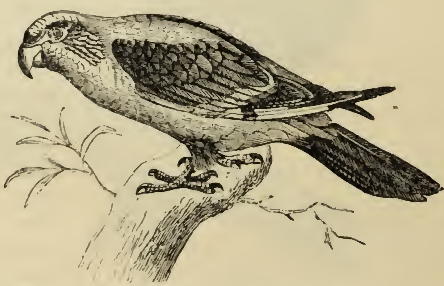


Fig. 75.—Parrot.

and two backward, enabling them, with the assistance of their bill, to climb with ease. Their remarkable intelligence has, more or less justly, earned for them the name of bird-monkeys. Like monkeys, they are only to be found in warm countries, and they people the intertropical forests of both hemispheres with their noisy flocks.

Fig. 76.—Peacock.

28. Gallinaceans. — The name *Gallinaceans* (from the Latin *gallina*, a hen) is given to the birds of this group because of their resemblance, more or less, to the *hen*, which has been taken as a type. They are grain-eating birds. Our *hens* appear to have come originally from India, to which we are also indebted for the *pheasant* and the *peacock* (Fig. 76); and the *turkey* and *prairie-chicken* (Fig. 77) belong to North America, where the *quail* (Fig. 78), which is closely

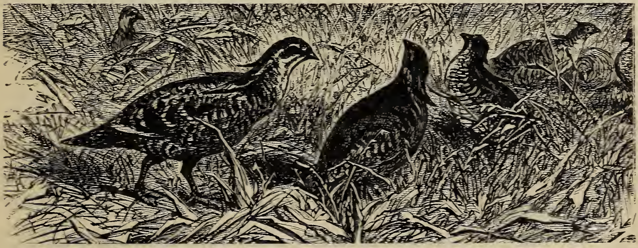


Fig. 77.—Prairie chicken.

allied to the partridge of Europe, may also be found. The *Guinea-hen* (Fig. 79) comes from Africa.


Fig. 78.—American quail.


Fig. 79.—Guinea fowl.

29. Pigeons.—Pigeons are neither numerous nor varied in species (Fig. 80). In this country we have the *ring-dove* or *wood-pigeon*, the *carrier-dove*, the *turtle-dove*, the *wild pigeon*, and the *stock-dove*, which has been domesticated.


Fig. 80.—Dove.

30. Waders.—Waders are so called because of their long, naked legs, which have the appearance of stilts. They are mostly marsh-birds, that wade through mud and water. [The front toes, which are three in number, are never completely webbed, as in the duck, but along the toes there are partial webs, which spread out and prevent these birds from sinking so far into the mud. Their wings are long, and their power of flight is great.] They have long necks and beaks, which enable them to catch the little animals on which they feed without stooping. The best known are the *heron*, the *crane*, the *lapwing*, the *curlew* (Fig. 81), the *snipe*, the *gallinule* or *water-fowl*, the *rail*, the *plover*, the *woodcock* (Fig. 82), the *flamingo*, and the *stork*.

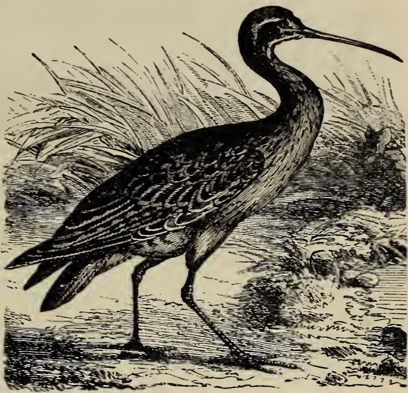


Fig. 81.—Curlew.

31. Ostriches.—Ostriches (Fig. 83) are large African birds whose wings are too short for flying, and serve rather for sails than for flight, so that their movement at full speed has more the appearance of sailing than running, and the swiftest horse is unable to overtake them. Their feathers are highly prized. The ostrich has two toes on each foot, both turned forward; it is the tallest of birds, being seven or eight feet high when standing erect.

Fig. 82.—American woodcock, bill two and a half inches long.

Fig. 83.—Ostrich.

The *nandu* (also sometimes written *nandow*), known as the *rhea*, is the American ostrich, and inhabits South America. It is not so large as the African ostrich, and has three toes. The *cassowary* (Fig. 84), a native of Malacca, Java, and the adjacent islands, is shorter and stouter than the ostrich, and, next to it, is the largest living bird.

Fig. 84.—Cassowary.

Large as these birds are, they seem small enough when compared with those of a species, closely allied to the casso wary, which the savages of Madagascar and New Zealand have entirely exterminated. All that remains of them are a few bones and some eggs. But what eggs! One alone is equal to six ostrich-eggs, or one hundred and fifty ordinary hen-eggs.

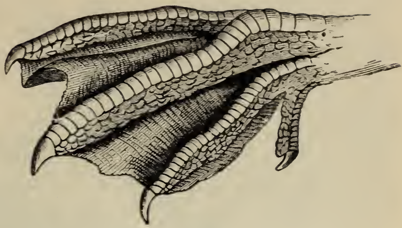


Fig. 85.—Foot of the domestic goose.

32. Palmipeds.—Palmipeds, as their name implies (Latin *palma*, the palm of the hand, and *pes*, *pedis*, a foot), have *palmated* or webbed feet (Fig. 85); that is to say, their toes are connected together by a skin or membrane (web). This allows them to swim with ease. Look at the duck's foot: when the bird throws it forward, it folds up and moves freely through the water, without interference; when it is pushed backward, it spreads out, resists, and so acts that the bird is pushed forward.

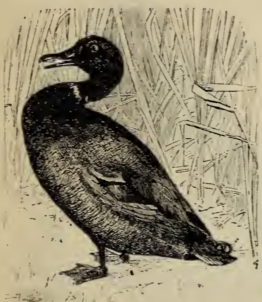


Fig. 86.—Duck.

Fig. 87.—Black swan of Australia.

Ducks (Fig. 86), *geese*, and *swans* (Fig. 87) are **Palmipeds**, that swim with perfect ease, fly very well, but walk very awkwardly. They have a broad beak, laminated or bladed, and not toothed. The *sea-gulls*, that are rarely seen away

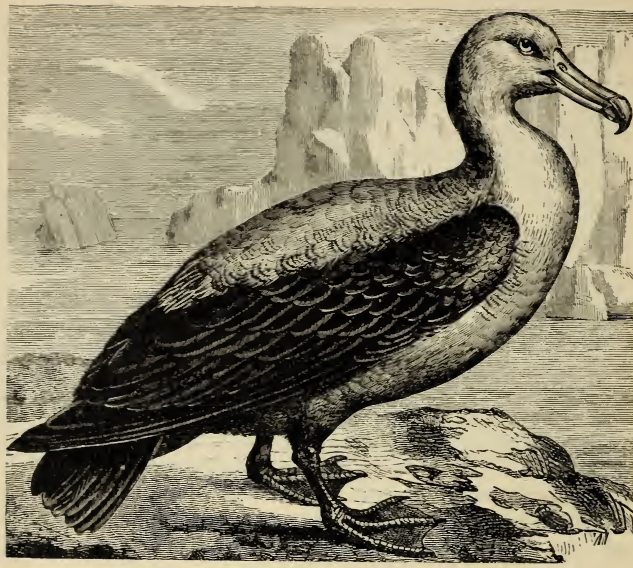


FIG. 88.—Albatross.

from the seashore, and the enormous *albatross* (Fig. 88), of the southern seas, have pointed bills, and fly with ease. The *pelican* (Fig. 89) and the *cormorant* (Fig. 90) have a web or membrane which envelops not only the three foretoes, as in the

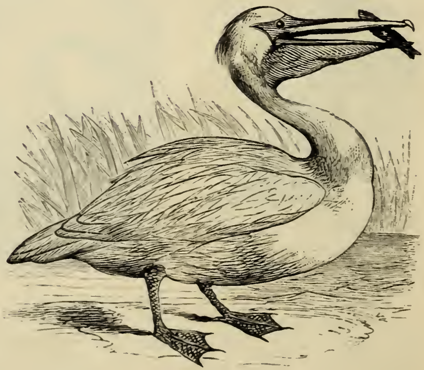


FIG. 89.—Pelican.

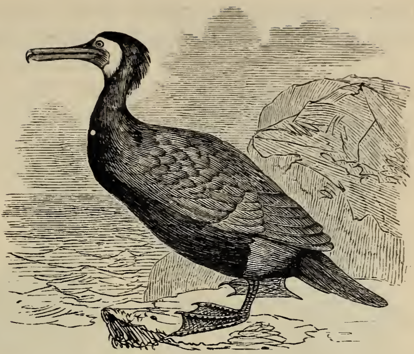


Fig. 90.—Cormorant.

duck, but also the first or great toe.

All along the South temperate and frigid seas are to be seen myriads of *penguins* (Fig. 91), where they represent the *auk* of the North. Neither of these species can fly, not because their wings are too weak to bear them, as is the case with the ostrich, but because they have no real feathers, and the penguin tribe only use their wings for swimming under water. [Special interest attaches to the *great auk* (Fig. 92) or gare-fowl of the North.

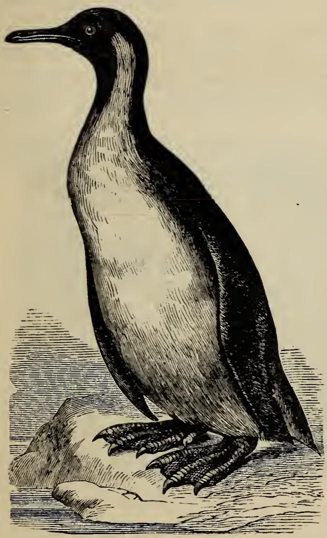


Fig. 91.—Penguin.

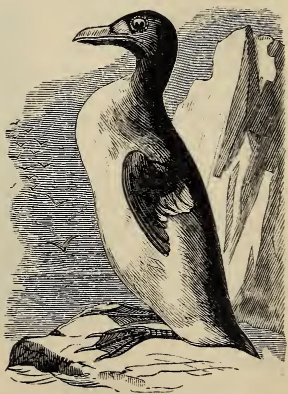


Fig. 92.—Great auk.

from the circumstance that there is no reliable record of its having been taken, or even seen alive, since 1870. At one time this bird was found on the coast of Maine. The Museum of Natural History of New York paid $650 for one specimen. Its length was about three feet and its wings four inches.

FIG. 93.—Woodpecker.

FIG. 94.—Robin.

33. Passeres.—Under the common head of *passeres* (Latin, *passer*, a *sparrow*) are included many species of birds which are neither *birds of prey* nor *palmipeds*.

Some *passeres* have two toes in front and two behind, and are admirably adapted for climbing up the trunks of trees. To this class belongs the *woodpecker* (Fig. 93), unjustly accused of injuring trees, as it only picks the holes already made by insects.

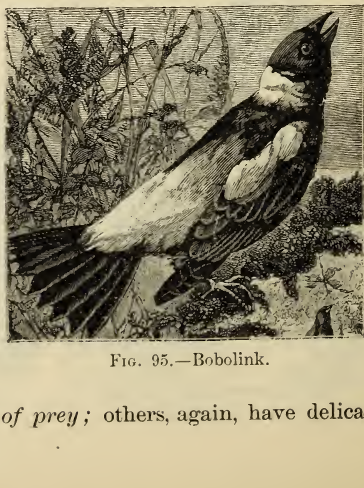


FIG. 95.—Bobolink.

Some *passeres* have hooked bills like *birds of prey;* others, again, have delicate and sometimes very long bills, by which they catch insects, such as *nightingales*, and *robins* (Fig. 94), and the *humming-bird*, so brilliant and so little that the smallest of them is not much larger than a good-sized bee. Others have beaks with wide gapes, like the *swallow*, and admirably adapted for catching gnats. Still others have thick, short, and strong beaks, with which they eat seeds or grain, like the *lark*, the *bullfinch*, the *bobolink* (Fig. 95), and others. Some have thick beaks, a sort of pickaxe, with which they turn up the ground and tear their dead prey to pieces, like *magpies*, *jays*, *crows* (Fig. 96), etc. The very interesting and varied group of passeres consists of a large number of species.

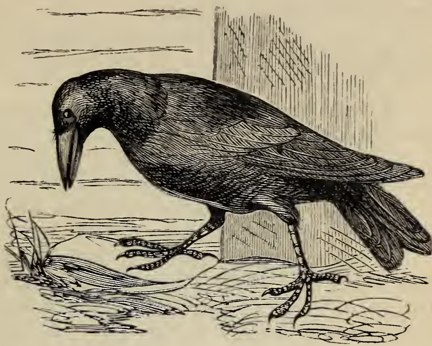


FIG. 96.—CROW.

SUMMARY.—BIRDS.

1. **Generalities** (page 52).—**Birds** have a horny *beak*, feathers, two feet, two wings, and lay eggs.

2. Eggs have a stony (*calcareous*, limy) shell, a *white* part (*albumen*), and a yellow part, the *yolk*. The yolk contains a little white speck called the *germ*, which becomes the little bird when hatched.

3. Ordinarily, the hen furnishes the necessary heat for hatching: but eggs can be hatched by artificial means.

4. **Birds of prey** (page 53) have a sharp, hooked bill; long, sharp nails called claws, or *talons;* long, pointed wings, and fly with great force and rapidity.

5. Those that hunt their prey in the daytime are called *diurnal*, and those that hunt at night are called *nocturnal*.

6. Among the *diurnal* birds are *vultures*, that feed on dead animals;

eagles, that feed on live animals ; and *falcons*, that were, in times gone by, trained for the chase.

7. Among *nocturnal* birds of prey are different varieties of *owls*: horned-owls, screech-owls, etc.

8. Owls of all kinds destroy rats and mice ; they should, therefore, be protected and not mutilated, as is sometimes done.

9. **Parrots** (page 56) live in warm countries.

10. **Gallinaceans** (page 57) are birds that bear more or less resemblance to the chicken, like *turkeys*, *pheasants*, *partridges*, etc.

11. **Pigeons** (page 58) in our country include *wild* and *domestic* pigeons, *ring-doves* and *turtle-doves*.

12. **Waders** (page 58) are perched upon long legs ; the best known are *storks*, *herons*, *cranes*, *snipe*, etc.

13. **Ostriches** (page 59) are large birds found in Africa. There is a South American species. Their wings are too short to fly with, but they run with great rapidity.

14. **Palmipeds** (page 61) have, as their name implies, *palmated feet ;* that is, their toes are connected together by a membrane or web, which enables them to swim with ease. *Ducks*, *geese*, and *swans* are *palmipeds.*

15. **Passeres** (Latin, *passer*, a *sparrow*) (page 64).—These include a great variety of species : *blackbirds*, *nightingales*, *larks*, *crows*, etc.

(Simple subjects for Composition on page 99.)

VERTEBRATES.—3. **Reptiles.**

33. **Reptiles** differ very much from one another in form. *Tortoises* have a horny beak like that of a bird, four feet, and a carapace in which their body is inclosed ; *lizards* have teeth and feet, but no outer shell ; *serpents* have no limbs. All reptiles lay eggs very much like those of birds, except that the shell is horny instead of limy.

34. **Tortoises** (from Latin *tortis*, twisted, so called from its crooked feet).—Some *tortoises* live on land, some in marshes and in fresh water, and others, again, live in the sea. *Sea-tortoises* or turtles, large specimens of which are found along our coasts, some nearly six feet long, have a flat carapace or upper shell, united to an under shell or *plastron* by certain bones, leaving openings for the head and limbs. These shells offer little resistance to the water, and by the aid of their long, flattened limbs or flippers, turtles can move through the water with ease and rapidity. Great multitudes of these turtles resort to certain parts of the American coast (the green turtle (Fig. 97) in the West Indies) to lay their eggs, and are cap-

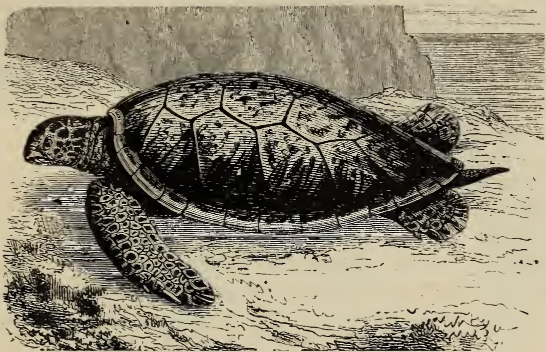


Fig. 97.—Green turtle.

tured there for their eggs, their flesh, and their shell. The tortoise-shell of commerce is almost entirely obtained from the hawk's-bill turtle.

Land-tortoises have very short legs and a more convex carapace, so strong that a man may stand upon the back of a tortoise, three or four inches long, without crushing it. Some are found in Africa over three feet long.

Fresh-water tortoises are, in form, between the land and the sea turtle. Some of them are very small. No doubt, you have seen some of these reptiles in public and private *aquaria*.

35. Lizards.—The largest animals of the lizard group are *crocodiles* and *alligators*. The former is an inhabitant of the Old World, the latter of the New World. They are both large enough and strong enough to be dangerous to man. Of all monsters they have the largest mouth, and move both the jaws equally. The crocodile has no true tongue. The *alligator* (Fig. 98) is common in the rivers of some of our Southern

States. Its head is shorter and broader than the crocodile's, and its feet are much less webbed.

Most members of the lizard tribe are perfectly harmless. There are a great many species, and among the most curious is the *chameleon* (Fig. 99). Its color changes more or less with the color of the objects around it, or with its temper when disturbed. In a cool, dark place it is nearly white or grayish; on admitting the light, it changes to brown, bottle-green, or blood-red, of various shades, and more or less mottled in arrangement. It is chiefly found in Asia and Africa; also in Spain and New South Wales.

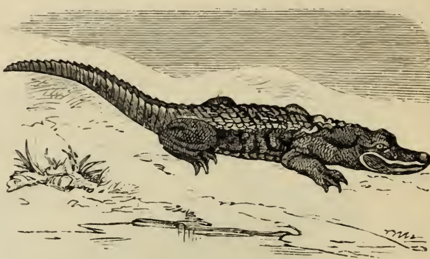


Fig. 98.—Alligator.

Fig. 99.—Chameleon.

Among the lizards of America may be mentioned the *Gila monster* (Fig. 100) of Arizona, the only poisonous one found in the United States, the *glass-snakes*, also of the United States, and the *iguana* of South America and the West Indies.

The *horned lizard* (Fig. 101) is often improperly called a toad. It runs with great rapidity, but does not jump like the toad. Lizards are to be found in all warm climates

Fig. 100.—Gila monster, a poisonous lizard.

except Australia. Lizards are very peculiar in this respect: the tail is so brittle that it is easily broken (Fig. 102). A glove or any other light object thrown upon it will break off portions of it. These detached pieces will squirm for some time after the body has left it, but, *what is still more curious is, that the stump soon grows out to its natural size.*

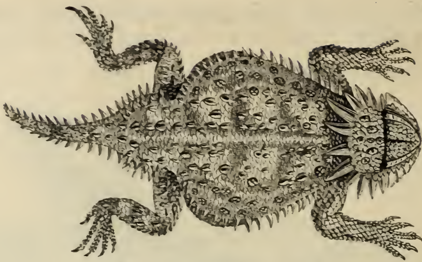


Fig. 101.—Horned lizard.

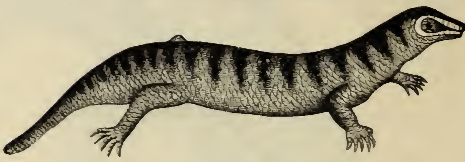


Fig. 102.—Skink—a lizard.

36. Serpents (from Latin *serpere*, to creep).—There are serpents or snakes whose bite, accompanied by the emission of a poisonous liquid, called *venom*, is attended with consequences more or less disastrous, often mortal; these are called *venomous serpents*.

Fig. 103.—Water-boa or anaconda.

Others do not bite, but coil themselves around their prey; these are only dangerous when very large. The *boa* (Fig. 103) of South America, the *python* of Africa, and some other species, some reaching a length of thirty-six feet, belong to this class. The *boa* watches for its prey, when with one spring it fixes its teeth in the creature's head, coils its body round its victim, crushes it


FIG. 104.—Rattlesnake.

to an almost shapeless mass, and then swallows it entire, even though the animal may be larger than the serpent. It then lies torpid for nearly a month, until its enormous meal has been digested, when it goes in search of another.

The *rattlesnake* (Fig. 104) is one of the best-known American snakes. It is of a yellowish-brown color, and has a series of horny joints at the end of the tail, which make a rattling sound, and which give its name to the snake. The *black-snake* of the Alleghanies is sometimes seven or eight feet long. The *copperhead* and the *moccasin* are American snakes, whose bite is venomous.

There is but one venomous serpent known in Europe, the *viper*, and it is one of the least dangerous. The venom is a liquid that is collected in a small pouch at the root of a very long, sharp tooth, in which there is an opening, through which the venom is carried. When this creature bites, the tooth presses upon the pouch, and a drop of venom is forced through the opening and is injected into the wound. When this tooth is pulled out (and there are two of them, one on each side), as is frequently done by so-called snake-charmers, the bite of the viper is perfectly harmless. The flesh of the viper is good for food, and broth made from it is said to be an excellent cure for dangerous maladies.

The venom of the viper causes fever, great inflammation, sometimes gangrene, and even death. But this venom is nothing when compared to that of the *horned viper* of Algeria, the *rattlesnake* (Fig. 105) of America, or the *cobra* of India, whose bite is nearly always followed by speedy death. Twenty-six thousand persons perished in British India alone from the bite of the *cobra de capello* (hooded serpent) in 1875. The country swarms with them, and the *cobra*, unlike the rattlesnake, gives no warning of its approach.

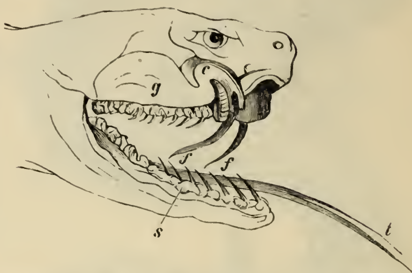


FIG. 105.—Jaw of a rattlesnake. *ff*, Poison fangs. *g*, Gland secreting poison. *c*, Canal leading from gland to base of fang. *t*, Harmless tongue. *s*, Saliva glands.

SUMMARY.—REPTILES.

1. **Reptiles** differ very much from one another in form. They comprise *tortoises*, *lizards*, and *serpents*.

2. **Tortoises** (page 66) have a horny beak, like a bird's, four feet, and a shell in which they are more or less incased.

3. Some live on land, some in marshes, and in fresh water; others, again, in the sea. The latter often reach a length of six feet.

4. **Lizards** (page 67).—*Crocodiles*, the largest of the lizard family, are sometimes over twenty-four feet long, and are dangerous. The *alligator* resembles the *crocodile*, but is a different animal. He is found in the United States.

5. Most *lizards* are harmless.

6. The *chameleon*, of Algeria, changes its color according to its humor and circumstances.

7. Ordinary lizards have very brittle tails, which break off easily, but soon grow out again.

8. **Serpents** (page 70).—Some are venomous, and others are not.

9. Among non-venomous serpents are the *boa* of South America, and the *pythons* of Africa. Some of these serpents reach a length of

thirty-six feet ; they coil themselves around their victims and suffocate them.

10. The *venom* of *vipers* causes fever, great inflammation, sometimes gangrene, and even death.

This venom is secreted in a pouch near the root of a tooth having a very small opening. When the serpent bites, the tooth presses upon the pouch and forces a drop of this liquid through the opening in the tooth into the wound.

(Simple subjects for COMPOSITION on page 99.)

VERTEBRATES.—4. **Amphibians.**

37. Metamorphosis of Amphibians.—We know that the animals of this group are *aquatic* in their primary state, and *aërial* when fully developed. They present some very curious changes in their forms ; these changes are called *metamorphoses* (from two Greek words meaning *to be transformed*).

Metamorphoses are most to be found among *toads*, *frogs*, and *tree-frogs*.

"You have all seen frogs' eggs ; now tell me, have you ever seen any with shells ?"

"No, sir, they have no shells ; you have told us that they are bare and soft, like the skin of the amphibians themselves."

"Quite right. Now you must learn something more. After a certain time, a little black creature comes out of it, which in a few days becomes very nimble. It soon grows, and displays a long tail, a body united to the head, and looks very much like a ball. (See Fig. 18.) Who can tell what it is called when in this shape ?"

"It is a *tadpole*, sir."

"Right again."

"As yet, it has no legs ; but these soon make their appearance, very small in the beginning, and the hind ones first. All this time the tail is gradually disappearing, and by the time it is entirely gone, four full-sized legs have grown out from the body. From a *tadpole* it has been transformed or changed into a *toad* or *frog*. In its tadpole state it was necessarily a water animal, but after its change has taken place, it is not able to live under water for any length of time, and is forced to come to the surface to breathe. From an *aquatic* it has become an *aërial;* from an *herbivorous* creature it has become a *carnivorous* — flesh-eating creature. Is not this really extraordinary?"

"Yes, sir, the frog is a very interesting animal."

"Do you know of any other species of frogs?"

"The *tree-frog.*"

FIG. 106.—Newt.

The tree-frog is a very peculiar animal. It has the ends of its toes expanded into rounded, viscous (sticky) surfaces, by means of which it climbs trees and sticks to the under side of smooth surfaces, like flies upon a ceiling.

Other *amphibians* have less complete transformations. *Tritons*, or newts (Fig. 106), a species of aquatic salamanders, retain their tails through life.

39. Usefulness of Toads; their Venom.—Toads harm only insects, worms, and snails, which they devour in large quantities. In some countries toads are destroyed with a cruel and superstitious stupidity. You will, perhaps, be surprised when I tell you that they are imported into Australia from Europe, and are regarded as the guardians of the garden.

But, if I advise you to respect the toad, I do not urge you to handle or touch it. Look at this one which I am about to take hold of with a pair of tongs. It seems to be in a very bad humor. Do you notice, all over its back and especially on its neck, those little white drops which ooze out of the pores of its skin? This is *venom, and it is a very quick and pernicious venom.* This drop, which looks like milk, and which I have scraped off the toad's back with my penknife, if injected under the skin of a chicken, would kill it in a very short time ; so you see it is quite a serious matter.

All amphibians, even frogs, have venom in their skins. If you should happen to rub your eyes after handling a frog they would smart severely.

SUMMARY.—Amphibians.

1. **Metamorphoses** (page 73).—Amphibians, *aquatic* when young, become *aërial* when fully developed, and undergo transformations in form known as *metamorphoses.*

2. In their primary state they are *tadpoles*, having a large head, long tail, and no legs. Later on they develop into *frogs* or *toads*, with no tail and four legs.

3. Toads secrete a venom which they can not inoculate. To make up for this they do us good service by devouring insects, worms, and snails.

(Simple subjects for Composition on page 99.)

VERTEBRATES.—5. **Fishes.**

40. Fishes are absolutely aquatic all their lives. If taken out of the water they perish, either quickly like the *perch*, or slowly like the *eel* or *cat-fish*, but they all perish sooner or later.

41. **Migratory Fishes.**—There are *fresh-water fishes* and *salt-water fishes.* Were a *fresh-water* fish to be transported suddenly into salt water, or a salt-water fish into fresh water, it would soon die. But they can be accustomed to the change if it is done little by little and with care.

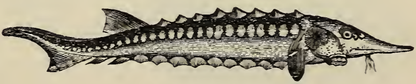


Fig. 107.—Sturgeon.

This fact accounts for *migratory* fishes (from Latin *migrare*, to remove from one place to another). *Salmon* (Fig. 114), *sturgeons* (Fig. 107), the *lamprey* (Fig. 116), and the *shad* leave the sea and go up rivers, where they remain

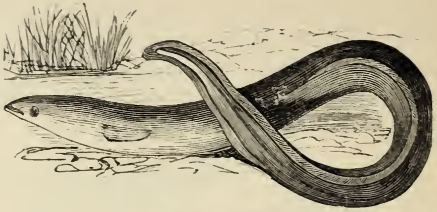


Fig. 108.—Eel.

some months to lay their eggs, and the young ones in their time go down to the sea, to return the next year. Not so with *eels*, however, which go down to the sea to lay their eggs, and whose young go *up* rivers in large numbers; those kept in ponds never lay eggs.

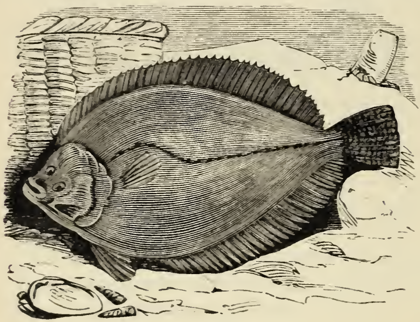


Fig. 109.—Flounder.

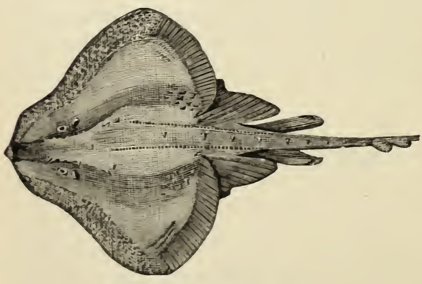


Fig. 110.—Smooth skate.

42. Structure of Fishes.—There is nothing more varied than the forms of fishes. The most common is that of a flattened spindle, but some, like *eels* (Fig. 108), for instance, resemble serpents ; others, again, have flattened sides, like the *sole* and the *flounder*, which have both eyes placed on one side of the head, the side that is uppermost when it is swimming (Fig. 109). Others are spread out, like the *skate* (Fig. 110).

Nearly all have

fins, a membrane (or thin skin) stretched out over rays or little bones, more or less strong and hard. *These fins are used to guide and balance the fish through the water; it is propelled* (driven forward) *by means of the tail, which is moved from right to left*, as you may see by watching my gold-fish in this globe. Look at its fins : there are two pairs, one representing the arms, the other the legs. Then there are three odd ones on the mid-line of the body ; one on the back, the *dorsal* (from Latin *dorsum*, the back) ; another at the tail, the caudal (Latin *cauda*, the tail) ; and the other behind the intestinal opening, called the anal fin.

All fishes have *gills*, which they *use for breathing.* You can see them—like little fringes—to which the blood, after it comes from the heart, is distributed in very tiny vessels. By the action of the mouth, a constant current of water is passed over the gills, and the air contained in this water affects the blood circulating through them, producing changes like those you see in other animals by air that has been inhaled or breathed. The blood does not return to the heart from the gills, but is passed down along the spine (backbone), to be distributed to the different parts of the body, and again returned to the heart through the veins.

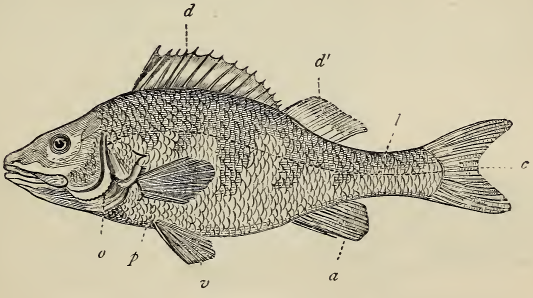


FIG. 111.—Common perch. *o*, Gill-cover, with the gill-slit behind it. *p*, One of the pectoral fins, the left. *v*, Left ventral fin. *d*, First dorsal fin. *d'*, Second dorsal fin. *c*, Caudal fin or tail. *a*, Anal fin. *l*, Lateral line.

43. Commonest Species.—The species of *fishes* are very numerous. Among *fresh-water* fishes may be mentioned the *carp*, the *cat-fish*, the *perch* (Fig. 111), the *roach*, the *pike* (Fig. 112)—one of the most voracious fishes—the *trout*, the *eel*, etc.


Fig. 112.—Pike.

Salt-water fishes are infinitely more varied in form and more numerous in species than *fresh-water* fishes.

The *herrings* spend the greatest part of their lives in the deepest waters of the northern seas. When the milting period comes, they approach the shores of the British Isles and France, in bands or *shoals*, pursued by large fishes, porpoises, and aquatic birds. But it is man that is their worst enemy, as whole fleets are loaded with them. Happily, each female herring lays about fifty thousand eggs, otherwise the race would soon become extinct.

The *sardine*, which inhabits the Atlantic Ocean and the Mediterranean Sea, is a species of herring that also lives in shoals.

The *codfish* (Fig. 113) is another marine species much sought after. Hundreds of vessels are engaged in fishing for it, especially along the Banks of Newfoundland. It has become a great staple of American commerce.

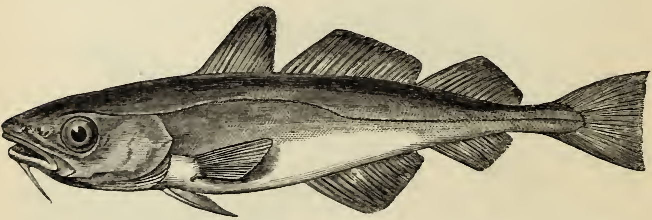


Fig. 113.—Cod.

Among the best-known *flat fishes* are the *plaice*, the *turbot*, the *flounder*, and the *halibut*. The *mackerel* visits our coasts in great shoals during the summer. It is spotted with blue, and largely used for food. It is found in the North Atlantic.

The *salmon* (Fig. 114), already alluded to as a migratory fish, ascends the rivers for spawning in spring, and penetrates to their head-streams. It is a remarkably strong fish, and will even leap over considerable falls which lie in the way of its progress. It has been known to weigh as much as seventy-five pounds; more generally it is from fifteen to twenty-five pounds. It furnishes a delicious dish for the table, and is an article of commerce.

Fig. 114.—Salmon.

One of the species of the *shark* (Fig. 115) has acquired celebrity over all its family for its great size and ferocity. It is sometimes over thirty feet long, swallows everything that comes in its way, destroys great numbers of fishes, and can snap off a man's leg with as much ease as you could bite off a radish. It has a very large mouth, situated, not at the end of the snout, as in other fishes, but *under the head*, and set with several ranges of formidable triangular teeth. The gills have five slits instead of one, as in ordinary fishes. *Skates* and *rays* belong to the shark family.

Fig. 115.—Shark.

Now, if you were to flatten out the shark from end to end by placing a heavy weight upon its back, you would have an animal very much like the *ray*.

The *lamprey* (from Latin *lampere*, to lick, and *petra*, a rock or stone) resembles the eel, but has no side-fins (Fig. 116).

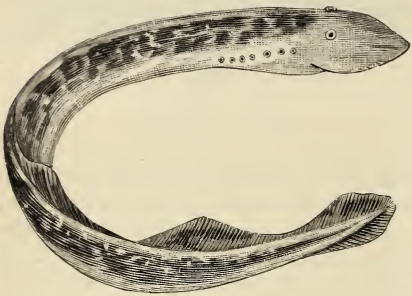


Fig. 116.—Lamprey.

It has seven gill-slits on each side of the neck, and a round, sucking mouth set with numerous minute teeth and two large teeth on the palate. It has the faculty of attaching itself to rocks and stones, whence it is sometimes called *rock-sucker*. The marine lamprey is found in the Mediterranean, in most of the European rivers, and in some parts of America.

There are a great many other curious fishes that I could tell you about, but we must stop for the present, so as to have time for other things.

SUMMARY.—Fishes.

1. *Fishes* are absolutely *aquatic*. Taken out of water they perish.

2. There are *fresh-water fishes* and *salt-water fishes*. Some species *migrate* from the sea into rivers. *Salmon* and *shad* are *migratory* fishes.

3. Fishes present a great variety of forms. Most of them resemble a flattened spindle; others, like *eels*, resemble serpents; others are flattened sidewise, like the *flounder*, or from back to belly, like the *ray*.

4. All fishes have *gills*, through which they breathe. Nearly all have *fins*.

5. The *shark*, sometimes from thirty to forty feet long, is the most dangerous to man. It has a very large mouth, *under the head*, and not at the end of the snout, and set with rows of sharp, triangular teeth with which it can snap off a man's leg with the greatest ease.

(Subjects for simple Composition on page 99.)

II.—ANNULATES.

You remember the meaning of the word *annulate.* The animals of this great group appear to be made up of a series of *rings* working upon one another. These rings are not always very much alike.

Let us take up in their order the groups into which *annulates* are divided : *Insects*, *spiders*, *millepeds*, *crustaceans*, and *worms*.

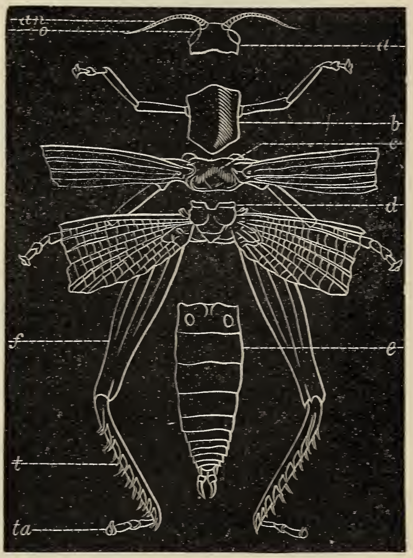


FIG. 117.—Diagram of an insect. *a*, Head carrying the eyes (*o*) and antennæ (*an*). *b*, First segment of the thorax, with the first pair of legs. *c*, Second segment of the thorax, with the second pair of legs and the first pair of wings. *d*, Third segment of the thorax, with the third pair of legs and the second pair of wings. *e*, Abdomen, without limbs. *f*, Femur. *t*, Tibia. *ta*, Tarsus.

44. Insects.—We have, in the first place, **Insects** *that have* **six feet,** like this insect (Fig. 117). The body is, as you see, composed of three parts: the *head*, the *thorax*, and the *abdomen*. On the head are two horns (feelers) called *antennæ*, and two large eyes, which, if you look at them through my magnifying - glass, will appear to be *cut with facets* (small surfaces), as precious stones are. The six feet are attached to the thorax (in insects that part of the body between the head and the abdomen) ; and it is the thorax also that bears the four wings of the butterfly, and the two wings of that fly. The abdomen has no *appendages.* (Antennæ, limbs, wings, etc., are called *appendages.*)

Insects often have *metamorphoses* or transformations as complicated as those of the frog. You are all acquainted with those of the butterfly. When it comes out of the egg it is a *caterpillar* (Fig. 118 A), which grows rapidly and sheds its skin four times. The fifth time the skin becomes hard and coriaceous (tough), and the caterpillar seems to go to sleep, after having, as often happens, spun a *silky cocoon*, in which it envelops itself. In this state it takes the name of *chrysalis* (B). Finally, at the sixth change of skin, the *chrysalis* opens and out comes a beautiful winged butterfly (C), ready to lay eggs. This is what is called a *complete metamorphosis* or transformation.

FIG. 118.—Metamorphoses of the butterfly. A, Larva or caterpillar. B, Pupa or chrysalis. C, Imago or perfect insect.

"But what beautiful wings your butterfly has, sir!"

"Yes; look at them more closely, and you will see that they are covered with fine hair or scales, like powder, which are pretty objects under the microscope, and give to the wings their beautiful color."

Grasshoppers undergo *metamorphoses, as the little insect has no wings when born*, but at each shedding of the skin they grow gradually, until after the sixth change the insect is perfect without having had to pass through the chrysalis period or the extraordinary transformations of the butterfly. This is what is called an *incomplete* or *partial metamorphosis. Flies,* *beetles* (Fig. 119), *fleas*, and *bees* undergo complete metamorphoses, while *dragon-flies*, *locusts*, and *bed-bugs* only undergo partial metamorphoses.

Fig. 119.—Tiger-beetle.

The jaws of insects are constructed very differently from ours or those of other vertebrates. Instead of working up and down, they work from *right to left*. This is the case with all articulates. Look at the beetle, with its powerful *transversal jaws* (separated from right to left, and not up and down as ours are), with which it can seize other insects and tear them to pieces. The *May-bug*, which feeds only on leaves, has much weaker jaws. The fly has a short but strong proboscis or *trunk*, made for sucking. Fleas and bed-bugs have *sharp bills* or hollow piercers, with which they pierce the skin and suck in the blood of their victims. The butterfly has a *long coiled trunk*, fitted for drinking in the sweet juice of flowers.

Insects are the most numerous in species in the animal kingdom, there being over **two hundred thousand.**

Insects comprise some very useful species, such as the *silk-worm*, the *bee* (Fig. 120), the *cochineal*, etc., and some very

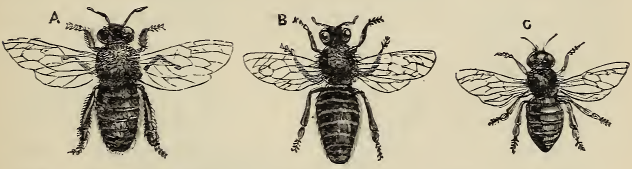


Fig. 120.—Honey-bee. A, Drone or male. B, Queen. C, Worker.

destructive ones, such as the *caterpillar*, the *grasshopper*, the *potato-bug*, the *phylloxera*, the *weavil*, etc., all of which have made their depredations felt at different times and in different parts of the world.

[The *Hessian fly* (Fig. 121). It is said this grain-destroying insect was brought to the United States by the Hessian troops that were hired to fight against us in the Revolution. Millions of dollars would not pay for the damage done to the farmers of this country by this insect.

Fig. 121.—Hessian fly (magnified); the body measures one tenth of an inch.

Fig. 122.—Wheat-midge (magnified).

The *wheat-midge* (Fig. 122) is much like the Hessian fly, and on account of its ravages may well be classed with insects that are injurious to vegetation].

Spiders.—After insects come **Spiders** (from Danish *spinder*, a spinner), readily distinguished from insects, with which they are very popularly confounded, by having *four pairs of legs* (Fig. 123), as well as by other characteristics. The head and thorax are blended together into one single body bearing the legs. They never have wings.

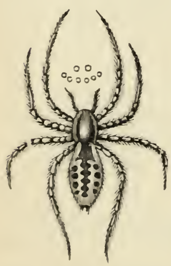


Fig. 123.—Common house-spider.

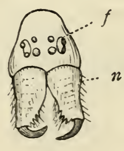


Fig. 124.—Front view of the head of the male common house-spider, showing the eight eyes (*f*) and the poison-fangs (*n*).

Spiders, properly so called, have in their mouth *large venomous* (Fig. 124) *hooks*, with which they pierce, benumb, and kill the insects they prey upon. Certain species in South America are about the size of a man's thumb, and are able to capture little birds and suck them to death. The *tarantula* of the Southern States and the West Indies is somewhat larger than its South American cousin. Its sting is painful and sometimes fatal to man.

Most spiders have on the extremity of the abdomen what is known as *spinnerets* (the organ with which they form their silk or web), from which they draw a very fine but very strong thread, with which many species weave artistically complicated webs (Fig. 125). This web entangles the insect, upon which the spider pounces immediately, and, after benumbing it with venomous stings, strangles it with its winding threads.

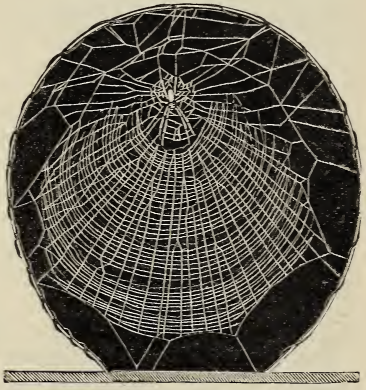


Fig. 125.—Web of the garden-spider.

Long-bodied creatures somewhat allied to spiders are found under stones in southern countries. Their feelers end in strong pincers; they do not spin webs, and their sting is not in the mouth but in the tip of the tail; these are *scorpions* (Fig. 126), whose sting causes fever in man and is fatal to small animals.

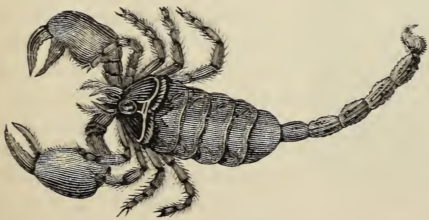


Fig. 126.—Scorpion.

The loathsome disease known under the name of *itch* is caused by *a very small animal, a sort of spider*, called the *acarus*, scarcely visible to the naked eye, and which burrows under the skin and produces a terrible itching. Formerly, this was considered a disease of the blood, and patients were worried with bleedings and purgings, to little purpose. Since it has been ascertained that it is simply due to the presence of these little mites, the skin is rubbed with a sulphurous ointment, and the trouble soon disappears. You may judge from this how useful science is, and how necessary it is to know who our enemies are.

46. **Millepeds** (Fig. 10), so called because they have a great many pairs of feet. Their head is distinct from the rest of the body. Properly speaking, their body has neither thorax nor abdomen, but a series of rings, like unto one another, and each of which, according to the species, has one or two pairs of legs.

47. Crustaceans.—All the articulates I have just told you about are *aërial* and live upon land. *Crayfish* or *crawfish* (Fig. 11), *crabs* (Fig. 127) and their like, on the contrary, are nearly all *aquatic*. Because of their *crusted* skin (Latin *crusta*, a crust) these animals have received the name of **crustaceans**.

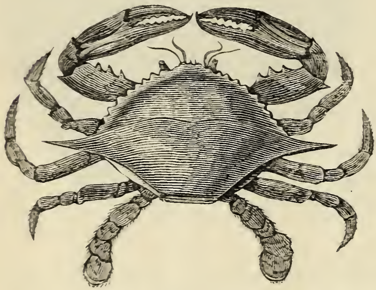


Fig. 127.—Crab.

48. Worms have no division between the head and the body, both forming one mass. These creatures have not true legs.

The *lumbric* or *earth-worm* (Fig. 12) is the best known of all. Here is one I have just cut in two. Now, put these two halves into a pot, with the earth kept a little moist, and *in less than a year you will find two whole worms*. A head will have grown on the part that had the tail, and a tail will have grown on the part that had the head.

Leeches (Fig. 13) have a sort of *sucker* with which they fix themselves firmly. The species used for medical purposes has, besides the sucker, teeth with which it can pierce the skin.

There are, especially in the sea, large numbers of worms having legs, and *setæ* of different forms. There are some that make their own stony shells.

Intestinal worms, that live in the intestines of larger animals, are absolutely white. They are sometimes found in the intestines of man.

The best known is the *Ascaris lumbricoides*, so called because of its resemblance to the earth-worm, except in color. The *tænia* (Latin, a ribbon), very improperly called the *solium* (also found in man), is not by any means rare. It is sometimes called the *tape-worm* (Fig. 128), and is frequently sixty feet long. At the pointed end of the worm may be seen, with the aid of the magnifying-glass, a very small head armed with suckers and hooks. Tape-worms are often found in human beings and in carnivorous animals.

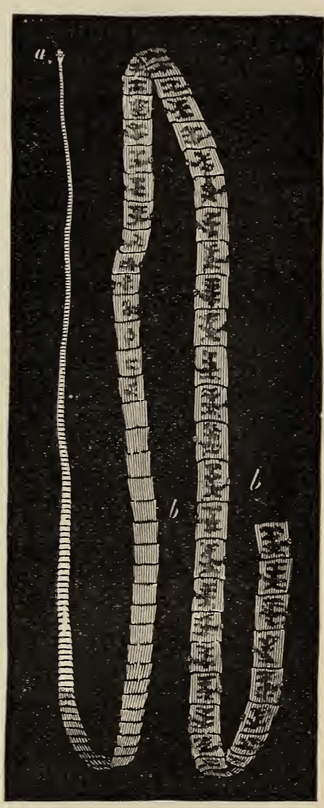


FIG. 128.—Tape-worm.

Nothing can be more curious than the history of these animals. They are, as you know, annulated, and each of their rings is filled with eggs, and is sooner or later expelled. The expelled ring dries up, the eggs are liberated and are scattered about. A *herbivore* comes along, a sheep or a rabbit, for instance, and, as it grazes, swallows some blades of grass covered with these eggs. As soon as the egg reaches the animal's stomach it is hatched and a tiny creature comes forth. It *works its way through the intestine* and fixes itself in some part of *the body*. A sort of ball now grows out of its body and barely shows its head, which is not unlike that of the tape-worm. It is these balls which, when developed under the hog's skin, give rise to what is generally known as *pig's measles*. The little animal will remain there indefinitely ; but, if a dog or even a man were to eat a piece of this pork, raw or insufficiently cooked (even though smoked and salted), the ball would be digested in his stomach and nothing but the head would remain. Soon rings or segments would be added to it, and the dog or the poor man would be said to have the tænia or tape-worm. From this you see *that none but sound and thoroughly cooked pork should ever be eaten*. As a general rule, meat *should be well cooked*.

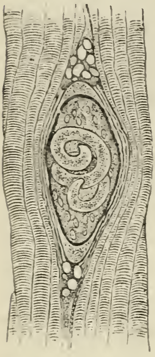


FIG. 129.—Portion of human muscle, inclosing a single capsuled *trichina*. (Highly magnified.)

Within the last half of the present century a very minute worm, almost invisible to the naked eye, has been discovered in the pig's flesh ; it is called the *trichina* (from a Greek word meaning hair). It is very common in Germany, and is known in America (Fig. 129). When trichinized pork, *insufficiently cooked*, has been eaten, the little creatures, which it contains in great numbers, lay eggs in our intestines. When hatched the young ones spread all over our bodies, giving rise to terrible pains, and often deadly fevers. *Pork should be* **thoroughly cooked** before eaten.

SUMMARY.—ANNULATES.

1. Animals of this group appear to be formed of a series of rings.

Annulates are divided into *insects, spiders, millepeds, crustaceans*, and *worms*.

2. **Insects** (page 81) all have *six feet*.

3. They undergo metamorphoses more complicated still than that of the frog.

4. The *butterfly* when it comes out of the egg is a *caterpillar;* after several changes of skin, the caterpillar appears to go to sleep; it sometimes wraps itself in a cocoon and becomes a *chrysalis;* the winged butterfly at last bursts out of the chrysalis. This is a *complete* metamorphosis.

5. *Flies, beetles, fleas,* and *bees* undergo complete metamorphoses. *Grasshoppers, locusts,* and *bugs* have *incomplete* metamorphoses.

6. The group of insects is the most numerous of the animal kingdom; it comprises more than two hundred thousand species.

7. The *phylloxera* is an insect almost invisible to the naked eye. It lives on the little roots of the vine, which it sucks until they are exhausted. In spite of the war waged upon it, millions of acres have been destroyed by it on the Continent of Europe.

8. **Spiders** (page 84).—Spiders have eight legs; they have venomous hooks in their mouths, with which they sting and benumb and kill their prey. At the extremity of their abdomen is the "spinneret" with which they spin their webs.

9. *Scorpions,* allied to spiders, are found in warm climates; their sting is in the tail; it is poisonous, and produces fever in man.

10. The *itch* is caused by a very tiny spider, almost invisible to the naked eye. It burrows under the skin and produces intolerable itching.

11. **Millepeds** (page 86) have many pairs of legs, and their bodies are composed of rings.

12. **Crustaceans** (page 86).—*Crustaceans* (crayfish or crawfish, crabs, etc.) are nearly all aquatic. Their skin is incrusted, hence their name.

13. **Worms** (page 86).—If a *worm* be cut into two parts and those parts kept in moist earth, in less than a year two complete worms will be found. A head will have grown on one half and a tail on the other.

14. The *tænia* or *tape-worm* is like a long piece of tape or ribbon divided into rings. Men and animals are often afflicted with the *tape-worm.*

15. The *trichina,* a little worm, invisible to the naked eye, lives in the flesh of the pig. Pork must be *fully and thoroughly cooked* in order to destroy it.

(Simple subjects for Composition will be found on page 99.)

III.—MOLLUSKS.

49. Mollusks are, as has been said already, soft animals, not annulated, and many of which are encased in stony shells.

50. Snails.—The shell of the *snail* (Fig. 14) is formed from a spirally-coiled tube, widening toward the mouth ; the body of the snail entirely fills the shell.

Look at this one; how quiet it is ! It stretches itself out, puts out its head, then its neck, then its four horns, two of which have eyes at the ends, and, lastly, a thick, fleshy foot with which it travels. All this will be instantly withdrawn at the slightest touch of your hand.

Slugs, like snails, have a head, four horns, and a foot, but no shell. Some species, however, have a sort of rudimentary shell concealed under the skin of the back. [The *whelk* (Fig. 130) is common on our shores. The shell has few whorls, and

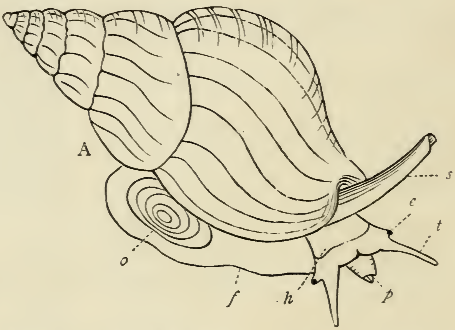


Fig. 130.—Sketch of a whelk in motion. *f*, Foot. *h*, Head, carrying the feelers (*t*) with the eyes (*e*) at their bases. *p*, Proboscis. *s*, Respiratory siphon or tube by which water is admitted to the gills. *o*, Operculum.

the opening is closed by an *operculum* or cover, which is attached to the foot and serves to close the shell when the animal is drawn into it. In some shells there is a long *canal*, to protect the siphon or tube which conveys water to the *gills*, as in murex (Fig. 131). The outside of some shells is quite

Fig. 132.—A group of univalves.

smooth, while in others it is rough and, moreover, furnished with long spines. The great variety of form in univalve shells is wonderful, and some idea may be formed by examining the illustrations of the group of *univalves* (Fig. 132, p. 91).]

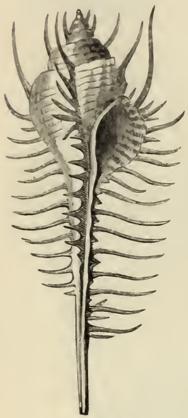


Fig. 131.—Murex (*tenuispina*).

51. Oysters, mussels, clams, etc., have a shell with two parts, or two *valves;* hence they are called *bivalves.* These animals have no heads and are *aquatic.*

Oysters are marine animals, found in our waters, where they live in colonies or *beds;* they are fixed upon rocks, and *can not move out of their place.* Mussels and clams *can* move about. Some live in salt water and some in fresh water, but they are not of the same species. The *mytelus* (Fig. 133) is a common mussel on the eastern coast of the United States.

The inner part or lining of the shells of mollusks, which is very beautiful, is used, under the name of *mother-of-pearl*, in the manufacture of buttons, handles for knives and forks, and for many fancy articles.

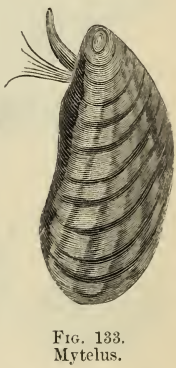


Fig. 133. Mytelus.

Finally, it sometimes happens that isolated pieces of mother-of-pearl are formed in certain oysters of the Indian seas. When the *nacre* or mother-of-pearl is deposited in the shape of globular drops, instead of being spread over the inner surface of the shell, it is called *pearl*, and is eagerly sought for, on account of its great value. A pearl was taken from a clam, near Salem, New Jersey, that sold in Paris for two thousand dollars.

The *boring-shells* (Fig. 134) will make their way into the hardest rock. The picture shows a block of granite cut away to expose the *boring-shells.*

Fig. 134.—Boring-shells.

52. Cephalopods.—There are in the seas, in many parts of the world, mollusks that have no outer shell, which are known by the names *octopus* (Fig. 135), *cuttle-fish*, *calamary*, or *squid*, etc.

Some of these are strange and frightful creatures, with a large head, two enormous eyes, a strong, horny beak, and eight or ten long arms around the mouth, each covered with suckers, like those of the leech, and which have the power of fixing themselves firmly upon whatever comes in their way. When irritated, some of them throw out a sort of black liquid, which darkens the water around them and enables them to escape. This black stuff is used by artists for tinting. It is called *sepia*.

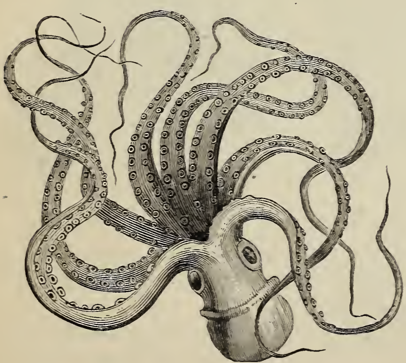


Fig. 135.—Octopus.

These animals sometimes attain

such an enormous size that they become dangerous to man. [A few years ago specimens of gigantic squids were found near Newfoundland. The largest measured twenty feet from the tip of the tail to the beak, and the two long tentacles were thirty-five feet in length. In these creatures the tentacles or arms are ten in number ; eight, however, are short, and two become very long.]

IV.—RADIATES.

53. The animals comprised under the name of **Radiates** vary greatly in form. Nearly all of them are inhabitants of the sea. The best known and most common among them are the *star-fish* (Fig. 16), the *sea-urchin* (Fig. 136), the *sea-anemone* (Fig. 137), the *medusa* (Fig. 138), and the *gorgonia*.

Fig. 136.—Sea-urchin.
Spines from one half are removed.

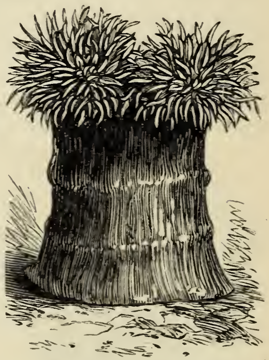


Fig. 137.—Anemone.

[Some of the sea-urchins are quite flat like a cake, and when the spines are removed their star-like character is readily seen (Fig. 139).]

[The **medusa** is also known by the names of *sea-nettle* and *jelly-fish*. These jelly-like bodies are frequently cast up on the sea-shore. When in a living condition they resemble little bells of transparent-glass, adorned here and there with most brilliant colors. Some of the sea-nettles are quite large, and have the power of stinging most severely.]

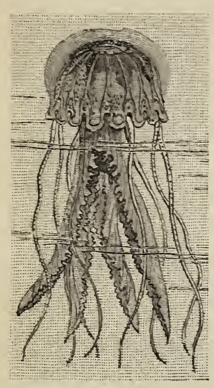


FIG. 138.—Medusa.

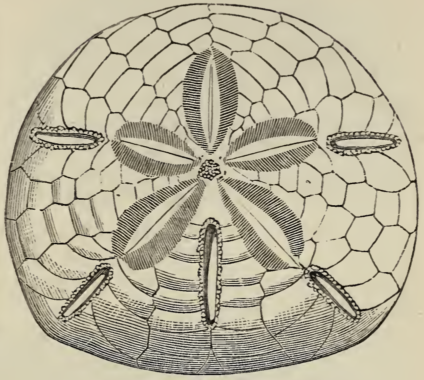


FIG. 139.—Key-hole urchin (Florida).

"Please, sir, what is the *gorgonia?*"

"Gorgonia (Fig. 140) is a Latin word meaning a coral which hardens in the air. It is represented by *sea-shrubs*, *fan-corals*, and the *red coral* of commerce. You have, no doubt, seen specimens of them in museums and in many private houses. Some of them grow in the form of shrubs and twigs. The sea-fan is found in the West Indies."

FIG. 140.—Gorgonia—sea-fan.

Polyps are very tiny creatures having eight arms. They gather in colonies and build enormous stony masses (Fig. 141) — sometimes entire islands — known as *coral islands* (Fig. 142). The water in the interior of the island is called a *lagoon*. The lagoon at Tortugas, Florida, is fast filling up, and in the course of years the interior lake will disappear.

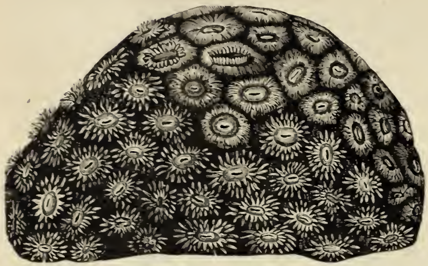


Fig. 141.—Star-coral (living).

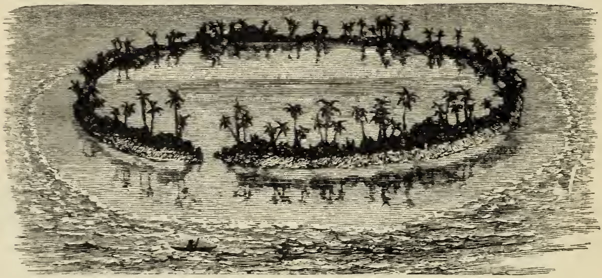


Fig. 142.—Atoll in the Pacific Ocean.

[54. **Protozoans.**—The sponge, which was formerly regarded as a plant, is not only an animal, but is closely related to the jelly-fish and the coral-polyps. Most naturalists now consider

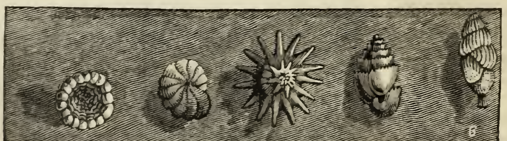


Fig. 143.—Shells of foraminifera.

the protozoans as one-celled animals, and the sponge (Fig. 144) is a many-celled animal, and as such is higher in the scale of life than a protozoan. This sub-kingdom comprises an enormous number of animals, but they are so small that you require a microscope to study them. The *amœba* is a shapeless, jelly-like mass, constantly changing its form. In the *foraminifera* (Fig. 143) the body is frequently protected by a shell of beautiful construction.]

Fig. 144.—Venus's basket. Skeleton of a flint-sponge.

55. Infusoria.—"I want to say a few words to you about animals that are found in ponds (Fig. 145), especially of some tiny but important creatures that may be found in an infusion. Look carefully at the contents of this glass of water. Hold it up to the light. Yesterday I steeped these bits of old hay in it. Do you see those little objects moving about in the water?"

"Yes, sir; are they alive?"

"Take my magnifying-glass, and you will be able to see more distinctly; but a microscope would do much better. Those little specks are *minute animals that live there in myriads*, and they are of every variety of shape. Some are so very small that the magnifying-glass will hardly reveal their presence. There are thousands of them in one single drop of water."

"Where do they come from, sir?"

"They come out of the hay."

"How did they get in there, sir?"

"They were there in a dried state, or *in the form of eggs.* They are to be found in the moss on old shingle house-tops, all dried up by the summer sun. If you examine them with a microscope, they look like little grains of sand."

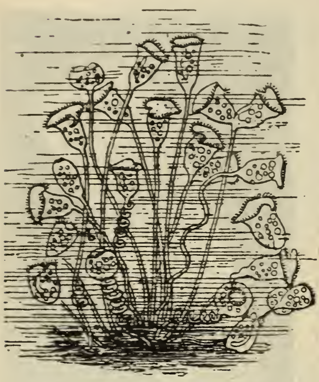


FIG. 145.—Stalked infusoria (magnified).

"Will they come to life again, sir?"

"The moment a drop of water falls upon them they revive and immediately start out to earn their living. As soon as the water evaporates, they roll themselves up again and become inert until the next rain. These are very peculiar little creatures, are they not? You see that the most interesting animals are not always the largest."

SUMMARY.—MOLLUSKS, RADIATES, AND PROTOZOANS.

1. **Mollusks** (page 90) comprise *snails, slugs, oysters, cuttle-fish,* etc.

2. **Nacre** (mother-of-pearl) is made from the inner lining of different mollusk-shells.

3. In some shells isolated pieces of mother-of-pearl are formed into little globules or balls; these are *pearls.*

4. **Radiates** (page 94). Nearly all *radiates* live in the sea. The best known are the *star-fish* and *polyps,* which sometimes build whole islands.

5. **Protozoans** (page 96). *Sponges* and *rhizopods* (or root-footed animals) are here included. With few exceptions they have no mouth and no members.

6. **Infusoria.**—With a microscope one can distinguish in a drop of pond-water, or water in which some old hay has been steeped, thousands of tiny animals of every imaginable shape. These are *infusoria.*

7. They existed in a dried state in the hay; the water awakened them to life and motion.

SUBJECTS FOR COMPOSITION.

I (pages 3 to 14). Mention the differences between animals, plants, and minerals. Vertebrates and invertebrates. The five grand divisions of the animal kingdom.

II (pages 15, 16). What characterizes vertebrates? Warm-blooded animals and cold-blooded animals? Characters of mammals, of reptiles, of amphibians, of fishes?

III (pages 16 to 18). Aërial animals, aquatic animals. Amphibians.

IV (pages 23, 24). Why a bat is not a bird.

V (pages 25 to 32). The cat's paws. Its teeth. Animals of the cat kind.

VI (pages 37 to 42). What is a ruminant? Principal ruminants? Their usefulness to man?

VII (pages 47 to 49). Why a whale is not a fish.

VIII (pages 52 to 54). General characteristics of birds. How eggs are hatched. Artificial incubation.

IX (pages 66 to 70). What characterizes reptiles? The three groups of reptiles. The alligator. What happens to lizards that have had their tails broken off?

X (pages 70 to 72). Venomous serpents. Tell about some of the venomous serpents of our country. Where do serpents keep their venom? Mention some serpents whose bite is almost instant death. Non-venomous serpents.

XI (pages 73, 74). Metamorphoses of the frog. How does the tadpole breathe, and how does the frog breathe? Venom of frogs and toads. Usefulness of the toad.

XII (pages 75 to 80). The various forms of fishes. Illustrate. Of what use are the gills?

XIII (pages 81 to 85). What is the word *annulate* derived from? Principal divisions. Mandibles of different insects. How many legs have they?

XIV (pages 85, 86). How many legs has the spider? Tell how spiders kill flies.

XV (page 96). Tell what you know about the sponge.

XVI (pages 97, 98). What can you find in a drop of pond-water?

PART II.

NATURAL HISTORY OF PLANTS.

PLANTS.

I. STRUCTURE OF OUR TREES.

56. Diversity in the Shape and Size of Plants.—You are all aware, my young friends, that the **vegetable kingdom** or **plants**, as they are called, differ greatly in form and size. An *oak*, a *lilac*, and a blade of grass present very different dimensions. We also speak of *trees*, *shrubs*, and *herbs*, or herbaceous plants.

All these plants are green. I must tell you, however, that *some plants are not green,* such as *mushrooms.* Then there are those yellowish, reddish, brownish, grayish spots seen on the trunks of trees and on walls, which are formed of little plants called *lichens.*

57. The Different Parts of a Plant.—Let us for a moment leave these exceptional plants and give our careful attention to the ordinary tree.

Look; there in the corner of the garden is a wild *pear-tree* that has sprung up of itself, and which is good for nothing. I am going to pull it up, and we shall examine it together. You all know the different parts of a tree: first, the **root**, which is hidden under the ground, and which branches out in every direction; the **stem** or **trunk**, which rises almost vertically; the **branches**, including *primary* and *secondary branches. Primary* branches spring directly from the trunk; and *secondary* branches, or those of the *second order*, spring from the *primary* or *main* branches, and branches of the *third order* spring from secondary branches; and so on, and finally the **leaves.**

Let us now look into certain parts a little more closely. Above the stalk of each leaf, just in the angle it forms with the trunk or with the branch on which it grows, you notice a **bud**. *This bud will grow and form a new branch. All the branches grow in this way* from what is called the *axilla* (Latin *axilla*, arm-pit) of *a leaf*, and *every leaf bears a bud at its axilla* (Fig. 146).

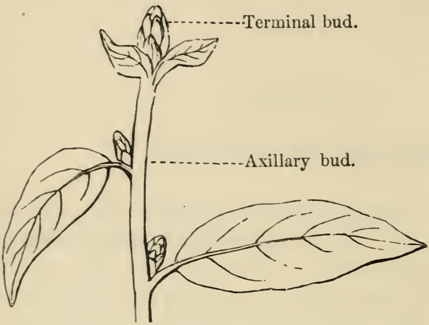


Fig. 146.—Axillary bud.

You notice that some branches are much shorter than the others, and, *instead of growing longer*, remain short and end in a flower **bud**. Some of these buds have already bloomed into **flowers**, which, in their turn, will give place to **fruit**—in this instance, pears.

58. The Trunk.—Let us first take the *trunk* and cut it across. You see it is composed of three parts. In the center is the **pith**, which is white and soft. Next comes the **wood**, which is hard ; and, lastly, you recognize the **bark**, which is green, and which comes off in strips.

But, our pear-tree is a very young one ; it sprang up only last year from the roots of the old pear-tree, which was killed by the severe cold of the preceding winter ; and its stem is quite small. I happen to have with me a piece of the trunk of the old tree, which I have kept as a curiosity. Let us compare it with the young stem.

The most striking thing is that it is very much larger than the young one ; it is forty inches in diameter. But see, the *pith in the old trunk does not take up any more room than that in the one-year stem.*

"How is that, sir ?"

"This surprises you, no doubt, but it is so, for all that ; *the pith never grows with age* in any tree. The *bark*, as you see, is no longer green and smooth ; it has become grayish, rugged, and much thicker. The greatest difference, however, is in the *wood*, which makes up almost the entire thickness of the trunk, by itself.

"Look at this section of an oak-trunk (Fig. 147) which I have had nicely polished. *Notice these* **rings** *all fitting closely into one another.* John, have the goodness to count them."

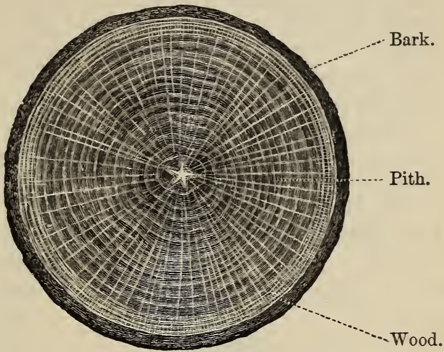


Fig. 147.—Section of the trunk of a tree.

"There are about twenty, sir."

"Why do you say *about* twenty?"

"Because, *the circles around the pith are very easily counted, but they are so close together near the bark that it is almost impossible to count them.* How does this happen, sir?"

"It is in this way: *Each one of those circles marks a* **year** *in the age of the tree.* In this case, you see, it marks twenty years. The tree grows thicker every year; you understand that this growth is all outwardly, for, were the layers shown in this section to have increased near the pith, the wood must necessarily have split. Hence the new layers of wood grow between the older wood and the bark. Each circle you see here represents a year in the growth of the tree. Now, when the tree was young, it grew much faster than when it became old; just as you grow much faster between four and five years of age than you will from fourteen to fifteen. This is the reason that *the circles grow thinner the farther they go from the center of the trunk;* that is to say, in proportion as they are more recently formed. Are there any other distinctions made between the different parts of the wood itself?—Paul, you ought to be able to tell me, your father being a carpenter."

"Yes, sir, there is the **sap-wood**, which is soft, and the **heart**, which is hard and is situated just under the sap-wood."

"Very good; and I will add that *the heart is harder because it is older, and a greater quantity of solid matter has been deposited there by time;* hence, it will create more heat, and produce a greater quantity of ashes, when used for fuel."

59. The Root.—So much for the *structure* of the trunk. That of the **root** is similar, except that the pith is often wanting. There is so little difference between the trunk and the root that, as is the case with the lime-tree, the acacia, and the chestnut-tree, when the root is laid bare for some considerable time, it gets to look like the trunk, and may even produce branches.

60. Branches.—The manner in which stems or trunks put forth **branches** is exceedingly varied. Look at the *fir-tree* (Fig. 148), which sends out at regular intervals almost horizontal branches; this *plum-tree*, on the contrary, branches out in all directions, and it is with difficulty that we can follow the main stem. But, whatever aspect the tree may assume, *the trunk will always be thicker at the bottom than at the top.* We can notice it gradually diminishing until it ends in a point. This is the case with most of the trees of our country.

Fig. 148.—Fir-tree.

61. Leaves.—Let us now turn to **leaves**. Those on our pear-tree have a stalk, or, as the learned men call it, a **petiole**. The petiole supports a broad, flat, green part, which is the leaf, properly so called—the **blade** or **lamina.** The *blade* is even the most important part, as many plants have leaves without stalks.

In some cases the leaf is a *simple* blade (Fig. 149),

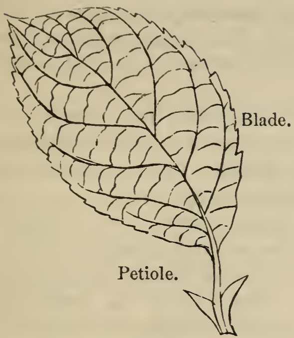


FIG. 149.—Simple leaf, blade, and petiole.

FIG. 150.—Passion-flower leaf, blade divided.

FIG. 151.—Horse-chestnut leaf, completely divided.

FIG. 152.—Acacia, showing six compound leaves and numerous leaflets.

while here is a *passion-flower* leaf (Fig. 150), in which it is divided. The divisions are *complete* in the leaf of this horse-chestnut (Fig. 151), and *extremely complicated* in the acacia-leaf (Fig. 152).

"Is not each one of those green lobes a leaf by itself, sir?"

"I hardly think so. Can any one tell me whether I am right or not? No one? Well, you remember I told you that *a little bud is to be found at the axil of each leaf;* now, in this case only one exists, and it is situated at the axil of the whole acacia-leaf. Furthermore, if those large petioles were little branches, they would not fall in autumn; and you know they fall as all leaves do.

62. Flowers (Fig. 153).—The things that most attract our attention in the pear-blossom are those five little outspread white leaves. They are called **petals**. On the under side of the flower are five other leaves, much smaller than the first, and which have remained green; these are called **sepals**. In the center of the flower you see a large number of little, roundish hairs, like bristles, terminating in yellowish balls; these are their *stamens*, and the yellow color is due to a sort of very fine dust which botanists (men who know all about plants) call **pollen**. You have all noticed this yellow dust; it comes off easily, very much like the scales on the wings of the butterfly I told you about some time ago.

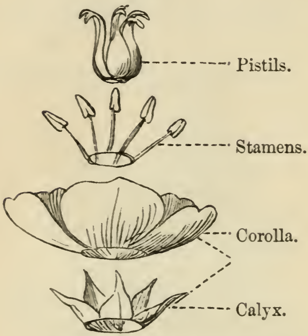


Fig. 153.—Parts of a flower.

Fig. 154.—Lily.

Let us now pull off the sepals, petals, and stamens. By the way, I must not forget to tell you that the petals taken together are called the **corolla** (garland or crown), and the sepals taken together form the **calyx** (cup). We have nothing left now but a little ball surmounted by five little stems.

This ball is called the **ovary** (or seed-vessel), the stems are the **styles**, and the ovary and styles taken together form the **pistil**. Try to find the corolla, stamens, and pistil in this lily (Fig. 154).

63. Fruits.—This ovary is a very little thing, is it not? Have patience: when the calyx, the corolla, the stamens, and the styles shall have fallen off, it will grow. It will fill with juice, sour at first, then sweet, and, finally, will become a *pear* (Fig. 155)—the **fruit**. You will easily recognize the ovary after its transformation into a pear, because on the summit of the fruit you will find traces of the parts that have disappeared; they cause that little hole opposite the stalk.

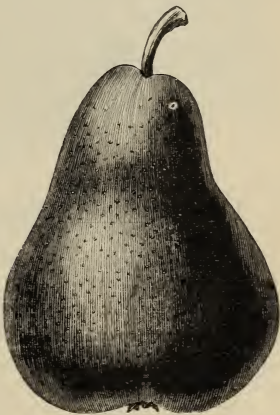


Fig. 155.—Bartlett pear.

In this fruit, as you know, there are **seeds** loosely suspended in little cells. Now, if we cut across the ovary of our pear-blossom, we shall discover that it contains little white specks. These specks, which we can pick out with a needle, are called **ovules** or *little eggs*, and will in due time become *seeds*.

Thus the **pear-blossom** is made up of a **calyx**, a **corolla**, and **stamens**, *which are to disappear*, an **ovary** *which becomes* a **fruit**, and **ovules** *which become* **seeds**.

64. Incomplete Flowers.—A flower like the one we have described is said to be *complete*. Some are *incomplete*. There are those in which the calyx or the corolla or both are missing, but this is of no great importance.

"How can a flower be incomplete, sir?"

"I see this surprises you, and that in your estimation the most important parts of a flower are those beautiful petals so often adorned with such bright colors. But you are mistaken. The truly important parts are the **stamens** and the **ovary**. I should go further, and say, the **grains** of **pollen** and the **ovules**."

The proof of this is that many flowers have neither calyx nor corolla. Take the flower of the hazel-nut (Fig. 156), for example ; and yet you know very well that the hazel-tree bears fruit, and that is the main thing. You may also pull the petals and sepals off of a complete flower without preventing it from bearing fruit, so long as the stamens and the pistil remain uninjured. But, *if you pick the stamens off*, *the ovary will not develop*, or, as the saying is, the tree will not *knot*.

Fig. 156.—Flowers of the hazel-nut.

Fig. 157.—Flowers of the maize or Indian corn. The top of the stalk is the flower with stamens, and the silk-like threads at the cob are the pistils.

There are flowers, too, that have not both *stamens* and *pistils ;* some bear stamens, others bear pistils. These flowers, *if kept too far from one another*, *will remain barren ;* that is to say, will produce no fruit. Sometimes both kinds of flowers will grow on *the same plant*, as is the case with the melon, the birch, the walnut-tree, and the maize or Indian corn (Fig. 157). Sometimes each grows upon *a different plant*, as in the case of hops, hemp, willow, etc., and, if these two plants are not near enough to each other, they will never bear fruit. Look at that beautiful weeping-willow (Fig. 158), down there by the water's edge ; it is a native of Asia, and as only one kind has been brought to this country (that having pistils), no seed has ever been seen hereabout, and all the trees that decorate our gardens or grave-yards come from *slips*, and bear ovaries that are not productive.

Fig. 158.—Weeping-willow.

65. **Seed.** — Let us return once more to our pear-blossom, or rather to its fruit. It contains *pips* or *seeds*, which when put into the ground *will produce a pear-tree like the first*—that is, the parent tree. Now let us examine one of these seeds carefully. We see, first, a **covering** or *skin*, and within it the seed, properly so called. As the seed of a pear-tree is too small for us to have a good view of all its details, we shall take a larger one.

Having removed the skin, we discover two large, fleshy bodies, which are good to eat, and which form almost the entire seed or nut. Botanists have given them the name of *seed-lobes* or *cotyledons.* I dislike very much to give you those ugly Greek words, but I am obliged to do it this time.

Fig. 159.—Two cotyledons, radicle, plumule.

I am going to separate the cotyledons very carefully. Notice that tiny little body at the pointed end of the seed (Fig. 159). Examine it closely and you will see that *it is a plant in miniature.* You can readily distinguish a tiny root (Latin *radicule*), a little stalk, and on the top a little bud.

"Of what use are the two cotyledons, sir?"

"They are simply the first two leaves of the plant."

"Would they grow if we were to plant them, sir?"

"When the whole seed or fruit is planted, the radicle will become the root, and the plumule, which is the bud or growing-point above the cotyledons, will become the stem or trunk of the growing plant. The history of the cotyledons is more complicated, and you will understand what becomes of them later on, when we take up *germination*."

II.—STRUCTURE OF THE PALM-TREE.

66. I have told you, in a general way, the history of our pear-tree. Now I want to examine, with you, another tree of an entirely different kind—the *palm-tree*. Unfortunately, none grow in the Northern States of our Union, except in hot-houses. To find one growing, we must go to warmer countries, because the palm is limited to an annual temperature of above sixty degrees, and is remarkable as having generally a very regular geographical distribution.

"But, please, sir, why have you selected the palm-tree, when there are so many other trees, such as the oak, the elm, the poplar, right here around us?"

"Very true, my young friends; but you must bear in mind that *all I told you about the pear-tree may be said of all these trees, and, indeed, of nearly all the trees of our country.* All these have a **trunk** *thicker at the base than at the top*—a *conical* (like a cone) trunk, to use a geometrical term; all have a **bark**, and **wood** harder in the center, with *rings* fitting into one another, and **pith**; their stems all bear **branches**, which spring from **buds** situated at the axillæ of the **leaves**; finally, they all bear **seeds** that have **two cotyledons.**

"But *with the palm-tree everything is entirely different*, and that is the reason I am going to tell you about it. Fortunately, I have at hand some good illustrations that will enable you to follow my description."

67. General Aspect.—In the first place, look at this palm-tree (Fig. 160) as a whole ; how different it is from the trees of our forests ! There are *no branches along the trunk*—nothing but a thick tuft of long, stiff, and hard *leaves at the top*. The trunk is of the **same thickness from top to bottom** ; it is *cylindrical* and not *conical*. Large bunches of flowers may also be seen hanging from the top.

Fig. 160.—Cocoanut-palm, cylindrical trunk.

This palm-tree, as you may judge by comparing it with the Arab passing under it, is about forty-five feet high. It is a beautiful tree ; and, if you should examine one nine feet high, *its trunk would be just as thick as its elder brothers'*, and you may depend upon it that, *however tall it may grow*, *it will never be any thicker*. This, then, is another great difference between the palm-tree and our apple-trees, oaks, and maples.

Look at the trunk of the palm-tree ; notice how it is marked with circular scars, indicating *the position of those leaves which have now fallen off ;* the highest ones alone remain, and form the beautiful tuft of large leaves which you see at the top. These trees have but **one bud** or **shoot** ; it is at the *top of the tree, and it is at that point that the plant grows*. It has no lateral shoots, and consequently no branches.

68. The Stem.—We shall now cut this piece of stem crosswise (Fig. 161). How peculiar it looks ! No pith, no circles of wood fitting into one another, no bark. In place of that regular arrangement we have been accustomed to see, we find a *soft*, *pithy mass*, *abounding in little*, *hard*, *black spots*, *very irregularly distributed*.

"What are these spots, sir ?"

"To find this out, we must cut the stem of this tree, not crosswise, as we did before, but lengthwise, through the middle (Fig. 161). We notice, running through this soft, pithy mass, looking more or less like the pith in our trees, hard, black filaments or fibers, the ends of which form the black spots we noticed a while ago in the cross-section we examined. These fibers follow a very irregular course, and seem to run through the spongy mass, to which they impart strength and solidity. Look closely, and you will see that they all come from the leaves, run down into the inside of the trunk, and return to disappear near the surface. *These threads are nothing more than the wood of the palm made up in a very peculiar manner*, if anything in nature can be called peculiar. The number of these fibers is sufficiently great to give the trunk solidity enough to admit of its being used as timber."

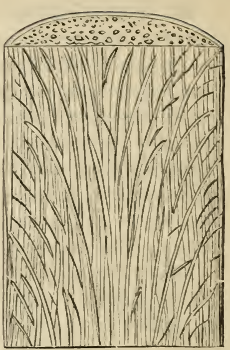


Fig. 161.—Transverse and longitudinal section of the trunk of a palm-tree, showing the hard, black fibers.

["Are there not some species of palms in this country, professor?"

"Yes, there are some species on this continent; the best known is the *palmetto* (diminutive of palm), growing in the West Indies and the Southern United States, notably South Carolina, which is the Palmetto State. Then there is the species known as the *cabbage-tree* (Fig. 162), found in the West Indies and adjacent parts of South America. It grows with a straight stem to a great height. The green top of the trunk is formed by the sheaths of the leaves a foot and a half in length.

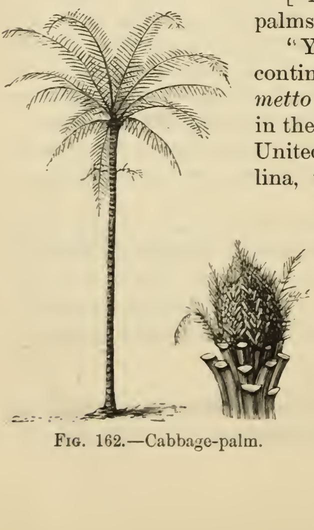


Fig. 162.—Cabbage-palm.

The natives cut off this top, take out the white heart, or terminal bud, consisting of the leaves closely folded together, very much like a cabbage, and use it for food. It is very nourishing. It is impossible to overestimate the utility of palms. They furnish food (cocoanuts and dates), shelter, clothing, timber, fuel, building-materials, fiber, paper, starch, sugar, oil, wax, wine, tannin, dyeing-materials, resin, and a host of minor products."]

III.—DICOTYLEDONOUS AND MONOCOTYLEDONOUS PLANTS.

69. There are, then, between a palm-tree and a poplar, for instance, very wide differences in appearance and in structure. While the seed of the poplar and of trees of a similar construction, as I have already told you, contains **two cotyledons**, it happens that the seed of the palm-tree and of kindred plants has but **one cotyledon.**

It has been found quite natural, then, to divide plants into **monocotyledons** (Greek *monos*, one) and **dicotyledons** (Greek *dis*, two).

In each group there are both trees and shrubs—that is, plants having hard or *ligneous* (woody) parts, and herbs or plants that are always soft and tender. Ligneous plants generally live the longest.

IV.—DURATION OF THE LIFE OF PLANTS.

70. Annual, Biennial, and Perennial Plants.—The duration of the life of plants varies very much.

There are some which, in the course of a single year, will germinate or sprout in the spring, grow stems and leaves, and give flowers, fruit, and seed, and then perish at the end of the warm season. These are called *annual* plants.

Others *vegetate* during the first year—that is to say, give only leaves ; they live during the winter. They do not flower and bear fruit until the second year, and then they die. These are called *biennial* plants.

Annual and biennial plants have but one *inflorescence* (Latin *inflorescere*, to begin to blossom) and one *fructification* (Latin *fructificatio*, the act of producing fruit).

Perennial plants are those which flower and bear fruit a number of times during the several years of their existence.

In some *only the roots are perennial*, as in the dahlia. Every year the knotted root or *tubercle* shoots forth beautiful soft stalks that bear flowers and die in autumn, as in the case of asparagus, hops, etc. These plants have perennial roots and annual stalks.

True perennials are *shrubs* and *trees*. They grow larger year after year ; none of their aërial parts, except the leaves, perish, and their young branches are covered every year with new flowers and fruit.

V.—CLASSIFICATION OF PLANTS.

71. I will now tell you about the *classification* of *plants*. It is, perhaps, a little more difficult than in the case of animals, because plants bear a stronger resemblance to one another than animals do. Everybody can tell the difference between insects and birds, and, among insects, between flies and butterflies, but it is not so easy to distinguish between plants.

"Come, Paul, suppose I were to ask you to make a classification of plants, how would you go about it ?"

"Sir, I should divide them into trees, shrubs, and herbs."

"This idea has already suggested itself to many people; but, just think of the difficulties in the way. Where do shrubs end and trees begin ? Where would you draw a line between herbs and shrubs ? Do hazel-nuts grow on trees or on bushes ? Is the sunflower an herb or a shrub ? Your distinctions, Paul, are hardly definite enough.—What do you say, John ?"

"Sir, I think plants might be classified as annuals; biennials, and perennials by roots, and perennials by stems, as you did a few moments ago."

"This will do better ; but, let me see. Does not grass at a distance look very much like wheat ? Yet wheat is annual while grass is perennial ; wheat and grass, then, would come under two different categories ? Again, the oats we cultivate are annual, while the wild oats that grow along the road-side are perennial. Here are two yellow *buttercups*, as they are commonly called, that I gathered, side by side, in the garden ; this one is annual, and that one is a perennial weed, almost impossible to kill. You see, John, that your system is not very much better than Paul's."

72. Important Characters in the Flowers.—By long and careful study botanists have concluded that the best divisions are those established upon the structure of *flowers*, *fruit*, and *seeds ;* in a word, upon all that tends to *preserve the species* of the plant.

This should not surprise you much, since you are already aware that the form and structure of the stems of trees differ widely, according to whether their seed has one or two cotyledons.

Thus, **plant families** have been formed by grouping together, under a common head, plants often very different in appearance, but *whose flowers are very much alike.*

Now, I am going to give examples from one of the most important families, with many of the representatives of which you are well acquainted.

73. The Leguminosæ.—You are all, doubtless, well acquainted with the lentil, the clover, the pea, the bean, the acacia, etc. Among these plants some are simple herbs, others are shrubs, others are trees; some are annuals, biennials, and perennials ; some creep along the ground, others climb, and others, again, stand firm and erect ; some have soft leaves and others have prickly leaves. Now, if you examine the *flowers*, the *fruit*, and the *seed* of all these plants very carefully, you will find that they are all formed in the same manner, or nearly so, and that in tracing the history of one of these flowers you are learning the history of all, as they differ but little, except in size and color.

I shall select for illustration a blossom of one of the pulse family, a pea or bean.

At first you will have some difficulty in finding the *sepals*, which are blended together, leaving only the five points visible. Inside is the *corolla*, with five *petals;* but, how different they are from one another! Here is one larger than the others (called the banner), and which stands almost erect; then, there are two little ones (wings), one on each side; finally, the two remaining ones are joined together so as to look like the keel of a boat (Fig. 163).

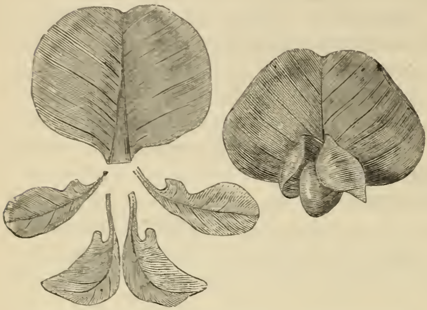


Fig. 163.—Dissected and complete flower of the pea. The dissected flower shows the banner, two wings, and the two petals that form the keel.

The *stamens* are also very peculiarly arranged, as you see. There are ten of them; nine are joined together at the base and only one is free. They thus form a long tube, split on one side and showing where the *ovary* is situated. It will be much easier for us to examine this ovary when it has become a fruit or pod. Not one of you but knows what the shell (or *pod*) of the bean is. It looks like a leaf folded and the two edges fastened together; and who has not seen inside the pod those seeds, good to eat, and commonly called *beans?* It is right here that you will be able to see very easily, not only the tiny plant, but the two large cotyledons which envelop it, and which, as we shall learn later on, serve to nourish it when it begins to sprout.

Fig. 164.—Pod of a pea.

After the bean take up the pea and examine its flower, its pod (Fig. 164), and its seed, and you will find in them the same parts and arranged in precisely the same manner as in the bean.

The flower of the clover is smaller, and can not, therefore, be so easily examined, but patience and good eyes will show you that the same arrangement prevails.

Botanists were right, then, in gathering all these plants into the same group, and under the same name. All of them, as I have already told you, belong to the **leguminous family**, or the natural order **Leguminosæ.**

74. Rosaceæ.—Let us go back once more to our *pear-blossom*, and look into it more closely even than we did before; or, what is still better, let us examine this wild rose (Fig. 165), which belongs to the same family and has a larger flower. You see, it has five sepals also joined together at the base and containing, first, five petals; next, a large number of stamens; and, lastly, the ovary concealed in the calyx and adhering to it. Well, the blossoms of the blackberry, the strawberry, the almond, the plum-tree, the cherry-tree, and others are all arranged in pretty much the same manner. The only important differences occur in the ovary, and consequently in the fruit, for there are among these plants some that bear *fleshy fruits with pips* (apples, pears, etc.), others with *stones* (peaches, plums, cherries), others with *little flesh* and *kernels* (almonds), etc. Now, because of the similarity of the blossoms or flowers of these plants they have all been gathered together into the *Rosaceæ family*, as they have more or less the same structure as the rose.

FIG. 165.—Sweetbriar rose (*Rosaceæ*). The ovary.

You now see the importance of the *structure of flowers.* Let us, then, go on to examine some of those that bloom about the same time as the pear.

Fig. 166.—Cowslip (*Primulaceæ*). Section of the flower, showing style and ovary.

75. Primulaceæ.—Here is the *cowslip* or *primrose* (Fig. 166), which abounds in our meadows. You see it has five sepals, joined together; next, five petals, also joined together at the base and forming a long tube. Let us cut this tube open, and we shall find it to contain five stamens adhering to its sides. Finally, at the bottom of this tube is an ovary, quite isolated, and bearing a long style. This ovary will become a fruit or seed-case, which will open somewhat after the fashion of a common candy-box.

With the primrose may be associated the blue and red pimpernel, etc. These flowers form the *Primulaceæ family*.

Fig. 167.—Common pæony (*Ranunculaceæ*).

76. The Ranunculaceæ.—Here is a common *buttercup* (Fig. 167). It has five sepals, quite free or separated this time; five petals, also free; a large number of stamens; and, in the center, quite a large number of ovaries, which will in time become so many little seed-cases, each containing one seed. This buttercup is the type of the great *Ranunculaceæ family* (Latin *rana*, a frog, and so called by

Pliny, because the aquatic species grow where frogs abound), to which belong the clematis, columbine, anemone, pæony, larkspur, hellebore, etc.

77. The Liliaceæ. — Here is another flower very different from any we have had yet; it is the *lily of the valley* (Fig. 168). It has but one floral envelope, which looks like a little bell. This bell presents six teeth or dents, situated at the extremity of the petals, joined together nearly their entire length. At the bottom of the bell are six stamens and an ovary which will become a small, fleshy fruit, or, as botanists say, *a berry.* The lily of the valley is allied to Solomon's-seal, and to such table vegetables as asparagus, onions, leeks, garlic, etc. It belongs to the *Liliaceæ family.*

Fig. 168.—Lily of the valley (*Lilaceæ*).

78. Salicaceæ. — I now show you a flower as dull-looking as possible. It is the flower of the *willow* (Fig. 169), the one which bears stamens, for I have already told you that in these plants flowers with pistils and flowers with sta-

Fig. 169.—Flowers of the willow (*Salicaceæ*). 1, Catkin with stamens. 2, Flower with stamens. 3, Catkin with pistils. 4, Flower with pistils.

mens do not grow on the same but on different plants. The willow has neither calyx nor corolla, but merely two stamens, situated at the base of a sort of little shell (*bract*). The willow belongs to the great **Salicaceæ family**.

79. Compositæ.—"I shall bring our lesson to an end with those little *daisies* (Fig. 170), whose pretty white heads adorn our meadows, and which when night comes on wrap themselves up in the pretty cover they kept unfolded to the sunlight all the livelong day. Now, James, I will trust you with this examination, but I warn you beforehand it will give you plenty to do. To begin with, how many sepals do you find ?"


FIG. 170.—Ox-eye daisy (*Compositæ*).

"More than twenty, sir."

"Ah! How many petals ?"

"Oh, sir, if all those little white blades are petals, there are a great many."

"Well, let us pass on. Now, count the stamens and pistils also."

"Ah, sir, I am completely lost; those little yellow things I mistook for stamens are nothing of the kind. By the aid of your magnifying-glass, I see that each has five teeth or notches, and they look as much like tiny flowers as anything else."

"You are quite right, James, they are, indeed, flowers. Each of those tiny flowers has five petals joined together, making a tube ; inside are five stamens with a pistil containing an ovule, or little seed. All this is clear through a strong magnifying-glass. These little flowers are called *florets*.

"The little white blades you at first took for petals are also flowers ; each blade is composed of five white petals blended together in a lamina (or blade) at the base, and which prolongs itself into a tube.

"This tube contains neither stamens nor true ovaries; they are *semi-florets.* Finally, your imaginary sepals are merely a crown of little leaves surrounding a bunch of flowers, very much like the leaves in which bouquets are sometimes wrapped."

The family to which our daisy belongs well deserves the name of **Compositæ**. It is a very numerous and varied family.

80. The Principal Families.—As the flowers come into bloom, we shall have occasion to examine the principal ones among them and to learn the structure, family, and name of each.

I desire, from the start, to indicate, in rapid review, how the most important plants, and those you are best acquainted with or have heard the most about, are classified. Let us begin with

DICOTYLEDONS.

First, here are the *Ranunculaceæ*, which we have spoken of already ; then the *Papaveraceæ* (Fig. 171), which includes the *poppy* (Latin *papaver*), the *yellow poppy*, and the *bloodroot*.

FIG. 171.—Common poppy (*Papaveraceæ*).

FIG. 172.—Mustard (*Cruciferæ*).

The *Cruciferæ* (Latin *crux*, a cross) (Fig. 172), a word which means *cross-bearer*, is so called because its four petals are

Fig. 173.—Sweet William—a pink— (*Caryophyllaceæ*).

Fig. 174.—Wild mallow (*Malvaceæ*).

arranged in the form of a cross. This is a very numerous family, and includes the stock or gillyflower, the water-cress,

Fig. 175.—Pea. (*Leguminosæ*).

Fig. 176.—Common cucumber (*Cucurbitaceæ*).

the mustard-plant, the cabbage, the shepherd's-purse, the radish, the horse-radish, etc.

The *Caryophyllaceæ* (Fig. 173), including the carnation, pinks, soapwort, chickweed, etc.

The *Malvaceæ* (Fig. 174), to which belong the mallow, cotton-plant, and the marsh-mallow, so much prized in the West Indies for its medicinal properties.

Fig. 177.—Wild parsley (*Umbelliferæ*).

The *Leguminosæ* (Fig. 175) and the *Rosaceæ*, already referred to; the *Cucurbitaceæ* (Fig. 176), including the melons, cucumbers, pumpkins, etc.; the *Umbelliferæ* (Fig. 177), whose flowers are borne upon little stalks, all clustered together at the top, forming a common plane or convex surface above (the umbel), as in the carrot, parsnip, parsley, caraway, the poison-hemlock, etc.

Fig. 178.—Madder (*Rubiaceæ*).

Next we have the *Rubiaceæ* (Fig. 178), including the mad-

Fig. 179.—Chiccory (*Compositæ*).

Fig. 180.—Borage (*Boraginaceæ*).

der, whose roots produce a red dye—hence its name (Latin *ruber*, red); the coffee-plant, cinchona, ipecacuanha, etc.

The *Compositæ* (Fig. 179) comprise three types. Some, like

Fig. 181.—Tobacco (*Solanaceæ*).

Fig. 182.—Digitalis, fox-glove (*Scrophulariaceæ*).

the little daisy, have a crown of semi-florets, with florets in the center, like the marigold, the sunflower, the Jerusalem artichoke, the camomile, etc. Others have only florets, like the thistles you put into one another's hair in the fall of the year ; others, again, have only semi-florets, like chiccory (Fig. 179), lettuce, dandelion, etc.

The *Boraginaceæ* (Fig. 180) include the heliotrope, forget-me-not, and the hound's-tongue.

The *Solanaceæ* (Fig. 181) comprise the potato, the bitter-sweet, the belladonna, tobacco, and thorn-apple or jimson-weed.

Fig. 183.—Wild thyme (*Labiatæ*).

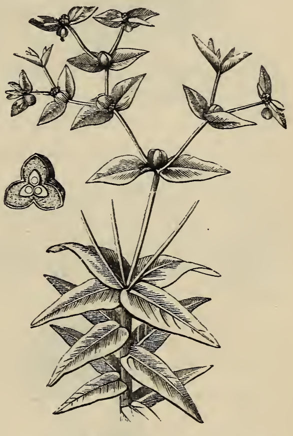


Fig. 184.—Euphorbia, spurge (*Euphorbiaceæ*).

The *Scrophulariaceæ* (Fig. 182), the best known of which are the digitalis or foxglove, the veronica or speedwell, the snapdragon, innocence, etc.

The *Labiatæ* (or square stems) comprise mint, sage, thyme (Fig. 183), marjoram, balm, rosemary, pennyroyal, catnip, and lavender.

The *Euphorbiaceæ* (Fig. 184) comprise the euphorbia or spurge, croton, castor-oil plant, box-wood, and cassava, from which we get tapioca.

Fig. 185.—Larch (*Coniferæ*).

The *Urticaceæ*, or *Nettle Tribe*, include the hemp, hop, nettle, bread-fruit, banyan-tree, etc.

The *Cupuliferæ* comprise the oak, the chestnut, walnut, hazel, beech, etc.

The *Coniferæ* (so called on account of their fruit), the greater part of which do not lose their leaves all at once at the end of autumn, and consequently merit their name of *evergreens*. The most prominent are the pine, fir, cedar, juniper, yew, larch (Fig. 185), and cypress. We now turn our attention to

MONOCOTYLEDONS.

The *Liliaceæ* (Fig. 186) are onion or bulb plants, among which may be mentioned the tulip, garlic, hyacinth, the onion, scallion, asparagus (Fig. 187), and aloe.

Fig. 186.—Parrot tulip (*Liliaceæ*).

Fig. 187.—Asparagus, root, fruit, flower, shoot, and mature sprig (*Liliaceæ*).

FIG. 188.—Iris (*Iridaceæ*).

FIG. 189.—Poet's narcissus (*Amaryllidaceæ*).

The *Iridaceæ* comprise the iris (Fig. 188), flag, gladiolus, and saffron.

The *Amaryllidaceæ* (Fig. 189) include the narcissus, daffodil, tuberose, snow-drop, and century-plant.

FIG. 190.—Vanilla (*Orchidaceæ*).

The *Orchidaceæ* (Fig. 190) are a peculiar family, whose flowers sometimes take the most fantastic shapes, some having the appearance of insects. Among these are the orchids, the vanilla, and the lady's-slipper.

The *Palmaceæ*, or palm family, belongs to warm countries, and includes the dwarf-palm—rarely more than three feet high—the date-palm, the cocoanut-palm (Fig. 160), and the sago.

Fig. 191.—Wheat-heads (*Graminaceæ*).

The *Graminaceæ* (Fig. 191) comprise the *cereals;* that is, wheat, barley, oats, rye, rice, millet, corn ; also sugar-cane, bamboo, and the greater number of food-grasses.

This family of plants contributes more to the sustenance of man and beast than all that have been previously mentioned. Moreover they are the most widely distributed, being found in all parts of the world, even encroaching upon the regions of almost perpetual winter. With but one exception, no poisonous member of the family has ever been found. The stems of many of them contain sugar, as the *sugar-cane.*

You now have the principal families. We shall learn, further on, the details of their structure, the forms of their flowers, and, in short, what is called their *characters.* Let us content ourselves for the present with this enumeration, tiresome enough already.

VI.—FLOWERLESS PLANTS.

81. There is still a large class of the vegetable kingdom that we have not yet studied. Indeed, all the plants we have gone over *bear flowers*, sometimes reduced, it is true, to stamens or pistils, but having these parts at least.

There are others that *do not bear flowers*, and, although they may not be so pleasing to the eye, or inviting to gather and to cultivate, they are none the less interesting.

82. **Ferns** (Fig. 192), which in our latitude are very small, have stems several yards high in the warmer latitudes.

"Please, sir, how is it that ferns, having no flowers, yet bear seeds?"

"I could tell you a great deal in this connection, as there is nothing more curious and complicated. I must content myself, however, by showing you this fern-leaf, so common in our woods, and which I have preserved in my *herbarium* (plant-album). Notice on the under side of this leaf, beneath each division, or, more properly speaking, under each *lobe* of the leaf, those little yellow dots laid out in rows. Under the magnifying-glass you will see that they themselves contain little grains (*sporangia*, spore-cases; spores are those minute grains in flowerless plants which perform the work of seeds in flowering plants). These, in their turn, contain the seeds (*spores*) of the fern. Imagine how very small those seeds must be."

FIG. 192.—Fern fronds, showing sporangia.

FIG. 193. — Moss, also case containing seed of moss.

83. Mosses, Lichens, Mushrooms, Algæ.—Leaving ferns, let us pass on to **mosses** (Fig. 193). You are well acquainted with them, and you may have noticed, among their foliage, some tiny balls borne on long, thin stalks; these balls are the cases which hold the seed.

Next to mosses are the **lichens** (Fig. 194), which I told you about a while ago.

FIG. 194.—Lichen.

Then come **mushrooms** (Fig. 195), which, as you know, are so varied in size, shape, and color. I need not tell you that some are good to eat, while others are terribly dangerous, and

Fig. 195.—Mushroom.

Fig. 196.—Fucus.

very hard to distinguish from the good ones. It is safe, then, to trust only to those cultivated in mushroom-beds.

Truffles are a sort of mushroom that live underground. They are considered quite a delicacy.

Some mushrooms are so small that they can not be seen without the aid of the microscope — *mold*, for instance. Another example is the *vine-mildew* (a species of the *oidium*), which has been very injurious to the grape-vine, and which, before the *phylloxera*, was its most fatal enemy.

The **Algæ** (Fig. 196) are water-plants. Those that live in the sea are especially curious and beautiful. The *Sargasso grass*, or sea-weed of the North Atlantic, belongs to this order.

This is all I can say to you this year and at this time about the history of plants. We shall have to recur to it frequently in our walks, when I shall be able to show you a large number of plants already spoken of, together with a great many others.

SUMMARY.—Plants.

1. **The Parts of a Plant** (pages 103, 104). An ordinary tree is composed of a **root, stem, branches, leaves**, and **flowers.**

2. There is a **bud** at the axil of each leaf, in the angle it makes with the branch.

3. In growing, this bud will make a new branch.

4. All branches shoot forth in this way at the **axilla** of the leaf, and every leaf has a *bud* at its axilla.

5. Some branches, instead of growing indefinitely, stay short and are terminated by **buds.** These buds open out into **flowers**, which bring forth **fruit.**

6. The **stem** or **trunk** (pages 104–106) of nearly all the trees of this country is composed of three parts: in the center is the **pith**, which is soft and white; around the pith is the **wood**, which is hard; finally, around the wood is the **bark,** which is green on the outside.

7. The pith occupies no more room in an old tree than it does in a young one; in other words, the pith does not increase with the age of the tree.

8. The cross-section of the trunk of an old tree reveals a number of *circles* fitting into one another.

9. Each of these circles marks a **year** in the age of the tree.

10. As the tree grew more rapidly when it was young, the circles nearest the center of the trunk are very distinct from one another, but the nearer they get to the bark the more indistinct they become.

11. In regard to its solidity, we distinguish in the wood the *heart* in the center, which is harder, because it is older, and time has deposited some solid matter there; and the *sap-wood,* situated between the heart and the bark, which is not so hard.

12. The trunk of our trees gradually diminishes in thickness toward the top and ends in a point; it is *conical.*

13. **The Branches** (page 106).—The manner in which trunks put forth branches varies exceedingly. Sometimes they shoot out horizontally, as in the fir; again, they ramify in all directions, as in the plum-tree.

14. **Leaves** (page 106).—Leaves are composed of a stalk or *petiole*, often wanting, and a green part called the lamina.

15. This lamina may be simple, as in the leaf of the apple-tree, or divided, as in the buttercup. It is extremely complicated in the acacia-leaf.

16. **Flowers** (page 108).—A flower is formed first of **sepals**, generally like little green leaves, which, taken as a whole, make the *calyx.*

17. Inside of these are larger leaves, generally colored, and forming the *corolla;* they are called **petals.**

18. In the center of the flower we see little rods terminating in yellowish balls; these rods are the *stamens*, and the yellow color is due to a very fine dust called *pollen.*

19. Finally, we find in the center of the flower one or more little

balls, each surmounted by a stalk. These balls are called **ovaries**; the stalks are **styles**, and the ovaries and styles, taken together, form the **pistil.**

20. **Fruits** (page 109).—The ovary, when it attains its full growth, becomes the fruit.

21. In the ovary there are little white specks called *ovules;* these ovules will become the *pips* or *seeds* that are seen in fruits.

22. **Seeds** (page 109).—The examination of a seed, a pea, or a bean, for instance, will show two large bodies called *cotyledons.*

23. Between the two cotyledons will be seen a plant in miniature, in which will be discovered a little **root** (radicle) and a growing **point** (plumule).

24. The cotyledons are the first two leaves.

25. **Incomplete Flowers** (page 109).—The most important part in flowers are the *stamens* and the *ovaries;* or, rather, the **seeds**, the **pollen**, and the **ovules.**

26. Should the stamens of a flower be pulled off, the ovary would not develop, the fruit would not *knot.*

27. Some plants have two kinds of flowers: one having stamens, and the other pistils (ovaries and styles).

28. Sometimes the two kinds of flowers are borne on different plants.

29. **Structure of the Palm-Tree** (page 112).—The trunk of the palm-tree is of the same thickness at the top as at the bottom; it is *cylindrical*, not *conical.*

30. The trunk of the young palm is as thick as that of the old one. It grows *taller*, but *not thicker.*

31. Trees of this kind have but **one bud** (terminal), at the *top of the tree*, and it is from this point that the plant grows. They have no buds on the sides, consequently no branches, nothing but a huge tuft of long leaves, hard and stiff, at the top.

32. In the trunk there is no pith, no wood with circles fitting into one another, and no bark.

33. In place of this there is a soft mass through which run hard, black fibers, which come from the old leaves, and, penetrating through the inside of the tree, return to disappear at the surface.

34. Finally, the seed of the palm-tree has but **one cotyledon.** This is the case with all plants similarly constructed.

35. **Dicotyledonous and Monocotyledonous Plants** (page 115).—It has been found quite natural to divide plants into **monocotyledons** and **dicotyledons.**

36. Trees, shrubs, and herbs are to be found in each of these groups.

37. **Duration of Plant-Life** (page 115).—Some plants germinate in spring, flower in summer, and perish in winter; they are called *annuals.*

38. Others put forth leaves the first year, and yield flowers and fruit the second, and then perish; these are called *biennials.*

39. Others, again, flower and bear fruit for several years in succession; these are called *perennials.* True perennials are generally trees and shrubs.

40. Finally, some plants are perennials **only in the root,** and annuals in the stem—like the dahlia.

41. **Classification of Plants** (pages 116–129).—All plants whose **flowers** bear a great resemblance to one another have been grouped together into *families.* Thus we have the *Leguminosæ*, the *Rosaceæ*, the *Primulaceæ* families, and so on.

42. **Flowerless Plants** (pages 130, 131).—There are plants that do not bear flowers, such as *ferns* (the seeds of which are borne on the leaves), *mosses*, *lichens*, *mushrooms*, and *algæ.*

SUBJECTS FOR COMPOSITION.

I. (Pages 104, 105.) The **stem.** The pith; where found in the trunks of young trees; in the trunks of old trees. What the rings indicate. The heart—the sap-wood.

II. (Pages 106, 107.) **Leaves.** What do you see at the axil of the leaf? Branches with buds and branches without them. Simple leaves; divided leaves.

III. (Page 108.) **Flowers.** Mention their diffrent parts. Tell what becomes of the ovary.

IV. The **palm-tree** (pages 112–115). Describe the palm-tree—its trunk, leaves, seed; its uses.

V. Tell what you know about the duration of plant-life (page 115).

VI. What have you learned about the bean (page 118)?

PART III.

NATURAL HISTORY OF MINERALS AND ROCK FORMATIONS.

MINERALS AND ROCK FORMATIONS.

I. MINERALS.

84. Having studied many things about animals and plants, it behooves us to do as much regarding the **earth** on which we live, and the **stones**, or, to speak more precisely, the **minerals** of which it is so largely made up. You will see that this study is not devoid of interest.

85. The Different Components of the Soil.—In the first place, you know that the soil contains many different components. You can already distinguish *arable land*, which is worked, sown with seed, and planted with trees, etc. ; then *stones*, more or less large, isolated in fragments and mingled with the soil, or in huge masses called *rocks;* and *sand*, composed in reality of very minute stones ; then *clay* or *aluminous earth*, which is plastic or easily molded and kneaded, retains water in its cavities, and is consequently *impermeable* (not allowing water to pass through it), and which, when it is baked, so hardens that earthenware of any kind may be made of it. Finally, you have all most assuredly seen very beautiful stones, having regular forms, and what are called *angles*, *edges*, and *faces.* They are called *crystals* (Fig. 197).

Fig. 197. Quartz crystal.

Here is already a beginning for us who have been in the habit of making classifications. But we have learned that it will not do to trust to the appearance of things, and that we must go deeper. Let us examine these objects closely and carefully.

86. Action of Acids upon Stones.—I take a little piece of **chalk** and throw it into this glass of strong vinegar. You see that *little bubbles of air* (gas would be a better word) *immediately escape from the stone, rise to the surface of the water, and give it the appearance of boiling.* Let us stir it with this stick and watch the effect. See, the piece of chalk has disappeared ; it has **dissolved**, as a lump of sugar would have done in water. We shall explain this later on, when studying chemistry. Let us be content with what we have seen to-day.

I now put into the vinegar a bit of *common limestone*, such as you see used for building purposes. This stone is very hard, and yet it gives off gas, and dissolves as the soft chalk did. A piece of **marble** will do the same thing.

The effect will be very different if I put a lump of **clay** into the vinegar. Hardly any gas will be given off ; the clay will spread itself on the bottom of the glass and remain intact.

Let us now try a piece of **flint**, a little shining **pebble** which the river has washed down from the mountain, and an **agate,** such as you use when playing marbles. Observe that *the vinegar has no more effect upon them than pure water would have.*

Let us repeat the same experiment with a very powerful acid—*sulphuric*, often sold under the name of *oil of vitriol*, and which burns and destroys most objects.

I take, with great precaution, a drop of this acid at the end of this glass rod and I put it on the **chalk**. Whew ! what a discharge of gas, or *effervescence*, as chemists would say !

Another drop on this chip from the corner of a **marble** mantel-piece, so highly polished and so hard looking : just the same effect. This will teach you, by the way, never to put a bit of orange, apple, or other acid fruit, upon marble, as it will be sure to leave a stain.

But I *can drop sulphuric acid on this lump of* **clay**, *this piece of* **flint**, *or this* **agate,** without the least effect ; the drop of acid remains inactive.

Here are, then, two very different kinds of stones : (1) *stones that dissolve in acids, discharging gas ;* (2) *stones that resist the action of acids.*

87. Calcareous and Silicious Stones.—*Chalk, limestone,* and *marble* are called **calcareous** (Latin *calx*, lime) **stones.** When heated to a very high temperature, in furnaces built for the purpose, they are changed into **lime**. Moreover, some of these calcareous stones are soft, like chalk ; others hard, like limestone ; yet none ever become as hard as steel, nor even as iron. You see, a *knife or a nail can scratch them.*

On the other hand, flint and stones of the same kind, agate, etc., *contain no lime, and are not changed by fire.* Furthermore, they are extremely *hard*, so much so that the point of a knife would have no effect upon them. Far from it; they can themselves, when they have a sharp edge, cut into or scratch a piece of steel. Finally, when struck sharply against a piece of steel—the back of a knife, for instance—the blow detaches a chip of steel, which becomes red-hot, and is called a *spark.*

When I was a boy, this way of obtaining fire was practiced by *striking the flint*, as it was called—that is, lighting the tinder with a spark ; powder was ignited in the same way, with the old flint-locks used on muskets many years ago ; the flint was also used for kindling fire. All these very hard stones are **silica**, or, rather, **silicious stones** (Latin *silex, silicis*, flint). There are a great many varieties, and some of them are very beautiful, rare, and valuable ; I shall tell you about them after a while.

There are, naturally, **calcareous sands** and **silicious sands,** just as there are **calcareous stones** and **silicious stones.**

Sandstone, which is simply *grains of sand more or less firmly united so as to form a stone*, may be either *calcareous* or *silicious.* Silicious sandstone consists mainly of quartz; but, if very hard, it is often called *grit. Granitic* sandstone consists of granitic sand ; *argillaceous sandstone* contains much clay. *Whetstones* are made of silicious sandstone, its hardness being such that it can wear away steel.

Stones and *lava* cast up from volcanoes are *silicious.*

88. Plaster, Slate, Clay.—I am going to show you a stone not so common, but one of the most useful. See how soft it is : I can scratch it even with my finger-nail ! A drop of acid would have no effect upon it ; but if I were to subject it to great heat in a furnace, it would be reduced to a sort of white powder, well known to you—**plaster.**

This stone is called **gypsum.** It is found in large quantities in New York, Virginia, Michigan, and Nova Scotia. It is very generally disseminated, the most famous localities for the finer qualities, worked into *alabaster* vases and figures, being Castelino, about thirty miles from Leghorn, while Montmartre, Argenteuil, and other places in the neighborhood of Paris, furnish supplies for the preparation of plaster of Paris and for fertilizing purposes.

Slate is well known to you ; its hardness is about the same as that of calcareous stones—that is to say, it can be scratched or marked with a knife, but not with the finger-nail, and acids do not affect it.

Clay, as you know, is very soft and plastic, and yet it is not affected by acids.

Calcareous stones, silicious stones, gypsum, slate, and **clay** *are the principal stones, or, at least, the most useful to know.*

89. Stony Mixtures.—You must not suppose that these rocks are always entirely pure, or distinct from one another. It most frequently happens that calcareous rocks contain a little clay, and clay contains more or less calcareous matter. There is a well-known stone used as a fertilizer, called **marl,** which is a calcareous stone strongly intermingled with clay. This is what causes it to split so easily with the frost, and allows the rain to dilute and mingle it with the soil.

Mold or **arable soil** is nothing more than a mixture of different kinds of stones ground to a fine powder and mingled with animal and vegetable waste. Here is some garden-soil in which there is not a pebble. Let us wash it carefully under the hydrant. You notice that the water runs off very dirty, carrying away with it all sorts of blackish stuff. Finally, after stirring carefully, nothing remains in the bottom of the glass but some very fine, clean sand. Let us now add to the water that remains a few drops of oil of vitriol (sulphuric acid). The effect, as you see, is immediate effervescence, which indicates that there is calcareous matter present. The effervescence over, you see that there is still a quantity of matter in the bottom of the glass. These are grains of *silica* (sand) and *clay-dust.*

90. Crystals.—Minerals, as I told you at the beginning of this lesson, often appear under the form of **crystals.** There are *calcareous* crystals and *silicious* crystals. *Gypsum* is often crystallized in the form of a spear-head. Calcareous crystals are worthless. One day a poor man from the neighhood came to me in great glee. Just think of it ! he had discovered a diamond-mine ! Poor fellow ! his diamonds were simply some calcareous crystals that had formed in a hollow rock. I showed him how I could scratch them with my knife, and, after expressing his great disappointment, he gave them to me.

A very interesting crystallized calcareous rock is known as *statuary marble*, so beautiful and white, and broken pieces of which look like loaf-sugar. Like sugar, it is composed of a mass of little crystals interwoven into one another.

Silicious crystals are sought after because of their great hardness, which fits them for cutting glass and prevents them from becoming dull like calcareous crystals.

One of the most common is **quartz** or *rock-crystal*, specimens of which have been found in crystals as large as a man's head. Some very beautiful specimens are to be found near Hot Springs, Arkansas.

Others are more rare, more brilliant in appearance, and still harder than rock-crystals. These are found only in small crystals. They are carefully sought after, cut, and made into jewels.

They are known as **precious stones,** such as *rubies* (red), *sapphires* (blue), *emeralds* (green), *topazes* (yellow), *amethysts* (purple).

Before proceeding to something more useful, I must say a word to you about *diamonds*.

"They are very valuable, are they not, sir ?"

"The diamond is the most beautiful of all crystals, the most brilliant, and the hardest, as it will cut glass or other minerals. You may well say it is valuable, as a diamond weighing fifteen grains is worth over a thousand dollars.

"We may add that two of the largest and most valuable diamonds in the world are, the Orloff diamond, in the scepter of the Emperor of Russia, which cost $450,000 and an annuity of 4,000 rubles ; and the Koh-i-noor, belonging to the Queen of England, and now on exhibition in the regalia-room of the

Tower of London. It is valued at $10,000,000. The Tiffany diamond is the largest in America. It was found in South Africa, and is valued at $100,000 (Fig. 198). And yet the diamond is not a stone; it has nothing in common with other minerals. It is *carbon—pure, crystallized carbon* (Latin *carbo*, coal)."

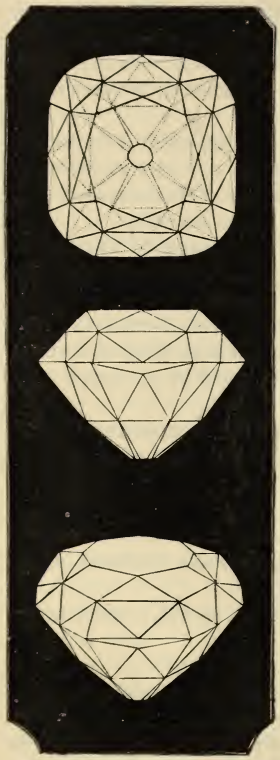


FIG. 198.—The Tiffany diamond. Natural size. Crown, side, and angular views.

"Do you mean, sir, that diamond is nothing but coal?"

"It surprises you, does it not? But such is the fact. When we take up the study of chemistry, we shall have more to say about it. Bear this in mind, however: *a diamond will burn just like a piece of coal*, only it requires a much stronger heat."

All these crystals are very beautiful, but they are not of much use. There are others, however, which *are* very useful—table-salt, for example.

A large quantity of salt is extracted from the water of the sea, which is evaporated and crystallized in **salt-marshes**. But salt is also found on land. Enormous crystallized masses are found in the earth, and it is then called **rock-salt**. Mines of rock-salt are to be found in France and Algiers, but these are in no way to be compared with the mines at Wieliczka, in Galicia, Poland. They are six hundred feet under ground, and miles of galleries have been excavated. The mass of salt is calculated to be five hundred miles long, twenty miles broad, and twelve hundred feet thick. This mine has been worked continuously for six hundred years. The salt-wells of western New York and Goderich, Canada, are said to belong to the Salina period of the Upper Silurian. The present annual product of the salt-wells of Syracuse, New York, is 11,000,000 bushels, having a value of $1,400,000.

91. Crystalline Rocks.—Crystals themselves are not always isolated. They sometimes mass together so as to form stones and rocks.

Thus, **granite**, which you have doubtless heard of, is composed of three kinds of crystal thoroughly intermingled together: **quartz,** with which we are already acquainted, **feldspar**, and **mica**. Granite is found in many parts of the United States.

[Syenite is a variety of granite, and differs from the latter only in containing hornblende in place of mica. It takes its name from Syene, in Upper Egypt, where it was quarried for monuments by the ancient Egyptians. The Quincy granite, of Massachusetts, is a syenite, and of it Bunker Hill Monument (Fig. 199) is made. Several varieties of syenite are found in New England, and are extensively used for columns, shafts, and monumental purposes in all the large cities of the United States.]

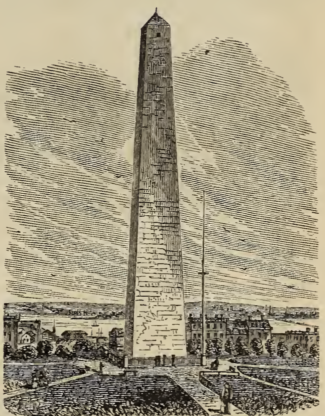


Fig. 199.—Bunker Hill Monument —221 feet high.

Mica is already known to us. There are coasts upon which the sea deposits it in such quantities that it is gathered and sold very cheaply in the form of *gold-sand*, and was used for drying up ink before blotting-paper came into such general use. Here are some ; they look like little, shiny, golden sands. Sometimes the shining matter is large enough to be used in certain countries for window-panes. In our country they are largely used in parlor furnaces and stoves.

Feldspar is less known, but is none the less interesting on that account. Very often, under circumstances not yet satisfactorily explained, it becomes decomposed and crumbles into dust. This dust, carried away and washed by the floods, becomes what is known as *kaolin*. This, when worked into a paste and baked, becomes *porcelain*.

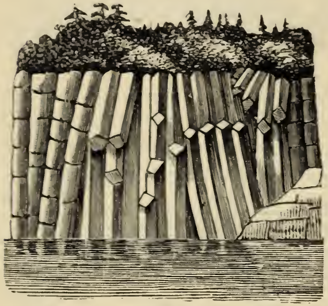


Fig. 200.—Basaltic columns, Lake Superior.

There are a great many rocks more or less allied to *granite*. The best known are **porphyries**, composed of crystals of feldspar set in a fine paste of feldspar, like raisins in a cake; and **basalts**, so common in many parts of the Old World, and of igneous or volcanic origin. Basalt has often a prismatic structure, as at the Giant's Causeway, in Ireland, where the columns are as regular as if the work of art. Good illustrations are also found along the shores of Lake Superior (Fig. 200).

We have, thus far, made a brief review of the principal stones or rocks, whether hard, soft, or crystalline; but I can not dismiss the history of matter found in the earth without a word about *metals* and *coal*.

92. Metals and Coal.—Metals are found in the earth in the state of **ore**, that is, mixed with other bodies. They are some-

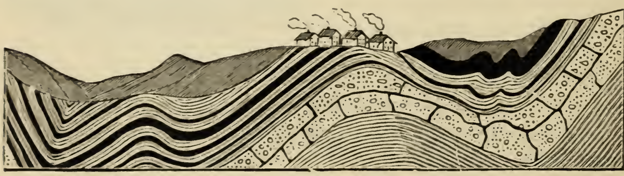


Fig. 201.—Coal-bearing strata.

times on the surface of the ground; but more frequently they are buried at various depths in the earth, which necessitates the opening of *mines* to obtain and extract them. They form in the earth either in thick masses or in **veins**, which, once found, must be followed carefully (Fig. 201).

It sometimes happens that rocks containing *ore* are cracked by rain and carried off and crumbled to pieces by the floods. The metal being heavy, **settles** in the deep places, where there is least motion. This accounts for the finding of gold in the beds of rivers either already dried up, or through which the water still flows.

Coal is the *residue of immense forests* buried in the earth ages ago. They were largely composed of ferns (Fig. 202) and trees closely allied to our firs. Coal is obtained from the earth by mining. It is one of the most important of all minerals; it consists chiefly of carbon, and is universally regarded as of vegetable origin. It is of inestimable value to man, not only as fuel for domestic use, but for the reduction of metals and for all purposes of the arts, including generation of steam-power, on which so much now depends. The greatest coal-fields in the world are those of North America, lying in the eastern part of the United States, and in New Brunswick, Nova Scotia, and Cape Breton. The largest coal-fields in the United States are in Pennsylvania.

Fig. 202.—Coal fern (fossil).

The **turf**, which is still formed in our day, is *very young coal* not yet buried. The plants of which it is made up may still be recognized. When prepared for fuel it is called *peat*.

II.—ROCK FORMATIONS.

You must not imagine that all kinds of stones, *calcareous* and *silicious rocks*, *clays*, and *slates*, are mingled together indiscriminately, to form the soil on which we walk. No, you are already aware that such is not the case.

93. Stratification.—We have already visited the quarry near by. You remember that at the bottom of that quarry there are calcareous stones with which houses in many countries are built. Just above this is a layer of clay, used for the manufacture of tiles and bricks; and, finally, at the top there is a layer of sand mingled with all sorts of little pebbles, just such as you might pick up along the banks of the river that runs at the foot of yonder hill.

Regular combinations of these and kindred rocks are known under the name of *stratified formations*. The hill over there, then, is composed of three superposed (one above the other) layers—*limy rocks*, *clayey rocks*, and *sandy rocks*.

94. Beds, Layers, or Strata.—We spent quite a while among the calcareous rocks of the quarry yonder. I brought to your notice the fact that the pieces of stone *were placed with great regularity*, *one above the other*, just as if they had been so arranged by the hand of man. Here and there you noticed horizontal bands separating *layers of stones*, differing somewhat from one another in hardness or color. In other words, as you heard the proprietor say, it is *formed of several* **layers** *or* **strata** *very regularly arranged one above the other.*

While climbing the road along the side of the hill we found the spot where the calcareous *strata* ended and the layer of clay began. And here we saw that *the line of separation was also very straight and regular*, like the lines of separation of the different strata of the quarry. What power could have brought all these stones together and arranged them with so much regularity?

95. Marine Organisms in Rocks.—Here is something that may help you to answer my question. The proprietor of the quarry was so kind as to give us a large number of *shells changed into stones*, or, as scientists would call them, fossils.

"What do you think about these shells, James?"

"Why, sir, I should say they look very much like mussel-shells" (Figs. 203, 204).

"Very well. Now, where do mussel-shells come from?"

"They come from the sea, sir."

"What does this go to

Fig. 203.—Fossil bivalve (*Solenomya*). Carboniferous Age.

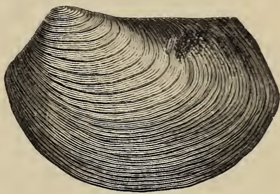


Fig. 204.—Fossil bivalve (*Allorisma*). Carboniferous Age.

show? You hesitate. I shall tell you. From what you have said, we may conclude that *the sea at one time or other came up as far as our quarry*, giving sustenance to these mussels, as it does to those of our day within its waters. When those mussels (bivalves) died, their shells became covered with mud, sand, etc., of a calcareous nature. In time the sea receded, leaving its deposits of *mud, sand, and shells, which stuck together, and finally formed the calcareous stones before us.* There is no other way of accounting for this; and, besides, it is borne out by what is now going on at different points along our sea-coast."

96. Movements of the Sea; Movements of the Earth.—"But, sir, how is it that the sea, which is so far off now, could ever have come up to our hill?" asked James.

"I don't see," said Paul, "how it got away if it ever *was* here."

"There are two ways of explaining this. The first is the supposition that at that time there was a great deal more water in the sea than there is now, and that, consequently, it rose to a much higher level then than now. But this would hardly be a sufficient reason, because sea-shells have been found in the Alps and Pyrenees, at a height of over nine thousand feet, and at great elevations in the Alleghanies in the United States. Now, if such was really the case, what could have become of this immense body of water ?"

"It might have evaporated into the air, sir."

"The whole firmament could not have afforded room for so many clouds."

"Could the earth have absorbed it, sir ?"

"We shall show you after a while that the interior of the earth is far too warm to keep this water. It can not have gone there. This, then, can not be a satisfactory explanation.

"The second way of accounting for this movement of the waters is the supposition *that the bottom of the sea* **rose up out of the water,** *displacing it without lessening the quantity.* Which of these two explanations do you prefer, Paul ?"

"Sir, I see at once that the first must be given up. The second one does not seem much better to me ; the earth is so solid. My father, who has been to sea, says that the water is moving all the time, while the dry land, or *terra firma*, as he calls it, is perfectly motionless."

"Ah ! my boy, let me tell you that your earth—your *terra firma*—does move ; but the motion is so very slow that we do not feel it. But it *falls here and rises there, and in some places it rises and falls alternately.* Very striking evidences of this may be seen along the coast in various places. At Pozzuoli, in Italy, now Puteoli, the Romans built a temple along the shore. The ground having subsided (sunk), the sea rose up around the temple and remained there long enough to allow marine shells to bore into the columns some thirteen feet above the pavement. In the course of time the ground rose again, and at the present day the shells are considerably above the level of the water. The same phenomenon is taking place slowly along the shores of Normandy. The western coast of Norway is rising, while that of southern Sweden is sinking."

"It has taken a long time to do that, sir."

"Yes, but centuries, which seem so long to you, are but *minutes* compared with the periods of the first ages of the world.

"Finally, we are sure to-day that the waters that once surrounded or even covered our hill have receded. This is the way it happened: The sea, we will suppose, was up to the highest point at which you gathered those shells, and deposited there, very slowly and very regularly, its calcareous matter and its shells. Later on, the bottom of the sea and the surrounding country rose to a corresponding height, and all its deposits dried up. Is it clear to you now, Master Paul?"

97. Differences between Superposed Strata.—"Yes, sir, I understand you now; but, please tell us how it is that the limestones are not the same from top to bottom in the quarry, and that there are several *strata*, as you call them."

"*Because*, my son, *it is very probable that, while the bottom of the sea was rising, the rivers and currents no longer carried the same matter with them, and no longer made the same deposits in the same place.* On a smaller scale we can ourselves notice, in the same place on the sea-shore, deposits alternating from fine sand to large pebbles."

"You spoke just now of rivers and currents in the sea. Are we to understand that there are really rivers and currents in the ocean?"

"Most assuredly; there are rivers in the sea, and such large ones, too, that the mightiest streams of the land are rivulets compared to them. They are either of warm or cold water, while their banks and beds are water of the opposite temperature. They move through their watery channels for thousands of miles without mingling with the confining waters. But I have not time now to tell you any more about them to-day."

98. Fossils.—Let us go back to the rise and fall of the bed of the sea and its curious deposits. I may surprise you still further when I tell you that, *during the* **immense period of time** *that this upheaval required, animals underwent changes in their nature.* In the same place, but at different elevations, the species, or rather the fossil remains, are not the same. So, in our quarry we find not only mussels, but also many other kinds of marine mollusks. These **fossils** (Fig. 205), as they are called, are widely different in appearance.

99. Divisions of Rocks.—*Rocks should be divided*, then, *not only according to the nature of the stones which compose them,*

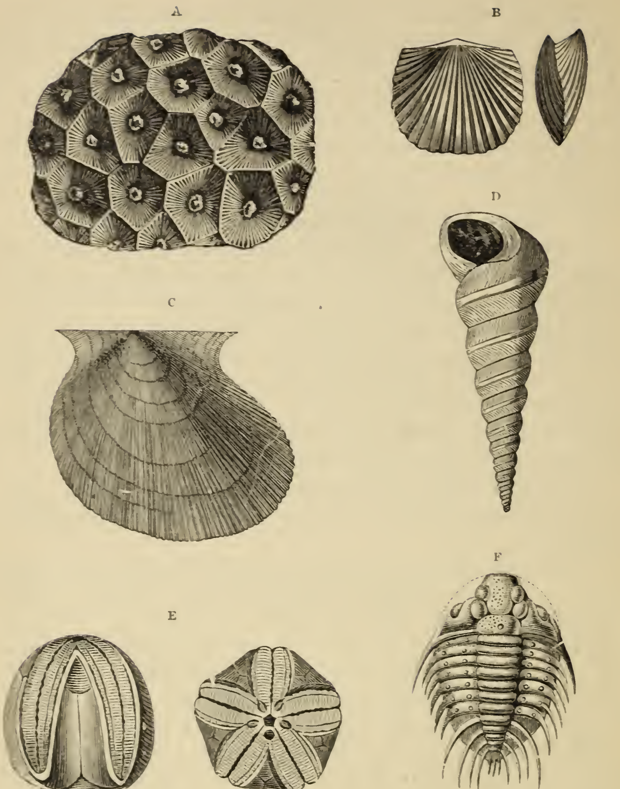


Fig. 205.—Fossils. A, Coral. B, Brachiopod (two views). C, Mussel. D, Univalve. E, Pentremite (star-fish family, two views). F, Trilobite (crustacean).

but especially according to the nature of the **fossils** *found in them.* For, along the sea-shore we often find, at short distances apart, deposits of calcareous sands in one place and clayey matter in another; but we always find the same animal life, consequently the same shells, which form the same kind of fossils. Thus, across the valley there is sand containing the same kind of fossils as those in the upper strata of our quarry. It is reasonable to suppose that they were deposited there at the **same time** as those in the stone-quarry.

100. Causes of the Movements of the Earth.—"Well, Master Paul, do you feel satisfied now? Do you want to know anything else?"

"Yes, sir; I should like to know what it is that causes such upheavals of the earth. It must be very powerful."

"*The reason that causes this slow and gentle upheaval of large portions of the earth is probably the same that causes* **earthquakes**, *from time to time, in different parts of the world.* In 1881 an earthquake destroyed the town of Chios and killed thousands of its inhabitants. In the summer of 1883 the inhabitants of Ischia, in Italy, suffered terrible loss of life from the effects of earthquakes; and in our own country, the city of Charleston, South Carolina, was on August 31, 1886, the scene of the most violent and disastrous visitations. Beyond this area shocks of more or less intensity were felt as far north as Vermont, as far south as the Gulf of Mexico, and as far west as Michigan and Missouri. The most violent shock occurred a little before ten o'clock on the night of August 31st. In February, 1887, an earthquake occurred in the northern part of Italy. About 800 people were killed, and much damage was done at the fashionable winter resort of Riviera (re-ve-ā-rah). So, you see, your *terra firma* is in times like these as much agitated as the waters of the sea!"

It is especially in the vicinity of volcanoes that earthquakes occur—for instance, in Central and South America, southern Europe, and Asia Minor. It nearly always happens that the earthquake is followed by a volcanic eruption.

You have often noticed the lid of the kettle rise and fall when the water was boiling. Well, just imagine the moving lid to represent the earthquake, and the eruption of steam from the spout carrying off the foam, to represent the volcano, and you can form an idea of these terrible commotions.

Then, it is not a little vapor or foam that is sent out, but immense stones that are hurled into the air, and vast streams of *lava* melted by the intense heat of the volcano, and which flow slowly from the fissures, carrying destruction to the regions within its reach. The American Continent contains a greater number of volcanoes than the divisions of the Old World. There are twenty in North America, twenty-five in Central America, and thirty-seven in South America. In Auvergne, France, there are some extinct volcanoes that have thrown up lavas entirely different from the lavas thrown up by the active volcanoes of the present day ; they are called *basalts* and *trachytes*. Porphyries of various kinds have been sent out from the interior of the earth.

[Sometimes, instead of lava, streams of boiling water are thrown up. These are called geysers. They are found in Iceland, in New Zealand, and in the Yellowstone Park (National Park) of the United States (Fig. 206). In the number and magnificence of geysers, this region of the United States surpasses any other in the world. The grandest geysers in the Park have been named the Giant, the Giantess, the Beehive, and Old Faithful. The Giant geyser has been described by Hayden as follows : "It has a rugged crater ten feet in diameter on the outside, with an irregular orifice five or six feet in diameter. It discharges a vast body of water, and the only time we saw it in eruption the flow of water, in a column five feet in diameter and one hundred and forty feet in vertical height, continued uninterruptedly for nearly three hours."]

101. Igneous and Aqueous Rocks.—You see, my young friends, from what I have told you, that there are two kinds of rocks, viz.: (1) *Rocks formed by water*, or **rocks of aqueous origin** (Latin *aqua*, water), and (2) *rocks formed by matter in fusion by a very high temperature*, or rocks of **igneous origin** (Latin *ignis*, fire).

102. Salt-water Rocks and **Fresh-water Rocks**. Among the *rocks of aqueous origin*, there are some that have been deposited by the waters of the sea, others by the fresh water of our lakes. They are distinguished from one another by the *fossils* they contain. In the first are found shells or fishes, resembling more or less those now found along the coast. In the second they are like fresh-water shells and fishes, together with the remains of land-animals.

When an animal dies on land it immediately enters a state

Fig. 206.—The Giant Geyser, Yellowstone Park, U. S.

of *putrefaction* (rottenness), and in a short time nothing remains but the bones. These are attacked by insects, water, air, frost, the sun, and finally disappear. If, on the other hand, the body of an animal found its way into some river and was carried to the quiet waters of a lake, it would sink to the bottom and soon be covered over with mud ; *its bones would change into stone, and remain as* **fossils** when the waters of the lake had disappeared. This may also happen in sea-water, but not so readily as in lakes, because of the constant agitation of the waves and the length of time required to find a resting-place. *It is therefore especially in fresh-water rocks that the remains of mammals, birds, and reptiles are to be found.*

It goes without saying that no fossils are ever found in rocks of an *igneous* character, since they come from the burning depths of the earth.

103. Order of the Superposition of Rocks.—*Savants* (learned men), who study the history of the earth, and who are called **geologists** (Greek *ge*, the earth, and *logos*, study), have, through *the study of fossils*, distinguished a large number of rocks to which they have given names, and which they have classified according to their ages.

When one rock overlies another, it is evident that it is more *recent* than the one upon which it rests, unless there has been an upheaval or volcanic disturbance.

[The older geologists regarded *granite* as a *primitive rock* of the earth's crust, forming the floor of all stratified deposits and the nucleus of mountain-chains. Such a view, however, has been long since exploded. It is known, indeed, that granite, so far from being in all cases an original rock, may be of almost any geological age. Some is undoubtedly as old as the Silurian period, while other granites are certainly as young as the tertiary rocks, and even of more recent date.]

Rocks lie in *regular layers*, like sheets of paper piled upon one another. The bottom or oldest ones are crystalline, and contain no fossils. Next above these come *rocks deposited by water*, and in which are found animal and vegetable remains.

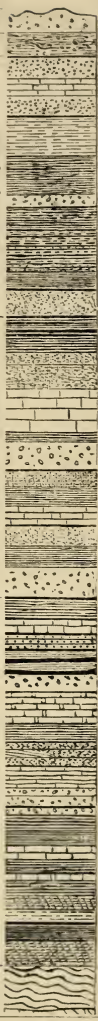
In *the more ancient soils a great difference exists between the animal remains they contain and the animals of the present day.*

In the strata immediately above the crystalline or lower strata very few fossils are found, and these belong to the lowest groups of animals. Then, as step by step we approach the present era, we discover animals more perfectly developed. Hence monkeys and men are quite recent.

Let us understand each other. "Recent," when taken in a geological sense, they (man and monkey) certainly are ; that is to say, they appeared last. But, if we wanted to measure the time man has inhabited the earth by centuries, it would be exceedingly difficult. This prevails all through geology. We can say this rock is more recent in its formation than the one under it, but to tell at what period it was formed, how long a time its formation required, would be an impossibility. There are limestones composed of such small shells that it requires a microscope to see them, there being millions of these shells in one cubic inch ; yet these rocks are in layers hundreds of yards in thickness. How many ages it must have taken to form these deposits !

104. Principal Formations ; Archæan.—The grand divisions of land—Europe, Asia, North America, etc.—were many *millions of years* undergoing changes before they became what they now are in outline. This vast extent of time has been divided into periods (Fig. 207), and the oldest is called the Archæan (ancient) era, in which there was only a small portion of North America above the ocean (Fig. 208). The fossils that have been found in these crystalline rocks show that the animals and plants were of the lowest grade.

105. Palæozoic.—The next division of time is called Palæozoic (old time), also called the Primary system. During this period North America passed through many changes, and more land was elevated above the ocean-level than was the case at the close of the Archæan era. There was still a great interior ocean separating the eastern part of the continent from the western. Palæozoic time consists of three *ages:* 1. The Age of Invertebrates. 2. The Age of Fishes. 3. The Age of the Coal-Measures. In the *first portion* of Palæozoic time, or the *Age of Invertebrates*, corals, mollusks, crustaceans, and starfishes (crinoids) were abundant in the ocean, but no animal possessing a backbone yet appeared, except probably just at



Age of Man.		Recent. Quaternary.	Horse, Bison, Llama, Tapir.
CENOZOIC. (Recent life.)	Tertiary System.	Age of Mammals.	*Pliocene.* Horse, Elephant, Mastodon.
			Miocene. Hyena, Tiger, Rhinoceros.
			Eocene. Monkeys, Carnivores, Rodents, Serpents.
MESOZOIC. (Middle life.)	Secondary System.	Age of Reptiles.	*Cretaceous.* Great Lizards, Ichthyosaurus. Plesiosaurus.
			Jurassic. Turtles.
			Triassic. Connecticut River Brown-stone Beds. First Mammals.
PALÆOZOIC. (Old life.)	Primary System.	Carboniferous Coal-Measures.	*Permian.*
			Coal-Measures. First Reptiles.
			Sub-carboniferous. First Amphibians.
		Devonian. Age of Fishes.	First Vertebrates, Many Invertebrates.
		Silurian. Age of Invertebrates.	*Upper Silurian.* Crinoids, Trilobites, Mollusks.
			Lower Silurian. Crustaceans, Mollusks, Corals.
		Cambrian.	Few Fossils, lowest types.
Archæan.		Huronian. Laurentian.	Rock Crystalline.

FIG. 207.—Section of the crust of the earth.

Fig. 208.—Map of the Archæan land. The white represents the lands in North America that were above the ocean level of that time.

the close of this age. The *middle age* of Palæozoic time is called the Devonian (Old Red Sandstone), or the *Age of Fishes*. The largest of Devonian fishes found in America was over fifteen feet long. The last division of Palæozoic time is of great practical importance, for this age furnished the remarkable plants which made the great coal-beds of Pennsylvania, West Virginia, Ohio, and Illinois. The mollusks, corals, crinoids, and fishes, all continued in vast numbers, but the *amphibians* became important forms of life, and even the *first reptiles* made their appearance, foreshadowing the extraordinary size and characters of these creatures in the next *age*. During the Age of the Coal-Measures vast *forests* of peculiar vegetation covered wide districts of the undeveloped continent and were transformed into coal. Man takes pieces of wood, covers them over with earth, and, by means of a smoldering fire, he makes what is termed *charcoal*. On a similar plan, long, long before the song of bird went forth into the air, or foot of mammal pressed the earth, the great coal-beds of our continent were formed. Ferns grew in this age in profuse and luxuriant abundance. The workable coal-beds of the United States are about 120,000 square miles in extent.

106. Mesozoic.—Following the Palæozoic came the Mesozoic (middle life), also called the Secondary system. Among the animals there were the same sub-kingdoms represented as in the preceding age. The forests were more like the forests of to-day. But this age is noted for its extraordinary *reptiles*. There were swimming reptiles from fifteen to forty feet in length; snake-like reptiles seventy feet long; reptiles that

Fig. 209.—Map of the central part of North America, near the close of the Age of Reptiles (Cretaceous).

walked liked bipeds; and others that flew through the air with a spread of wing of twenty-five feet. Thirty-seven species of Mesozoic reptiles have been found in Kansas, among which was a turtle that had a breadth between the tips of the extended flippers of fifteen feet. Well may we call this the *Age of Reptiles*. There was still a great inland sea extending through the interior of the continent to its northern limit (Fig. 209).

107. Cenozoic.—In the next division of time, called Cenozoic, which comprises the Tertiary and Quaternary systems, the continent, and also the various types of life, are much more like the present than any preceding age. Instead of reptiles, it is the *Age of Mammals.* The fossils that have been studied show, beyond a doubt, that animals related to the *hyena*, *tiger*, *rhinoceros*, *camel*, *elephant*, *horse*, *deer*, etc., roamed over North America during this age. The map (Fig. 210) shows the continent without the long arm of the Gulf of Mexico extending through the interior. But it did extend to the confluence of the Ohio and Mississippi Rivers. One thing we must remember, that in all these years, during which we know the coal was stored away in the earth, the monstrous reptiles held sway, and strange mammals occupied the continent. **Man** had not yet appeared. The earliest records of

Fig. 210.—Map of the central part of North America in the Mammalian Age (Tertiary).

man's existence show that it was about the time of the final shaping of the continent, or, more definitely, at the closing part of Cenozoic time. The antiquity of man dates back to about the middle of the Quaternary. (See Quaternary, in the section of the earth's crust illustrating the Geological Ages, Fig. 207). At this time the remains of man, or traces of human industry, are found.

It was, then, a very poor industry. *Man*, then a savage, lived in caverns along the rivers, and in a rude manner hewed out silicious stones with which to make his weapons. He had to contend with the *mammoths*, *rhinoceroses*, *tigers*, and gigantic *bears*. He slew them, ate them, and fashioned their bones into divers utensils.

108. Is there anything under the Primitive Crystalline Rocks?—"Now, have any of you any remarks to make or any questions to ask?"

"Please, sir, do crystalline rocks go to the bottom of the earth, or is there anything under them?"

"Ah! you are not asking easy questions. No one, as I have already told you, has ever seen in position what there is under these rocks; but volcanoes seem to penetrate pretty deeply into the earth, and the lava they throw up undoubtedly comes from very great depths. Such being the case, lava must form below the crust of the earth."

"But, sir, how is it that lava, being so very hot, does not heat the earth so as to burn our feet? And why is it so very hot?"

109. Central Heat and Crust of the Earth.—"Well, my good friend, pay strict attention to this: When a very deep hole is dug or bored into the ground, it has been ascertained that *the deeper we go the hotter it is at the bottom.* As we descend through mines into the interior of the earth, we find the temperature to increase at the rate of about one degree Fahrenheit for every fifty feet of perpendicular descent. In very deep mines it is impossible for miners to live without a constant current of fresh air to cool off the temperature. A limit is soon reached beyond which men have found it impossible to work. It does not exceed twenty-five hundred feet below the surface.

"Careful study warrants the belief that matter will begin to be in a state of *fusion* at a depth of about one hundred and fifty thousand feet, or, in other words, that the **crust of the earth** *is not over thirty miles in thickness.*

"Now, you have learned in your geography that the earth is a globe whose diameter is eight thousand miles. You see, then, that *it is nearly all in a state of fusion, with a thin, solid crust all around it*, and which does not represent more than about one-hundredth part of the entire thickness of the globe. *This is much less in proportion than the skin of the orange is to the orange.* "Thin as it is, this crust is solid enough to hold together, and thick enough to prevent the **central fires** from overheating the surface."

110. Changes in the Earth's Crust.—It may be safely affirmed that there was a time when the earth was without this crust, and when it was a ball of melted matter, still luminous, and somewhat like red-hot iron. The earth then gradually became cooler by turning and revolving in space, and a first crust was formed, perhaps of *granite* and *crystalline rocks.* When this crust became so thick as to prevent the surface from being too hot, water was formed, and gathered into seas and oceans, and, as the heat diminished still more, living creatures began to appear. These oceans, sent hither and thither over the surface of the globe by the movements of the terrestrial crust, less solid than it is now, deposited the matter and its fossil contents I told you about some time ago.

The same thing is going on at the present time, but with less energy, as the crust of the earth becomes thicker.

During all this time great movements, upheavals and depressions, fractures, etc., have taken place in the earth. In mountainous countries, strata, which the sea must have deposited in a flat position, have been seen at times upheaved, and in an almost vertical position. The interior of the earth has always been in communication with the exterior. Melted matter has always been, and is still, thrown up from its depths. At first great masses, like *porphyries*, forced their way to the surface through the thin crust. Later on there were only vent-holes, or volcanoes, which formerly belched forth basalt, and now eject lava.

This is the history of our earth, no longer made up of pure imagination and invention, but as true and certain as things can be that have never been seen, and for which we must depend on reason and good judgment.

SUMMARY.—Minerals and Rock Formations.

1. **Different Kinds of Stones** (pages 139–142).—Stones may be divided into two kinds: 1. Stones that dissolve in acids and discharge gas. 2. Stones that resist the action of acids.

2. The first, among which may be mentioned *chalk, limestone, and marble*, are **calcareous stones,** because when heated to a very high temperature they become **lime** (Latin *calx*).

3. The second, the principal type of which is *flint*, are for the most part **silica**, or rather **silicious stones.** They are not affected by fire, and are very hard.

4. Silicious stones include clay.

5. As there are calcareous stones and silicious stones, so, too, there are calcareous sands and silicious sands, calcareous *grit* and silicious *grit*.

6. There exist other stones besides these. **Gypsum**, or *plaster-stone*, which acids do not affect. Heated to a sufficiently high temperature, this stone becomes reduced to a white powder, called *plaster*. Slate also belongs to this class.

7. **Stony Mixtures** (page 142).—Different kinds of stones are often mingled together.

8. **Marl** is a *calcareous* stone mingled with a strong proportion of *clay*.

9. **Arable Land** is a mixture of *animal and vegetable waste*, of little *calcareous* stones, grains of *silica*, and *clay*-dust.

10. **Crystals** (pages 142–145).—Minerals often appear in the form of *crystals*. There are *calcareous* crystals and *silicious* crystals. There are also *gypsum* crystals.

11. *Calcareous* crystals and *gypsum* crystals are of little value, because, being soft, they are easily scratched and tarnished.

12. *Silicious crystals* are highly prized because of their great hardness; such are *quartz*, or *rock-crystal*, which is quite common; and precious stones (rubies, sapphires, etc.).

13. The diamond, which is the most beautiful of all crystals, is not a stone; it is pure carbon crystallized.

14. **Crystalline Rocks** (pages 145, 146).—Crystals sometimes mass together and form stones and rocks.

15. The *granite*, upheaved from the depths of the earth, is composed of three kinds of crystals: *quartz, feldspar* (which gives *kaolin*), and *mica*, which you see in stove-doors.

16. **Porphyry,** which is also of igneous origin, is composed of crystals of feldspar set in a fine paste of feldspar.

17. **Basalts** are of igneous origin, and were ejected from volcanoes now extinct, just as *lava* is now ejected from active volcanoes.

18. **Metals and Coal** (pages 146–148).—**Metals** are found in the earth, where they form *veins.*

19. **Coal** is the residue of immense forests buried ages ago.

20. **Turf**, or **Peat**, is a sort of very young coal, still unburied.

21. **Strata** (pages 148–160).—Limestones, clays, slates, and silicious stones are not all mingled together promiscuously; they are arranged in *layers* more or less regular.

22. These strata, together with the fossils they contain, have permitted a classification of different rocks.

23. In the first place we must distinguish—1. Rocks of **igneous** origin. 2. Rocks of **aqueous** origin.

24. Rocks of *igneous* origin are formed from matter in fusion, at a very high temperature, thrown up from the depths of the earth. They comprise **granite, porphyries, basalts,** and **lavas.** No fossils are found in them.

25. Rocks of aqueous origin are deposited by the *waters of the* **sea,** also by **fresh water.** They are distinguished:

(1) **Primary or Palæozoic Rocks** above *crystalline* rocks. During this period the vast forests that covered the earth were submerged and were gradually transformed into coal.

(2) **Secondary or Mesozoic Rocks** rest upon primary rocks. At that period the sea covered a large portion of the earth. Reptiles unknown in our day (the ichthyosaurus, pterodactyl) have left their remains in the deposits then formed.

(3) **Tertiary Rocks, or Cenozoic.**—During this period there lived a large number of mammals, very different from those of our day.

(4) Finally, **Diluvian** or **Quaternary Rocks** (in which are found the first traces of human remains and human industry) were deposited on the soil thousands of years ago.

26. **Movements of the Earth** (pages 149, 150).—The earth is continually upheaving and subsiding, but so slowly that we do not feel it.

27. This has always been going on; thus the distribution of land and water on the surface of the globe has undergone great changes.

28. Under the influence of pressure from inside, similar to that which causes earthquakes in our day, the bed of the sea has been *upheaved* at certain points, displacing the water that once covered it. In other places the land that was above water has subsided (sunk) and been covered by the sea.

29. But all this has taken time. Centuries, which seem so long to us, are but minutes when compared with those enormous periods of time.

30. A similar phenomenon is taking place in our day and along our own shores. The eastern coast of the United States is subsiding in many places. In Europe, the southern coast of Sweden is sinking and the coast of Norway is rising.

31. **Central Heat** and the **Crust** of the **Earth** (pages 162, 163).—When a deep hole is dug in the earth, we notice that the temperature rises about one degree for every fifty feet. Hence, at a depth of 328,000 feet the temperature would be 6,560°, which is more than is required to melt porphyry and lava.

32. It has been concluded that the whole earth is, internally, in a state of fusion, and that the solid crust on which we live is about thirty miles in thickness, a proportion less than that which the orange-skin bears to the orange.

SUBJECTS FOR COMPOSITION.

I. (Pages 139–142.) Nature of calcareous stones and silicious stones. Effect of acids on each. Gypsum. Slate.

II. (Page 142.) Composition of arable ground.

III. (Pages 142–145.) Crystals, calcareous, silicious, gypsum. Diamonds.

IV. (Pages 145, 146.) Tell something about granite, porphyries, basalts.

V. (Page 144.) How and where is salt obtained?

VI. (Page 147.) Where is coal found and how is it obtained?

VII. (Pages 154–157.) Aqueous rocks. Igneous rocks. Tell the order of their superposition.

VIII. (Pages 157–162.) Fossils found in different strata.

IX. (Pages 162, 163.) Describe the movements of the ground. Internal heat and the crust of the earth. Changes in the distribution of land and water, and the causes.

INDEX.

END OF BOOK I.