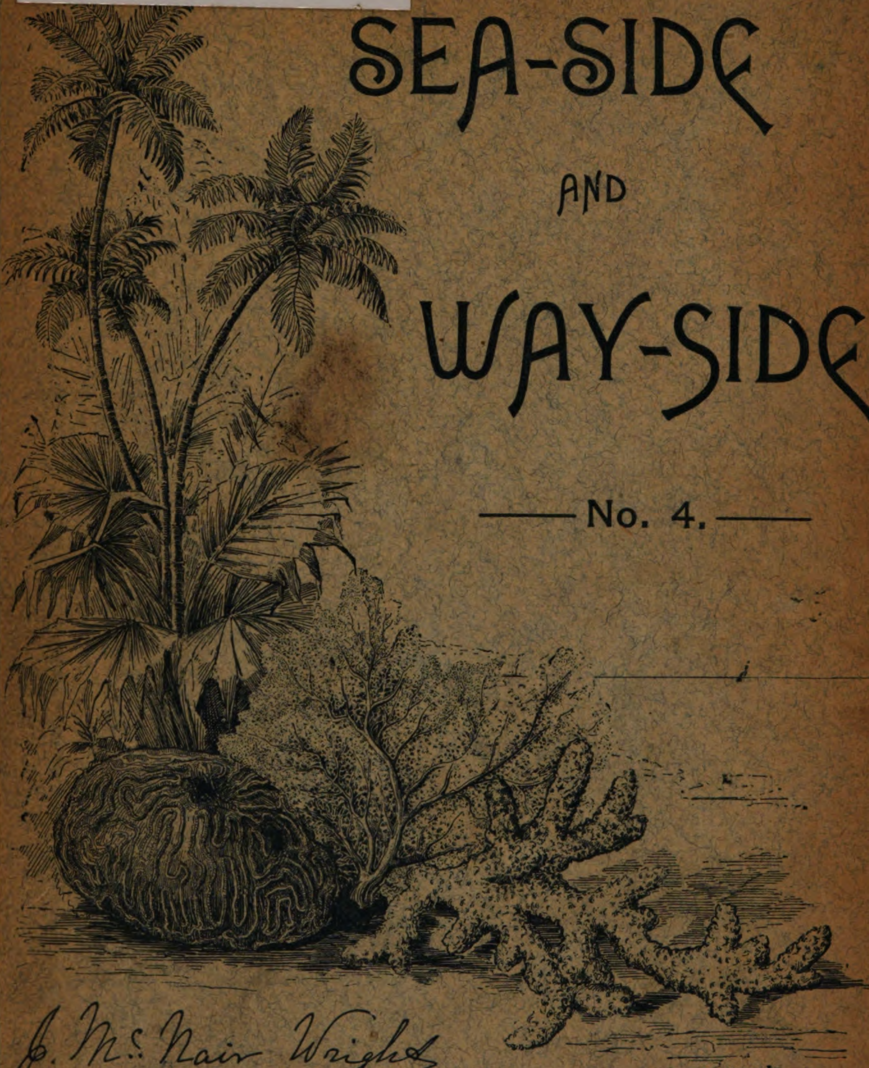
READERS.

SEA-SIDE AND WAY-SIDE.

No. 4.



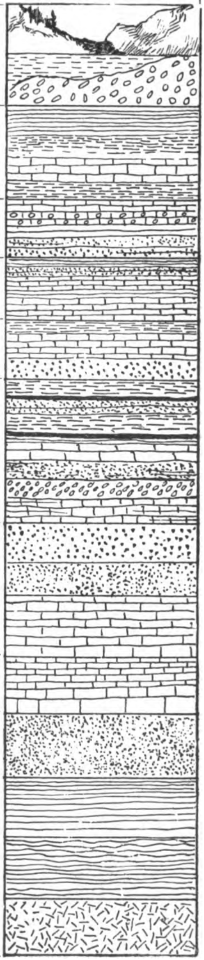
J. McNair Wright

D. C. HEATH & CO., Publishers, BOSTON.

IDEAL SECTION OF EARTH'S CRUST

ERAS		AGES	PERIODS
BYCHO-ZOIC	MAN	QUATERNARY	TERRACE CHAMPLAIN GLACIAL
CENO-ZOIC	MAMMALS	TERTIARY	PLIOCENE MIOCENE EOCENE
MESOZOIC	BIRDS	CRETACEOUS	
	REPTILES	JURASSIC	
		TRIASSIC	
PALEOZOIC	ACROGENS AMPHIBIANS	CARBONIFEROUS	PERMIAN CARBONIFEROUS SUB-CARBONIFEROUS
	FISHES	DEVONIAN	CATSKILL, CHEMUNG CORNIFEROUS, Etc.
	INVERTEBRATES	SILURIAN	LOW HELDERBERG NIAGARA
		ORDOVICIAN	LORRAINE, TRENTON CHAZY
		CAMBRIAN	POTSDAM, ACADIAN GEORGIA
EOZOIC		ALGONKIAN	KENESAW HURONIAN, Etc.
		ARCHAEAN	LAURENTIAN, Etc.
AZOIC ERA			

STRATA



FRONTISPIECE.

Nature Readers.

SEA-SIDE AND WAY-SIDE.

No. 4.

BY

JULIA McNAIR WRIGHT.

"'Come, wander with me,' she said,
Into regions yet untrod,
And read what is still unread
In the manuscripts of God.'"

LONGFELLOW, *Poem on the fiftieth birthday of Agassiz.*

Illustrated by C. S. King.

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PREFACE.

Says Cicero: "There is nothing so charming as the knowledge of that branch of literature which enables us to discover the immensity of nature, the heavens, the earth, and the seas; this is the branch which has taught us religion, moderation, and magnanimity, and has rescued the soul from obscurity to make us see all things above, below, and between both."

Such literature as this is now markedly in the ascendant. Natural science seems to be pre-eminently the coming pursuit of the coming man, and natural science has been wonderfully popularized in books suited to those who without expecting to be specialists desire to be well informed and to look understandingly at the world which lies about them.

Several decades have gone by since Michelet, with his marvellous books, "The Bird" and "The Insect," and Hugh Miller, chaste, graphic, and enthusiastic in his "Old Red Sandstone," "The Cruise of the Betsy," and "The Testimony of the Rocks," opened glorious new worlds before a rising generation. That generation is now doing good work under the inspiration of the impetus then received. Our library shelves are to-day affluent in books that are handmaids of natural science. Tait and Balfour Stewart in their

"Unseen Universe" have brought marvels of world-building within range of our narrower ken. Argyle in his "Unity of Nature" and "Reign of Law" and "Primeval Man," interpreted mighty and far-reaching harmonies. Principal Sir William Dawson, in his "Story of the Earth and Man," brings the successive geologic ages before us with the vividness of some master-painter. Darwin and Huxley, detailing experiments, have not scorned to come within the reach of the unlearned mind. In botany, the pleasing, enthusiastic, if often erroneous generalizations, of Grant Allen have their use and place beside the stronger works of Cooke, Gray, Jaegar, Taylor, and others. Our Gray, taking a leading rank among systematic botanists, did not disdain to write for children "How Plants Grow." No man has done more toward popularizing natural science than Rev. J. G. Wood in his numerous works. Kingsley, with his exquisite English, has given us "Town Geology," and Tyndale has told us of "Forms of Water." Buckland and Gosse have written what young and old have rejoiced to read. The elders have sat down with the juniors to revel in Arabella Buckley's "Fairy-Land of Science" and "Life and Her Children," while Camille Flammarion has made doubly eloquent to us the midnight skies. It seems almost invidious to name a few out of the many authors who have written not merely technical books for study, but popular works on natural science, to be read on sea-shore and road-side, on a bench in the garden, or lying under orchard trees, or sitting in the woods with a brook purling at our feet. McCook has made many insects our daily friends and teachers. Thompson, Mrs. Treat, and Olive T. Miller have made the birds not only the guests of our maples, but of our hearts.

The parent and teacher need no longer complain that they cannot find the information clearly given needed for replies to multitudinous hourly "whys" and "hows": the present age is prodigal to its children.

The Nature Readers have been written to direct the minds of our youth in their first studies to the pleasant ways of Natural Science. Their main object has been to cultivate the faculty of observation, awaken enthusiasm, and direct taste in noble lines.

The present volume is designed to open the way for severer studies in geology, astronomy, and biology.

THE AUTHOR.

NOTE.

NATURAL SCIENCE is so placed in the fore-front of the studies of the present age that no apology is needed for pressing it upon the schools. To object to this pursuit is simply to write oneself a laggard behind the times. We can do little that is better for our children than to teach them that the world is law-full to the core.

Two methods of study are ardently advocated by those who instruct in natural science. The one demands practical personal investigation, — nothing but investigation, — deprecates the use of text-books, and insists upon the object only. Another, perhaps a lazier fashion, is to ignore the object and relegate the pupil only to the text-books.

But *in medio tutissimus ibis* holds here. The child should indeed observe, and, if it can, discover; but let us by no means deprive it of the inheritance of the ages.

Why should we set the fortunate child of the nineteenth century in the condition of the child of the first or fourteenth centuries? Let us give the pupil the benefit of the best that has been discovered and detailed.

And what benefit shall he derive from such study? Let us quote from the Report of the British Royal Education Committee: "If the object of education is the fitting of pupils for those duties they will be called on to perform, then instruction in science is second only in importance to instruction in reading, writing, and arithmetic. No subject is better calculated to awaken the interest and intelligence of pupils than the study of Natural Science."

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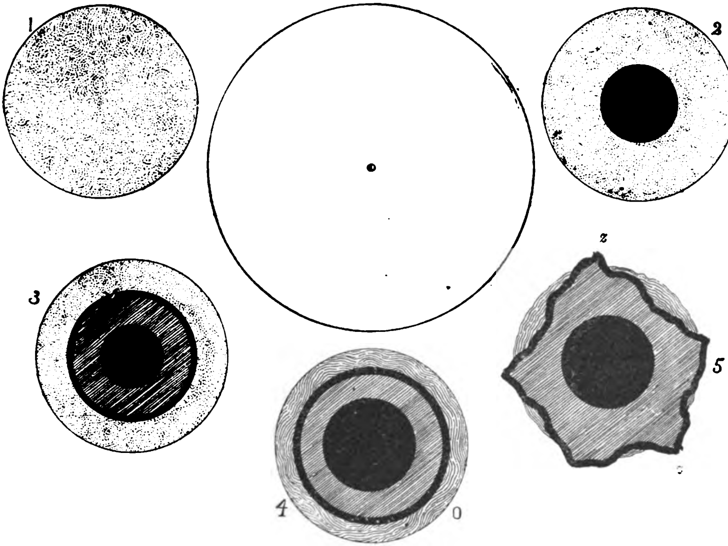


PHASES OF EARTH-BUILDING.

SEA-SIDE AND WAY-SIDE.

LESSON I.

EARTH-BUILDING.

"Fair world! these puzzled souls of ours grow weak
With beating their bruised wings against the rim
That bounds their utmost flying, when they seek
The distant and the dim.

"Contentment comes not therefrom; still there lies
An outer distance when the first is hailed;
And still forever yawns before our eyes
An utmost that is veiled." —JEAN INGELOW, *Honors*.

THE starry heavens do not exist merely for us or for our earth. Among the splendid orbs which roll in space, earth is but one, and it shines with pale and borrowed light.

Unnumbered systems moved upon their courses before our globe was lighted by the sun. But, for us who live upon the earth the history of the Universe opens with this small planet, a part of which we see and know.

It seems to us, when we begin to inquire about our earth-home, that it must always have been a complete and finished world, just as it now is. Science denies this. Geology leads us far back, before time began to be reckoned here, and shows us some of the processes of world-building. Time was when this firm, beautiful, and life-filled earth was a vast sphere of gas, destitute of all its present order, and without germs of life. As the palace or the temple rises into beauty and harmony out of vast masses of material, such as wood, stone, brick, mortar, iron, and course after course is laid up in the building according to a definite pattern, so along the process of earth-building, force and matter, power and material, have been laying up the courses of the earth upon a uniform plan.

And is the earth now finished? That we cannot say; there may be many more astonishing changes yet in store for it. We are now apt to call it the "solid earth," because those parts of it with which we are acquainted, the soil and the rocks, are the most solid things that we know; but in plain fact the earth may still be partly liquid, with the exception of a comparatively thin crust. The distance through this ball, our earth, is nearly eight thousand miles, and the surface, or crust, is perhaps nowhere over a hundred miles thick. Thus we might typify the world[1] by

[1] This theory is not universally accepted; some consider that the interior of the earth by cooling and pressure may be in a much harder than molten state.

a metal ball, having a thin shell of solid metal, and filled with melted metal. But as this crust, thin as it is in comparison, has for many thousand years proved thick enough and safe enough for a dwelling-place for men, I think we need not feel any anxiety because it is not thicker.

To read the story of this earth-building, it has been necessary for science to begin at the end; that is, at the present time, which is the last chapter of the story. With long and patient care wise men have read back, page by page, the earth-building story; we cannot say to its beginning, but as far back as science has yet been able to go. Now we are able to take up the narrative at such beginning as has thus far been found, and read it forward to our present day like a plain story. Will this be interesting? It seems to me that it is like some magnificent fairy tale, more marvellous than the story of Aladdin's Lamp, or Sinbad the Sailor, or The Caliph of Bagdad. The nights of Arabian story were not half so full of wonders as the days and nights, the vast periods, of geologic story.

Our earth is a globe in rapid motion. The motion is dual, i.e., double; it rolls over and over upon its axis as you might spin a ball round on a knitting-needle thrust through its centre; but the ball on the needle would stay in its place, no matter how many times it whirled over. The earth, as it whirls, rolls along a great path. Every time it turns over it measures off on this path a distance equal to its own circumference, but at the same time it sweeps on with the motion of the whole system, so that each day it travels over a million and a half of miles. The earth's path is not in a straight line; it is nearly circular; it is what is called elliptical, or partly egg-shaped. As far back as we can trace earth-history, the twofold motion and the globe shape have belonged to our planet.

In the earliest state of which we can speak, our earth was a globe of gas at least two thousand times as large as it now is. Science has made a guess that, before this, our earth was a ring or layer of vapor around the sun. This ring, being spun off into space by the rapid motion of the sun, took, after a time, the sphere shape, and being held by the attraction of the sun from wandering farther off into space, has ever since whirled around in a great path about its ancient source. If this theory be true, then all the other planets of our system were probably once cast off in their order by the sun, as vast fiery rings. That must have been an age of grand and splendid fireworks indeed! If only one had been there to see!

Why cannot we imagine that we were there to see? Can we not fancy ourselves back, through all the wonderful ages, until we reach the beginning of all things? The Arabians have a kind of fanciful being, whom they call an Afrite, or Afreet. They say that this being is formed of pure heat, smokeless flame. Did any of you ever see, on a very scorching day, the air quivering above a dry, hot road? That quivering of hot air is often seen on the desert, and the Arabians say it is the waving of an Afrite's robe. Let us fancy we were Afrites, gigantic flame-spirits, present when the earth, from a fiery ring, had just become a fiery ball.

Heat, such as we cannot imagine, is the chief characteristic of our globe at this stage. But being Afrites, and ourselves made of heat, we shall not mind that. We see that the whirling hot ball has in it all the atoms which will one day become solid rocks. But these atoms are kept apart by heat, and are in a state like gas. As we Afrites peer at the glowing, whirling ball, we see that there are two forces at work within it. Heat is one force, keeping all particles expanded, and not letting them come together; but there is another force called gravitation at work also. This is a force which causes all things to tend toward each other — to draw together. It is this force of gravitation which first gives the gaseous ring its globe shape, pulling its particles together; and as Afrites, we watch with interest the results of this force by long and slow degrees condensing the matter of the globe.

While this is going on, we perceive that two great changes are taking place. First, the sphere is growing cooler, by radiating, or throwing off its heat. Heat a poker red hot; wave it in the air, and it cools by giving off its heat to the air. Thus the hot globe throws off some of its heat as it whirls along its path in space. But as the sphere cools, the loss of heat allows the particles to shrink and come together and unite with each other. The uniting of some of these various simple substances produces other substances, and as the cooling and uniting go on, the great globe becomes smaller and smaller. As we are Afrites, and not afraid of heat, we wander into this fluid ball, and we find that by all this cooling, condensing, and uniting, the material for future rocks is forming.

Still imagining ourselves Afrites, the next change does not please us as well. We find that the outer particles of vapor in our great hot ball, as they ascend into space and cool, unite with each other and become a vapor like steam, and this steam cools and condenses into rain and mist. If a plate is held before the nose of a tea-kettle from which steam is rushing out, the steam condenses at once into drops of water. If the plate with the water-drops on it is set out in sharply cold winter air, it is at once covered with frost or ice. Thus it happened with the vapor about that hot sphere, our world; and the rain and mist fell back upon the glowing ball from which they had risen. They helped to cool it and to increase the hardening, but they were also reheated and sent off again as vapor, to cool once more in space.

If at that time we, as Afrites, had travelled to some other planet, and taken a seat there to watch our world from a distance, we should then have seen it in its greatest beauty as a heavenly body, because in that age it was at its greatest size, and was far larger than now: also it must have shone as a clear and lovely star, with a glory which has now almost passed away.

In the illustration at the head of this chapter the large ring represents the earth as a vast ball of hot vapor. The very small ring in the centre shows the present size of the globe as compared with its first expansion. The circle marked 1 shows the earth as a simple sphere of vapor, its earliest condition. The circle 2 shows us the stage where, by the force of gravity, and the cooling resulting from the radiation of heat, the sphere of gas began to have a fluid centre, or core.

We must understand that the condensing particles in the centre were not rendered solid, but fluid, as you may see the molten glass or iron at a glass-works or iron-foundry. This fluid state probably still continues at the centre of the earth. Figure 3 shows us the condensation going on. As the globe cools, a solid crust, marked *x*, is formed around the fluid centre, and between the centre and the crust the matter of the globe is hardening, while the outer envelope beyond the crust is still gas.

Figure 4 shows another change. The vapor has cooled and condensed in space, and has fallen back upon the globe in rain and snow. These rains corrode and wash the surface of the crust, and finally by their excess cover the whole crust of the earth with an ocean, marked *o*. Thus the liquid centre and the solid crust are wrapped in a mantle of water. This universal ocean is not cold and clear as are the oceans of to-day. The intense heat of the globe has made these waters boil and send off dense clouds of steam, and thus the water-wrapped world is further enveloped in a veil of mist.

Would it then have been hidden from our sight if we had been Afrites, watching it as we sat on some far-off planet? No; we should have seen it still, grown smaller and paler perhaps, but the mist-veil would have caught and reflected the sunlight, as the clouds do at sunset.

This was the reign of the waters upon the surface of the globe, while the central fires were burning and rolling in the abyss beneath the waters and the hardened earth-crust. When we say fires, of this interior heat, we must not think of flames, but rather of such heat as that of molten metal in a furnace. The universal ocean that wrapped the world at this time was full of salt and earthy matter and was turbid, as a river in flood time. From the deposit of this matter upon the earth-crust, rock strata or layers were formed.

Figure 5 shows us still another stage of earth-building. The reign of the waters is disputed by the long-imprisoned heat. This heat exerts its force, and tugs and lifts at the earth-crust until it bulges and cracks and rises up, or, as we say, is elevated. Earthquakes and volcanoes alternately depress or upheave a part of the earth's surface. Great depressions are formed, into which the waters gather, while the thick earth-crust is tilted up into mountain chains, marked *z*, which are reared above the waters. These wrinkling folds of the crust are the world's first dry land.[1]

At that time we, as Afrites, would have flown from our distant planet back to the earth, and have laughed to see the fire or heat driving away part of the water from the surface. We should have danced with glee to see the volcanoes pouring out ashes and cinders, and to watch the cinders crumbling and changing and beginning to form new rocks and lighter soil. And so at last we should have seen our earth formed, a rude earth, rough and bare, its seas warm and muddy, its mountains treeless, its fields without a single blade of green, a veil of mist all about it. And how long did it take to complete all this? No one can answer. No one can number the years of creative ages. Earth-building is not

[1] At the present time the interior of the earth has probably become much more solid than in the earlier building ages. We really *know* little of it below a depth of a few miles from the surface.

a process that can be hastened. After the globe had reached the state which we have now indicated, vast successive changes took place until our own time. Science has divided the succession of these changes into periods or ages, and at these periods we shall now glance, as at some marvellous panorama.

LESSON II.

THE FIRST CONTINENT.

> "As he who sets his willing feet
> In Nature's footprints light and fleet,
> And follows fearless where she leads."
>
> — LONGFELLOW, *Keramos.*

FOR convenience in study, scientists have divided the story of earth-building into vast epochs, known as times. The times are again divided into ages. At first the names used for these times were derived from the Latin, and simply meant first, second, third, and fourth times.[1] The first time or period was that in which dry land first appeared above the waters. The fourth time meant the period during which mammals, fruit, grain, and man appeared. The second and third periods or times of course divided the interval between these two.

Other names, made from Greek words, are now coming into general use to represent these building periods.[2] If we

[1] Primary, Secondary, Tertiary, Quaternary.

[2] Eozoic, Paleozoic, Mesozoic, Cenozoic.

put these new names into plain English, they mean the time of first life, or first living things, — the age of ancient life, when most of the fossils, or petrified plants and animals which we now find, were buried up in the rocks; then the middle time; and finally the "new time," when man and most of the plants

LOOKING FROM AFAR.

and animals that now belong in the world appeared. Such long hard names make the beginning of science seem dry and dull, but we must not be alarmed: a very beautiful garden has sometimes a rough and ugly gate.

The *ages* into which the *times* were divided have their names either from what was produced in them, or from the part of the world where their rocks chiefly appear on the present surface. Thus the Carboniferous age is the carbon or coal age, because then most of our coal-beds were formed. The Silurian age, on the other hand, takes its name from a part of Wales, where its rocks are most conspicuous, and in this part of Wales a people called Silures used to live. A study of the "Table of Earth-building," which is the frontispiece of this book, will show clearly these times and ages.

It is concluded that the first land which appeared was a range of rocks, which is best known in the valley of the St. Lawrence River, and represents the oldest land on the globe. We need not fancy that the new continent occupied a large part of the globe; it was comparatively very small. Neither can we look for it to-day, and find it as when it rose over the hot ocean. The first land of the world lifted above the waters and sank again, and so rose and sank more than once or twice in great lapses of time. This rising and sinking was caused by the action of heat and steam in the interior of the earth, which elevated and rent the crust.

From Labrador to Lake Superior the old Laurentian rocks crop out. If you go to the Adirondack Mountains, you stand on the first continent, though it is now covered with a soil which did not exist in that early time of its uplifting. There are spots of this old continent in Nova Scotia, New Brunswick, Sweden, Norway, Bavaria, and the Hebrides. These are then, the oldest parts of the world, and you could take your atlas, and by sketching a continent, long, narrow, and crooked, that would cover these places with a few outlying islands to help it out, you would have a fair idea of the first continent.

Probably nothing grew on it, but in the sea there were some plants and animals.

The beds of Laurentian rocks in North America are sometimes thirty thousand feet thick. These early rocks, more than any others, show the action of great heat. The action of heat has changed the rocks from their first condition. Time and heat will turn sand, lime, and clay into crystal and marble.

For a long time the Laurentian age was supposed to have been wholly destitute of any life, and was called the azoic, or life-lacking time. But Sir William Dawson, after long explorations among the Laurentian rocks, found in them the fossil remains of a once living creature. He named this creature the Dawn Animal, or Eozoön. The name suggests that this is the most ancient animal yet discovered, and represents the dawn of life on our planet.

What was this Dawn Animal like? So far as can be judged from the fossil, it was a very large creature, soft and gelatinous like a jelly-fish.[1] It had a stem by which it was fastened to the bottom of warm, shallow seas. Thus it never moved from its place, but swayed with the moving waters, and perhaps had the power of expanding and contracting itself. Like the mollusks,[2] the Eozoön wanted a house for its delicate body. Therefore, as it swayed to and fro, it collected from the water carbonate of lime, and covered itself with a thin shell or crust. As it continued to grow it continued to cover itself with crust after crust of lime. This lime crust

[1] Nature Reader, No. 2, Lessons 36 and 37.

[2] Nature Reader, No. 1, Lesson 37.

was not a solid mail over Eozoön; it was rather like a fine net or sieve through the pores of which could pass the jelly-like threads or filaments whereby the creature collected lime and food. But here we are led to another discovery. If the Eozoön was a living animal, it must have had food to nourish it, and living creatures feed upon animal or vegetable substances.[1] Therefore in these warm seas there must have been minute animal or vegetable organisms which Eozoön could gather with its long nets or lines, as it grew at the bottom of the sea. Was the Eozoön beautiful? We cannot speak positively; but as we find no age of the world when there was not beauty of form and color, as we see beauty often followed as an end in creation, we may suppose that the Eozoön had gay colors and looked like some great vivid flower waving upon its stem in the water.[2]

There are beds of limestone in the Laurentian rocks, which bear indications of former animal life. Also in the Laurentian rocks there are beds of iron ore, and these have been supposed to indicate that there was some vegetation in the Laurentian period. Now as in the Laurentian period the Eozoic age shows us vast beds of iron, graphite, and limestone, we may suppose that there were in the warm waters of that era great beds of eozoön like the coral reefs of to-day. In the deep seas of the present age there are myriads of little creatures called foraminifera; and though we have found no trace of these in the earliest rocks, it may be that

[1] Nature Reader, No. 3, Lesson 1.

[2] And after all so few and indefinite are the traces, that Eozoön may not have been an animal form at all, but a merely mineral structure.

the first ocean swarmed with them and that they were then busy building limestone strata just as they are busy now.

During the Eozoic age the warm, turbid ocean that nearly covered the globe constantly deposited sediment, and at last the thin earth-crust gave way under the strain and weight upon it. The earth-crust collapsed, or fell in, as a great floor which has been overburdened. We sometimes hear of the floors of large rooms which give way under some heavy strain. If we go to see a place where such an accident has occurred, we shall notice how flooring and timbers do not fall flat, as a whole, but are crushed and crowded together sidewise or edgewise. When the Laurentian continent sank, many of its ranges and beds of rock were bent and tilted in this fashion, and we so find them to-day.

How long was this first or Eozoic period? That, no one can tell. If we should try to tell, we should merely use numbers so great that, as applied to years, we cannot imagine them. The Dawn age seems a very good name for it, as it was the age of the earliest continents, and of the first animal and vegetable life. As the study of the earth goes on, and other and deeper-lying rocks are examined, we may learn much more about this first world-building period. Now, as we look far, far back to it, it strikes us, I think, chiefly as distant, barren, silent. If we had been Afrites, and hovering over that early continent, I think we should not have heard a sound, except the lap of the warm waves on the rocks; we should not have seen a living thing. But if instead of Afrites we had been Pixies, or water-sprites, we should have gone down into the waters of that wide, warm sea, and what should we have found? We can as well fancy ourselves Pixies as Afrites. Let us fancy ourselves in those seas. I think we should have seen sea-weeds, fine and small, but of many curious shapes, and millions of creatures with and without shells, some large, some small, tinted like rainbows, and lively and happy in their water-world.

LESSON III.

THE AGE OF CRABS AND CORALS

"And delving in the outworks of this world
And little crevices that they could reach,
Discovered certain bones laid up and furled
Under an ancient beach." — INGELOW.

THE earth-building period which followed the dawn of life is called the "time of ancient life." Our lesson about this period will be like unlocking the gate to some beautiful domain, giving a glance at its delights, but leaving the wayfarer whom we have brought thus far on his journey, still standing without, yet now, no doubt, with ability and desire to enter.

This ancient-life time is, so far as we know, the longest of all the earth-building periods. It has the thickest deposits of rock, and includes the most numerous ages, or great successive changes. It also retains in its rocks numerous fossils, or casts of formerly living things, both animal and vegetable. In coming lessons we shall discuss what fossils are, and describe some of these ancient plants and animals.

When this new age of the world opened, we find that there was plenty of life, and that there were many creatures akin to some that we have living to-day. To enjoy that time of

THE WATER-SPRITES.

the world we should have been no longer Afrites, or flame-spirits, for the reign of the fire was over; we should have been Pixies, and able to wander at our will among the plants and animals in the water. There we should have noticed that there were many animals of the articulate or jointed class — creatures that have no backbones; and we should have seen that the plants were sea-weeds of various kinds.

As the ages of this great time moved on, creatures with vertebræ forming backbones appeared, and the land had vegetation. There were reeds, rushes, lichens, ferns, mosses, plants of the toadstool kind, and great trees such as are now not found on the earth. Some of the rushes called calamites were larger than the great bamboo.

The first age of this great time is called the Cambrian, from the outcrop of its rocks in North Wales, the ancient Cambria. The name Huronian has also been applied to it, as these rocks largely appear in the region about Lake Huron. In this age new land rose above the ocean. The waters were still warm, and the atmosphere was hazy and full of moisture, hot, but without clear sunlight. The animals were corals and crabs; the vegetables were sea-weeds. The rocks of the Cambrian are chiefly sandstone and slate, and we find the fossils not scattered through all the rocks, but in layers, so that some ledges of rock are nearly destitute of organic remains, and then come others crowded with fossils of animals and vegetables.

Among the earliest and most curious of the fossils are the lingulæ. These are bivalve[1] shells, about the size and shape of your finger-nail. The lingula was fastened to the sand bed by a fleshy stem. Opening its valves, it put forth a fine fringe which served it as fingers for gathering its food from the waters, much as barnacles do.[2] The lingulæ belong to the group of lamp shells, and have existed through all the ages from the Cambrian until now, as they swarm

[1] Nature Reader, No. 1, Lesson 39.

[2] Nature Reader, No. 2, Lesson 33.

at the present day in the China seas. Along with the busy little lingulæ lived many varieties of crabs, cuttle-fish, star-fish, and many kinds of corals.

Probably there were not many insects in this period: only a few fossils of large insects somewhat like dragon-flies and May-flies have been found. There were no birds, and the great forests of reeds and club-mosses were silent, unless the few insects could produce a chirping sound. Possibly their wings and bodies were gaily colored as those of the dragon-flies are to-day.

No doubt, also, many of the crustaceans of this period were very ornate in their colors, and in the arrangement of bands, knobs, and ridges on their shells. The numerous corals building in the shallow seas, and carrying their reefs up into the light on the surface, waved purple, orange, and crimson filaments from their limestone towers, until the waters looked like garden beds in full bloom.

Among the earliest fossils are worm-casts,[1] from which we learn that even so long ago the worms were helping to build the world. The sponges shared the shallow seas with the corals.

Next came the Silurian age, named as we know from a part of Wales where its rocks lie bare. This was a very long age, and is divided into upper and lower Silurian. During all this time the world was becoming richer and richer in life, both of animals and vegetables, and of both land and sea. We find strangely beautiful fossils of this age, as, for instance, the stone lilies. No form of life seemed for a time so hardy

[1] Nature Reader, No. 2, Lesson 12.

and so rich in variety as these stone lilies. These were not plants, but animals, and yet they looked more like beautiful snowy flowers than like animals.

In very deep water of the present day we find some few species of these crinoids, or stone-lily animals, and from them we can understand those of the ancient time. They grew rooted in one place, waved on long, pliant stems, and from their snowy cups spread forth filaments that looked like delicate stamens and pistils. Swimming about among the stone lilies, went the nautilus, relative of our "paper nautilus" of which the poet sings: —

> "This is the ship of pearl, which poets feign
> Sails the unshadowed main —
> The venturous bark which flings
> On the sweet summer wind its purpled wings,
> In gulfs enchanted where the siren sings,
> And coral reefs lie bare,
> Where the cold sea-maids rise to sun their streaming hair."

The nautilus of the Silurian time perhaps looked quite as lovely and harmless, yet really was a mighty monster, devouring millions of its fellow-denizens of the deep. To-day we see a relation of this old-time nautilus, in our cuttle-fish, sometimes called the devil-fish.

To the Silurian age belong the written stones. The tiny fossils imbedded in these rocks are like little coal-black stains, which appear as minute writing in an unknown tongue. These small cells are indeed writing, and help us to learn the story of the ancient world.

The corals increased greatly in the Silurian age, and extended far up to the polar regions, where corals are now unknown. In these early ages the chief home of life was in the sea. The waters brought forth living things before the earth produced them, while the creatures of the air, the birds and insects, came later still. Two very important facts are here to be noted: Just as the Silurian age was closing, several kinds of fish-like creatures appeared, the first vertebrate or backboned animals.

Let us imagine ourselves back in that age, as Pixies, or water-sprites. Suppose that we are in a warm, shallow, almost waveless sea, over which the sunshine pours, warm and mellow, through thin haze. We are sitting on a ledge of coral, and from every tiny limestone tower about us opens and waves a radiant creature, purple, gold, green, or crimson. Among the corals grow the tall and stately stone lilies, rolling back their petal-like valves, and waving forth long white plumes. We gather tiny live things from the water and offer them to the stone lilies, and they grasp them in their snowy hands.

But now we see a monster coming towards us, a new creature such as we have never seen before! It swims strongly, has a thick skin, great jaws filled with big teeth, and we perceive that it has its bones inside its body, not outside, as the crustaceans do. It sweeps past a bed of pretty little lingulæ and crops off fifty of them at a mouthful! It darts up to our lovely stone lily, and bites it from its pearl-white stem! Yonder comes a crab swimming along at ease, a prophecy of a king-crab, that will come many ages after. The fish-like monster takes him at a mouthful.

We Pixies are angry at this devastation; we cry, "We hope you will try to eat a trilobite[1] and choke yourself!" But here comes an unlucky trilobite, and the new monster crushes it in its great jaws! It would eat us, only we are Pixies, creatures of myth, mere bubbles. As it is, we hide in our coral groves, and weep over our lost lingulæ and stone lilies. These fish-like creatures reign as kings. They multiply and devour, and in the Devonian age, which comes next, they become more like true fishes.

This Devonian age comes with mighty changes. We Pixies feel the sea-beds rock with earthquakes. We fly to the rivers, and find the land rent with volcanoes. We hasten to the crests of the waves,—for the torrents of lava rush along the shores and far out into the ocean,—and we see the Afrites laughing to find vast plains of land where waters had been. We hope that all these convulsions have destroyed the greedy, cruel fish. But no; we go deep into our sea-homes, and find most of the crabs and nautili and stone lilies gone, and the fish more abundant than ever!

And now we Pixies feel that the new age has come, and we rise to the sea-surface to look about, and we find new land in many lovely islands, and there are vast swamps full of reeds and club-mosses. Green lowland jungles laugh in bright sunlight, among warm, clear, blue seas, where the corals that we love grow to their greatest glory. No more soft-shelled crustaceans and trilobites: have the fishes eaten them all? If we make an excursion to the land to see if any fairies live there, we find no flowers, but there are very beautiful trees.

[1] See Lesson XVI., p. 119.

The great work of this Devonian age seems to be the rapid laying down of beds of red sandstone. This red sandstone, deposited by the waters, finally rises into vast continents, joining island to island, and spreading out a rich soil, very fit for vegetable life. Vegetation creeps away beyond the polar circles; for in this time the climate of the earth is nearly uniform.

Let us fancy we meet an Afrite, and say to him, "Of what use is all this land and vegetation?"

He replies, "O Pixy! a new age is coming, — the age of coal. In it vast beds of coal will be laid down to feed future fires for a creature called man. These beds will have oil, gas, naphtha, all things in which we Afrites rejoice. These carbon beds will be merely storehouses of well-cooked vegetation, for warming and lighting a world."

But as we Pixies stand and talk with Afrites at the limit where land and water meet, what do we see? We see thousands of insects in the air and creeping on the ground, — cockroaches, dragon-flies, weevils. And now, oh, wonder of wonders! what fearful thing is this? A REPTILE HAS APPEARED!

Frogs and toads of curious patterns have foreshadowed him, but the true reptile was the first vertebrate lung-breathing animal. You perceive it is a vast advance on earlier forms, for a creature to have a nose, to be able to inhale air through its nostrils!

The life-filled, tree-filled Carboniferous age, with its continents was long, very long; and now, when life seemed everywhere to dominate, these continents slowly sank beneath the waters, and the Permian age came on, — the age of the death and burial of a busy world, — the last age of the ancient life time. The sinking was slow at first, so slow that trees grew above the buried trees; but at last the sinking hastened, and stones and sand and surf dashed and rolled above the forests, and the Coal age was drowned.

The reason of this sinking was, that the interior of the globe had continued to cool and harden, and with cooling shrank from the crust, which collapsed in great wrinkles. The collapse was slow, because much of the interior rock was in a wax-like condition, and crowded up to fill the rents left in the downward pressure of the earth-crust. The heat, pressure, collapse, half-fluid state, explain to us many of the curiosities of geologic formations.

After these convulsions the surface again arose, land lifted above the water, and the Permian age exhibited a flora very like that of the preceding age. The great frogs, toads, and lizards increased in size and numbers. The convulsions of the Permian had not destroyed all land life, and probably the sea-depths with their inhabitants had been but little effected. The buried forests of the previous age were slowly changed into the coal-beds of to-day, and in them we find, held for our study, seeds, roots, leaves, insects, and footprints, belonging to the long-gone ancient life time.

LESSON IV.

THE REIGN OF THE PINES AND THE REPTILES

"A monster then, a dream,
A discord. Dragons of the prime,
That tear each other in their slime,
Were mellow music, matched with him."—

— TENNYSON, *In Memoriam.*

GNOMES IN A CAVE AT WORK.

WE have now reached the middle period of the earth-building story. We have thus far seen how from a great globe of burning gas, our earth shrank, cooled, hardened, became wrapped in waters, uplifted continents and islands, and through successive periods became filled with plants and animals of sea and land. The period at which we have now arrived was the age of wonderful monsters, of pines, and of palms. For the first time also the earth was splendid with flowers. The seas grew constantly cooler, and the earth crust as constantly thickened. As the seas cooled less vapor rose into the air, the atmosphere cleared, and a bright sunshine poured over the continents.

The continents of this middle period of world-building were some of them larger than now. Probably North America stretched over much nearer to Europe; England was not an island, but was joined to the mainland of Europe, and extended far south and west in what is now the sea. The mountains were very high, so high that it has been supposed that they had snow-covered tops, and glaciers formed in their gorges, and icebergs, breaking from the glaciers, sailed off to distant seas.

At this time the earth was green with ferns and grasses and dark with forests. Among the most noble of the trees were the cycads. They were partly like pines, and partly like palms. Beside the cycads grew great pines, and probably pines were the distinguishing trees of this cycle. The vegetation was more like the present vegetation of the tropics than like that of northern climates, because the earth was warmer then than now.

In our last lesson we spoke of the red sandstone as a very rapid deposit of sand by water. When the deposit is slow, the red color is washed out of the sand by the action of air and water. This red of the red sandstone is due to iron-rust, which stains the sand as it does iron or steel. When the deposit of these stained sands is rapid, in thick beds, the color does not have time to bleach out. There are two vast layers of this red sandstone, the old and the new. The new is largely present in the beds of the middle period of world-building, and sometimes gives the first age its name — the age of the New Red Sandstone. The northern shore of Scotland is banded by the old red sandstone, as if held in a sandstone frame.

Another rock of this time is called conglomerate, or mixed stone. Some call it "pudding-stone," and say it looks like a pudding full of plums and lumps of suet. Such stone is very common, various kinds of pebbles and rocks being held together as if they had been baked or boiled into one mass. Near the conglomerate we sometimes find limestone full of tiny broken shells, and also beds of marl. Marl is a rich greenish earth, which crumbles easily and is valued for enriching cultivated lands.[1] All these varieties of rock are interesting when we study them, and can read the stories they tell of long-gone ages, of fire, volcanoes, earthquakes, floods, storms, — where strange animals and plants lived and died.

Do we ever stop to think what a treasure-house of wonders and of choice and beautiful things the earth is? There are sands filled with grains of pure gold, and rocks where gold glows in grains and veins and nuggets. I have seen lumps of silver-bearing rock which look as if in some age of heat the pure silver had melted, boiled, and bubbled until now it lies in the stone in curious shapes, like balls, and stars,

[1] Marl is also used with sand in making Portland cement.

and chains, and moss, and tiny trees,—all fantastic and pretty forms. There are mines where diamonds, and rubies, and garnets, and sapphires lie hid as if the gnomes, or fabled earth-spirits, had stored them away. What crystals shine among the rocks, and red bands of carnelian glow, and purple amethysts and vivid carbuncles blaze! Kings have rooms full of such treasures kept for show; but the silent earth hides in her bosom many more and far richer jewels.

Come here, and let me show you just one marvel made in the earth in some of these long building periods, when heat was working wonders. Since you have been handling all these minerals and curiosities your hands are dirty. Take this towel and wipe them. Look at the towel. What do you see?

"Just a coarse cotton towel," you say; "nothing fine about that."

"Very well. Have you wiped your hands? Here, let me throw the towel into the fire." You stare at that.

"Do you always burn your towels?" you ask.

"I never burn them up. I just wash them in fire. Look sharp!" You look. The fire curls into and over and about the towel, and it becomes red hot, yet does not fall into ashes. Watch me. I take the tongs and pick my towel from the fire. As it is, red hot, I dip it into a pail of water. Now it is cool, pray take it and examine it. It is clean and whole as if new! That towel is made of rock! It is called asbestos. It is a very hard rock, and lies in layers of fine, silky fibres. You can pull these fibres or threads off, and apart, like flax; they can be spun and woven. Plenty of it is found in Canada. See, it looks like common cotton cloth. Found in thin sheets it is called "mountain-leather," in thick sheets it is named "mountain-cork." But it is all asbestos — a rock fibre. And what do they do with it? They mix fire-proof paints with it; make boiler felting; firemen's cloaks; gloves for fire-workers. Long ago the ancients wrapped dead bodies in it, so that their ashes might not be lost when they were burned upon the funeral pyre. Wonderful stuff, is it not? But the brown still earth is full of such wonders.

Let us return to look at the products of the middle period of earth-building, and see how the world grows more and more fit to be the home of the coming man. We find now palm, fig, oak, tulip, walnut, and sweet-gum trees. As all these trees produce fruits, seeds, or nuts suitable for food for animals, we should look for animals to feed upon them.

We find the fossil bones of some of the dwellers in these woods; the rocks also retain their footprints. The great creatures, marching over the soft earth and mud, made deep tracks, and these remained like casts or moulds as the soil hardened; then sand and other sediment were deposited over them, and so the footprints were encased. The deposit, hardened into rock, has preserved the footprints for thousands of years. Strange that a thing so fleeting as a footprint on sand should remain to tell a story for ages!

But what of the creatures that made these footprints? These were huge, two-legged animals with three-toed feet, stalking through the woods, and calmly browsing on the tree-tops! Science reconstructs some of these creatures, and finds that they had small heads, long necks, huge tails, and thick legs. These were mild but hideous creatures, and munched nuts and fruits. They may have glistened in the colors of the rainbow for all we can tell, but even color could not make beautiful a creature with a giraffe's neck, an elephant's legs, a crocodile's tail, and a kangaroo's head.

I think we may be very glad that we did not live in that age. Who could have played in a wood filled with such fearful creatures? Who would have wished to go out in a row boat, or for a little sail, when the sea was full of monsters, like sea-serpents, and all the rivers swarmed with huge reptiles? Little beasts like rats and kangaroos began to run in the woods, but there were no shy rabbits, no squirrels with full, waving tails and bright black eyes. What would woods be worth to ramble in, if not a bird flew, sang, or pecked upon a tree?

We can fancy that far down in the heart of the earth the fabulous creatures, the gnomes, were busy. The Danes and the Germans have tales of queer little men, called gnomes, which live and work underground, and have charge of all the metals and jewels in the earth. The gnomes wear little pointed caps, and shoes with pointed toes. If in this far-off age we had been gnomes, we should have seen in the earth beautiful crystals forming.

Diamonds, rubies, emeralds, all the precious gems and all the choice, fine stones, such as carnelian and agate, are very hard and of close grain and can take a brilliant polish, but as they lie in the earth they may look dull and pale, and be covered with a crust or case of common stone or clay. Cutting and grinding bring out their clear light and beauty. If we had been gnomes, wandering through the interior of the earth, we should have wondered who and what the coming creature could be, for whom was stored up things so rich and rare and useful. For whom were the vast beds of iron, coal, salt, tin, veins of precious metals and gems, rivers of oil, storehouses of gas? And some day, as we worked with tiny pick and crowbar, we might hear coming to meet us the pick and spade of earth's new master — man! But that would be long, long after the Mesozoic, or Middle age of world-building had passed away.

As the ages followed each other, there would constantly be new treasures hidden for the gnomes to guard. As one layer after another was buried by new material, in the buried layers were left the bones, teeth, footprints, and remains of the reptiles, insects, birds, and land animals of the passing age. Every new earth-bed was a vast graveyard.

The last age of the middle building-time was called the Cretaceous, or Chalk age, because during it such vast quantities of chalk were built into rocks. All the English coast along the Channel is lined with chalk cliffs. The chalk is soft and white and easily worked. When, in England, we went down on the sand beach, and wanted something to play with, we would take a lump of the chalk cliff and whittle out balls with our knives. When we were done playing we left the balls for the sea to carry off; it was so easy to cut more. I often saw stables, cow stalls, wagon sheds, cut out of the chalk to save the farmer the trouble of building sheds of wood. The chalk cliff made fine, dry, clean houses for the animals.

Stuck all through this chalk, like plums in a cake, are hard flints or pebbles, and these can be cut and polished into very pretty jewelry.

The Chalk age was one of great and violent changes. Once more the continents began to sink. The earth-crust could not uphold the mighty weight of deposit upon it. The shrinking and cooling core caused the settling of vast stretches of land, and the continents were depressed lower than they had been since the time of the first continent. Down, down went the land, and over it the waters flowed, and where hills and forests had been, creatures of the deepest depths of ocean played. Europe probably settled lower than America.

Once more the globe was like a vast ocean, above which rose what had been high ranges of mountains, now forming long islands or reefs. Of these surrounding ridges might have been noted the hills of Great Britain, the Scandinavian Mountains, and the Ural range. In the Western hemisphere the hills of the St. Lawrence and the Appalachian Mountains rose over the water, and here and there a peak of the Rockies or the Andes.

Why did the little hills of Britain rise up when the great Alps and the Himalayas were not to be seen? Britain itself did not sink so low at that time, and the Alps and the Himalayas were not yet born. They rose at a later day. The seas ebbed and flowed and deposited their chalk sediment over a drowned globe for a very long time. Then once more the earth crumpled, and amid earthquakes and volcanoes the Chalk age perished, the Rocky Mountains, Alps, and Himalayas were crowded and tilted up to be the great mountain-ranges of the world, and the last building-time of the earth had come.

LESSON V.

THE PALM AND THE MAN.

"So careful of the type she seems,
So careless of the single life.

'So careful of the type?' but no,
From scarped cliff and quarried stone
She cries, 'A thousand types are gone,
I care for nothing, all shall go!'"
—TENNYSON, *In Memoriam*.

READY FOR MAN.

WHAT have we thus far found to be the processes of earth-building? First, rocky crust uplifted into mountain ridges. Then deposit of sediment by the waters until islands and continents capable of maintaining animal and vegetable life are formed. Ages of increase and successive growth follow: then sinking of the earth-crust, accompanied by earthquakes and volcanoes; after this, fresh upheaval. With these surface changes come changes in the plant and animal life, especially in the former; for plants seem not to have the happy faculty of animals in accommodating themselves to new conditions. With the changing ages some animals entirely disappear, and are known to us only by their fossil remains. Others are modified and fitted to their new home.

We must observe that in no period of sinking after the first land age was the land all covered by water, nor were all the living things of any period destroyed. There has been a continuance of animal life on the globe from the first earth-building time until now. The Permian and Chalk ages were probably the periods of greatest changes. During the Chalk age certain of the later forms of life appeared. The fruit trees, and all the highest and most choice forms of vegetable life, were present among the plants. Fishes and reptiles, crabs and lobsters like those which now live, and the first specimens of the great Order of the Mammals, were found in the troubled seas of the Chalk age. It was with plants that are called exogens or outside growers, having two seed-leaves,[1] such as our fruit trees, and the oaks, maples, chestnuts, and elms, that modern plant life began. When the mammalians came, they were the advance guard of the higher class of animal life. This class of mammalia includes all animals which have young which are nourished with milk by their mothers.

The first age of the Neozoic, or New Life period, is

[1] Nature Reader, No. 3, p. 23.

marked by a certain singular kind of limestone rock, called nummulite or money-stone. The stone receives this odd name from a great variety of flat shells which fill the rock, and have been fancied to resemble pennies, shillings, and sixpences. These nummulite shells are very curious; some are so small that you can scarcely see them without a microscope; others are as broad as the above-named coins. Each shell is made up of a great number of little cells, set in rings, beginning with a very small ring about the central cell, and the next a little larger, and so on. The shells were the homes of creatures called foraminifera, some of which are now living and building shells in the bottom of our seas.

When these creatures were alive these cells were filled with a soft substance such as we see in jelly-fish.[1] We can scarcely realize the vast amount of work done by these small, feeble creatures, in earth-building. The nummulites were the stonemasons of continents. The nummulite sandstone is found in beds, sometimes thousands of feet thick. Imagination fails to compass the multitudes of tiny living creatures which piled up ten thousand feet of the Swiss Alps, and built the snowy peaks of distant Thibet, and grain by grain laid up the long chains of the Pyrenees.

Little microscopic creatures, close kin to these nummulites, built the rocks in Egypt of which the Sphinx and Pyramids are made, and the enormous platform upon which they stand. These little animals also laid up the vast beds of building stone of which nearly all the great city of Paris is made. How did they do this? The little jelly-like creatures wanted

[1] Nature Reader, No. 2.

covering for their frail bodies, and so gathered from the sea-water particles of lime and built them into shells. Millions upon millions of these shells fell down in layers on the sea-floor, and then water, weight, and heat became the forces to consolidate the myriads of shells into stone. The processes of earth-building are slow and long.

The last world-building period, the Neozoic, had five ages. You will find their rather hard names on the plate which is our frontispiece. We might look at them as a splendid panorama. Shall we imagine that as fairies flitting through the woods; gnomes guarding the treasures of the earth; fair Pixies, floating in the rivers and seas; or giant Afrites standing in the hottest sunshine on the desert, we watch these five beautiful and wonderful ages roll on?

What shall we see? Palms first: great tracts of palms, waving their feathery tops against the sky. The earth was warmer in those days than now, and plants and animals, now ranked as tropical, were found as far north as England. Not only were there palms widely spread, but cypress, plane trees, maples, elms, oaks, red-woods, figs, sweet gums, sour gums, tupelos, cinnamon and clove trees. The cape jasmine swung its censers of perfume; ferns and mosses made the woodland depths soft and green. Through these forests, and over the grassy plains, roved hyenas, wolves, bears, elk, antelopes. The famous mastodon was there, with many forms of deer, and thick-skinned creatures of the elephant and rhinoceros tribes that are now known no more. Along the river sides, among the sedges, were great wading birds, turtles, tortoises, crocodiles, serpents. Insects and birds increased, and here and there a monkey might be seen climbing among the tree-tops.

As time moved on, a new, strange change overtook the earth. The climate in the Northern hemisphere became colder and colder; frost and snow held possession of lands that had hitherto been warm and sunny. Colder, still colder; what is called the Glacial or Frozen period was drawing on. As the atmosphere and soil chilled, fir, pine, birch, and dwarf willow succeeded to the palms; animals of woollier coats lived where the thick-skinned, smooth-coated, tropical animals had found a home. The ice-sheet, which at this day wraps the poles, began to extend southward, and an icy sea, such as now washes the shores of Greenland and the North Cape, rolled over the northern half of the globe.

The Ice period has occasioned much dispute and wonderment among men of science. Its remaining traces are chiefly drift, ice-markings such as ice-worn rocks and boulders, with the bones of animals and the traces of Arctic plants found far south of the regions which such organisms occupy at the present time, or did occupy in an age earlier than the Glacial. They indicate a period when ice and cold had sway in lands now temperate.

In a future chapter we shall consider for a little the work of icebergs and glaciers in carving the world. At present we can only say that geologists consider that the ice-cap came down to the 40° parallel of latitude north, while others believe that the frequent ice-markings and boulders found throughout the temperate zone are the work of icebergs drifting in Arctic currents, and swept much further south than they are now seen. Up to this period we have considered red-hot worlds, melted worlds, drowned worlds; the Glacial age gives us a frozen world.

But the one great fact written over the face of the globe is change. Earth-building sweeps through great circles or periods of change. That a certain state exists is, it seems, merely proof that presently it will not be, but will have made room for some new and different state. Even the Ice age was not to last forever. Frost was king for a time, as fire had been king and water had been king. But the Ice age began at last to loosen its cold clasp upon the world. The atmosphere grew warmer; the land rose up above the icy seas; the bergs sailed into equatorial regions and were dissolved in the warm currents of the Gulf Stream.

The Northern hemisphere never returned to the warmth of climate it had enjoyed before the Ice age came on, but it gained the mild temperature of to-day. As the ice-sheet slowly retreated plants sprang up on the earth, the flora following the withdrawing edges of the ice. There was an age when in England and Ireland and France flowers bloomed which now are found only on the high Alps. After a time the flora of the earth became what it is now.

The mastodon and his associates disappeared, and sheep, horses, and dogs, and the bovine animals, — the animals that especially contribute to the comfort and service of man, — became numerous. On the surface of the earth streams and rivers did their work, and arable land was ready for coming harvests. The Ice age had been a bitter winter time; it was followed by a spring. Centuries stormy as March, and changeful as April, and soft as May, followed each other, bringing the earth-building epochs to a close, and putting on the globe the finishing touches to fit it for the home of humanity. Now at last were seen the cereals, the corn-food of man, the stately and golden maize, the silver wheat, the bearded barley. With these came the gourd and lupine families, bringing us all manner of melons, cucumbers, pumpkins, peas, lentiles, and beans. The hosts of the apple order of fruits were marshalled in array; the peach, plum, cherry, apple, pear. The vine and the olive covered the slopes; earth was now a rich and splendid kingdom waiting for its destined king. The king came, and flora and fauna were at his service; his name was MAN.

LESSON VI.

THE STARRY HEAVENS.

"Sit, Jessica: Look how the floor of heaven
Is thick inlaid with patines of bright gold;
There's not the smallest orb, which thou beholdest,
But in his motion like an angel sings,
Still quiring to the young-eyed cherubim."

— *Merchant of Venice*, Act 5.

THE kitten plays with its tail, the lamb nibbles the grass, the chick scratches on the ground for a living, and none of them feel any curiosity about the reason of things around them. But the smallest child begins to ask questions, especially about the natural objects that surround it. It is not satisfied with having water to drink; it wants to know from whence water comes. Fruit is good, but how do fruits grow? No doubt the first human beings felt this same curiosity, or rather desire for knowledge, the food of the mind. As soon as there was a man to observe natural objects, what they were, and how they came to be, were questions that early presented themselves to his attention, and afforded theme for the first legends and fables.

The wonders of the heavens were among the primary subjects of human thought. The rising and setting of the sun, and his splendid way through the sky; the milder beauty of the moon; the marshalled hosts of the stars aroused the admiration, interest, even worship, of the earliest representatives of our race. Men concluded that the heavenly bodies were gods or men, who for great deeds had been taken to shine in deathless glory in the skies. With enlarging ideas they understood that the stars are worlds, but they had no means of determining how large or how distant they might be. The first students of the skies thought that the earth was the largest of the heavenly bodies, and stood still, while the others moved. They considered also that the earth was flat, and that the skies above it were a vast hemispherical dome. Such notions are instinctive even at the present time.

How natural it is for us to believe that the earth is the lower half of the universe, and the skies the upper half! We speak as if the heavens and the earth were two separate creations. We are slow to recognize the fact that the earth is merely one little part of the heavens. The heavens are about us on every side. By the heavens we mean that part of space which seems to be star filled. In these heavens our world is as a globe suspended, and every star that we see is another globe suspended in space. Of these globes we can, with the unaided eye, see countless thousands; millions more are reached only by powerful telescopes; very likely myriads still exist which no glass is strong enough to bring into human sight.

In ancient times people fancied that the stars ruled the lives of men, and from them came good or evil influences, wars, famines, plagues. They foretold the events of years by the stars that showed highest and brightest, and cast the horoscopes of individuals by dividing the sky into "houses" or sections, and considering the appearances of these houses at the hour when a child was born. This pursuit was called astrology, and it extended to the study of comets, eclipses, and all the appearances of the skies. This astrology was an elaborate science, and one of the most ancient studies of men, and by degrees led the way to the present noble science of astronomy.

When we look at the skies they seem to be crowded with shining bodies sown thickly together without any particular order. Looking more carefully, we see that in parts of the sky the stars are thickly clustered, and that there seem to be empty spaces. We observe too that there are differences in the size, brightness, and color of the stars. Some stars are red, some white, some blue, some green or yellow: some shine with a clear, steady ray, some quiver, tremble, disappear, reappear.

During the day we cannot see the stars, because of the greater brightness of the sunshine. When the moon is full and bright at night the stars seem dim, but on a cloudless, moonless night the stars are well displayed.

The early observers divided the stars into constellations, and traced upon the sky fanciful figures of chairs, dragons, sheep, crowns, bears, persons, each of these constellations having some few prominent stars and a number of smaller ones. While the outlines of these objects are entirely fanciful, the arrangement is of great use in helping us to find or describe stars.

Distant in the starry space are vast shining clouds, which were once supposed to be whirling masses of vapor or "star dust," and received the name of nebulæ, or clouds. Better telescopes have revealed the true character of the nebulæ, and we find that they are thickly crowded stars, so immensely distant that their light mingles as one mass, and the spaces between them are not seen. It is also true that there are some nebulæ which are really "cloud-masses of glowing gas."

Wandering among the stars are seen at times brilliant bodies with long trains or tails of glowing vapor. These are comets. Once their appearances caused great terror, as indicating disaster to the human race, and even now some persons are alarmed lest one of these sky wanderers should, in his frantic flight, run against our earth and dash the poor little globe to pieces! But these comets are not such vagrants as they seem. Law reigns in all the universe, and even comets are subject to it, and come and go on a distinct track. The motion of many comets has been determined, and their return into the range of our vision is accurately foretold. There are some comets which always remain in our own solar system; others come from the depths of space, pass about our sun, and dash away into infinite distance to return no more.

Various opinions are held as to the material of comets. Some consider that they are composed of myriads of small bodies like tiny meteors; others consider them made of gas. The head or nucleus is doubtless more solid than the tail, and it has been found that tails of comets differ in composition; they contain hydrogen, carbon, iron, chlorine, and other kinds of matter, such as we have in our world. The tails of comets always turn *from* the sun, and as the comet nears the sun in its circuit the tail expands; as it leaves the sun the tail decreases in size.

Some comets have no tails, some have several. It is supposed that the tails of comets diminish and finally disappear, from destruction of their expanded material by the sun's heat as they repeatedly draw near to the centre of our system.

Some comets go and come in their orbits in three or four years, others roam for centuries before they sweep again into our range of sight.

As marvellous as the comets, are the temporary stars. Several instances are on record where stars have suddenly appeared where no star had been seen before. They shone for a time with splendor, then faded away. In November, 1572, a magnificent new star shone in the constellation of Cassiopea. In eighteen months it vanished. During the seventeenth century "Kepler's Star" appeared in the constellation of The Serpent Bearer, and surpassed all the finest stars near it in brightness. It gradually lessened, and in two years was lost to view.

Other wonders of the heavens are the variable stars. The light of these stars changes greatly. Week after week they brighten as the sun brightens from dawn to noon; then for an equal period they pale and fade, to revive in splendor and again to wane.

There are also stars that fix our attention by being binary or double. These are twin stars situated very close together, and revolving around each other. After the binary stars were discovered, it was found that there were also multiple stars; that is, three or four stars similarly situated in relation to each other, and circling about each other. These binary and multiple stars are usually of different colors, as a green and a red, an orange and a blue, or blue, green, orange, and red in a four-fold star.

Most of the stars are so very far from us that we cannot learn much about them. What we call our own solar system embraces our sun and a certain number of planets, which depend on our sun for heat and light, and constantly move about the sun in great and nearly circular paths. By means of telescopes and other instruments we are able to study our own sun and his system of dependent planets. When we examine distant stars they seem to us to be like our sun, and so we conclude that like him they may be centres of systems and have planets wheeling about them.

If there were such planets we could not see them, owing to the greatness of the distances. Planets are dark in themselves, as our world is, and shine only by reflected light from their suns. These suns are the stars of the field of heaven. Suns are stationary with respect to their accompanying planets, but with respect to other systems it is probable that each system is in motion and moves about some distant centre, led by its sun along some path which no mind can calculate.

As we look upon the heavens we can consider that all these glowing bodies are moving on some majestic path through infinite space. The star Alcyone, in the Pleiades, has been conjectured by Mädler of Dorpat to be the centre of gravity, or central sun of all the known universe.[1] The Pleiades, often called "The Seven Stars," are a grape-shaped cluster, of which six stars are large and beautiful, while many smaller ones appear like a soft, golden haze.

Ancient poets said that once there were seven Pleiads, but one wept itself out at the fall of the city of Troy. That is a pretty fancy; but if one of those so distant stars had gone out when Troy fell, its light might yet be shining for us, and certainly would have shone on Ovid, who told the tale. A poet has written truly: —

"Were a star quenched on high,
For ages would its light
Still travelling downward through the sky,
Fall on our mortal sight."

So vast are these star-distances that it takes hundreds of years for the light of a star to reach us, and yet light moves

[1] This, of course, is merely a conjecture, which it would need ages of observation to confirm.

one hundred and eighty-six thousand miles a second! This is much faster than Puck, who could "put a girdle round-about the earth in forty minutes!"

What an immensity is this about us! All that void amid the starry systems we call stellar or inter-stellar space. Lit by so many splendid suns, is it not then glowing with the light of high noon a million times multiplied? No. The higher we rise above the earth, the darker becomes the color of the sky, until it hangs like a pall of unspeakable blackness. Why is this? Why is light not light? Why this absolute darkness among so many, many suns? It is simply lack of dust! There must be something to throw back and scatter the rays of light before it can be visible. Unless far up in stellar space there is dust, star-dust, a whirl of motes or stones to seize and throw back the light, then all must be very dark. Here on our own little globe the glorious sunbeams lighten us, thanks to dust in our atmosphere. The sunshine reveals to us the dust, but the dust makes the sunshine visible. Sunbeams and dust, each one invisible without the other!

LESSON VII.

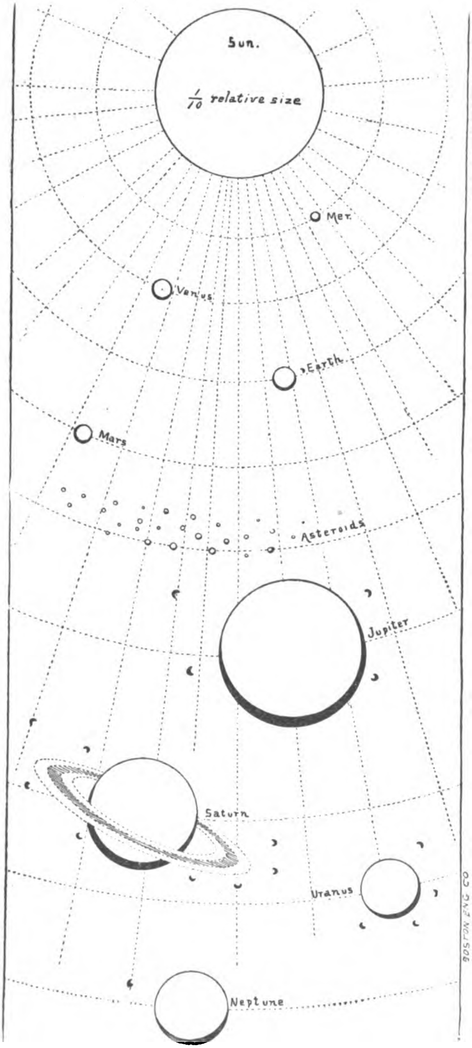
A FRAGMENT OF THE MILKY WAY.

"And now the still stars make all heaven sightly.
One, in the low west, like the sky ablaze;
The Swan, that with her shining Cross floats nightly,
And Bears that slowly walk along their ways.
There is the golden Lyre, and there the crown of fire:
Thank God for nights so fair to these bright days."
— LOWELL, *Summer Nightfall.*

LOOKING up into the heavens we cannot fail to notice a broad, shining band that crosses the sky. We are early told that this is the Milky Way, receiving its name from its pale, silvery light and its path-like track across the firmament. All the heavenly bodies are arranged in clusters or nebulæ; no one of them is isolated. The Milky Way is one of these nebulæ. Its shape is that of a wide, irregular ribbon deeply notched at one end. The reason of the white and shining appearance of the entire nebula, is that it is densely crowded with stars, and is so immensely distant that the spaces between the stars are lost to view. About one hundred years ago Herschel endeavored to count the stars in the Milky Way. He found eighteen millions of stars in the central belt alone.

How long is this nebula? Light starting from one limit of its longest diameter, and travelling one hundred and eighty-six thousand miles a second, would travel fifteen thousand years before it reached the last shining star in the Milky Way! Such distances as this are beyond our power to imagine. The Milky Way is a gigantic cluster of suns, and if each sun has its planetary system about it, each system rides like a shining archipelago in these seas of space. Earth and all other planets, being dark in themselves, do not count in these burning distances. So then our sun is but a star, and the Milky Way is made up of millions of such stars. More than this, our sun is one of the many stars that compose this wonderful band of light. We have now found our place in the heavens — we are a portion of the Milky Way.

All the large stars which grace our most brilliant nights belong to this same



HUNG IN SPACE.

great cluster. We are ourselves lying near its centre. Among all these suns our own appears to us to be the largest and most magnificent. This is because it is nearest to us, and it is to us the source of life, light, and heat. There may be other suns of tenfold splendor, and there may be other nebulæ far larger and more crowded with suns than the Milky Way.

There are other nebulæ which have received different names, from the shape of their outlines, as globular, annular, spiral, double, multiple; the Crab, the ship Argo, — which is shaped like a comet, — the Magellanic clouds, and so on. These lie like splendid islands rocking in distant space, so far away, that if we travelled with the inconceivable speed of light, we might be millions of years in reaching them.

Many of the greatest human minds have, during many ages, been occupied in studying our solar system, investigating its laws, measuring its distances. The discoveries so made have been applied to other systems, and in this way, by long and slow but sure degrees, the science of astronomy has been built up.

From ancient times it has been the custom to divide the stars into classes according to their apparent size. This apparent size depends chiefly upon their nearness to us, and evidently, as the few only are near, and the many are far off, stars of the first magnitude are few in number, and as they diminish in apparent size the number embraced in the successive classes increases. Thus we find but eighteen stars of the first magnitude; but of the third there are one hundred and seventy, of the fourth five hundred, and thus on.

When we look upward in a starry winter night we fancy we can see millions of stars. In truth with the unaided eye we can see only six thousand at most, and it needs very strong eyes to see more than four thousand. But when we turn a telescope upon the sky we begin to count stars by millions.

All the stars are in apparent motion; they have their rising and their setting as does the sun; the constellations appear above the horizon, and move swiftly down the sky. Only one star is, as viewed from our world, immovable, remaining forever fixed in its place; we call it the North Star, or the Pole Star, because to us of the Northern hemisphere it seems to be always watching above the Northern Pole. But, while unalterable as regards us, the Pole Star is not released from the general law of motion which rules the stars.

When we begin to trace out constellations, we usually take the Pole Star as our starting-point. The Pole Star is in the tail of the constellation of the Little Bear, and we find it by imagining a straight line drawn from the two upper stars in the square of the Great Dipper. The Great Dipper we shall easily find, as it is composed of seven large, bright stars, four of which form an irregular four-sided figure and from one corner of this square three others extend in a slightly curved line. This constellation, seen from any place north of New Orleans, La., never sets, but slowly turns around the fixed Pole Star. In ancient times the Great Dipper was sometimes called the Chariot, or David's Chariot, and among English country people it is known as Charles's Wain, a wain being an old English name for a wagon. The

Chinese name the Great Dipper "The God of the North"; the Mohammedans often call it "The Hand of God." It is also called the Great Bear.

Of all the stars the one nearest us is in the southern constellation of the Centaur; but that is so far off that its distance is beyond our comprehension, being over two hundred and eleven thousand times as far distant as the sun. If we could take a ray of light for our steed we must ride three years and six months to reach this sun that is nearest to our sun in the starry hosts.

But is light for a steed all that is wanted for such a trip among the stars? No; for a very little way from our earth we should be in want of an atmosphere, or air to breathe, and also in want of light and heat. Light, heat, and air are probably alike lacking in starry space.

Before we consider the orbs which compose our own solar system, their motions and relationships, which we shall do in another chapter, let us consider for a little the theory of the origin of systems, taking our own for a sample of the rest. Tennyson the poet, puts the story of system-building thus: —

> "This world was once a fluid haze of light
> Till toward the centre set the starry tides,
> And eddied into suns that wheeling cast
> The planets."

We saw in a previous lesson that our world was once a vast ball of fiery vapor. The great astronomer Laplace, after many years of study, published a theory about system-making, called the "Nebular Hypothesis," which, as simply as we can put it, is this: First, there is a great cloud of glowing vapor, the various particles of which are by the law of gravitation drawn toward a single centre. As the particles press equally to the centre from all sides, it is evident that the first result will be a ball of constantly increasing solidity. This nebulous mass possesses also a motion of rotation, or turning over on its own axis. As the ball grows smaller and more dense, it will spin round faster and faster.

The gaseous matter of the sphere having become fluid or partly fluid, the ball still whirls on, and we must now notice a second motion, called centrifugal or tangental, which has become more apparent as the rotation increases in velocity. While by the force of gravity all atoms seek the centre, by this centrifugal force atoms are driven from the centre. This tangental motion is familiarly seen in the case of mud on a wheel-tire, the mud being flung off from the wheel by a motion created by rotation. So from the spinning globe a ring of matter will be detached and fly off into space.

If this ring were equally hard and thick in all its parts, and exactly poised about the globe from which it sprung, it might keep the ring shape. But in nearly all cases the ring when flung off would be irregular, and would consequently break up. As it broke, the largest fragments, keeping the wheeling motion and made spherical by gravity, would draw into themselves the smaller near fragments. Then, after a while, following the example of the globe from which they spun off, these new globes would cast off rings of matter which would contract and harden into globes, and become their satellites or attendants, as they, held by the force of gravity, remain attendants upon the first great globe.

This is the nebular theory of system-building. We see that in it three things are pre-supposed, or taken for granted; first, matter in a state of slowly rotating glowing vapor; second, a law of gravitation; third, a law of tangental motion. In the one hundred years since this hypothesis was first developed by Laplace, no one has ever seen the glowing vapor consolidating to suns. These processes are far too long to have been within any human observation, but long and careful study has enabled man to learn some of the wonderful laws by which the universe is governed.

Let us see if this explanation of Laplace fits anything which we find in our solar system. Has any great globe rings wheeling about it? Yes; the huge planet Saturn has a triple ring. Besides this ring, Saturn has eight moons, as if some other ring had broken up, and its parts had come together into satellites. The planet Jupiter has four satellites, Mars has two, Uranus has four, Neptune one, and our earth has one, called the moon. There are also in our system a number of very small planets, closely grouped, called asteroids. In the nebular hypothesis these asteroids might represent matter cast off at first in rings, breaking and finally condensing into spheres. Here we find in our solar system between the larger planets Mars and Jupiter a splendid zone of minor planets.

Comets are also explained by this theory, as large masses of material, too evenly balanced among the planets to yield to the attraction of any one of them, but owning the attraction of the sun, the centre of gravity of our entire system, and wheeling about it in vast elliptical orbits. Finally it is supposed by some that the general speed of our entire system is slackening. This "slowing up" of the system is supposed to be due to the friction of ether which pervades all space, and also to a great depth of hot and expanded material more thin than air, which extends about the sun, wrapping it in a vast, fine mantle of gas, as our atmosphere surrounds our globe.

But if it is true that the motion of our system is growing slower, it will be many millions of years before the change will be great enough to notice; just as, granting that the sun is losing its heat, it will be many millions of years before it ceases to shine upon and warm our globe.

In fact the lessening of speed in the solar system, and the lessening of sun heat, are as yet only theories and not proved facts. The sun will shine on, and the worlds will whirl around it, through time which no human mind can calculate.

Attraction, the attraction of the sun over the planets, and the planets for each other, has been several times mentioned. What is this attraction? Attraction is a "drawing to." If a magnet be held near steel filings it attracts the particles of steel, and they adhere to the magnet; this attractive power is magnetic attraction. The attraction or pulling power which bodies have for each other, is called the attraction of gravity or of gravitation.

All bodies have this attraction for each other, but in small bodies we do not observe it. Its force is due to the weight or mass of the bodies, and diminishes as their distance from each other increases. It is by this force, or attraction of gravitation, that whatever is thrown into the air falls towards the earth. If you throw up a ball it moves upward, obeying the force you put into your throw, but soon that force is used up, and the earth pulls the ball back. You jump, and you rise from the earth by the force expended by your legs in the act of jumping, but that force is used up soon, and the earth pulls you down. You jump from a tree or roof, and down you come to the earth, pulled by the force or attraction of gravitation.

This force or attraction, exerted by the great strong sun over our earth and all other planets, keeps them travelling in nearly round paths about the sun. This attraction, exerted by the earth over the moon, keeps the moon travelling in a nearly circular path about the earth. And does not the moon then attract the earth? Oh, yes, all bodies attract each other; but the moon is of much less weight or mass than the earth, and her pull is weak in comparison; she cannot pull the earth out of her orbit. She does pull something however, and what do you suppose she pulls? She pulls the water that is on the earth, heaping it up in the tides! The tide is simply the ocean obeying the attraction of the moon.

It seems a pity that in a few simple lessons on the solar system, we should use any terms that are hard to be understood. But some few such terms we have been obliged to use. "Attraction of gravitation" is one of these which we have tried to make a little plainer. "Inclination of plane to orbit" is another. What does that mean? Can we make it clear?

Let us set a lamp on the table, and call it the sun. Now take an orange and call it the world. Call the stem-place, and the spot opposite, the poles of this world. Next run a knitting-needle through the orange, from pole to pole, to represent the axis on which the earth turns. As we spin our earth-orange around on its axis, let us move our needle around the lamp, in a lemon-shaped path. This shape is called an ellipse. Thus we represent the earth turning around on its axis, or over and over, and at the same time travelling around the sun.

Now it is clear that we can hold our knitting-needle straight out, horizontally, or we can hold it straight up and down, perpendicularly, as it moves around the sun-lamp. But neither of these straight positions would represent the direction of the axis of the earth; we must *tip* the needle a little, so as to hold it in a slanting position. Now if we held the needle exactly up and down, or exactly straight out, the sun-lamp would shine on just half of the orange, as divided from pole to pole. But when we tip the needle you see we bring our orange-world in such a position that, as it passes around the sun-lamp, the light falls now more around one pole, now more around the other; this tipped position is "inclination to the plane of orbit."

LESSON VIII.

PLAN AND PROGRESSION.

"They rise in joy, the starry myriads burning —
The shepherd greets them from his mountains free;
And from the silvery sea
To them the sailor's wakeful eye is turning —
Unchanged they rise —"

— HEMANS.

WE have now found that our earth is one among several planets revolving around a great central star which we name the sun. The sun and his attendant planets and their satellites form what is called the solar system. We have also found that the heavens are filled with such systems, and that these are gathered together in nebulæ or clusters. Prominent among these clusters is the Milky Way, near the centre of which our system is placed.

The bodies which in our system revolve about the sun, are called planets. With respect to the sun and other great stars the planets are small, but considered in themselves they are enormous bodies. They are all dark spheres,[1] having no light in themselves. Is it true that the moon with her silvery radiance and Venus and Mars with their steadfast beams, are dull and dark as burnt-out cinders? This is indeed true; the planets receive their light and heat from the sun, and it is as they reflect back this light that they shine so brilliantly. As an example of such reflection take a new tin plate; it has no light in itself; shut it in a dark room, it gives out no

[1] Professor Newcomb considers Jupiter partly self-luminous.

light; but hold it where a broad ray of sunshine strikes it, and at once the light is reflected back from the tin with such burning splendor that the eyes can scarcely look upon it. So we have observed windows struck by the light of the setting sun, and at once blazing forth like fires.

The planet nearest to the sun is named Mercury. It is distant from the sun about thirty-five millions of miles,[1] and is the smallest of the eight major planets. Mercury is so close to the sun that it is nearly always lost in the sun's light, and can be seen by the naked eye only occasionally, immediately after a clear sunset, or before a clear sunrise. The telescope shows us that Mercury has phases as the moon has; possesses, as far as known, no satellites, and its path is not so nearly in a circle as that of other planets. To the naked eye it appears as a small star, with a white light faintly tinted with red. Lying so near to the sun it receives much more light and heat than we do. Its day is twenty-four hours long; its year has but eighty-eight days, and each of its seasons is but twenty-two days long. The shortness of the year and of the seasons is the result of the nearness of the planet to the sun, which so shortens its path that it can be traversed in less than three of our months.

The next planet in order of distance from the sun is Venus, the most beautiful of what we popularly call stars. But Venus is a planet, not a star. Venus is visible nearly all the year, and is often the first star to shine forth in the evening or the last one to fade away in the morning. It

[1] Sir B. Ball says 36 millions; others 35 millions; Newcomb makes mean distance 40 millions.

has even been seen shining at noon-day. This dazzling light of Venus is supposed to be caused by a dense layer of cloud, which wraps the planet about, and proves an admirable reflector of the sun's rays. The day of Venus is about half an hour shorter than our own;[1] its year is two hundred and twenty-four days. The French astronomer, Flammarion, tells us that mountains, much higher than any on our earth, have been measured on the planet Venus. The changes of temperature on Venus are much more sudden than on our earth; but it has no ice at the poles, for its winter does not last long enough for ice to accumulate as it does at the earth's poles.

As the orbit of Venus is between the earth and the sun, it happens that at certain times Venus lies between the sun and the earth, and so shows us its dark side. Again, when it is to the right or left of the sun, we see only a crescent formed by its quarter,[2] and it is at this phase that its mountains have been measured.

Venus is sixty-six millions of miles from the sun, and when nearest us about twenty-six million miles from the earth, being, with the exception of the moon, our nearest neighbor in the skies.

The third planet from the sun is our earth, ninety-two million miles from the source of its light and heat. Circling around the earth, and moving with it in its orbit, goes the moon. The earth rotates on its axis once in about twenty-four hours, giving us day and night in that period of time,

[1] Sir R. S. Ball. Story of the Heavens, p. 161.

[2] These phases can be observed only through a telescope.

according as, during its revolution, a part of the surface is turned to or from the sun. As the earth rolls over upon itself, it also rolls along its orbit, or sky-path. The path of the earth about the sun is travelled over in three hundred and sixty-five and a quarter days, giving us our change of seasons by the inclination of the earth's axis to the plane of its orbit.

Next removed beyond the earth from the sun, is the splendid planet Mars, which is easily distinguishable by its red light. It is in some parts of its path only seven millions of miles further from the earth than Venus. Mars has a day of about the same length as ours, and its seasons are of nearly the same intensity; but while a season is three months long with us, on Mars it is very nearly six months, for Mars takes almost two of our years to travel round the sun. Mars has a snow or ice-cap at each pole; it has also an atmosphere, as with a telescope we can observe clouds drifting across its sky, the clouds being formed as clouds here, by the evaporation of water from the surface of the globe, which moisture, being carried up in invisible vapor, is condensed by colder currents of air and forms clouds.

The red light of Mars is supposed to be produced by the color of its surface, and by some it is considered that the vegetation on Mars may be red, as ours is green, and that to an observer on Mars, our planet would shine with a green light, as to us Mars shines in red. The poles of Mars are always white. Next after the moon Mars is the planet best known to us, because sometimes, as our globe and Mars pursue their paths through space, they come upon the same side of their path at the same time, which shortens the distance between them, and enables close observations to be taken.

Between Mars and the next planet Jupiter there is a very great space, so great that astronomers considered that it could not be empty, but must have in it planets too small for easy observation. They therefore resolved to search that part of the sky constantly and carefully with telescopes. On the first day of this century a small planet was seen in this space, and was named Ceres. This was the first-found asteroid. From their small size these planets are called asteroids or starlets. Others were found, slowly at first, and then more and more; in April, 1891, the 309th was discovered by Dr. Palisa.

Ceres, the first-found asteroid, is so small that one hundred and twenty-five thousand little worlds of its size could be made out of our own world. Fifty little globes like Ceres, set side by side, would form a line as long as the diameter of our world. As the mass of Ceres is so much less than that of our world, the attraction of gravity is less — anything is fifty times as heavy on our world as it would be on Ceres. So if a boy could live on Ceres, and have as much muscular force as he has here, he could play easily with a ball that here weighs a quarter of a ton. A baby on Ceres could tumble about a cannon-ball as easily as a baby here plays with a rubber ball. If a house fell over on a man, he could set it up as easily as here he could set up a fallen peach-basket. Of course it is only a play of fancy that there are men, boys, or babies on Ceres. Perhaps there is no living thing there. If there are living creatures, all their habits and ways of life must be very different from ours. But if people from our earth could go to Ceres, why would they find such wonderful differences there in weights, and in the effect of an output of strength? We have seen that Ceres is very much smaller than our earth; its mass is greatly less, and just in proportion to the smallness of its mass is the force of the pull it exerts over objects, or the attraction of gravitation; this attraction is dependent upon the mass of the body exercising it, and upon the distance of the body attracted. When the distance between two bodies is great the attraction is weaker, and when a body is small its attracting power is less in proportion. Ceres is such a small planet that its pull over objects is small. Similarly, we might say of the planet Mars that its mass is so small, as compared with that of the earth, that a body which on the earth would weigh one hundred pounds would weigh much less on Mars; and where you could jump up five feet here, you could rise many feet there.

The best athlete who can make a jump here, can rise only a few feet into the air; then down he comes, pulled by the force of gravity, the attraction of the earth. But on Ceres attraction is so small an affair that a man could jump over a dome as high as St. Peter's or St. Paul's without creating any excitement. In fact, on Ceres a man would weigh only one-fiftieth part what he weighs here, and the same output of muscular activity as is used here would have a fifty-fold value. Much the same conditions exist on the other asteroids.

When first discovered it was supposed that the asteroids were fragments of some very large planet which had gone to pieces. That theory has been disproved, and now the nebular hypothesis of Laplace is generally admitted to account satisfactorily for these little planets.

After passing the asteroids in our system, we come to Jupiter, the largest of the planets. Jupiter often shines more brightly than Venus. It is more than one thousand times larger than the earth, and is seen during most of the year. The year of Jupiter; that is, the time which is required for its journey around the sun, is almost twelve of our years. Day and night are equal, and of about five hours each, and there is probably no change of seasons. But Jupiter seems to be to-day a still highly heated body, as our earth was very many ages ago, and its surface is disturbed by terrific storms.

Jupiter is accompanied by four moons, and its globe is surrounded by several dark belts, which seem variable in number, but apparently belong to its surface. The belts somewhat resemble sun-spots, and indeed the whole planet is considered by astronomers to be much more like the sun than like our earth. The reason that Jupiter does not have changes of season is that the inclination of the planet to its orbit is very slight. When we consider that Jupiter turns on its axis in less than half the time that our earth requires for a rotation, and is also so very much greater in diameter than our earth, we will realize how marvellously rapid its daily motion must be.

Next to Jupiter in place, and next also in size, is Saturn, the sixth planet from the sun. Ancient astronomers supposed that with Saturn our solar system ended. Saturn has eight moons placed at different distances, and is further distinguished by a very beautiful triple ring surrounding the entire planet on its equatorial line. Within this glowing triple ring the planet turns, and the rings themselves are carried round the planet in a circular movement of still greater swiftness. These rings are not always visible, as they, like their planet, shine by the reflection of sunlight, and so are seen only when the sun and earth are both on the same side of the planet.

In 1781 Sir William Herschel, the English astronomer, who had made for himself a very fine telescope, discovered another planet. At first he supposed this was not a planet but a comet. Finally it was received into the family of the planets and named Uranus. Uranus is much smaller than Saturn, but many times larger than the earth. A year on Uranus is eighty-four of our years; that is, it takes Uranus eighty-four years to make its circuit of the sun.

With the discovery of Uranus astronomers began to hope that yet other bodies belonged to our solar system. They saw that the motion of Uranus was often disturbed, as if some other planet near it exercised over it some attracting force. Searching carefully, a planet was finally found, about one hundred times larger than the earth, and so far from the sun that to an observer placed upon it the sun must appear like a large star; even the planet's day would be no brighter than twilight. This new-found planet was named Neptune, and is thus far the last known planet of our sun system. Its place was determined in 1846. Neptune is the only great planet that has been discovered by a set search in the heavens for it, based on reasoning that such a planet ought to exist. A Frenchman and an Englishman discovered Neptune almost simultaneously. The planet has one moon. Uranus and Neptune are so exceedingly distant from our earth, and from the sun, that the study of them has afforded very little of interest.

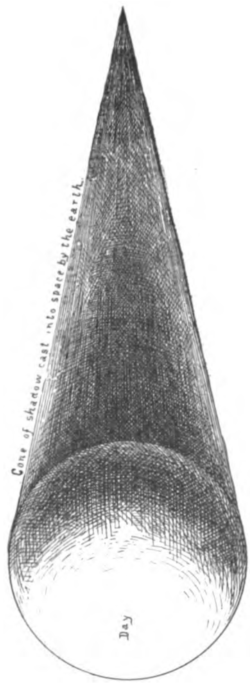
LESSON IX.

THE KING OF THE DAY.

> "In them hath he set a Tabernacle for the sun,
> Which is as a bridegroom coming out of his chamber,
> And rejoiceth as a strong man to run a race,
> There is nothing hid from the heat thereof."
> — *Psalm XIX.*

If it should happen that the sun were blotted out, our earth would at once cease to be habitable. Within forty-eight hours the globe would be covered with a deluge of rain, and buried in piles of snow, owing to the condensation of all the moisture in our suddenly chilled atmosphere, while more than Arctic cold would freeze the oceans to their depths. In this reign of cold and darkness all animal and vegetable life would perish. All the planets of our system would share the same fate, and as the light with which they shine is reflected from the sun, they would become invisible, rolling on through space in total darkness.

How far from us is this sun, so important to us as the centre of light, heat, and attraction? Ninety-two millions of miles. But how far is that? An engine running thirty miles an hour, without once slacking speed, could go around our globe in thirty-five days. Start it off for a trip to the moon, and with the same speed it would reach there in eleven months. And then send it from the earth to the sun, at an equal rate of travel: year after year it must rush on, until three hundred and fifty-one years were passed before it could reach the sun. But so much faster does light travel than a railroad train, that light comes to us from the sun in eight minutes and nineteen seconds!



"THE LIGHT AND THE NIGHT."

The sun is the centre of our planetary system, and holds all the planets in their proper orbits by the force of his attraction. We have seen in our glance at the asteroid Ceres, that the attraction of gravity depends upon the distance and the weight or *mass* of the body exercising it. If our earth should suddenly grow lighter it could not hold the moon in its present orbit; if its attractive power over the moon ceased, the moon would go tumbling off into space. The sun exercises immense attractive force by virtue of its enormous mass. If all the planets were put into one pan of a pair of scales, the sun in the other would outweigh them seven hundred times over.

Three hundred and fifty thousand such globes as we live upon would be needed to balance the sun.

This gives us some idea of the mass or weight of the sun. What is its size? Our world is nearly eight thousand miles in diameter at the equator; over two hundred and forty thousand miles distant from the earth the moon revolves around it; but if a circle as large as the sun could be drawn, the earth might be placed in the centre, the moon rolled in her proper path around it, and beyond this orbit to the line representing the circumference of the sun would be a distance of nearly two hundred thousand miles more.

This vast orb shines with no borrowed ray. It is a great fountain of burning light which shines now as it shone long before the building of our world began. No light is so powerful and intense as sunlight. A flash of lightning is scarcely seen across a sunny sky; the light of lamps is not visible in strong sunshine; no invented light can approach sunshine in brilliancy. Twenty millions of the brightest stars would not shed upon the earth the radiance poured out by the sun.

According to the nebular hypothesis of Laplace, the sun not only provides the planets with light and heat, but is the source and parent from which they sprung into space. Thus the most distant planets, as Neptune and Uranus, were the ones first thrown off, and the earth, as only in the third remove from its source, is one of the latest of the sun children.

We know that in the far-off ages, when the earth was being built into a habitable globe, the sun shone just as it does to-day. We know this from the *eyes* of fossil animals, which show that they were formed to receive sunlight just as eyes do to-day. Also the petrified rain-marks, of which we spoke in a former chapter, tell the same story; for without the sun there would have been no rain, nor would imprints have dried or baked so rapidly.

The heat and light of the sun are indispensable to the production and growth of all vegetation. Age after age the genial rays of the sun nourished on this earth an improving and enlarging vegetable growth, which on its decay left added soil for generations of plants to come. Thus the sun was not only the parent but the cherishing nurse of our little globe. We have seen that in the coal period of earth-building, the atmosphere of the world was heavily charged with carbonic acid gas, but under the stimulating effects of sunshine, vegetation continually increased, used up most of the carbonic acid gas, and the atmosphere became constantly richer in oxygen,[1] and more and more fitted for the use of animals. Thus we see the sun, as a prudent householder, storing up in the world supplies of coal, and purifying at the same time the air. Meanwhile, by the action of sun rays on the salt, shallow seas, vast salt beds were produced and buried, providing a mineral especially needful to man.

Our dependence upon the sun awakens a desire to know something about the orb itself; but how can a body so intensely bright be studied? Smoked and colored glass plates are used, through which the sun can be observed with comfort, and there are certain occasions when the study of

[1] Nature Reader, No. 3, pp. 40–24.

this vast, glowing, and distant body can be favorably pursued. These especial occasions favorable to sun-study are during an eclipse, and when the planets Mercury and Venus cross the sun's disk. Such a crossing is called a transit.

It was once supposed that the sun was no larger than the moon is, and as near to the earth as that planet is; both sun and moon were believed to be much smaller than the earth, and very near to it, and revolving in an orbit about it. To us the sun appears to rise above the horizon, move across the heavens, and sink beneath the horizon, and return after a few hours' absence to pursue the same path. Meanwhile, the earth does not appear to us to move. This is not the only case in which our eyes deceive us until we call reason to their aid.

When we are on a swiftly moving train of cars, it seems to us that trees, posts, telegraph-poles, go rushing by us, while we remain at rest. Although no one now questions that the earth moves, and that with regard to the earth the sun remains fixed in one place, we still use the language that fits appearances rather than facts, and we say, "the sun rises, the sun sets," when in truth the earth is merely turning over and over, and so constantly bringing a different part of its surface under the sun's rays.

As the various planets move about the sun, in paths which we may call concentric circles, or rings set one inside the other, it is evident that there may be occasions when the different planets will come between the sun and some planet with an orbit beyond their own. For instance, Mercury is a planet travelling in a circle around the sun, but a circle smaller than that in which the earth travels. Mercury may then sometimes pass across the face of the sun at a time when the earth is on the same side of the sun, and in that case we can observe Mercury moving like a little black ball across the glowing front of the King of the Day. To see such an occurrence we must use smoked or darkened glasses, else Mercury would simply be lost in the unshaded splendor of the sunlight. Why is not such a transit of Mercury seen every year? Every year Mercury must cross the disk of the sun, and the reason we do not see a transit yearly is that the orbits of Mercury and the earth differ in plane, and long periods will elapse between the occasions when the sun, Mercury, and the earth come into line thus:  As Venus overtakes the earth in its journey around the sun once every nineteen months, shall we have the benefit of a transit at each time of passing? No; because Venus is usually either above or below the line of the earth's orbit. But when at long intervals such an event as a transit of Venus does occur, no astronomical incident can be more valuable, because it gives us the best means of measuring the distance between the earth and the sun.

A grand opportunity for studying the sun is afforded by an eclipse. An eclipse of the sun is occasioned by the moon's passing between the earth and the sun. Children are frequently warned that it is discourteous to pass between a person and the fire or light; our child, the moon, happily for us, often passes between us and our fire, the sun, and on the fortunate occasions when this can be observed out come the glasses for sun-study. As the moon revolves about the earth, she sometimes stands between the sun and the earth. When the moon passes between us and the sun on a clear day, between sunrise and sunset, the day grows dark, a twilight comes over the world, and continues until the moon has crossed the disk of the sun.

How can so small a body as the moon obscure so great a body as the sun, and how can the moon pass in seven minutes across a disk nearly a million of miles in extent? All this can be explained by the nearness of the moon to our globe, and consequently the moon's great distance from the sun. Any one of us can hide the sun from us by a dinner-plate, or even a dime, if we hold it close enough to our eyes. So we can move a dinner-plate across the disk of the sun, by one sweep of the arm. All depends upon the nearness to ourselves of the screen used. Now as the moon is so near us in time of eclipse, she hides the sun from us; the eclipse may last for an hour, but will be total only for a few moments.

Every year there must be more than one eclipse of the sun. The greatest number possible in a year is five, the least two; but these will not all be visible from the same part of the globe.

Astronomers call an eclipse partial when the moon passes over one or the other side of the sun's disk. An annular or ring eclipse is one where the moon is at such a distance from the earth, that she hides only the central part of the sun's disk, while around the dark shadow thus cast appears a ring of splendid light. A total eclipse of the sun is where the moon is so near us that she hides the entire face of the sun. This can happen only at long intervals for any given locality. Thus, when there is a total eclipse of the sun visible from New York City, it may be hundreds of years before such an eclipse is again seen from there.

When the sun is in total eclipse a glorious halo of clear light called a corona, or crown, rays out on all sides behind the black body of the moon. Horns, cones, and streamers of violet, scarlet, orange, and pink light rise up from this crown, and seem to toss and whirl like clouds in a storm.

In the careful study of the sun with telescopes, it has been found that there are spots on its surface, which look as if the outer portion of the sun were torn. Now by watching these spots a very wonderful fact has been discovered. What do you think that is? Why, that the sun turns over on its axis, as the earth does. But while the earth rotates once in twenty-four hours, it takes the huge sun about twenty-five days to turn around once.

Not only is the sun turning over on its axis, but it has a great path along which it travels in space, and as it goes on it draws with it all the planets and satellites of our system, each held in its proper path by the great force of the sun's attraction. Thus we have learned that from the sun these great globes, the planets, were thrown off into space, by tangental force, and lest they should go too far away they are held in their paths by his strong attractive force.

LESSON X.

THE QUEEN OF THE NIGHT.

"That orbèd maiden, with white fire laden,
Whom mortals call the moon,
Glides glimmering o'er my fleece-like flow,
By the midnight breezes strewn."
— SHELLEY, *The Cloud.*

No orb in the sky has attracted more attention than the moon. Beautiful names have been given to this lesser light that rules the night, and poets have sung some of their sweetest songs, and artists have painted some of their finest pictures, to depict the wonderful charm of moonlight. The moon is in our minds associated with peace, silence, rest; the silver radiance causes no pain to the eyes, and like charity, while revealing objects, it adds to their beauty, and subdues defects. Much that by the light of day seems harsh and ugly appears picturesque and fascinating in the delicate splendor of the moonlight. Of moonlight rather than sunset might the poet sing: —

"The splendor falls on castle walls
And snowy summits old in story,
The long light shakes across the lakes,
And the wild cataract leaps in glory."

Those nations who have worshipped the sun as god of the day, have paid similar worship to the moon as goddess of the night. The ancient myths spoke of the moon as a pure and lonely maiden, fond of silence, hunting, and the forest shades. Increasing knowledge has shown us the moon as neither goddess nor maiden, but as a satellite of the earth, from which many ages ago it was cast off into space, and by the attraction of which it is held as by invisible and unbreakable chains.

Being so much nearer to us than any other heavenly body, the moon was one of the earliest and best understood, and to it, about two hundred and fifty years ago, the first telescopes were turned with eager expectations of wonderful discoveries. The moon, at the nearest point in its orbit, is distant from us about two hundred and twenty-five thousand miles, only about twenty-eight times the diameter of the earth. Those travellers, who have again and again made the circuit of the earth, have in the aggregate passed over a greater distance than lies between us and the moon. Steam could take us there in less than a year; but if the man in the moon should begin to pelt stones at the earth, they would hit their mark in a little less than three days and two hours.

Shining large and fair in the heavens, the moon seems, as a queen, to lead forth the hosts of the stars, but if we watch its course each of the twenty-seven days which it requires for its journey around the earth, we shall see that it continually falls behind the progress of the shining hosts, and possesses a motion entirely independent of them. The moon, like the earth, shines by the reflected light of the sun, and this causes the lunar or moon phases. Thus sometimes we see the full moon; then by slowly lessening degrees, which we call waning, we see the half, and the quarter, and the little crescent, or octant. Then we lose sight of the moon, and again it becomes visible as a slim crescent, the hornèd moon it is called, and so waxes to the full. In the circle which the moon describes about our earth, the moon passes between us and the sun once in about thirty days, and so presents us a dark side, which is called the new moon. In fifteen days more it is on the opposite side of the earth from the sun, and shows us its entire disk illuminated, which we call full moon; passing still about us, in fifteen days after full moon, having changed from full to gibbous, and to the third quarter, half, and second quarter, once more we are presented with the slim octant of the hornèd moon.

Generally the moon in its orbit passes a little above or below the disk of the sun, but sometimes it moves exactly across the face of the sun, and so occasions an eclipse of the sun. Again, sometimes the moon, as it passes behind the earth, comes within the cone of shadow cast by the earth, and so an eclipse of the moon, either total or partial, is caused.

There are many nights when we say "there is no moon." We should not understand by this that the moon is not in the sky; the simple fact is that in the progression of its rising, the moon has come to a time when she moves during the day through the part of the heavens that is visible to us. So sometimes toward sunset, we see the moon high in the sky, and during part of the day, when the nights are moonless, we see the moon when not obscured by the greater light of the sun.

In all these various changes of its life, if we study the moon with telescopes, we shall find it to be a globe, opaque, lit up by the sun, having mountains and valleys on its surface.

Those dark lines and spots which with the naked eye we see on the full moon, are ranges of volcanic mountains. The surface of the moon has been mapped out by astronomers, who have given names to the various eminences and depressions, and from a study of the moon much has been learned of planets in general. For, while the moon is so small a body and has its orbit around the earth, which is its centre of attraction, it is not to be considered as a mere satellite, but is to be respectfully ranked among the planets.

There have been many foolish myths about the moon: its ray has been considered poisonous to sleepers; the full moon has been regarded as a source of disease and madness, and has been supposed to affect the growth of plants, the medicinal properties of herbs, and the fortunes of human lives. The moon owes all these slanders to its nearness to us.

In size the moon is about one-fourth the diameter of the earth, and its volume is but one-fiftieth that of our planet. The days and nights of the moon are not twelve hours long, but three hundred and sixty hours, equal, therefore, to fifteen of our twenty-four hour days. Only a little more than one side, or face, of the moon is ever seen by us. There have been many romantic fancies about what may be on the other side of the moon, but probably the side we do not see is very similar to the side which we do see.

What is the past history of the moon? The first condition of any planet is that of burning vapor or gas, which must slowly cool and form a nucleus of solid or half-fluid matter. It is evident that the smaller the planet the more rapidly it will cool and become solid, and the greater the planet the longer it will remain in a partly fluid state. Thus Jupiter and Saturn will require much longer time to cool than Mercury or Venus. The sun, being by far the largest body in our system, will be gaseous or semi-fluid long after all the planets which he cast into space have cooled and hardened; while the moon, being one of the smallest planets, hardened long before the great planets, and before the earth. Thus the sun is still in the early stages of its existence, and the moon has run the course of its changes and is a burnt-out and aged world.

No doubt the stages of moon-building were very like those of earth-building, with variations due to the much smaller size of the sphere. The nucleus would partially solidify, there would be a hardened crust which at intervals would crush in from the withdrawal of interior molten matter, or would be suddenly torn and flung up by the pressure of boiling lava from within. The condensing atmosphere no doubt sent down water upon the moon, but by long degrees the heated volcanic surface has parted with its seas, and we find the map of the moon now presenting us not with oceans, but empty sea-beds, volcano craters, and strange and arid depressions.

The moon has no atmosphere; no rain falls on her barren surface; no clouds move above her; no tempests howl in her caverns; no snows crown her volcanic peaks; no sunsets shine in gorgeous colors; there are no violet and crimson skies at dawn. The moon is the kingdom of eternal calm, and sleep, and stillness. If any blow disturbs the lunar surface, it is from the fall of meteors rained upon it through space. It is to our atmosphere we owe the glories of the clouds, the beneficence of waters, the magic of frost changes, the rush of storms, the balmy breezes, the sky.

As it has no seas and no air, it follows that the moon has no sky. The lovely blue we see above us, is merely caused by many miles of air, but from the moon one would merely look away into immensity; and day, and night, sun, moon, stars, comets, and meteors could not be seen, while instead of the lovely blue dome above us, where stars innumerable shine and tremble, space, as seen from the moon, is a perpetual, limitless, black abyss.

We have found the moon destitute of both air and water; it is evident that it is also destitute of all vegetation; in fact of all life. As there is darkness above, so there is silence below. The moon is a desert land where no foliage rustles, where no flowers bloom, where no bird builds or sings. No feet climb the lofty mountains, or explore the gaping craters of moon-land. No voice causes an echo in the vast yawning caves that penetrate moon-mountains.

A curious fact about these mountains in the moon is that they are annular or ring-shaped. They are skeleton mountains, burnt-out craters, mighty hollow cones thrust up, so that if one might climb to the top of a moon-mountain, he could walk around the rim, as a fly walks around the edge of a cup; or he could go down, down, down, on the inside to the level of the plain from which he began his ascent.

The surface of the moon changes, not by the motions of life and growth, but by a slow decay; for changes in the moon's face are occasioned by the crumbling of mountains and the falling down of lands. Thus we see the moon to be a dumb, dead, deserted planet, wheeling on in its orbit around the earth, and carried with the earth in its greater orbit around the sun. Silvery sweet and fair, this queen of the night is a planet that long, long ago passed its childhood and its prime, and fell, in its old age, a prey to fire.

LESSON XI.

VANISHED FAUNA.

"I said: 'When first the world began
Young Nature through five cycles ran,
And on the sixth, she moulded — man.'"

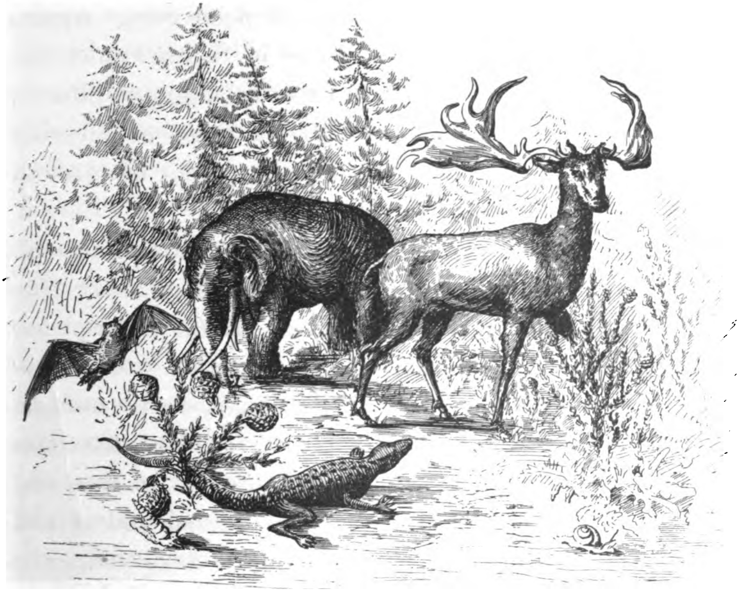
— TENNYSON, *The Two Voices.*

THE old fairy tales inform us of genii, and gnomes, and brownies that live underground, and in rocks and caves, guarding treasures of gold and of gems. Let us fancy that there are truly genii and gnomes that have lived from the time when life began until now.

In every passing age each country has had its peculiar forms of animal life: these are called its fauna. The plant-life of an age or country is called its flora. As each age of earth-building came, it brought its especial fauna and flora. As the age passed away, this plant and animal life went away with it, and returned no more.

But from every age some form or type has lingered until now. The pretty little lamp shells of the China seas come from the far-off second period of world-building. Some of these forms that have lived through all the ages have changed much to suit the conditions of new times; others have scarcely changed at all.

And from all these periods, hidden in rocks and earth-beds, are frail remains of things that lived and perished long ago.



THE LOST BEASTS.

Let us fancy that gnomes and genii keep these wonderful treasures.

In the distribution of the plants and animals of past ages we read much of the earth's history. For instance, when we find buried under the later soil of England, the bones of elephants and hyenas, and the leaves and fruits of palms or other tropical plants, we decide, on reasonable grounds, that at some period the climate of England has been warmer than it is to-day. Similarly, when in layers above these tropical specimens we find the relics of an Arctic vegetation, and the skeletons of elk and bears that belong only to polar or subpolar regions, we conclude that the days of tropical warmth in England were succeeded by days of polar cold. Again, when we find under the warm plains of South France the remains of animals and vegetables now belonging to Siberia, we say, "In former ages France had a reign of Siberian weather, for a period sufficiently long to permit the growth of Siberian plants and animals."

When we trace in regular succession the remains of such organisms back to the edge of the Polar circle, we say, "This northern cold, which once dominated all the hemisphere, slowly retreated to its present limits, and with it went its appropriate flora and fauna." In all these instances the animals afford better indications than the plants, for plants have less capability than animals of adjusting themselves to new and untoward circumstances. If exposed to unusual cold or heat the plants die out, but many of the animals take thinner or thicker coats, to suit their new environment.

Very nearly all the species of plants and animals belonging to the five cycles of earth-building preceding our own have perished. No doubt there were many of the early living organisms which disappeared and left no trace; the first ages may have been far more abundant in varieties than we imagine them to have been. Many hundred of different families have been found, and perhaps as many more flourished and utterly disappeared. We observe, concerning all these old-world families, that when once they perished they are, as we say, "gone for good"; a type does not disappear and reappear.

As one description of animals became extinct, another was ready to take its place. This constant succession of animal types represents a constant approach to those creatures best fitted to occupy the earth with man. We have now on the earth large and destructive animals, as the rhinoceros, the hippopotamus, the lion, tiger, alligator, boa-constrictor, and others, but all of these "are tamed, or have been tamed, of mankind," and constantly recede before the advancing demands of the human race for territory.

But many of the earlier forms of life were so enormous and so destructive, that man could by no possibility have debated with them the empire of the globe. The battle would have gone the wrong way for man. It is well that various changes removed these creatures before man appeared.

Another consideration is here of great interest; the forms of life which survived their respective cycles, and came down nearly unchanged to our day, were not the strongest and largest creatures, apparently best able to fight their battle and live; but many of the feebler and smaller creatures, which, if we had been spectators of those ancient times, we should have expected to see perish under the encroachments of monsters and dragons of their day. As, for instance, the large, strong, numerous, armor-plated trilobites[1] of the second earth-age perished ages ago, while the little lamp shells live on until now. Far back in the reptile time, little mammal

[1] For description of trilobite, see p. 110.

quadrupeds, scarcely larger than rats, ran in the woods, and these types have been continued with various adaptations in the marsupial or pouched animals, like the opossum of our own day, while the vast scale-dressed giants have only left a few of their scattered bones to tell their story. The dragon-fly survives, very like his ancestors of the Triassic period, while the mighty pterodactyles,[1] a kind of reptile bat that pursued the dragon-flies as part of its prey, have gone never to return. The flying reptile has left us only his enormous lithograph upon the ancient rocks, while still each year the jewel-like dragon-fly, once the big beast's defenceless prey, bursts his brown case, and comes forth informed with light and life.[2] As the poet tells his story: —

"To-day I saw the dragon-fly
Come from the wells where he did lie, —

An inner impulse rent the veil,
Of his old husk; from head to tail
Came out clear plates of sapphire mail.

He dried his wings, like gauze they grew;
Thro' copse and pastures wet with dew,
A living flash of light he flew."

We should not forget that each one of the earth-building ages had some particular form of animal life which seemed in that age to be king, and conquer the other animals. Also in its own age each of these forms reached its greatest strength and perfection. Then in after ages, when some new type was dominant, the former types that still survived became smaller and more feeble.

[1] Pronounced *Ter-o-dak'-tils.* [2] Nature Reader, No. 2, Lesson 43.

We have crabs and other crustacea now-a-days, but none so enormous as in the second world-building age when they first appeared. The mollusks,[1] which you call shell-fish,[1] were largest and most numerous in the upper Silurian time. The sea-weeds that flourished with these crabs and mollusks were larger and more splendid than any sea-weeds now, for this is the age of man, and grass, and corn, not of crabs and sea-weeds.

Before man came into the world the woods and waters swarmed with great reptiles. There are none such now-a-days, — reptiles with long legs, reptiles with wide wings! Shall we see what they were like? The great objection to them is that they have such hard names. Among distinguished examples of the "vanished fauna" was the lælaps, which from its relics we conclude to have been a ferocious land-lizard, fierce and huge; but as yet its form and habits have not been fully decided.

We know more of the reptile bat, a fellow-citizen of the lælaps, and well-fitted to hold his own in the society of that grim monster, for to ferocity and size it added the accomplishment of flight. Was it then a bird? No; it was more like a bat. The largest pterodactyles found have been discovered in Kansas, and the remains suggest animals perhaps eighteen feet in extent of wing.

It is singular that the smaller forms of these creatures had teeth, and the larger ones were toothless. The legs and feet were very weak and had small claws. In our bats the tip of the wings has a claw, sharp and hooked; the pterodac-

[1] Nature Reader, No. 1, Lesson 34.

tyles seem to have had no claws on the wings. Some think that the bodies of these flying creatures were well covered with scales, but there is no clear evidence of this fact. The upper-arm bone was of moderate length; the forearm, of about the same length, had two bones, and had claws on the first three fingers, and then the fourth finger stretched out to several feet in length and sustained the membrane that formed the wing. The flight must have been jerky and uneven like that of bats. The famous roc, seen by Sinbad the sailor, fades into insignificance before this creature out of Nature's wonder-book; and the great vulture of the Alps,[1] which carried off lambs and even babies, and is now happily extinct, must have been, compared with the ancient reptile bat, a small and gentle flying thing.

Another wonderful family of animals that now-a-days exists only among the rock treasures of the genii were the mosasaurs, whose nature and habits were long subjects of dispute. Specimens of these creatures have been found over eighty feet long, with a skull more than a yard long, and the jaws set with strong, cone-shaped teeth. The trunk of this reptile was ribbed like that of a snake, and it possessed two pairs of webbed feet, or paddles, to guide its course in the water. On land it must have moved with the wave-like motions of a serpent. It was covered with small scales, and was driven through the water by strokes of its mighty tail.

No animals perhaps are of more interest among the vanished forms than the ancestors of the *horse*. We first trace it several ages before man appeared, as a small creature not

[1] Nature Reader, No. 3, page 238.

larger than a fox, with four toes on each foot, and the rudiments of a fifth toe; it had also two bones in the lower part of the leg. After this little creature came a horse-like animal as large as a sheep, with only three toes, the middle one being much longer and broader than the others, while the two bones of the lower leg began to unite.

The next age shows us a horse as large as a Shetland pony; the two bones of the lower leg are merged into one; the big middle toe occupies nearly all of the foot. And finally, shortly before human beings came into the world, we find a true horse. The big middle toe had come to occupy almost the whole foot. Its nail had enlarged and strengthened to a hoof. Thus we see that the horse really stands on the tip of a single toe of each foot. Meanwhile, as the lower leg and the foot thus modified, the horse gained his present size, symmetry, beauty, and strength.

LESSON XII.

A MOUNTAIN OF FOSSILS.

"The bleakest rock, upon the loneliest heath,
Feels in its barrenness some touch of spring,
And in the April dew, or beam of May,
As moss and lichen freshen and revive."
— Beaumont.

Each successive age of the world brought forth its children, nourished them to their prime, accompanied them in the stages of their decay, and laid them in the tomb. Each new age rocked its cradles above the cemeteries of the age that had preceded it. Some sea-bed swarming with corals and mollusks was slowly lifted; in the shallow waters, sand, chalk, or clay were deposited, and gradually formed thick beds above the "swarmers," which had suffocated in the mud, or, having lived out their span, had failed to reproduce their like. So in successive strata the present surface of the world was built, and sometimes in throes of uplifting, some long-buried stratum was doubled upon itself, and having been thrust up through deposits lying above it, once more reached sunlight. But it spread out into the sunlight not living creatures, but their sepulchres.

Let us now make a journey to one of the world's wonderful graveyards. It is, in the first instance, wonderful for its great age. Is it then that acre on Coles' Hill, sown with the graves of those who came in the Mayflower, with sweet Rose Standish in their midst? No; that in comparison is but of yesterday. Is it the graveyard at Battle Abbey, where, after the defeat of Harold the Saxon, Norman and Saxon lay down together in the peace of death? No; that in comparison is most modern. Is it the rock tombs of the Pharaohs before Moses? No; those tombs compared with this graveyard are newest possible fashions. The dead Pharaohs lie in their tombs in Egypt, with their servants and even the beasts and birds of their day, all turned into mummies. These mummies are so hard that many thousands of them have been chopped up for fuel by the Egyptians. This is a queer use for dead kings!

The creatures laid in the burial-ground where we shall now go, are turned not into wood, but stone. I think I see the little genii and gnomes guarding them well through all the countless ages since they died.

Come then to this very ancient burial-ground. We trot briskly over a long, level stretch of prairie land, and now our stout horses fall from trotting to walking slowly up the steep hill. The wheels grind on the bare rocks; on the road-sides among the gray stones gleam patches of cinquefoil, blue-grass, and strawberry. Now the long faces of the horses no longer front the ascent, but the sharp crest is reached, and they look down upon the narrow valley into which the road suddenly falls. Across the valley lifts another range of hills, and these are colored like a map of various countries, by the masses of white dog-wood, rosy red-bud, purple birch in its soft springtime haze, green of young maple leaves, and the gold, rose, and bronze of the unfolding oak leaves.

Just here, in the midst of this flowery beauty, the roving eye detects on the road-side a gravestone with a well-cut inscription. Lo! here we are in one of the world's most ancient burial-grounds. Here are the monuments; here the mummy-cases; here are the unburied bones. We can scoop them up by handfuls. How old is this graveyard? Who can tell? How long are the ages of geology? No doubt these dead were laid down here hundreds of thousands of years ago. Most ancient then is it not, and well worthy of our visit?

But quite as wonderful as the antiquity of this graveyard is the place where we find it. Here we stand: nine hundred miles to the east of us, as the crow flies, the

Atlantic surges beat upon the coast, and wear away and rebuild the boundaries of our land. Two thousand miles to the west, lies the Pacific; nine hundred miles south, the Gulf of Mexico warms the Gulf Stream in its sunny bosom. Three thousand miles to the north, the Arctic Ocean, which no keel has ever crossed, groans and growls under the ice-floes. Very far from the seas are we not? What station could be more truly inland? And yet this graveyard is built up of corals and sea-shells and strange sea-creatures lie buried here.

Over this height where we stand the waves have thundered. Here was "a yellow beach of sand"; here the busy coral polyp built its palaces up, up, up, from sea-bottom to sunshine. These are not pebbles crunching here beneath our feet, but sea-shells, mollusks of the prime. This is the burial-ground of fishes and of zoöphytes. Is not this burial-ground wonderful for its locality?

And again it is wonderful for the distance which we must travel to find it. What is that? Did we not come here in a carriage, driving over a few easy miles, in a May morning? Let us see about that. Let me take you by the hand and lead you the real distance you must travel to reach this ancient burial-ground. Brace up your nerves, for we have to journey with the speed of thought, which is swifter even than light.

Our starting-point is this modern age of the world, the age which has brought forth grasses, palms, fruits, the higher mammals — man. Swiftly we traverse this age, and leave its landmarks far behind us, as we pass them with our faces set toward the old, old world. This modern age is one of the five divisions of the Neozoic, or *new* period. Through all the five we go, and at the gate of the one called the Eocene we pass out from under the palm shadows, from the mammals ranging in the forests and feeding on the green savannahs, and now we are back in the middle time, the age of the reptiles. The forests are dark with cycads and pines. Crocodiles, alligators, salamanders of very old-fashioned patterns, swarm the brakes and the bayous. Rushing above our heads go skin-winged flying things, with the tails and hands of lizards, and they crowd and cry about us for three ages more.

We must needs be brave as knights as we go back deeper still into mystery and antiquity, and by the door of the earliest reptilian age we find our way into the longest of the epochs, the time with six ages, the age which saw the coal-beds laid down and so many fossils locked up in rock — the Paleozoic[1] time.

We now find about us tree-ferns, club-mosses, reeds, calamites, lichens. There are fishes swarming in the warm seas; a few insects and spiders crawl among the ferns; here and there are toads, newts, and scorpions of curious patterns. One, two, three, four, five ages back we wander, and now the mosses and pines, the fishes and reptiles have disappeared, and we are in the age of sea-weeds and corals, crabs and mollusks, such as have few types in the modern world. And here, in the lower-Silurian, we have arrived at our ancient burial-ground. Have we not come a long way to find it?

[1] Pay-lee-o-zo-ic.

Is there no shorter way to reach it? We have come here by the every-day style of a carriage over a few miles of plain and hill. We have come here also by a dash in imagination through three great times and thirteen busy ages of world-building. We can take yet a third way. Go yonder to the valley and sink a shaft for seven hundred feet, and you will pass through these ages and times and reach the era of this burial-ground. There it is hidden seven hundred feet deep; here it crops out into the sunshine; here have been tumult and convulsion, and what in some places might be thousands of feet below the surface, is here thrust up among modern methods, among apple trees, and bleating sheep, and white cottages, and little children at their play.

There is still another method of reaching this same burial-ground. Go into the valley and wander five miles toward the mouth of the little creek that divides it. As you touch its grassy bank you stand in the modern age of the present earth-building time. As you travel down the creek, the successive beds or stages of earth-building are laid bare, one after another, until at the end of five miles you stand on the lower-Silurian stratum of this burial-ground. Take a pamphlet, fold the first leaf over one half, the next a little less, and so on for thirteen pages, and you have a pattern of the manner in which the spring and autumn torrents flushing the brook have laid bare the rock strata, and shown them as they lie here closely crowded upon each other.

This is, however, an unusual case, for each of these ages has in many places left deposits thousands of feet in thickness. Here the uncovering has been rapid, deposit light, and we can turn over the geologic pages in a volume a few hundreds of feet thick.

And having reached this ancient burial-ground by all these various lines of travel, what do we find here? Stoop and gather a handful of these little gray stones — small pebbles did you call them? The frost and rain of the past winter have washed away the sand and light soil which had hidden them. Why! these are shells, not pebbles. Stone shells, fossil shells! See how perfect every delicate fluting is, how sharply the hinge of the long-perished bivalve is defined. Some are of a delicate pale gray, others almost white; but long ago in the Silurian seas perhaps they shone in brown and yellow, red, pink, buff, and maroon, as gaily as the scallop shells of to-day, which in shape they much resemble.

What is this lump of stone covered with little star-shaped knobs? Trace the lines along the side where it was broken from some larger fragment, and they seem to branch; is it like the veins on a leaf? No; rather like the branches of coral, and in fact that is just what we have found, — a lump of fossilized coral of the Silurian age. The lower-Silurian was the age when coral was king. When after the two earlier epochs with their meagre fauna the Silurian age opened, suddenly the seas swarmed with life. They were warm tropic seas, warmer than any on the globe to-day, and in them these industrious coral-polyps built their towers. They built up from the sea-bottom to sunshine, and from each of these star-like towers a living creature unfurled itself like a flower, just beneath the surface of the sea. In orange, scarlet, purple, white, and pink, they expanded their coronals of filaments, and waved to and fro with the warm tides. No flower-garden ever bloomed more gorgeously than did these gardens of the sea in the Silurian age. Plume-like, fine as the stamens of a flower, these myriads of living things leaned from the towers and palaces themselves had built, and drank and fished in these clear seas under the glow of the sun.

Meanwhile among and around about these coral towers, cuttle-fish and nautili darted, while mailed crustaceans chased each other, fought and frolicked and devoured each other. See, we have another fossil in the rock, the beautiful stone lilies; they must have a chapter to themselves; and here again are lamp shells and other and different mollusks of the Silurian time. Here they were crowded, swimming and playing in these living coral bowers. How they were dashed by thousands upon this beach of sand! And by and by when life was in its prime, what strange mishaps overtook them all? Did the seas grow too hot or too cold? Did the bed of ocean rise? Did great sand-waves roll in among the coral bowers? They had had their day, another age was drawing on; there would be mollusks and crabs and crustaceans still, but these must perish and be locked up in this burial-ground. O gnomes and genii, keep your treasures well!

LESSON XIII.

WRITTEN IN ROCKS.

"There rolls the deep where grew the tree,
O earth, what changes thou hast seen!
There where the long street roars, hath been
The eternal stillness of the sea.

"The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, these solid lands,
Like clouds they shape themselves and go."

— TENNYSON, *In Memoriam.*

We have been studying for some time about earth-building. We have learned a little of how the rocks and the soil of our globe were formed. What is that study of earth-building called? It is called Ge-ology, which means earth-lore or history, for the old Greeks called the earth Ge, and ge-ology just means the story of earth-making.

But in these lessons we have been talking not of the rocks and earth-beds, but of the gnome-treasures hidden therein, the bones, patterns, stone images, burial cases of things that lived long ago. This is a new study, and is a very important branch of geology; for unless we learn about these old organisms and understand what they tell us, we cannot well learn our geology. These fossils shut up in the rocks are the writings or pictures which keep the story of the long ago. This study has been given the long name of Palæontology — it merely means the study or lore of fossils.

But pray what are fossils? We have heard much about them. What are they? The word fossil really means a thing "dug up." Once it was applied to any kind of mineral substance. Now we mean by fossil organized substances or their imprints, which have been preserved in any natural fashion, that is, not by the art of man, but by nature.

The study of fossils embraces the study of all forms, from the most ancient here in the rocks of the Dawn, or first period, to those which may have only been buried for a few score of years.

Thus you may see in a cabinet a bit of limestone full of ancient foraminiferæ, and near it a fossil clam from some bed in southern New Jersey, which was producing living clams one or two hundred years ago.

The study of fossils does not assert any limit as to the grade of an organism. A fossil may be some large and curious fish, a rare bird, a beautiful stone lily, or merely a lump of resin which long ago dropped from some tree of the coal period.

So also, we have fossil leaves, fruits, roots, fossil rain-marks, fossil foot-prints, fossil worm-casts and burrows, and little fossil cases of caddis-worms. Some very valuable fossils are called coprolites; these are the droppings of digested or partly-digested food of animals, and they are valuable because they often contain traces or portions of plants or animals, upon which these other creatures fed, and which now would be entirely unknown unless preserved in this way.

The vulture has a habit of swallowing mice, little birds, and similar prey, with small ceremony of breaking or tearing; they go into the vulture's maw feathers, fur, bones, and all.

When fully gorged, the vulture sits in a meditative manner on a tree, and finally, in the process of digestion, the food parts of what it has eaten separates from the bone and feather refuse, and this latter is rolled into a ball and disgorged by the vulture. I have found such balls, probably a year or two old, bleached white and dry, and unrolling them have laid bare tiny skeletons, perfect, and white as ivory, of the feet and heads of mice. Now if mice had disappeared, it is evident that their skeletons, found in portions in such remains would be valuable, affording us a knowledge of an otherwise unknown creature. So the coprolites tell us their tale of the smaller fauna of the ancient lands and oceans.

The term fossil is not limited to any especial method or state of preservation. In regard to preservation there are three principal varieties of fossils. First: All or nearly all the animal matter may have disappeared, and mineral matter may have taken its place; so that the organism is mineralized or petrified. This is the condition of the majority of fossils. Second: It may have happened that the entire organism has decayed, and as the animal matter when it perished was not rebuilt with mineral deposit, only a cast or natural lithograph of the former living thing remains in the rock. Third: The animal or plant may have been preserved unchanged for hundreds or thousands of years, so that the very creature, with its bones, flesh, hair, even the soft portions of the body, as the brain and eye-ball, may remain complete. This has happened in a few instances, as where ice or frozen mud has been the preserving agent, so that in Siberia certain animals, as the mammoth, have been disentombed after a burial of thousands of years. Of course as soon as these frozen fossils have been exposed to air and moisture, they begin to fall to pieces, and speedily only the hard parts, as the bones, are left.

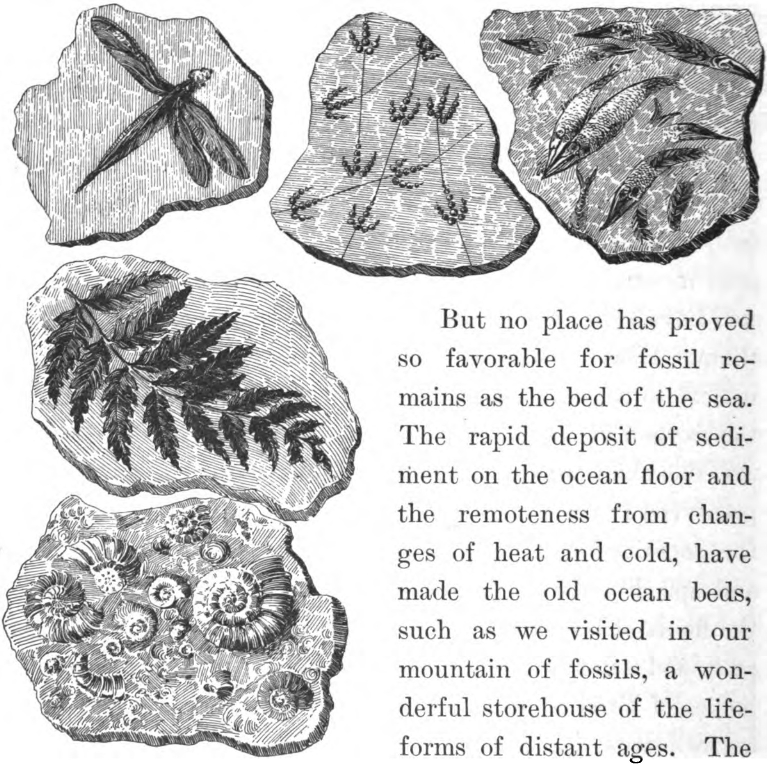
In most animal fossils only the bony or shelly portions, which consist largely of lime, have been petrified. Thus we find many fossil skeletons. Sometimes there has been a change on this wise: the action of water has carried off, grain by grain, the lime as well as the animal matter of the organism, and while it thus took the object to pieces, it rebuilt it in a similar way, adding grain by grain of flinty matter, or even of metal, so that in countries where silver abounds, fossil plants have been found cased in silver. I have seen some fossil bones of recent origin, as they were taken from an ancient burial-mound, and the marrow of the bones had been carried off by the action of water and replaced by delicate, shining crystals, so that the hollow or marrow portions of the bones shone as if filled with broken glass.

The chief agents in the decay of animal and plant organisms are air, rain-water, and atmospheric moisture, as dew, mist, and frost. We can see the destructive effects of air in the case of canned meats or fruits. If the sealing of the can is imperfect, the air penetrates, and carries some germ which corrupts the contents. All the vegetable remains that cover the ground each autumn, do not accumulate year after year, but speedily decay and become soil. The animals and insects, large and small, that die in the fields and woods each year, do not long remain where they fell; carnivorous birds and small animals, especially ants and beetles, devour the soft portions, and a few years of exposure to air and moisture reduce the bony skeletons to powder. As the thing that is, is generally the thing that hath been, and shall be, we may conclude that nearly all the animals and plants of each age perished with their age, and that what remain as fossils are but a small fragment of the whole, and have been preserved in unusually favorable circumstances.

Ice, as we have seen, has served as a wonderful preservative, but the instances where animals or plants have been subjected to the ice-process are naturally few. Next to ice, peat mosses have exhibited remarkable preserving qualities, and have kept entire remains, as deer, bison, oxen, buried in them. Heavy beasts becoming mired in the peat, have sunk into it to a great depth, and were hermetically sealed from the oxygen of the air, and from spores called *bacteria*[1] which are the chief agents of decay. Many fossil organisms are preserved in the silt or débris at the mouths of rivers, where the deposit of earthy matter carried down the stream is rapid, and speedily buries up whatever is dropped upon it. On the floors of lakes also, there are often deep deposits of marl, peat, and sand, and these sometimes bury and preserve the bodies of birds or other animals, and the seeds, branches, or entire plants, that have been swept into the water. Caverns, especially those in limestone or chalk rock, have proved famous treasure-houses of fossils. Where, in these caverns, there is a dripping of water charged with lime or chalk, it speedily encloses objects in a safe case which effectually preserves them. Sometimes also these bone caves, ancient

[1] Bac-tee-re-a. These are really unicellular plants.

homes of wild beasts, have been closed up by silt or earth-falls, and have retained many specimens of large, ancient fauna now extinct.



DONE IN STONE.

But no place has proved so favorable for fossil remains as the bed of the sea. The rapid deposit of sediment on the ocean floor and the remoteness from changes of heat and cold, have made the old ocean beds, such as we visited in our mountain of fossils, a wonderful storehouse of the life-forms of distant ages. The mollusks, corals, and crinoids furnish us the most varied and beautiful fossil remains, and in some cases the preservation is so perfect, that traces are retained of even the former colorings of the shells of mollusks and the scales of fishes that lived in the remotest times.

The grand march of life has been an ascending series, and for our knowledge of this line of ascent we are indebted to fossils, which tell in successive strata of the earth the history, not only of the changes in the earth's crust, but of the animal and vegetable life of different periods.

No doubt only a very, very few of the fossils that are hidden in the treasure-houses of earth and sea, have ever been found. There are millions of strange and beautiful things that have never met mortal eye.

Let us sleep and dream. Let us dream that we have built a great and splendid museum, and lined it with shelves and cases. Let us dream that we have found a ring that once belonged to King Solomon, which gives us power over all gnomes and genii. Let us dream that we open wide all the doors and windows of our museum and stand in the midst and clap our hands, and command the genii and gnomes to bring us the treasures hidden in rock, sand, and sea, in lake and river and peat moss and earth beds.

They come! They come! They fly through the air, gnomes, pixies, afrites, fairies, genii, and they fill every shelf and case of our museum with fossil forms and pictured rocks and sands, and give us examples of every animal and vegetable that lived so long ago. How rich and happy now are we! We wake: our dream has fled: the airy walls and shelves and cases of our museum are gone: the gnomes and their brethren, the treasures untold, are vanished with our sleep. What have we left? Nothing? Yes, the best that we can have; industry and observation — these are better than the magic ring and seal of Solomon.

LESSON XIV.

FOOTPRINTS IN THE SAND.

"So where some trivial creature played of old
The warm soft clay received the tiny dint;
We cleave the rock's deep bosom, and behold
Deep in its core, the immemorial print.
Men marvel such frail record should outline
The vanished forests and the trees o'erhurled."

A TEACHER and his class sat one day upon some tree-trunks which had fallen across a bed of bare, slightly-sloping rocks. The teacher, with his head between his hands, looked steadfastly down. "What are you thinking of?" demanded a pupil.

"I am reading," said the teacher.

"And what do you read? Is the rock your book?"

"I read that this stratum of rock was once a beach of sand. It was just such sand as a child likes to play in; just such sand as it is fabled that the Sibyl took in her hands when she asked long life of Apollo."

"And how did it become rock?"

"You must know that all new rocks are made of the wear and tear of older rocks, reconstituted and relaid. This sandstone was once sand, and the sand was chiefly tiny quartz crystals, the residue left after the softer mineral portions of certain ground-up older rocks had been carried away. These quartz crystals could not be melted, nor held in solution by water; being heavy they could not be held in suspension by water. So the water which was carrying about the rubbish of the older rocks, dropped the sand, and it formed long beaches, such as we see to-day. Observe that sand seems to be more plentiful than any other substance in the earth's crust. Most soil is largely composed of it. If it were not for the sand in the soil to keep its particles loose and allow the percolation of water, and the growth of roots, the soil would soon become packed so heavily that almost nothing could grow. The sea-shore, the river-beds, the great Sahara, are sand, sand, sand. As sand is the most plentiful loose material in the earth now, so no doubt it has always been, and we find that sandstone, namely, rock made of sand, is the most abundant in the structure of the globe. The grains of quartz themselves are naturally gray or white, but they are covered with a film or crust which takes different hues from coloring matter mixed with it. In iron regions the sandstone is red, and in anthracite coal regions the sandstone is dark gray or nearly black. Other sandstones are brown, yellow, or purple, according as they are mixed with other coloring matter.

"But you asked me how the loose sand became rock. Understand that the most important factor in the process was an indefinitely long time, while the agents required were very simple — great pressure and the presence of water. The water carrying with it silica, or some kindred material, formed a cement about each grain, and thus aided by pressure and a certain amount of heat — for in this world nothing is done without heat — the individual grains were finally consolidated into massive rock."

"What else have you read?" asked other pupils, as they too began earnestly to contemplate the ledge of sandstone.

"That was only the preface, or first chapter. I remember that the grains of sand, composed largely of silica or tiny quartz crystals, were heaped up here by water, which washed from the crystals and then carried away, little particles of lighter matter, as mud. When I look at these long, gently sloping ledges of sandstone, I read that they were once a beach. The ravine and the hills, the cornfields and the forests are now here, but once — the sea. Warm salt waters ebbed and flowed here, and shells were rolled up on this beach and were carried out again by the tides."

"Can you read any thing further?"

"Yes: One day, long ago, — was it at the close of the Carboniferous or the beginning of the Permian age? — there was a rain-storm here. It came up with a strong wind, from the south; the drops fell heavily, and were very large. I think it must have been what we call a 'black squall.' It soon passed, and the sun shone out hot."

"Oh, oh! now you are guessing at what might have been!"

"Not at all. I am reading what really was. Are not these rocks my books? Look now at this ledge. Here is a thin layer of mud-rock, as well as of sandstone. Here was some marl-mud laid down. I think that here must have been an inlet. Observe here on this exposed surface, these pits or dents. You can put your finger tip in them. See how they slant from the south, and how deeply they are driven into the sand. Suppose now that we stood by a low level beach of sand and marl-mud, and a sharp shower, driven by a strong wind, came up from the south, and the big rain-drops pelted violently on the sand and mud. Would they not leave marks identical with these? So we know that here were big rain-drops from a southerly gust. We know that it was soon over; for if rain had fallen long, all the surface of the sand would have been washed and saturated, and prints of individual drops would have been obliterated. We know that the shower was followed by a hot sun, and as the sun was very hot, we infer that the time was somewhere in the middle of the day, between ten and four, the time when the sun rays are most powerful. We know that the sun was hot, because these rain-marks dried quickly, before they had time to lose the sharpness of their imprint. It is also evident that such delicate markings must have been quickly covered up, else the next heavy mist or drizzle of rain, or creeping tide, would have smoothed them out. Therefore, I make a guess that when the marks had dried hard, being sun-baked as some bricks are, a strong breeze came up, sweeping sand before it, and so buried the prints under sufficient sand to protect them; or, possibly, a fresh layer of ooze, or mud and sand mixed, came down the estuary and rolled gently over these rain-prints and cased them safely."

"Who would have thought of reading all that in sand!"

"Do we not daily read footprints in sand in this fashion? As we came here we crossed the road lying deep in summer dust. There in the dust were the prints of a three-toed foot.

We recognized the size and shape; it was the track of a hen's foot; a large fat hen we judged, because the prints were large and deeply indented. Around her tracks were the small delicate marks of the feet of young chicks. There were many of them; evidently the hen had a large brood with her. Here she had scratched in the dust where some grain or meal had been scattered: here was a deep hollow where the dust was flirted about on all sides; the hen had been taking a dust-bath. Here were some much larger marks of three-toed feet, their distance apart showing a longer stride: we felt quite certain that a big rooster had marched that way. We knew about the hen, the chicks, the cock, the feeding, the wallowing, as well as if we had watched the birds themselves and their performances. But we had only seen footprints in the sand. Has any one of us wondered at Robinson Crusoe's conclusions when on the beach he found the print of a naked human foot?"

The pupils admitted the justice of this reasoning. "What else have you read?" they questioned.

"Shortly after the shower an animal passed this way; a two-legged animal with three-toed feet, and a stride six feet in length. Such a creature would make an ostrich seem small. Whether it was a bird or a lizard I cannot tell, at all events it has neither kindred nor descendants in the modern era. If a bird, it was of that antique type which had teeth and no feathers and wore a lizard's tail. It was probably a wader of some kind, and ate mollusks and fish. I say that it passed this way about the time of the shower, because I find its footprints near the rain-marks, and on the same level of rock, and because they seem to have been covered up about the same time, and in the same manner."

"Do you suppose if we broke up some of this rock we should find remains of the living creatures that moved over it?"

"No; sandstone is not rich in fossils. Perhaps the oxide of iron that frequently accompanies the sand has destroyed plant and animal organisms, or it may be that when the heavy quartz grains dropped out of the water, the plant and animal remains were carried off by tides or currents. Still, in some parts of the world fossils are found in sandstones."

"Do all the strata of sandstone tell this same story?"

"Each varies the story somewhat to suit its own circumstances. Some tell us which way the tides flowed and the rivers ran that brought them to their resting places long ago."

"Are all sandstones alike, except in color?"

"No; some sandstone, especially that lying near the surface of the ground is soft, and the grains are loosely held together, and are large and distinct. Other sandstone has been pressed together into a mass nearly as hard as marble or granite. Flagstone is sandstone laid down in thin beds, and capable of being readily split into flags or slabs. Freestone is a soft sandstone which is capable of being readily cut in any direction; buhrstone is a particularly hard, rough sandstone, of which grindstones for mills are made. Roll yonder great, rough stone here. What do you think of it?"

"It looks like plum-duff," said one of the pupils, "only the plums are rather large and numerous, and the dough is very hard and scanty."

"It is conglomerate," said the teacher, "and conglomerate differs from sandstone in the size of its grains. Where sandstone has tiny quartz crystals for grains, conglomerate has pebbles, fastened together with mud hardened like cement. Coarse sandstone closely resembles fine conglomerate. Another kind of sandstone is called greywacke. Greywacke often exhibits the ripples and sun-cracks of the ancient beach. In greywacke the grains are rounded, or nearly rounded, are uncolored, and are cemented together by a very hard paste of chalk or silica. If you look at a piece of greywacke you might think it a portion of igneous or fire-made rock, it is so fine and hard. You must remember that rocks which have been — let us say, well cooked, by the earth's internal fires, are very hard and compact; they have been fused together and then cooled, and the process has made them very strongly coherent. But sandstone in all its varieties is a water-made, not a fire-made rock. These water-made rocks are called fragmental, while fire-made rocks are termed igneous. Whatever heat has been applied to sandstone has served only to melt and harden the fine cement, but has not been sufficient to fuse the grains. The term fragmental, as applied to rocks, means that the parts are easily divisible, and are largely individual and fragmentary. Clay rocks are fragmental, and so are limestone rocks. There are also a few of the fragmental rocks which have been very greatly heated, and indeed were once flung out of volcanoes in a red-hot or melted state. But as they are in a loose condition much like cinder and ashes, they are classed among the fragmental rocks. Among these are tufa, breccia, volcanic conglomerate, and two or three others."

"It needs much learning to read so much from a few footprints in sand," said one of the pupils, as they rose to go homeward.

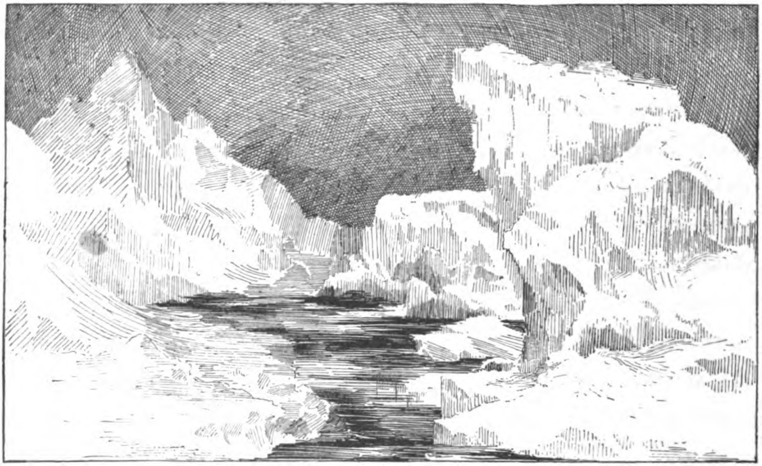
"Say, rather," said the teacher, "that by close observation and by comparison of observed facts, we may gather more or less valuable information. Pupils are too ready to depend for information rather upon memorizing what is in books than upon the cultivation of the faculties of observation. Now, the books are very valuable as giving us the knowledge amassed by many minds, and also they help us to reason judiciously upon what we see. But the information gathered from books is much more easily forgotten than that which comes to us from observation, and we must, in the study of natural science, yoke the book to practical observation, and closet study to out-of-doors study."

LESSON XV.

THE WINTER OF THE WORLD.

"Hark to that mighty crash !
The loosened ice-ridge breaks away —
Seaward the glittering mountain rides,
While down its green translucent sides
The foaming torrents dash." — BRYANT.

ONCE upon a time the North Polar region, where all is now snow and ice, intense cold and six months of night, was a land of warmth and sunshine. At that time, how long ago it was we cannot tell, the North Polar Circle was a green and luxuriant flower-garden. The beech, oak, poplar, maple, and walnut grew there. The fragrant lime tree and the beautiful magnolia were there. Before this flora appeared, plants of the carboniferous era had flourished there, — pines, club-mosses, tree-ferns, cycads; and these had so abounded that a bed of coal thirty feet thick was laid down. Over this



WHEN ICE WAS KING.

buried coal-bed the spruce, pine, fir, birch, cypress, elm, hazel, and viburnum grew in the Arctic zone. These trees were not the only representatives of the plant world; on the plains the grasses grew, on the ponds the water-lilies rocked, and reeds and sedges fringed in dainty beauty the borders of the pools. Many families of plants then growing in northern Greenland had at the same time their representatives in Central Europe.

Evidently at that date the Arctic zone had a mild climate, and day and night of moderate length. That the above numerated plants and almost two hundred other species grew within nine degrees of the North Pole is proved by finding their remains in all stages of growth, from seed to matured plant, from root to fruit, scattered over an extensive area of country. How did this happen? What occasioned the change? How came Greenland then to be a warm and smiling land? These are questions to which no answer can at present be given. No one knows how this could have been.

Over against this marvel of a mild climate, luxuriant vegetation, and nearly equal days and nights within the Polar Circle, we may set that other wonder of the glacial or ice age — the time when the polar cold wandered beyond its bounds and came down into the temperate zone to stay, for how long we cannot tell; for very long indeed, no doubt, though not for as long as a world-building epoch. The Glacial age was only a portion of the age that came just before the human period. This Glacial period is also one of the problems which continue to puzzle the geologist. Why was the Northern hemisphere then so cold? What occasioned the change from tropic warmth to nipping frost? How suddenly did this change come on? How far did it extend, and how long did it last? All these queries cannot be answered, but some of the wonders of that strange, forbidding age we can unfold.

We know that the northern half of the world grew colder and colder, and that in this chilling climate the flora and fauna greatly changed. The plants could not accommodate themselves to the cold and most of them perished, and their places were taken by flowers and trees which belonged to colder climates. Instead of palms, figs, cinnamon trees, and magnolias, grew dwarf birch, the willow, and pines, while the less hardy vegetation left representatives only in the tropics. The animals also changed, but more slowly than the plants. Some migrated to the south, others lessened in size and put on thicker coats of fur or feathers; many species perished entirely.

Still the cold increased. Vast snow fields loaded the Alps and the Pyrenees, and all the plains and valleys of northern and middle Europe and North America began to be filled with glaciers.

Here let us pause to consider that three-fourths of the surface of our globe is water. As we have seen from the study of the moon, a waterless globe is also a lifeless globe, bereft of plant or animal, and we owe in a large part the habitable character of the earth to its abundant water. This water has many forms, as lakes, seas, ponds, springs, rivers. It is salt and fresh, and varies in temperature from the boiling springs or geysers, to the icy seas of the poles. Water has changes of state; from the liquid form it changes by loss of heat to solid ice; moisture, frozen as it falls through the air, becomes crystals of snow; water diffused in the air is mist and dew; partially condensed in the air it forms clouds; and dew in a frozen state is frost.

Let us now see what was the work of water in its forms of ice and snow in the Ice age. Here we do not wander in uncertainties; for what we see to be now the work and changes of icc and snow in the High Alps and the frozen oceans of the north, we may accurately account to have been the work of the same agents in the Ice period. Let us therefore reason from the present to the past. A vast region such as Greenland or Spitzbergen or the high Alpine country is covered deep with snow, which falls upon it nearly every month in the year. For a little time in the summer the sun partially melts the snow even on the heights, so that floods of snow-water begin to run into the valleys. But freezing generally takes place in the night, and the melting period is short, so that the higher plains and valleys become filled with beds of ice; yet from beneath some of these ice-beds water runs out and descends to the lower plains and valleys, becoming in their warmer temperature broad rivers to water the land. As you look from the distance upon the snow-covered Alps, you see broad spaces flashing and shining like silver. These are the glaciers or ice-rivers between the snowy peaks.

These glaciers seem as you observe them to be stationary, but when they are measured they are found to have a steady motion. Thus, you set a post in the glacier and a post in line with it upon the rocks on each side of the glacier. Even in a day or two you will see that instead of three posts in line, thus • • •, they stand in this fashion •.•, and in a few weeks the central post will seem to have travelled some distance down the glacier. But no; the glacier has been sliding along in its bed and carrying the post with it. As the glacier of the Alps moves down, down, down, it comes into warmer levels, melts and crumbles away, and feeds rivers. But the glacier of the Polar circle when it reaches the limit of its bed has not found a warmer level; it breaks off by its own weight, with a tremendous crash, and falls into the Polar sea, among floes of moving ice. The fallen fragment of glacier settles into the water for about eight-ninths of its entire height, and now takes a new name, — it is an iceberg.

The iceberg is often of great height above water; some bergs weigh hundreds of millions of tons. The air, sun, and dashing water cut the berg into beautiful and fantastic shapes of domes, pinnacles, and towers, from which the sun flashes back as from molten metal. The iceberg floats about the Polar sea, and finally may be carried by the currents southward into warmer waters and a milder climate. Then the melting process goes on swiftly, and when the lower portion becomes so much lessened as to destroy the equilibrium of the floating mountain, it turns over, or portions of it break away and fall into the sea. Thus the history of the marvellous mountain of ice is: first snow falling upon high lands; then from the melting and freezing of the snow, glaciers or ice-rivers; then the glacier moving beyond its bed, breaks off into a berg, and the vagrant of the Polar seas drifts to its destruction in warmer climes.

Now let us go back to the snow mountains and the forming glaciers. As these rivers of ice grind and crowd down their ravines they tear and crush the sides of the mountains and the face of the valley, so that they have beneath them what we may call another stream, and that not of ice, but of broken stones of all sizes. These are frozen to the bottom of the glacier and are dragged along with it as it slides down the ravine. The bottom of the glacier moves a little more slowly[1] than the surface; finally it comes down upon the valleys in something of the shape of a V, or the share of a plow. Thus entering the valley it drives a vast amount of débris, as boulders and pebbles, before it, and carries a vast amount more clinging to its upper and lower surfaces.

Now it is evident that as the glacier melts rapidly in the warm valley it will drop the load of stone that it carried with it in its descent from the heights. Such a bed of glacier-driven stone is termed a moraine, and when people have once seen a moraine they will not fail to recognize one wherever they find it, even if it is thousands of miles away from any glaciers. They will say: "Here is a moraine; once there must have been a glacier slowly moving here." However warm the climate may now be, when we see a moraine we may be assured that once it was cold enough for snow mountains and for glaciers. It is as certain as that every peach-stone we see must once have been in a peach.

Again in the present glacier-districts we find that when glaciers and icebergs slide over beds of rock or masses of stone, they cut and groove them, chisel them in a peculiar fashion; and when on any rock we find these chisel-marks of the ice, they are unmistakable, and we know that ice heavy and strong enough to cut the rock has been there. When

[1] The bottom of an ice-stream moves more slowly than the surface: this is the case with any stream; thus the surface projects at last beyond the bottom and breaks off in bergs; while at last the lower part enters the valley something like the share of a plow.

we see a name or initial cut in a tree we know that some person with a knife has been there and cut the letters. We recognize the glacier-work just as clearly on the rock as the human work on the tree.

Once more, to go back to our glaciers, we find that they tear from the rocks large masses or lumps of stone; and these fragments being ground and dragged in the ice-bed, lose the sharpness of their edges and become rounded and smooth. The icebergs, as they break from the glacier, carry away these stones frozen to their lower surface, and as the ice melts the stones are let fall. These peculiar stones are called boulders, and some name them "lost stones," as they are found so far away from their original rocks. These boulders, or lost stones, are scattered over a large portion of the Northern hemisphere. On high hills,[1] in wide fields, and deep valleys, they lie as the ice left them. Some are lodged in the most singular places. When we see a boulder on the crest of some high hill it may be hard to believe that once an icy sea rolled over such an eminence and covered it so deep that icebergs with their enormous masses had rocked above it in the cold, dark waves; but so it truly was. Sometimes we see a wide field covered with boulders lying so closely together that very little vegetation can grow among them. In this field, long ago, some iceberg grounded in the shallow waters and, melting away there, left its load of stones.

[1] On the bluffs of the Missouri River, Howard County, Mo., are ice markings, and a lump of copper weighing 23½ pounds was found on these bluffs. This copper was a "lost" lump brought by ice from the coast of Lake Superior. — J. B. S.

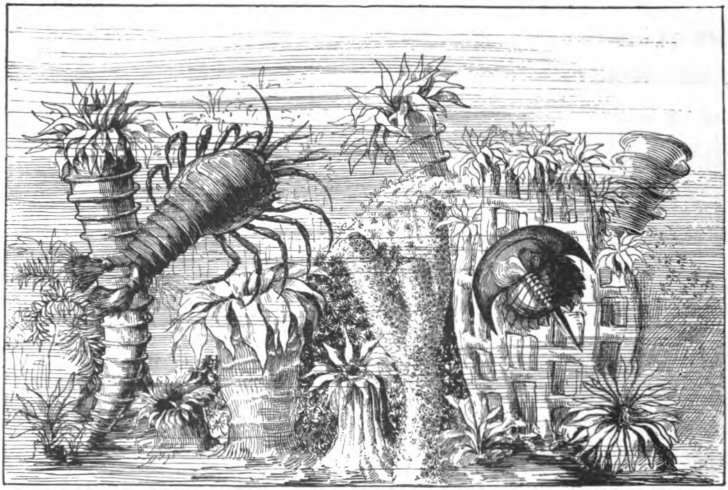
There are some geologists who consider that a solid cap or sheet of ice covered nearly the whole of the Northern hemisphere at some distant time, and that the boulders and boulder-clay were the deposit of this ice-sheet, and were not dropped by floating bergs. It is very likely that there were not only floating bergs carrying boulders, but also an ice-sheet extending below the Polar circle. Altogether the drift, the moraines, the ice-scratched rocks, and the boulders lying solitary hundreds of miles from the rocks of which they once formed a part, point out clearly to us what were the general features of the Glacial age of the world.

LESSON XVI.

THE FIRST CRUSTACEANS.

"Look on this beautiful world, and read the truth
In her fair page: see every season brings
New change to her of everlasting youth;
Still the green soil with joyous living things
Swarms, the wide air is full of joyous wings,
And myriads still, as happy, in the sleep
Of ocean's azure gulf, and where he flings
The restless surge." — BRYANT.

IN those long ages when there were no human beings in the world and the lower orders of animals had the globe all to themselves, each successive period of change was distinguished by some special class of living creatures, which were then chief in numbers and importance. Each of these in its own age reached its prime in size and dominion. But while these particular families passed away at the close of their earth age, the classes to which they belonged frequently survived in changed forms, which have continued to the present. These late descendants of the old time possessors of the world have generally decreased in size and numbers, and increased in beauty and in capacity for ministering in some way to humanity.



CHILDREN OF THE DAWN.

But there are some ancient classes of living creatures which have changed very little, and are to-day practically what they were at their origin. Thus the foraminifera were among the very earliest of living creatures, as they were also among the smallest, the most simple in structure, and the most widely distributed. Their work seemed to be first to collect material from sea-water to build into their own forms, and then to bequeath themselves to the formation of rock. There is no family of creatures so ancient, for beside them all other fossils seem modern. As living animals they still survive in almost unchanged conditions, and abound everywhere except in the Polar seas. In the tropics they are found in shallower waters than in the temperate zones.

The hard name of these creatures comes from the word *foramen*, a little hole like the eye of a needle. Now these queer animals were made of a soft substance like jelly or glue in shells with many divisions. The walls of the lime-cells or rooms were full of tiny holes like the holes in a sieve, and through these the jelly part of the animal poured itself, and so filled and pervaded all the chambers or cells. Many of these creatures can be seen only through a microscope. In a former lesson we spoke of the nummulites, large specimens of this same order, and of their work in stone-making. We found that most of the building-stone of Paris, vast beds of stone in India, and a large part of the chalk rocks are nummulitic. The great pyramids of Egypt and the enormous terraces upon which they stand are built of the same nummulitic limestone, while many other vast ledges of limestone rock are composed of the minute shells of foraminifera.

In most ancient times the coral polyps were building up their towers, and were perhaps larger and more plentiful in the lower Silurian age than at any other period; but coral polyps are still busy on the Pacific sea building their beautiful islands or atolls.

The mollusks, or shell-fish, with single or bivalve shells, with heads or without,[1] were, no doubt, larger and more abundant in the Silurian epoch than ever after; but they remain plentiful now, as all collectors of shells are glad to realize, and though in many orders they have decreased in size, they have increased in beauty of form and coloring.

The crustaceans, or crab family, were among the earliest of living creatures. The class survives in many varieties, but some of its earliest families have entirely perished. In the age in which they first appeared, the crustaceans were the most numerous of living things. The crustaceans are of the ringed class of animals, to which also insects belong,[2] and here we find that the ringed creatures of the sea preceded by a long time the ringed creatures of the air and land; for crabs of many kinds crawled in the shallow seas and were cast upon the rocky shores of the earliest continents and islands long before a solitary dragon-fly or cockroach found life, or could have found a wooded or grassy piece of land upon which to rest.

The first of the ancient crustaceans which we shall mention is represented by a very numerous class of fossils called trilobites. There are no living trilobites, but the creatures now nearest them are the isopods. The trilobite was more like an isopod in its larva state than like a full-grown one. The trilobite had a hard plate or shell over his head and the front part of his body. This piece of armor was shaped nearly like the large front portion of the shell of a horse-shoe

[1] See Nature Reader, No. 1, Lessons 34–36.

[2] Nature Reader, No. 2, Lesson 1.

or king-crab. The king-crab uses this shell as a mud-plough to plough its way through the slime, where it finds its food and deposits its eggs.

Some of the ancient trilobites were as small as a split pea, and some were a foot across their head-plate; but large or small they all had the head-shell and used it for the same purposes not only for protection, but as a mud-plough for digging burrows in the ooze below the shallow seas or on the shores. On the sides of this hard buckler were placed the eyes, which were large, prominent, and compound, or furnished with many lenses, as we find in the eyes of insects.[1] These round, prominent eyes are a very marked feature of a fossil trilobite; they seem to be staring at creation still, though the creature has been dead thousands of years.

The body of the trilobite was composed of numerous rings or segments, and each of these rings was divided into three lobes, from which it receives its name, tri-lobe-ite, or three-lobed animal. All the rings of the body were so joined that the trilobite could roll itself into a ball, doubling its tail forward under its head, and so bringing all parts of its body under the protection of the horny shield. Have you never, in turning over earth or breaking a decayed stump, found numbers of small, oval, soft, gray, ridged creatures called slaters or wood-lice? Have you noticed how as soon as they are disturbed they roll themselves into an apparently lifeless coil? In this fashion some of the trilobites were like the wood-louse.

[1] Nature Reader, No. 2, Lesson 17.

For a long time it was supposed that the trilobite had no legs; but at last it was found that they had a number of small, thin-jointed legs, like those of a young spider-crab. Thus we see that in its head-shield and eye-placement, the trilobite was like a horse-shoe crab, or limulus, which is no doubt its near relation; in general form it was like a young isopod; in its method of rolling itself up for rest or safety, it was like a wood-louse; in its long, thin legs it was like a small spider-crab.

During one earth-building age, the trilobite was the chief representative of the crabs, and many hundred species of trilobites have been discovered.

We find that their patterns varied much in the days when they were the leading order of the earth. The track of the trilobite in the mud in which it lived was peculiar, and has gained the name of "ladder footprints." These footprints have been preserved in the hardened mud, as have rain-drop prints and birds' tracks. The slim, sharp-toed feet of the trilobite made little rows of dots, and on each side of these was a deep groove, the rows of dots looking like the rounds, and the grooves like the sides of a ladder. This double groove was caused by the dragging edges of the shield or head-plate, and the ladder footprint is much like the track of a king-crab.

Floating above the primordial mud, in good fellowship no doubt with the trilobite, was the brachiopod, or "arm-footed" creature. This name was given because of numerous slim finger-like appendages, such as the barnacle uses for its fishing apparatus.[1] The bra-chi-o-pod was partly like the crusta-

[1] Nature Reader, No. 2, Lesson 34.

ceans and partly like the mollusks, while some learned men have concluded it to be closely related to worms and star-fish! In fact these ancient families of animals had many points in common. Perhaps the ancient lamp shells were the representatives of the brachiopods when all these first families of the world lived together in the Cambrian seas.

The brachiopods had two valved shells of very lovely shapes. They were a prophecy of the wonderful beauty that was to appear in the world. Some of the shells were only a quarter of an inch across, others were four inches, and a few varieties have been found with shells a foot wide. These were giants of their class. The outer surface of these shells was exquisitely chiselled, as a jeweller ornaments gold and silver plate, and the beauty of the shell was increased by brilliant colors. Red, green, yellow, blue-black, and rose-pink were the hues in which these pretty creatures disported themselves before the big staring eyes of the trilobites. Many of these animals moored themselves by peduncles to rocks or to other creatures, as barnacles do, and thus holding fast, they fished for their dinners with their fine net of filaments; for these delicate threads were not for locomotion, but were mouth appendages to catch something to satisfy the creature's hunger.

The brachiopods were, next to the trilobites, the most numerous and important group in the Cambrian age. But, while the trilobites died out with their age, some of the representatives of their pretty neighbors have existed ever since, and, no doubt, in the Silurian days they lived as contentedly among the corals, as they now live among coral groves in the South Pacific. Observation of a living animal of this class shows that having fastened itself by its peduncle to some firm holding place, it can very rapidly fold and unfold its finger-like filaments, creating around itself a little whirlpool, which inclines towards its mouth, and draws its food within reach.

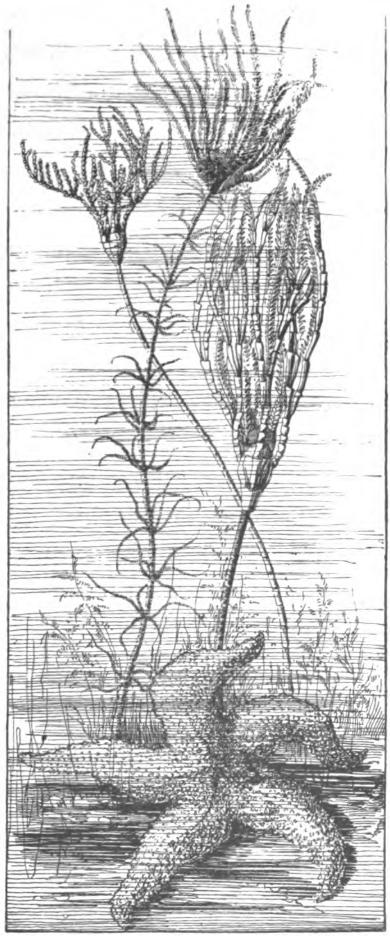
LESSON XVII.

STONE FISH AND STONE LILIES.

"The floor is sand like the mountain drift,
  And the pearl-shells spangle the flinty snow;
From coral rocks the sea-plants lift
  Their boughs, where the tides and billows flow;
The water is calm and still below,
  For the winds and waves are absent there,
And the sands are bright as the stars that glow
  In the motionless fields of the upper air."

—PERCIVAL, *The Coral Grove.*

IT was not an unusual incident that a lawn gate should have been carelessly left open, and, the gate being open, it was not surprising that a stray cow should turn in thither to feast on blue grass. Given the open gate and the intruding cow, it was in the usual order of affairs that Scroggins, our black boy, should arrive upon the scene, gesticulating and loudly remonstrant. Scroggins seized a large lump of hard clay and flung it at our neighbor's Alderney, by way of emphasizing his objurgations. The cow was already hastening her departure, and the lumps of clay struck not the retreating cow, but the granite horse-block, and so fell to pieces. At that instant I came by, and oh, joy! as the coarse matrix of clay crumbled, there fell out of it the most perfect crinoid, or stone lily, I had ever seen. White and clean, its sharp ridges, or folds, perfect, an inch of stem in good preservation — "Scroggins! Tell me quickly, where you found the clay which you have brought to level up that hollow in the lawn?" "I done fotch him from Hopkins' quarry, missey. A clay bank jest clost along side dat quarry, suah."



THE STONE LILIES.

Verily then there are fossil crinoids to be found in that quarry; therefore let us take a hammer, and some one strong-armed to wield it, and away to Hopkins' quarry. The rock of Hopkins' quarry is of the lower Silurian. Here and there we search among the fragments torn out by blasting, and lo, plenty of portions of crinoids. The crinoid found in the clay had evidently been broken from the rock in some blast, and had been flung over into the soft clay of the bank, which had hardened about it. At last we carefully chisel from the rock a stem a foot long, and another fair, cup-shaped, fluted stone lily.

As the rock is cut away we indulge in some meditations on this beautiful form of ancient life, the animal water-lilies of the olden time. They came first in the lower Silurian, when coral was king, and in their enormous numbers they soon divided the empire of the sea with the busy polyps. Moored to the sea-bottom, waving on their long flexible stems, as fleets of pond-lilies now ride at anchor, stretching out their plume-like arms, more like flowers than animals, grew the Silurian crinoids. A few of them now remain in the deep seas, but with these few exceptions the crinoid has vanished from the living world, but has left its representative descendants in the great order to which the star-fish, sea-urchins, and sea-cucumbers belong.[1]

The adult crinoid of the Silurian was very like the larval comatula of the present age.[2] The comatula is attached to a stalk that grows upon a rock or some other fixed substance, but at the age of six months the comatula detaches itself from this stalk and swims off. In this it differs from the barnacle which, as you may remember, is free and vagrant as a larva, and attached when adult. The crinoids of the Silurian were always fastened and grew each in its individual

[1] Nature Reader, No. 2, Lessons 37–40.

[2] Nature Reader, No. 2, p. 127.

place, as firmly as the lilies from which they take their name.

The stem of our crinoid as it is laid bare in the rock, exhibits a series of little disks or plates. These are set one above the other to form the stem, which is often several feet long. Through all these little plates there ran a soft solid substance, like an elastic cord. As the stone which holds the fossil is laid open by our chisel, and the crinoid stem and flower-cup are well displayed, they remind us of the spinal column and brain of vertebrate animals. The great German scholar and poet, Goethe, remarked that the spinal marrow threaded through the closely united vertebræ enters the skull by an opening at its base, and expands, or blooms out, into the brain. Goethe considered this a growth like a lily; the spinal cord being the stem, and the brain the perfect flower. This white stone lily looks like a prophecy in stone of the spinal cord and its brain expansion.

When this crinoid was alive, these valves or petals, which now in the petrified specimen form a solid cup, were capable of opening or unfolding, and from them the long feathery filaments spread forth. Following our crinoid down the ages have come all the marvellous families of the radiates.

It has become a common form of speech to call nearly every animal that lives in the sea, a fish. Thus we speak of star-fish, meaning members of the radiate family which have nothing in common with true fishes, except the habit of living in water; we call mollusks shell-fish, but they are very far removed in structure from the fish-class; also we call whales, dugongs, and their kin, fish, when instead they belong to the mammals, as we shall find when we come to study them. These star-fish, as we wrongly call them, belong to the same class as their ancient forerunners the crinoids, and the crinoids were living with the corals long before there were any fish in the ancient world. The Silurian period was almost at its close [1] before a single fish appeared in the swarming life of the ancient ocean.

The progress of life from its beginning until now has been upward, and in the main the latest forms of life are the highest forms; but this is a rule which has many exceptions. We have seen many of the lowest and earliest forms of life continue living and reproducing themselves in the present age, and also we have seen the many types of life remain which are not now in their highest development, but are degenerated examples of higher forms that existed long ago. The noblest type of life is found in vertebrate animals; but the vertebrates have many families, and it is only when we finally reach the chief class of vertebrates that we find the highest type of life. The first vertebrates that appeared were fish. In their distinguishing characteristic, the backbone composed of many vertebræ, they were a prophecy of all the wonderful orders of vertebrate animals.

The fish were of several species, and had not sprung from any preceding type of animals. In their vertebrate construction they were something entirely new in animal life. The first fish of which we have any knowledge were

[1] In the last months of 1890, fish remains were found in rocks at Cañon City, Colorado, belonging to the first Silurian series. New discoveries constantly change such statements as that in the text.

not poor little weaklings, hardly capable of maintaining existence; on the contrary, they came bravely into a world swarming with great crustaceans and polyps and long-armed cuttle-fish, another fish-named creature which is not at all a fish. Among these huge and ravenous animals the new specimen held its own, and asserted its higher condition. When most of the great forms of life which had witnessed its arrival had perished with the closing of the age, the fish continued into the next era, and there thrived exceedingly, and had their turn at being world-masters. With each advancing age of the world the fish-class has gone on increasing and reaching new forms of beauty and excellence.

The crustaceans, polyps, crinoids, and nautili, which preceded the fish, had their bony structure upon the outside, and the soft parts of the body securely placed within this covering. The fish came with its bones inside its body, thus depending for safety upon its agility and its teeth. The first fishes had thick, tough skins, without scales. Their skeletons were rather of cartilage, or gristle, than of bone, but their spines were long, and their teeth were particularly large and strong. They were about the size of a dog-fish,[1] and were probably even more hideous to behold.

Among these fish, however, and perhaps the oldest of them all, were some that, while having no scales, wore great bony plates, like the side plates of a sturgeon.[2] From the

[1] The dog-fish here meant is the dog-fish of the sea, well known on the Atlantic coast. The " dog-fish " of the rivers is a very different specimen.

[2] Nature Reader, No. 3, Lesson 40 *ad fine*.

coprolites found with these fossil fish we discover that they ate sea-snails, crinoids, which were unceremoniously bitten from their swaying slender stems, and lingulæ, which they tore off the submerged rocks, as cheerfully as a boy helps himself to cherries or blackberries.

The first fragment of a fossil fish ever found, was in a bed of sandstone near Ludlow, England, and geologists have been eagerly searching ever since for more complete specimens, and to discover, if possible, traces of fish in the earlier rocks. Finally the United States Geological Survey has found earlier fish remains in Colorado. One of the most ardent students of fossil fishes was the noble man of science, Agassiz, who even as a young lad began a valuable collection of fish fossils. When we consider how many organisms must moulder away and perish entirely, for every one which survives, we need not wonder that comparatively few fossils have been found, but should rather wonder that so many have fallen into sufficiently favorable circumstances to survive.

With the next age after the upper Silurian, fish became very abundant, and in that and every age succeeding, they predominate in the waters, where the older animal forms begin to disappear. One peculiarity about the fossil fishes of the Devonian era is, that they are often found in hard, flattened, oblong concretions. When one of these lumps, like pebbles, is given a smart tap with a hammer, it splits open, and a fish or part of a fish, is found in the centre. Hugh Miller, the Scotch geologist, graphically describes in several of his works the joy with which he secured perfect specimens of fish from such pebbles. In the Devonian age fish improved in fashion, and began to wear scales. Sometimes fossil scales are found tinged with the beautiful iris-hues which they wore in the ancient waters. Sometimes in the rocks of this and the succeeding age there are found whole beds or thick strata of fish-fragments. When these beds are opened they give forth a faint odor, like decayed fish, but all the soft parts of the fish have been destroyed long ago, and merely the bones, scales, and especially the wonderful teeth remain.

LESSON XVIII.

THE BURIED REPTILES.

"*Hamlet.* Do you see yon cloud, that's almost the shape of a camel?
Polonius. By the mass, 'tis like a camel indeed.
Hamlet. Methinks it is like a weasel.
Polonius. It is backed like a weasel.
Hamlet. Or like a whale?
Polonius. Very like a whale." — SHAKESPEARE, *Hamlet.*

WHAT is the chief bone in the human body? Does any one say the arm, or leg, or breast-bone? No, it is the backbone, or spinal column. That is a wonderful bone that gives the name of vertebrate or backboned animals to all creatures which possess it. This spinal column, or backbone, is made up of a number of little bones or joints called vertebræ. These are threaded together like beads on a string. The spinal cord runs through them, enters the skull, and expands or blooms out into a brain. Bend your body every way, backward, sidewise, forward, how flexible is this many-jointed spinal column! This wonderful backbone marked the creatures that possessed it as a class higher than the jointed creatures or articulates.

We have found that the first vertebrate animals were fishes. The fish of the Devonian age were not only numerous and greedy, but instead of scales the majority of them wore large bony plates, which served them as armor while they

THE REIGN OF THE PINE.

fought, not merely for existence, but for conquest. At present there are only about thirty species of plate-wearing or ganoid fish in the world, and nine thousand species without this heavy armor. But in the age when fishes were kings of creation, this proportion was reversed, and the plate-wearing fish were the more numerous. The fishes were the only representatives of the backboned animals until the Coal age was well advanced. Then a new vertebrate of a still higher type arrived in the world. These new creatures aped the fish in their backbones, or spinal columns, their thick skins, and their plate armor. But they were of a higher type than the fishes; for they were in possession of legs, toed-feet, and had lungs instead of gills for a breathing apparatus.

In the earliest representatives of this higher stage of life, the lungs were an air sac associated with gills, but the next form dropped the gills entirely, and had well-developed lungs. The possession of lungs gave them power to live out of the water, which hitherto had been the home of nearly all living things. The new vertebrates were amphibians, and no doubt the earliest of them found themselves better fitted to live in the water than on the land, as their legs were feeble, and their strong tails served them well in swimming; but like the amphibians of the present, they made themselves at home in any place.

The reptiles marked the introduction of a higher animal class than had previously existed, and being of a higher type, their destiny was to live and thrive and assert themselves. Almost immediately we note in the class two branches, or fashions, which continue to distinguish them. Some became very large, had enormous heads and jaws, and terrible teeth, resembling the present crocodiles. These, living on the shore, preyed upon fish or other animals. The second division comprised smaller and more delicate reptiles. They had better developed limbs and lungs, large ribs, beautiful, brightly colored scales and skins, lived on land, and fed on insects, spiders, and snails.

Thus in the latter part of the Coal-making age, we may imagine the shores and bayous swarming with great reptiles ten feet long, furnished with thick armor and monstrous teeth; while the forests of tree-ferns, club-mosses, reeds, and other plants, were rustling with the agile feet of gayly colored, active little beasts, from a few inches to a foot in length.

Here at last was an animal with a pair of nostrils through which it could inflate a pair of lungs. The reptile with his improved breathing apparatus and convenient feet had come into creation to stay. Individuals and families would indeed perish and leave only fossil remains to exhibit their characteristics, but the class was to remain. When the Coal period passed away, we find that the first lizards accommodated themselves in improved varieties, to the demands of the new time; their teeth, limbs, lungs, and tails, were better developed, and they could claim to be highly organized creatures; in fact, the reptiles became the leading animals of the epoch, which from them is often called the age of the reptiles. The crustaceans, corals, mollusks, and fish had had their day of being the rulers or leading families of the world; now came the turn of the reptiles; while certain groups, previously chief, sank into lower places.

These crustaceans, polyps, crinoids, and others which we have mentioned, were the predecessors of the reptiles. They did not disappear when the reptiles arrived, nor have they disappeared yet. No doubt all these creatures, and others which have come into existence, will survive and share the globe, as long as the globe lasts. No researches have discovered any animals created since the arrival in the world of man.

While the foraminifera, crabs, corals, mollusks, fish, and other creatures came successively into the world of life, there is nothing to prove that any one class descended from the class preceding. There is no evidence that any mollusk, crinoid, or fish, though in existence a few thousand years before the reptiles, could claim to be the reptiles' grandfather, and there is no likelihood that the inside skeleton of the backboned animal was developed out of the outside skeleton of the mollusk. We must take these successive classes as we find them: we see each class in itself, developing into higher and better types; then, some maintain this improved development, some dwindle away and disappear.

There will always be many things in nature which we cannot understand, but this need not discourage us in efforts to know; for the old saying is a good one — "He who grasps after a gold coat, is likely to get at least a sleeve." In those old ages before man arrived, there were new things in the world. Since man came, there is nothing new under the sun: the facts which we learn and call new, are all old, very old.

The reptiles were of the improving classes of animals. To be in full harmony with their habitations, and not miss any of the possibilities of their kingdom, we find the reptiles accommodating themselves to the earth, the air, and the sea. There was, for instance, the hadrosaurus, a two-legged reptile, which had long, strong hind legs, and a strong, pointed tail. These legs and the tail formed a tripod, like the three legs of a milking-stool, or the two legs and cane whereon an aged man supports himself. The enormous body of the hadrosaurus was upheld by the strong hind legs, and it paced slowly about: then when it wished to rest, or seat itself at ease, while with its small, hand-like fore-paws, it picked fruits and leaves from the tree-tops, it brought its strong tail into play, and rested on this and its legs. Thus we see the lucky hadrosaurus always carried about its own camp-stool. This creature was a land-living, herb-eating reptile.

One very great reptile of the sea was the ichthyosaur, or fish reptile. This creature had paddles and a very strong tail-fin for swimming. The ichthyosaur could roll in the heavy billows like a porpoise, and liked to be far out on the sea busy at fishing. As it chased fish at sea, it held its head high above the water and breathed air with true lungs. Probably no fish could hold its own against a monster twenty-five feet long and protected by broad, solid plates of armor. The empire of the fish had finally departed.

A third wonderful reptilian form was fitted for airy flights; the pterodactyl was the reptile monarch of the air. While its cousins, the biped reptile and the fish reptile, were ravaging the land and sea, the flying reptile, or bat reptile, whichever we choose to call it, spread its parchment-like wings, lifted itself far above the trees, and swooped from its height upon fish, land animals, or the few stray insects of the period. The flying reptile was a prophecy of the coming bird, which arrived in the middle part of this period.

When true birds came, they introduced a class that was very closely related to the reptiles. The lady who holds a pet canary on her finger, offers it sugar with her lips, kisses its pretty yellow head, and considers it one of the most dainty and delightful of living things would, perhaps, shriek wildly if a lizard ran across her foot, or upon her sleeve, and would call the innocent little reptile, hideous, disgusting, hateful. Some one says the bird is a "glorified reptile." There is similarity of structure, but the bird class is not descended from the reptile class.

The backboned animals are divided into the class of the fishes; the amphibians; the sauropsida, or class containing birds and reptiles, which you see are put together; and the highest class of all — the mammalians — to which we ourselves belong.

Some years ago it was usual to class together as "four-legged creatures that lay eggs," all turtles, tortoises, newts, salamanders, snakes, toads, frogs, lizards, and crocodiles. The great naturalist, Linnæus, named all these creatures amphibia, because they can live with equal ease in the water or on the land. After this some of the French naturalists concluded that the creeping method of locomotion of these animals was a more general characteristic than their amphibious habit, and called them reptiles, or crawling creatures. But as these animals have been more closely studied, wider differences have been noted between them, and the toads, frogs, newts, and salamanders have been set in a class by themselves.

The study of nearly all forms of life has two branches, the investigation of living objects, and the similar investigation and classification of fossil specimens. Thus the study of fishes embraces not only the examination of those species now to be found in the waters of the world, but of the fossil fish found whole or in parts, in the treasure-house of the rocks, and these fossil fish have very numerous varieties. Botany also regards not only plants now growing, but the varieties which have become extinct, during the five earlier earth-building periods. Of the ten orders into which it is common among scientists to divide reptiles, five are now extinct, and remain to us only as fossils. But so learned and accurate do some ardent students of fossil remains become, that from only a single bone, tooth, or scale, they are able to decide to what class and family the creature of which it was a part belonged, provided, of course, that the creature itself has become known.

No ancient creature seems to have accommodated itself more closely to its circumstances than the reptile. It appeared to be equally at home in the water, on land, or in the air; it ate fish, flesh, and vegetables; walked on two legs, or crawled on four. The biped land reptile had many of the characteristics of the present kangaroo; the bat reptile had many of the qualities of a bird; and the sea reptile was probably more like a whale than a fish. In fact the reptile seems to have been as complaisant as Polonius the courtier-friend of Prince Hamlet in Shakespeare's play.

Let us now write out a little table for reference, showing the improving scale of life in plants and animals, from their first appearance until the reptiles came.

ANIMALS.		PLANTS.
Amoeba.		Sea-weeds.
Foraminifera.		Mosses.
Crustaceans.	Crinoids.	Ferns.
Polyps.	Spiders.	Reeds.
Mollusks.	Scorpions.	Pines.
Fishes.	Dragon-flies.	Cycads.
Amphibia.	Cockroaches.	
Reptiles.	Kangaroo-rats.	

The amphibia and reptiles brought into the world not only those famous backbones, but lungs and noses. The amphibia had at first gills and lung-sacs, but the reptiles had true lungs and drew air through their nostrils. Try it: draw in your breath and fill your lungs until your chest rises and expands; now breathe it forth again. Very simple that, do you say? So it seems; it is very common now-a-days, but there were many ages when not a living creature had a pair of lungs and a pair of nostrils, when such breathing apparatus would have been a marvellous affair. These reptiles introduced a brand-new fashion.

Each advancing age was richer in both flora and fauna than the ages that had preceded it, because the soil, climate, and atmosphere of the earth became more and more favorable to both animal and vegetable existence. Nothing in all this succession lived or died in vain. The plants freed the air of carbon and enriched it with oxygen;[1] the decay of animal and vegetable matter increased and enriched the soil.

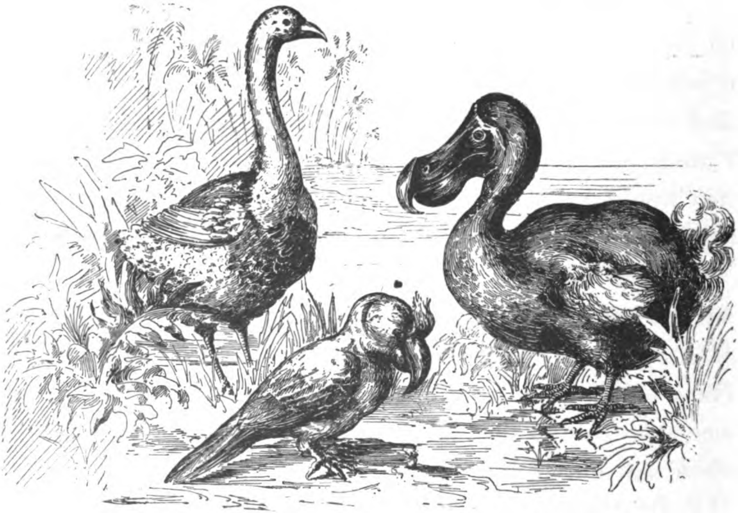
[1] Nature Reader, No. 3, Lessons 6, 7.

LESSON XIX.

THE BIRDS OF OTHER DAYS.

"Thy flitting form comes ghostly dim and pale,
As driven by a beating storm at sea;
Thy cry is weak and scared, as if thy mates had shared
The doom of us: thy wail — what does it bring to me?"
— DANA.

IT was an often-repeated saying of the great Linnæus that "Nature never makes a leap." By this he meant that the law of nature is a law of gradations, and that in the long



OLD FASHIONS IN FEATHERS.

up-growth of organisms, the steps are short between the various classes of living things. The work of creation is harmonious, and moves from one grade of organization to another, with the easy transition of carefully shaded colors, or the ascent of the scale from note to note. But this creative harmony began very long ago, and in the innumerable ages which have rolled by with their train of living things, many types have been lost. Enough remain to fill us with wonder and admiration, when we see how the organism of one creature has been changed and adapted in some other succeeding animal.

We quoted in the last lesson the remark, "a bird is but a glorified reptile"; and, far apart in type as we might at first glance consider an eagle and a crocodile, or a lizard and a dove, it is not very difficult to trace, by the help of fossil forms, the similarity of organism and the steps in the process of change. Reptiles and birds belong to the class vertebrates; the backbone is then the first distinguishing feature. In the reptile, the spinal column with well-defined vertebræ passes from the head to the tail.[1] In the bird we find the vertebræ of the neck well marked, and more numerous than in the reptile; the shoulder-plates, breast-bone and hip-bones are largely developed, forming the box-like body of the bird, and embracing the backbone. In a similar fashion we often find certain insects in which one of the rings of which the jointed body is composed is developed far more than any of the others.

In the tail of the bird, we find the vertebræ flattened and crowded together into a triangular stump, while the tail of the reptile is extended, pointed, and supple. The reptile has

[1] These differential characteristics apply only to existing species of birds and reptiles.

four limbs; in the bird the two front limbs — the hands of the reptile — are changed to wings. The long-toothed jaws of the reptile become the horny beak of the bird. The reptile has scales and the bird has feathers, but there are spots on the reptile bare of scales, and on the bird bare of feathers.[1]

The sea had its inhabitants long before the land was populated, and the first vertebrates, the fish, were citizens of the sea. Before the earliest reptiles came, there were amphibians, which lived more readily in the water than on the land; then followed land reptiles, and finally flying reptiles. In like manner, the first birds were chiefly aquatic or swimming birds; then came huge, unwieldy walking birds, and finally flying birds. The earliest birds also diminish the distance between themselves and the reptiles, by the possession of teeth. In regard to feathers, we find that the plumage of the first birds was coarse and scanty, and consisted chiefly of quill feathers. The legs of all birds are covered with true scales such as the reptiles have.[2]

When we look at the reptile and the bird, the differences that seem most startling are between the wings of the bird and the fore-feet of the reptile, and between the scales of the reptile and the feathers of the bird. When we find the fossil form of one of the first flying creatures, we see that the huge wings were made of parchment-like skin, stretched upon the arm and fourth finger, which extended in claws in front of the membrane. If we examine that curious flying mammal, the bat, we shall see a similar construction, one finger of the

[1] See Nature Reader, No. 3, Lessons 28–30.

[2] This adaptation does not indicate any descent of the bird from the reptile.

bat's fore-leg extending beyond the wing into a hooked claw, by which it can hang itself up for rest, or upon which it can walk, going on all fours, in a clumsy fashion.

Now, if we take the bones of a bird's wing, we shall find that it has a large, thick upper bone, corresponding to the upper bone in our own arm; then the next section has two smaller bones, one slightly curved and one straight, to match the bones in our arm from the elbow to the wrist; and then in that small, pointed first section, we find three finger-bones. If we lay all these bones in their order we shall find a very good arm and hand. But now take these bones and construct from them a leg, and we shall notice that any arm is a modified and reduced leg. In nearly all animals the fore-legs are smaller and more symmetrical than the hind-legs. In the reptile family the fore-leg looks very like an arm and hand.

To return to the case of the bird and the reptile, we find that the first bird-like flying creatures, were not birds but reptiles of a bat-like construction; while the first biped creatures, supposed from their footprints to be birds, were not birds but biped reptiles. An enormous space of time separated biped reptiles from real birds.

The remains of the earliest birds seem to have been less well circumstanced for preservation than those of other animals, for very few are found; and of the first animal that can really be called a bird, for many years only part of a single specimen, and that lacking nearly all the head and breast-bone, was known. Enough, however, of the specimen remained stamped on the Bavarian slate to show that this had been a feathered flying creature, with two slender legs, and feet suitable for perching upon trees. It was of about the size of a crow, and had a very singular tail. This tail was long and formed of extended vertebræ like the tail of a lizard, and from every joint grew a pair of large quill feathers.

Such a tail must have greatly hindered the creature's flight, and in fact in the many years that passed before the existence of the next birds of which fossil forms remain, a new fashion of tails had come in; the huge court-train had vanished, and birds appeared with the closely crowded vertebræ of the tail, only sufficient to support the tail feathers.

But the print on Bavarian slate is not the only fossil of our long-tailed bird of early days. A feather was also found imprinted on stone, and then about 1880, a very complete specimen, showing that the jaws had teeth, and that the bird had claws. "A fearsome fowl, surely!"

The bird next found was aquatic, about the size of the nearly extinct penguin, but wingless. In the chalk shale of Kansas, birds of the size of pigeons, with short wings, but especially remarkable for having teeth in the old reptile fashion, have been found. Modern birds have lost their teeth, finding it more convenient to depend upon gizzards for crushing their food! A bird very nearly the size of a swan has been taken from the New Jersey marl.

It is only when the first age of the last world-building period opened, that we find a huge bird as large as an ostrich. This bird was not alone as a giant of the race; there seem to have been other species, too bulky to fly, but able to swim, and no doubt capable of running swiftly on land, aided by the rowing motion of their wings.

As the ages move on, more birds appear, having affinities with yet existing types. In some, the jaws had bony points and serrated edges, showing that the birds were fish-eaters, aquatic in their habits, and possessed of webbed feet. Birds allied to the gulls and kingfishers were numerous, and shortly after them came specimens of the flamingo tribe; and still we see that the aquatic birds, the birds that had their living from the all-bountiful sea, were most numerous.

It must not be concluded that of all these birds perfect specimens have been found. In some cases eggs, feathers, nests, footprints, or stray bones have been the only traces. The extinct bird frequently has had to be reconstructed from small portions of its body. Each succeeding age of the last world-building period has produced new birds. In France the strata from the first age of this period have yielded many species. The ancient beds of lakes have been especially rich in bird remains, as lying in the undisturbed ooze, the fragile bodies were less exposed to destruction. Very many of these birds of ancient days represented forms now living,—as barn-yard fowls, storks, woodcock, crows, and falcons. Possibly the birds were not more numerous in the Miocene than in the succeeding age, but its numerous lake beds, and other circumstances may have been more favorable to the preservation of the remains.

A great many fossil birds and remains of birds have been found in the caves of the succeeding eras. Many varieties of birds are still given to inhabiting caves, or any quiet and shady place. No doubt "the temple haunting martlet" haunted caves before temples were built, and swallows that now multiply in chimneys and eaves must have gone for shelter to the crevices of the rocks in ages before men displayed architectural talent. Thus the caves of the ancient world had numerous bird inhabitants, while the captured bodies of birds were no doubt carried to their cave-dens by carnivorous animals.

The division of "sub-fossil birds" embraces birds that have existed during the human period, but have now disappeared. In what are called the "kitchen-middens"[1] of Denmark, and in the lake dwellings of Switzerland, in recent fens and peat mosses, and in various islands, as Madagascar, New Zealand, and the Canaries, the remains of the great auk, the capercallzie, the dodo, the crested parrot, and in New Zealand the huge dinornis have been found. Within the historic period various other birds have been exterminated, and are now represented only by ancient drawings, stuffed skins, or relics of their nests and eggs.[2]

[1] The word means "kitchen refuse heap" and is applied to shell-heaps mingled with bones, found along shores and recognized as traces of ancient human habitations.

[2] See Nature Reader, No. 3, Lesson 39.

LESSON XX.

THE EARLY MAMMALS.

"'Tis there the otter dives, the beaver feeds,
Where pensive osiers dip their willowy weeds,
And there the wild-cat purrs amid her brood,
And trains them in the sylvan solitude,
To watch the squirrels leap, or mark the mink
Paddling the water by the quiet brink."

— BRAINARD.

COMPANIONS AND FRIENDS.

THE last nine lessons have been occupied with brief descriptions of some of the fauna of the first five world-building periods. A knowledge of these early forms of life is not only pleasing in itself, but valuable, as giving us clearer ideas of the past ages, and because the animals and plants that then existed have a close relationship to those of our own day.

The earliest animals described were the foraminifera, from which class we have our most ancient fossils. We might infer from this fact that the foraminifera were the first forms of animal life. But no; even these had predecessors, but of groups from which no fossils remain.

The foraminifera, minute as they were, had shells. There is no doubt that they were preceded in the scale of creation by tiny creatures without shells, creatures that with neither arms nor legs, heads nor stomachs, yet could provide themselves with arms in an emergency, and were all mouth and stomach. Such an animal has been named a proteus from its constant changes of shape, Proteus in the classic fable being a sea-god who was constantly changing his form.

The amœba, or proteus, belonged to the class protozoa, and may be described as a minute drop of a jelly-like substance, never at rest, but ceaselessly changing its shape. Imagine such a particle of jelly held suspended in a glass of water. Now it seems to extend or pour itself out on one side, into what we may call an arm, because it is reaching for an atom of food. This extended portion is drawn back, and whenever it returns into the drop, there the food is received and digested. Therefore we say the amœba is all mouth and all stomach, because it can receive and digest food in any part of its substance.

The earliest of the protozoa was probably a jelly-like drop composed of a single cell. Sometimes a number of these cells, or individuals, clung together in a loosely united mass or community. When a new individual was formed the process was by "budding," the single cell becoming two, dividing and parting, so that each individual was complete in itself; and which was the new one, and which was the old one, or whether both were part new and part old, certainly they themselves did not know.

Parallel with this group of one-celled jelly-like animals, was a group of one-celled jelly-like plants. Each of these groups stood at the beginning of a great and constantly ascending series; the two groups were different in their nature and in their method of nutrition, yet each so like the other, that it is very difficult to distinguish them. Thus when we consider the dawn of life we must put the shelless protozoa ages back before the busy shell-housed foraminifera.

Yet in so placing the shelless amœbæ we must not fancy them extinct. By no means: in myriad millions they still exist, and have through all the ages, and there is no pond today that has not its restless kaleidoscopic representatives of life's lowest grade.

It was a long, long journey from this formless speck of jelly to the highest grade of life — the mammalian form; and up this long ascent, conducted on a definite plan, life moved without faltering or contradictions. Let us then in our last look at vanished fauna, regard some of the fossil remains of that crowning class of animal life at the head of which stands man — "Time's noblest offspring and the last."

Our knowledge of the earliest mammals is very incomplete, and is constantly changing, as the discovery of new beds of fossils shows to us new forms, and supplies new information concerning their relationships. The mammals were late in their arrival upon the earth. They could afford to wait, for they had come to stay and to possess the kingdom of nature. The first mammals lived in the first age of the Reptilian time. They were nearly the size of large rats or squirrels, and curiously enough their teeth and jawbones are the portions of their bodies which have survived decay to tell their story.

The teeth of mammals differ in construction from the teeth of all other animals, and thus if only one single tooth is found we may be sure that it is a part of a mammalian creature; and, being a mammal, we know certain facts in regard to it, as for instance that it was born alive,[1] and while young was cared for and suckled by its mother. When the teeth are molar, or grinding teeth, we know that the animal lived on grain or herbs — and thus from the formation we may decide that it was a grazing animal; sharp-pointed canine, or dog-like teeth, show a meat-eating animal, a hunting, flesh-seeking creature; worn teeth, teeth with the enamel ground down, tell us that the animal was old. Among the teeth found, some suggest mammals that lived on insects, fruit, and roots, and some teeth found in the ancient rocks are very like those of the kangaroo rat; so that by observing the present animals of this type, we can in general arrive at the habits of these long extinct creatures.

Probably the rat and squirrel families, capable of living on roots and nuts, and small enough to hide in crevices, in decayed trees, and under stumps, where the large reptiles could not follow to destroy them, were the earliest mammalian

[1] A later lesson will describe a mammal that comes from an egg!

forms. It is a singular fact that the rocks of the Chalk age, the last era of the time before the last world-building period, have afforded no fossil mammals. This is evidently not because there were no mammals in that age of the world; for the rocks of the succeeding periods have yielded abundant forms of many species, showing that mammals had extended, multiplied, and improved exceedingly. Either the circumstances of the close of this age were not favorable to the preservation of such remains, or there are in the chalk rocks fossils which will yet be found.

In the earlier ages of the present or last building-time, the mammals were not only numerous, but far exceeded in size any now existing. Indeed, it seems that as the type improved the more bulky forms passed away; the higher animals being less unwieldy. Still this suggestion must at once be met by exceptions: for in the case of the horse, as the model improved, the size of the animal constantly increased. The mammals had finally become world-masters, and before them the gigantic reptiles perished. For a time mammals and reptiles of equally stupendous proportions seemed to face each other, but the new type gained the victory over the old.

The mammals, as well as the reptiles, had the faculty of adaptation; they seemed suited to a wide variety of conditions. They fed on fish, flesh, herbs, fruits, and fowl. Some of them had bare tough skins; others wore long scanty hair; others again were clad in fur, or heavy wool. Some of them burrowed in the ground; some lived in caves and dens; some were tree dwellers, or arboreal; others wandered over wide savannahs or in the forests, careless of other shelter than trees or reedy jungles.

Next after the rat-like families came a tribe of insect-eating creatures like the present ant-eaters, but far exceeding them in size, some of them being nearly as large as a rhinoceros. The mylodon was a fruit-eater and so large and strong that it was able to tear down the trees which bore the fruit it coveted; certainly a destructive fashion of fruit-gathering, proving the mylodon much more barbarous than a Saracen.[1]

Meantime, while these mammals flourished on the land there were numerous others in the sea, and these of a very large size, although no fossils have yet shown that the sea-mammals preceded those of the land. The whales and the sirens seem to have appeared many years ago, and have since continued.

Enormous armadillos, covered with mail and very like the tortoise family of reptiles, marched about the woods or sunned themselves upon the shores. When twilight settled over the ancient woods and savannahs the mammals of the air came forth, and bats flew zigzagging about, hunting after insects or little birds.

The bone-caves of the age before man came have abundant bones of mammals; bones which represent the pursuers and the pursued, hunters and hunted,—some the relics of the meat-eating, hunting beasts, and some, the gnawed remains of their prey.

Among the vertebrate vegetable-eating animals we note the elephant, the great woolly elephant now extinct, and the

[1] The Mohammedan soldiers were forbidden to destroy fruit trees.

mighty mammoth, known only by its remains, yet very well known, because the frozen mud of Siberia has preserved for us the entire animal, even to its eye-balls. We have in another lesson indicated the life history of the horse-like animals which belonged to these successive periods. There were also many families related to the tapirs, deer, bears, and musk-oxen of the present day. In fact the majority of the mammalian forms of the earlier ages have their modified representatives in the present age; while others, as the mastodon and many more, have made way for more modern families and are known only by fossil remains.

The Ice period no doubt made a great change in the fauna of the globe. During its desolation and cold many families of animals perished. Other creatures changed their homes, migrating from the formerly temperate polar regions to the tropics, retreating to warmer latitudes as the ice-sheet advanced. Some of the carnivora especially were capable of resisting the cold by increasing the thickness of their coats; but animals dependent upon a vegetable diet must either perish with the flora of the regions they inhabited, or follow the changed lines of vegetable growth, as the northerly plants perished and vegetation flourished only in the warm southerly lands.

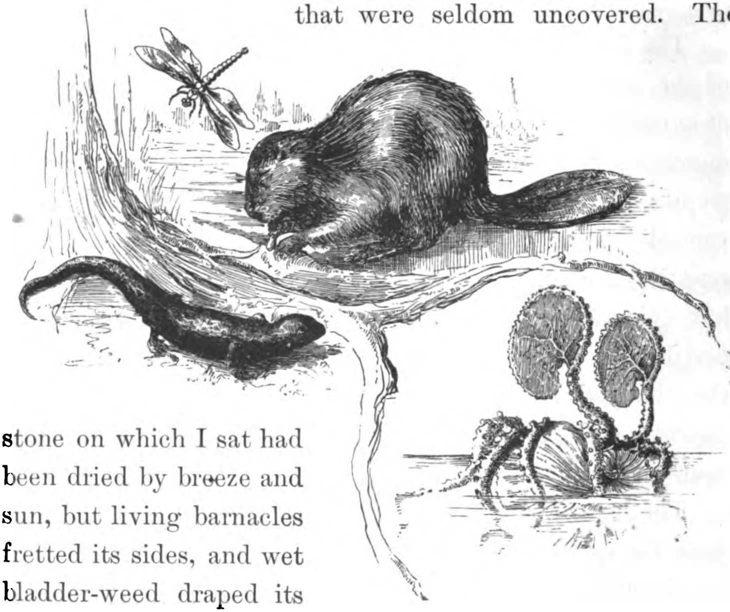
The last of the mammals to appear in the brute creation were the quadrumana or monkey tribe, which hold the highest place in the brute creation.

LESSON XXI.

A VERY OLD FAMILY.

"'Twas when the world was in its prime,
When the fresh stars had just begun
Their race of glory, and young Time
Told his first birth-days by the sun." — MOORE.

ONE June morning I was sitting by the ocean. The tide was out and was unusually low, laying bare beds of sand that were seldom uncovered. The stone on which I sat had been dried by breeze and sun, but living barnacles fretted its sides, and wet bladder-weed draped its edges, indicating that usually the waters flowed above it. A little farther out, a multitude of small black sea-snails lay, each with tightly



ANCIENT ARISTOCRACY.

closed operculum to retain moisture sufficient until the sea returned; but now and then some few crawled to a more favorable position; and here and there a pale pink foot shod with a little black shoe reached forth, and taking hold upon the sand the creature pulled itself over by a muscular contraction.

Near me on the right the sand disappeared under a bed of dark ooze; for here was the mouth of an inlet, and twice each day the tide hurrying back through its intricacies brought black mud from the marshes to deposit upon the beach. In this layer of pasty soil I presently discovered a track very like what we call "ladder footprints" in fossils. There were numerous holes as if made by some slim, sharp instrument, and on each side a furrow. I rose and traced this track until it disappeared under a fresh deposit of mud.

As I turned seaward again I saw at the edge of the water a dark-brown shining object over a foot in diameter, with rounded front and convex surface, moving laboriously along the slime. After it had travelled some yards from the water to a place where the mud-bank overlaid the sand by two or three feet, the creature came to a pause and presently began to disappear. The large, rounded shield entered plow-like into the mud-bank, sank lower and lower, and then the triangular hinder shield vanished, and finally the long spiked tail. This animal was a limulus, or horseshoe crab, and he was now plowing his way about in the mud, seeking for his dinner.

The previous day the tide had been very high, and I knew that in the high tides of June the female limulus comes up to lay her eggs on the margin of the sand. I further reflected that numerous boulders and small sharp rocks were strewn along this coast, and that the high tide had been accompanied by a violent wind. From these facts I concluded that I might find a dead limulus among the rubbish at high-water mark. At the summit of the beach was a long swath of sea-weed, empty and broken shells, bits of wood, and the flotsam that is cast up by the sea.

All this débris was dry atop, but thoroughly wet a few inches below the surface, and there "beach fleas" were hopping actively, and scallop shells lay tightly closed, and certain hapless crustaceans were on their backs entangled.

Being sorry for these poor creatures, likely to die long before the lagging tide returned for them, I spent some minutes in flinging back into the water the scallops and crabs which had been cast out. As I pursued these benevolent labors, I saw in the wreck heap, the long, spiked, serrated tail indicating a limulus, or horseshoe, or king crab. Removing the rubbish I disentombed a limulus, full twenty inches across the widest part of the shield, and that shield so hard and thick and dark, that it resembled a piece of sheet iron rather than a portion of an animal. But hard as it was, some wave flinging it upon a sharp rock had wrought its destruction, and a large break on one side told how Madame Limulus had perished.

The animal was remarkably heavy, but dragging it to my rock, I made it the theme of my meditation.

What ancient family of humans in all this world, Mistress Limulus, but is modern as the last new fashion, compared with your hoary antiquity of lineage? Mongol or Hindoo, Russian or Saracen, Emperor of Austria or King of Italy, who of them can count grandfathers with you? Compared to you all Adam's line are but of yesterday. If you had been a reasoning being, and capable of handing down traditions, all the lore of all the ages might now be hidden under that vast head-shield.

Limulus, or horseshoe crab, or king crab, whichever you prefer to be called, do you know that the last age of your race has come, and you are bearing down on extinction? The seas of China and Japan, and this ancient eastern coast of North America, still cherish you and your relatives; but the hapless fortunes of the times, the elements, and man the pitiless, have doomed you, and soon the day will come when not a limulus of you all will survive, except in the cases of museums. The doom of your old-time, far-off cousins, the trilobites, is upon you. Let me trace you back to your origin; for the rocks, more faithful than your dull and imperfect brain-cell, hold your history.

Very modestly, as if hesitating whether you would be entertained in the world's great hostelry, one small and insignificant species of your race arrived in the Upper Silurian age. You found the seas warm, the sunshine tempered by vapors, the stone lilies white as that then unknown thing, snow; the coral polyps like rainbows shimmered in the waters. You ate, swam, and were happy. You throve; you lived unobserved through Devonian days, and, ah, what vast mud beds, black with the decay of moss and ferns, awaited you in the Coal period! Seven species more came into your enlarging race, but you were humble still, and remained small and unobtrusive, lest some vast reptile should end your family line in his capacious maw.

One of your species, however, seized with ambition, developed beyond all the rest, and here in America grew into the size and shape you wear to-day. Fortune favored the bold, and the enterprising Yankee limulus stands at the head of your tribes until now. Back there in the Coal period your family were most of them weak, and wore the form not of adult king crabs, but of larvæ, with all the segments of the hinder shield free of each other; and that brave tail was but a rudimentary thorn. Perhaps this very humility, intense as that of Uriah Heep, has engineered you through the convulsions of the ages, to be the fellow citizens, and alas! the victims of the human race.

But now the anatomy rather than the history of my limulus attracts me. One of the ringed creatures you are, O crab, but your first ring has become enormously developed into the vast head shield with rounded front and beautifully bevelled edge, sweeping back into sharp and spiny corners, which, dragging upon the sand or mud, make the furrow on each side of your footprints. Here is this hinder shield, a rude triangle with the apex cut out to admit the insertion of the great tail; and this triangular shield is also made of rings, but they have grown together into one single piece. Still we can count them from the free, horny points.

This sword-formed tail, my limulus, did not belong to you when, first free of the egg-case, you sported in the water. It appeared only at your second moult. In this you were like your progenitors of the Coal period, who wore no tails; tails being then, no doubt, the royal insignia of the reigning line of reptiles, upon which meaner animals might not venture.

Your eyes are fitted into your head shield, and so are well protected. Let me turn you over and look at your feet. This great head shield it appears, houses not only your eyes, but all your walking and eating apparatus, which seem to be closely connected. When you were in the larval state you could double under the rings of your hinder shield, which then were not soldered together, so that you were neatly encased, and how safe you were!

Your legs are wondrous small for your size, and, O singular creature, you use not only your legs, but your hands and your antennæ and your maxillars for walking. And what is this? At the base of them all you have jaws. So away you travel on your numerous limbs, and whichever lucky member finds a morsel of food, behold a pair of jaws right at its base to devour it! Therefore are you rightly named a "mouth-footed" creature. There are certain mollusks with heads, which also have their heads and mouths and stomach in their feet. We hope, meeting them in the ocean, you do not hold yourself superior to them, for they are of lineage yet more ancient than your own.

Yesterday, Madame Limulus, you met your death as you came up the beach heavily laden with eggs, which you intended to deposit in the sand. If I state that a million of eggs now lie under your enormous shield, I do not think I shall over-estimate the number. You meant, as for many years past you have done twice each year, to come near high-water mark and place your eggs in the sand, where twice daily, as the tide was low, the heat of the sun would strike the eggs and warm them into life.

What was your own infant experience, my limulus? Fifty days, or seventy days, perhaps more,[1] you lay hidden in the egg, because all those changes which other crustaceans undergo after hatching, the royal limulus completes in the privacy of its elastic case. Change, change, still change, within the curtains of the cradle, and at last, out comes the living limulus, tailless, large-eyed, its hinder segments free of each other. Spiny, tiny, pale brown, glossy, a shell finer than a human baby's most delicate finger nail, able to swim, to find your own food, to double up and protect yourself, such you were, O limulus, on coming out of the egg.

You needed no parent to guard you, or forage for you; the sun had warmed you into life, and the ocean was your food-bringing mother. Child of the sun and sea! Such the ancients fabled Venus, the queen of beauty, and you, O my limulus, are one of the most uncomely of living things. When first you found your egg-case cleft away, and came out upon the wave, six pairs of feet were ready for your walking, swimming, and food-grasping apparatus. So well endowed with members for use, and with no brain capable of large ambitions, content with to-day, and ignorant that there was ever a yesterday, or that there will be a to-morrow, you,

[1] Dr. Lockwood kept some king-crab eggs in a dark place, three hundred and sixty days before they hatched.

no more than a child of the house of Hapsburg, expected beauty to be united to the splendor of —

A Very Ancient Line.

LESSON XXII.

THE MARVEL IN MAIL.

"The woods decay, the woods decay and fall,
The vapors weep their burden to the ground,
Man comes and tills the fields and lies beneath,
And after many a summer dies the swan,
Us only cruel immortality consumes." — TENNYSON.

THE first five lessons in this Nature Reader, No. 4, were devoted to a description of some of the prominent facts of the periods during which our globe was built up from an immense sphere of fiery gas, to the compact and inhabited earth which we know to-day.

The next theme of study was the solar system, under the laws governing which our world exists, part of which it is, and upon the members of which, the sun and the moon, we are so dependent that without them life on our globe would be impossible. That magic power whereby the plant world grows and ripens its fruits abides in the sunlight. It is the sun's heat which raises water from the earth in vapor, which returns to us in showers and dew. It is that same forceful heat, poured out on vast continents, that gives rise to the winds that cool our summers and speed the sails of our commerce. During how many ages has this lavish sunlight stored up coal for our use, that coal which flames in our grates and stoves, glows in our gas-lights, and drives the engines of our age of steam!

That lesser light which rules the night, the silver moon, not only serves to inspire poets and artists, and to light so many otherwise dark hours, but with mysterious attraction controls the tide in ebb and flow.

After our brief glance at the solar system, we have learned, by means of fossils hidden in the rocks, something of the wonderful progress of life through all the earth-building ages. As we have traced this slow ascent of life from its far-off, simple beginning, we have found that the first home of life was the ocean. When the world was wrapped in a mantle of seas, before the first continent thrust its rocky ridges above the waves, no doubt those warm waves swarmed with busy life. "The waters brought forth abundantly the moving creature that hath life"; and to-day, as in all previous ages, the sea is the headquarters and busy home of living things. In every zone the waters teem with animal organisms, so numerous that we doubt whether the sands on the shores, or the stars that fill space equal them for multitude.

After the survey of some of the vanished fauna that peopled the earth in past epochs, the next step suggested is to make acquaintance with yet remaining animal life, such as is more nearly related to extinct species than to any other surviving families. There are even now animals more or less common, that have altered little in the slow lapse of ages, and have their nearest affinities with fossil types. Such an one we have found in that most venerable of crustaceans, the limulus, or king crab.

Coming into creation some thousands or even some hundreds of thousands of years later than the crustaceans, the reptiles have left one of their early representatives, a conservative which has adapted itself to no new fashions, accommodated itself to no living species, but maintained its integrity as a near relation of a family of fossil lizards, whose remains are found in England near Warwick, in Scotland at Elgin, in Central India, and in South Africa, indicating that in their palmy days they were citizens of the world, widely spread, numerous, and nicely adjusted to the conditions of their age. This scion of a most ancient family whom we now introduce, claiming for it the regard due to long lineage, is named the sphenodon, or hatteria.

At present the hatteria holds aloof from general society, and unless forced to exhibit in zoological gardens, confines itself to a very limited haunt in New Zealand. In New Zealand a score or two of years ago, the hatteria crawled about with the slowness proper to long years and high dignity, and enjoyed a numerous family and a comfortable independence. Behold him, then, honorably divested of foolish pride in his pedigree, but carefully adhering to all the manners and traditions of his venerable line.

What a wonder is this, that a frail and short-lived creature should have maintained itself unaltered, generation after generation, while, with mighty convulsions the face of nature has changed, and changed, and changed again; the whole surface of the globe undergoing transformations which left unaffected this one little reptile.

The hatteria belongs to the lizard-like reptiles with tails and scales; is possessed of four legs, the front pair being hand-like in structure. The creature suggests to us some venerable grandparent who has divided a large part of his patrimony among numerous descendants and collaterals; for the other four orders of reptiles all share some of the characteristics of the hatteria, as if it had divided its traits among them. We might write them thus:—

Snakes. Crocodiles. Lizards. Turtles.	HATTERIA.	Fossil Saurians and Lizards.

So there is the hatteria, or sphenodon, a link between the new and the old. To explain all the points of likeness and difference would be to write an elaborate treatise on comparative osteology, or the science of skeletons.

While passing over in silence the matter of the bones, we can note a few plain points of likeness between the sphenodon and other reptiles. When the tail or any part of the tail is broken it is renewed as the crustaceans renew a leg or claw;[1] this power it holds in common with some of the lizards, which have very brittle tails. The vertebræ of the tail are made in two portions, and the line of junction in each vertebra is the weakest part; so if the tail is broken it is broken on this line, and not between two vertebræ; and on this line it is renewed. The famous philosopher, Aristotle, and that other famous ancient student of nature, Pliny, seem to have been much impressed with this ability to renew broken tails.

[1] Nature Reader, No. 1, Lessons 1–6.

The skull of the hatteria is more like that of a crocodile than like that of any other reptile; but on the other hand its legs are like those of the lizard, so that a description of the bones of the leg and foot of a lizard, would answer almost equally well for a sphenodon. The hatteria has nine more vertebræ in its tail than in all the rest of its body and its head together; and to aid it in its motions while impeded by this long tail, it has some especial muscles, such as are very prominently developed in the serpent family. As the hatteria grows old its teeth wear down to a simple cutting edge, as do those of snakes.

The New Zealand native name for the hatteria is rather pretty — tuatera. Strangely enough the Maoris of New Zealand have a superstitious horror of the creature, and turn pale and shiver with abject fear if they merely see one. Does the tuatera merit their aversion? Not at all. It is not handsome, some call it exceedingly unpleasing in appearance, but no creature is so absolutely harmless. It is without weapons of offence or defence, and without energy to use such weapons if it possessed them.

The hatteria, or tuatera, now lives in only one place in the world, and that place is a small rocky islet called Karenha, in the Bay of Plenty, in New Zealand. Formerly, the creature was abundant all along the rocky coasts of New Zealand, living in crevices of the rock, or in little burrows dug by itself. The settlers in New Zealand took a fancy to the hatteria as an article of food, and the hogs which the settlers brought with them, shared the taste of their masters, so that between men and swine, the poor creatures have nearly become extinct. Their sole chance of maintaining existence is to confine themselves strictly to Karenha, where not a shrub, nor blade of grass, nor lichen grows, and where not a fresh-water spring is known.

On this desolate island the hatterias lie, clinging to the bare rock, absolutely quiet, apparently unconscious, and alike indifferent to the whipping of sharp, cold spray driven by a strong wind, and to the fierce beating of the sun.

The hatteria is from eight to twenty inches long, is of a bronze or olive-green color, spotted with yellow above, and fading into greyish white below. Down the back and along the tail, are sharp spines or bristles in a ridge or crest, which the creature can erect at will. Its eyes are golden, and instead of the vivid quickness of the jewel-like eyes of many lizards, these organs in the hatteria have the dull stare of glass eyes. Also, instead of the flash-like motions of many lizards, the hatteria is the slowest of living things. Hour after hour, day after day, it will lie like an animal fashioned of wax, desiring neither food nor drink, and seeming to need almost no air.

Often people stand for a long time before the glass case of the hatterias in the London Zoological Gardens, and from the absolute quiet of the creatures, conclude that they are stuffed. But finally they see the head turning, or the body sliding forward, with an almost imperceptible motion, slow as that of the minute hand of a clock. Or, looking a little closer, the motion of the heart may be recognized by the slow palpitating of the loose skin near the fore-arm.

The hatteria seems as contented when kept in a glass case, as when extended on its native rocks. One wonders how a creature can possess so few of the evidences and the needs of life. It makes no noise, shows neither fear, hope, affection, nor anxiety; one might think that the accumulated age of all its long race had invaded its cold veins, and that it was verging on petrifaction.

The hatteria in one single small specimen is the sole living representative of the genus, family, and order to which it belongs. Its fossil relatives partook of characteristics now scattered among members of different classes. One of them approached the birds, in having no teeth and a beak-like projection of the jaws; others were like fish, in having teeth set not only in their jaws, but also, as some fish do, "in the velvet,"[1] namely, all down the sides of the throat.

The great value of the hatteria now, is the light which it throws on obscure points in the structure of its fossil relatives. Helpless and inert, it seems to belong rather to past ages and to the dead, than to to-day and the living.

[1] Nature Reader, No. 3, Lesson 45.

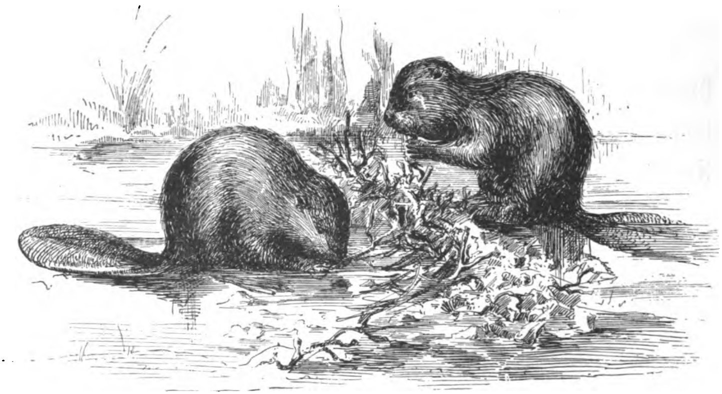
LESSON XXIII.

THE ANCIENT BUILDER.

"Again the mossy earth looks forth, again the streams run clear;
The fox his hillside cell forsakes, the musk rat leaves his nook,
The blue-bird in the meadow brakes is singing with the brook;
'Bear up, O mother nature,' cry bird, breeze, and streamlet free,
'Our winter voices prophesy of summer days to thee.'"

— WHITTIER.

ONE of the most celebrated animals in the world is the beaver. This creature belongs to the mammalian order, Rodentia, or the "gnawers." The mammals of this order are distinguished by their strong, chisel-shaped front teeth. They



THE WONDERFUL BUILDER.

have a greater number of species, and a wider distribution over the earth than any other terrestrial mammals. To this order belong squirrels, rabbits, rats, mice, and many other species, and the order, as a whole, will be briefly described in a later chapter. At present we must fix our attention upon the beaver, which Buffon said constituted such a link between quadrupeds and fishes, as is the bat between quadrupeds and birds. In fact neither bat nor beaver is a link between different orders, but the beaver is nearly as aquatic in its habits as a fish, and its tail is about as well covered with scales as is the body of a fish.

The beaver is an animal of great geologic age: its fossil remains have been found freely distributed over northern Europe, Asia, and America. At present it has entirely disappeared from many countries where formerly it abounded. In some places in Europe it has abandoned many of its most peculiar and interesting habits of life, and sunk slowly to nearly the condition of its distant relative, the water-rat.

In truth, the beaver, like the king-crab, is a creature evidently doomed to extinction. The cause of the rapid disappearance of the beaver is the value of its fur, which has caused it to be hunted with a reckless disregard of the danger of destroying the entire family. The story of the fate of the goose which laid golden eggs is not wholly a fable, but holds true of many valuable and beautiful plants and animals, which human greed has ruthlessly destroyed. The beaver no doubt had a very happy time building its huts and dams, feeding on roots and bark, and swimming merrily in the rivers, before men were known upon the earth.

The beaver is the largest of the rodents except the capybara or water-hog of South America. The beaver is sometimes three feet long, exclusive of the tail, and a very large beaver will occasionally weigh as much as sixty pounds.

The oval, flattened tail is about ten inches long, and is covered with scales. About this tail, as about the habits of the beaver, many foolish stories have been repeated. It has been stated that he uses it as a little cart whereon to drag loads of stone and mud for his dam; also that he uses it as a trowel to smooth in nicest mason-fashion the earth walls of his house. Neither of these tales of a tail is true.

The scaly tail of the beaver is of especial use in helping to support his body when he stands on his hind-legs cutting down trees. One of its uses is that of sounding an alarm when disturbed in his retreats: then the beaver rounds up his back, and brings down his tail on the water with a blow which can be heard for a long distance.

The hind feet of the beaver are webbed up to the toe nails, like those of a duck or gull. In swimming the beaver uses only the hind feet, the front feet, which are small and serve almost exclusively as hands, are kept hanging close by his side while he moves in the water. The head of the beaver is short and rounded, and its upper lip is cleft, probably for convenience in using its powerful incisors in cutting down trees and stripping off bark.

The front teeth of the beaver are very remarkable; they are long and chisel-shaped, with a sharp, cutting edge. The outer layer is made of very hard orange-colored enamel; the inner portion is softer and wears away by the constant use of the teeth; and thus a chisel-like edge is left. As the four front teeth wear down they are reproduced, growing up constantly from the roots. The teeth of the beaver are so sharp and hard that the Indians formerly used them, fastened into handles, for cutting their bone implements.

The eyes of the beaver are small, and the ears are inconspicuous. When swimming or diving the beaver can draw its ears close to its head, closing the orifice against the admission of water. The whole appearance of the animal is without beauty, as the soft, silky brownish fur is hidden by a growth of long coarse reddish-brown hairs.

In America the beavers still live in communities and build homes, but in Europe, where they cannot find secluded and undisturbed ponds and rivers, they have changed their habit and live solitary and in burrows, their huts and dams being now known only in one place in Europe. In America there are found some few beavers living alone in burrows; these are called "idlers," or "bachelors." They are supposed to have left the colony because their mates have been killed.

In their natural state beavers live chiefly on the bark of shrubs and trees such as birch, alder, poplar, willow, while a favorite article of food is the root and stem of the yellow water-lily. In captivity they eat bread and raw vegetables, and while they greatly enjoy water for a bath or a swim, they will learn to content themselves without it. It is a pity that any web-footed creature should be held in captivity, where it cannot be provided with an abundance of its natural and favorite element.

In summer the beaver leaves his home, and setting off as if intent upon having a merry time, spends the warm season in roving about the streams and banks, feasting on fresh herbs, and playing with his fellow-citizens of the stream. During August, with provident care he cuts down trees for the repair of his home and dam, but does not begin their renovation until the frosts come. This delay probably does not arise from mere idleness, for the beaver is not the tramp of the brute creation, who keeps the roads until forced by the cold to seek shelter. The late repair has its advantages. The last coat of mud applied to the habitation presently freezes hard as a stone, and neither wolves nor wolverines can break up the roof and disturb the repose of the owners of the house.

The beaver is an inhabitant of north temperate climates, where the winters are long and the cold sharp: he is a creature of solitudes where wild carnivorous animals share with him the woodlands and the banks, and to them as to man, he is likely to fall a prey. The hunters and trappers as well as the wolves consider the beaver's flesh a toothsome morsel, and not only is his fur an article of commerce, but a substance called castoreum found in two small sacs in his body is used to some extent in medicine and perfumery.

Against the wild beasts, the well-built wigwam and the doorways entirely under water, in a measure protect the beaver; but the trappers secure him by traps set in his pathways or near his door. No wonder that the beaver always abandons a locality as soon as it is settled by his chief enemy — man.

And now what of this dwelling which the beaver constructs for himself, provisions, and makes his winter quarters? Wonderful tales have been told of it, as that it is well built of logs and interlaced wattles, plastered securely, and that a proper depth of water over its entrance is secured by the construction of a dam, so large, strong, and well-built, that a man on horseback can ride over it where it lifts above the water. Unhappily much of this is fiction. Let us sift out the truth.

The natural home of the beaver is not a burrow like that of a water-rat, but a wigwam above ground, built of heaped-up poles, branches, and roots, filled in with short sticks, stones, and sods. The shape is that of a low dome-like brush heap. Inside the irregular dome which is some eight or nine feet in diameter, is a small room which is the living room of the beavers. Several of these huts are placed near together and each has but one compartment; the tales of homes of many rooms have arisen from finding the various separate homes of the colony resting against each other. In each of these huts from four to eight beavers live. In the sides of the room are the beds of leaves, each beaver having a bed of its own. The centre of the apartment where they gnaw the bark from the short sticks which they bring in serves as a dining-room. They are very cleanly, and carry out all rubbish and refuse. The beaver house has no opening above ground. The two doors to the wigwam are in the floor, opening into long underground galleries, one connecting with the piled-up store of food branches, the other leading out toward the bank. Thus there is no approach to the home of the beaver except by passing under the water, and it is to secure a depth of from twenty inches to three feet of water over the entrance passages that the beaver builds a dam.

If the bank or island where the home is built is so placed that a proper current and depth of water over the passages to the food pile can always be had, the beaver builds no dam. If the water is likely to run low the dam is built. The dam is a loosely constructed barrier, seldom in water over three feet deep, and generally rising but little above the surface. As the parts of trees of which it is built are of kinds which easily take root from rods or wands, as willow, birch, and alder, these sometimes shoot up and spread, growing into a kind of hedge, which, catching débris coming down stream, constantly increases the strength and size of the structure. Slight and low as the beaver dam is, it is marvellous that a brute should construct it, and its size is by no means contemptible. One giant dam, seven feet high and a quarter of a mile long, is mentioned by H. P. Wells, an accurate observer. Especially is it marvellous that in the places where there is little current the dam is carried straight across the stream, while in those where the current is strong the structure has a deep curve down stream, and is thus capable of resisting the force of the water.

In building, the beaver trusts to the water for the conveyance of most of its materials, but it carries roots, stones, sod, and mud, by holding these between its chin and fore-paws. It floats its wood wherever it wishes to have it by swimming behind it. Not only this, but this wonderful builder is shrewd enough to cut down trees with its strong, chisel-like teeth. It selects those near the stream bank, and is sufficiently skilled in woodcraft to make the tree fall toward the stream, by cutting into it most deeply on the water-ward side.

The beaver works almost entirely at night; but whether under the direction of some one skilled beaver architect, or whether like the ants and bees,[1] all work guided by a common instinct that produces harmonious labor, is not known.

Quite as wonderful as the dam building is the canal making. This work they undertake in order to facilitate the moving of food and building material. Canals are described by Wells which are three feet wide, over two hundred feet long, and which carry from eighteen inches to two feet of water.

In the huts in winter the mother beaver suckles and rears her young ones. When the family in one cabin becomes too large the young beavers move off and build a home of their own, not too far from the original dwelling, to share the advantages of the same dam. Frequently remains of old beaver dams are found in fields now grassy or under cultivation, but which were formerly ponds or wide curves in the beds of streams. While to the casual glance these may appear to be natural ridges, their regular sweep, equal strength in all parts, and their material prove them to be the work of this ancient family of builders.

[1] See Nature Readers, 1 and 2, Lessons on Bees and Ants.

LESSON XXIV.

AN OPOSSUM HUNT.

"Within the twilight come forth tender snatches
Of birds' song from beneath their darkened eaves;
But now a noise of poor ground dwellers matches
This dimness; neither loves, nor joys, nor grieves.
A piping slight and shrill, and coarse dull chirpings, fill
The ear, that all day's stronger, finer music leaves."
— LOWELL.

"IF you want to find out anything about 'possums, go to Uncle D'rius; he knows all about them" — this was the universal opinion in F—— and one day, when my mind was greatly exercised about opossums, I repaired for information to "Uncle D'rius." I found that mine of didelphian wisdom seated at his front door, with his hands on his knees. "Uncle Darius," I said, "I want you to tell me all about opossums."

The old negro rubbed his gray head: "'Possums!" he cried, his bleared eyes lighting at his favorite theme, "'possums! 'possum am 'bout de bes' thing in des y'ere worl', w'en h'it am roasted!"

"But tell me something about them *alive*," I urged.

"'Live? 'Possum am a mighty onconsideratin' animal when h'it 'live. An' w'en a man kin ketch 'possum any time he go fur him, he am a berry sma'at man, fo' sho! Dere's ony one sech man in dese y'ere pa'ats, an' h'it am Uncle D'rius w'en he was young an' spry."

And that was all Uncle Darius could tell me about opossums. Certainly he knew very much more. He had hunted them, and eaten them, and brought home baby opossums to bring up for pets — but unluckily, Uncle D'rius had not habits of observation, nor any gift for telling what he knew. Fortunately I had other means of learning something about opossums. Let us first indulge in a few plain statements about the opossum, and then devote a little time to some of its interesting habits.

1. The opossum, like the beaver, is a very ancient animal; its fossils are plentifully found in the strata of the Eocene age, the first age of the last world-building period.[1]

2. The opossum is entirely an American animal; is unknown in Europe and Asia; and is found from the northern part of the Southern States to the north boundary of Patagonia.

3. It belongs to the mammalian order of marsupials, or pouched animals, furnished with a pouch or pocket for carrying the young.

4. Its nearest relatives are found in Australia.

5. With one exception it is the lowest of the mammalian orders.

6. Its scientific name is Didelphys.

7. This family has two groups: first, a very large group to which the opossums and their nearest kin belong; the other group has but one species of animal, the yapock, which thus claims a whole genus for itself.

The yapock is a little creature with webbed feet, aquatic in its habits: it feeds on fish and small crabs; its home

[1] The chart which serves as frontispiece should be often consulted to fix these periods in the pupil's mind.

is in Guatemala and Brazil; its fur is gray marked with brown.

Having disposed of the genus represented only by the yapock, let us describe the opossum and the general characteristics of its kindred. The animal is small, varying from the size of a mouse to that of a large cat. It has several very marked characteristics.

First, the opossum has a great number of teeth, fully fifty. These are fitted for tearing and eating flesh, for grinding up the horny bodies of insects, and also for devouring roots, berries, eggs, and fruits. While belonging to the carnivorous class of feeders, the opossum is thoroughly omnivorous, and seldom finds any variety of food which he disdains to taste.

The second marked peculiarity is the pouch, formed of a large fold of the skin of the under part of the mother opossum's body. This fold makes a bag, supported by two slender but strong bones, from which the order receives its name — didelphys. In this bag the mother opossum stows her little ones, and carries them about with her until they are old enough to be weaned, and can look out for themselves.

The third notable mark of the opossum is its tail, which is long and supple, and has its terminal half bare of fur and covered with scales. This tail is called prehensile, because hand-like it can clasp itself closely about any object with which the creature would servè itself as a support. A few turns of this lithe tail about a branch will bear the weight of even a mother opossum loaded with her pouch full of little ones; and a vigorous shaking of the branch cannot dislodge her.

The fourth remarkable characteristic is to be found in the feet of the opossum. These have each five toes, and on the hind feet the large toes are without nails, and are set thumb-like in opposition to the other four, so that these hind feet are really strong and supple hands.

Finally, the opossum is distinguished by the large number of its progeny. A cow marches about followed by a single calf; a sheep but seldom has twin lambs; the lion never has more than two whelps; but the prolific opossum goes skipping around with fifteen or sixteen little furry children gambolling after her, or thrusting their sharp noses from her warm pouch.

The nose of the opossum is sharp, long, and well provided with whiskers, as is that of a cat; the eyes are dark, sleepy looking by day, but bright and alert by night, for the opossum is a night-prowler; the ears are erect, large, and leaf-like.

The fur is coarse and of a light gray color; occasionally a pure white opossum is found, while the smallest of all the species is dressed in bright red. This soldier-dressed opossum is no larger than a house mouse, and is a native of Mexico. In Brazil there is another small species which looks much like a "chipmunk," having a reddish gray coat with three black bands down the back.

One very interesting member of the family is called "Lord Derby's opossum"; it is a native of South America, and is rather larger than a gray squirrel; its fur is short and close, its tail is entirely covered with scales; and usually the mother is without the pouch for the young. To make up for this lack, she arches her long tail forward, puts all her children on her back, and they curl their limber little tails about the over-arching tail of their mother; thus, secure from falling, they ride around in state on their soft, fur coach.

An extreme love for its numerous offspring is an eminent trait of the opossum. The mother does not, like many human mothers, leave her children alone, or in the streets, or with a nurse, while she goes visiting, shopping, or feasting. She always takes the children with her, and is never happy unless her furry brood is close beside her.

The largest and best known of all the opossum tribe is the Virginia opossum, a common variety in many parts of North America. Although it is of too nervous and irritable a disposition to be made a pet, it frequently lives in towns. Hiding by day on the roof or in the sewers, and coming forth at night for food, it acts as a scavenger.

The little opossums are born in the spring, and the mother packs them all in her fur pocket, and carries them about with her until they are able to run, and to feed themselves. When they begin to go alone they keep near the mother, and if alarmed rush to her and try to nestle back in their safe early quarters.

The Virginia opossum is particularly fond of the banana-shaped fruit of the pawpaw tree, and on the moonlight nights in the autumn when these are ripe, the opossums gather from far and near about the low, wide-spreading trees, and have a grand picnic. It is useless to try to shake the animals from the trees; for, wrapping their flexible tails about the branches, they hold on with a persistency that defies the rudest jar.

When caught, the opossum feigns death, and no abuse, less than putting a live coal to its nose, will cause it to give sign of life. Happily this cruel test cannot often be applied. Many an opossum, caught robbing a poultry yard, has been left for dead by the farmer, and as soon as his back was turned has nimbly picked itself up and glided away. So, too, many a negro has brought home from a "'possum hunt," a captive, which he designed for his favorite feast; but as he kneeled by the hearth to stir up the smouldering fire, the wily opossum lying where it had been flung on the floor, stealthily opened one eye to investigate the situation, then like a flash leaped from door or window, and was back to the woods.

Opossums live in clefts of rocks, holes in the earth, and in hollow trees. When hunted they take refuge in the first hollow tree they can find, and many a tree is felled by the 'possum hunters that they may cut the animal out of its retreat. The flavor of the flesh is much like that of a young pig.

In South America the opossum seems to fill the place of an insect eater, occupied in other countries by the true insectivora,— the hedge-hog, mole, and shrew. Probably in countries where they are plentiful, the opossum eats more insects than all other insect eaters put together. Its teeth are provided with numerous little points which enable them to grind, as in a mill, the horny bodies of insects.

Young birds, and young barn-yard fowls, eggs, such little animals as mice, moles, toads, and the young of rabbits and hares, tempt the appetite of the opossum, who is a general depredator. In return, either for vengeance, or to obtain its flesh for food, the opossum is preyed upon, and were it not for its enormous yearly increase would soon be exterminated.

In Australia a little animal named a phalanger, or fingered animal, is called an opossum, and, indeed, closely resembles the real opossums, though it is of a different family. Its size, pouch, and general habits might lead it to be mistaken for one of the opossum tribe. Many of these phalangers have the skin stretched as we see it in a flying squirrel, on each side the body between the front and hind-legs. Extending this as they spring from tree to tree, they are up-borne and can make enormous leaps.

One of these flying-squirrel phalangers is often called "the most beautiful of all mammals"; its shape is so graceful, its fur so rich, and its tail so long and handsome. Another phalanger is called the *acrobat*, on account of its wonderful jumping: it is smaller than a mouse, and lives daintily upon honey and certain honey-seeking insects; thus its appetite offers a strong contrast to that of the greedy opossum.

LESSON XXV.

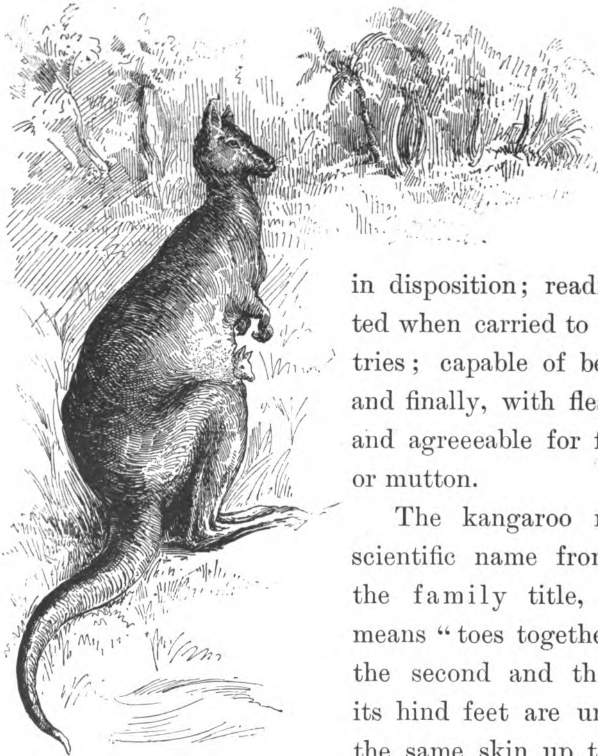
A NEW FASHION OF PAPPOOSE.

"Still this great solitude is quick with life;
Myriads of insects, gaudy as the flowers
They flutter over, gentle quadrupeds,
And birds, that scarce have learned the fear of man
Are here, and sliding reptiles underground." — BRYANT.

THE opossum was chosen as the first representative of the pouched animals, not because it is the most remarkable, but because it is the best known, and because living specimens of it may be easily obtained if desired. In our study of the opossum we spoke of Australian animals, because the opossum has its kinship with the quadrupeds of that great island continent.

Australia is the country of ancient forms of animal life, and most of its quadrupeds are marsupials. Zoologists have wondered why the types of animal life in Australia are so few and so ancient, and have endeavored to find the explanation of these facts in considering that during many geological ages Australia has been divided, as it now is, from the Asiatic continent and that the great series of creatures which have arisen since that division took place, including all the higher mammals, never reached Australia, until recently introduced by Europeans. Thus, as the stronger and more dominant creatures did not appear to disturb or displace them, there was nothing to hinder the continuous development of pouched forms; and families became permanent which in more crowded localities have been forced out of existence.

Chief among all the Australian marsupials stands the kangaroo. This is really a beautiful animal; wonderful in its structure, interesting in its habits; amiable, and gentle, yet courageous in disposition; readily acclimated when carried to other countries; capable of being tamed, and finally, with flesh as useful and agreeeable for food as beef or mutton.


A QUEER PAPPOOSE.

The kangaroo receives its scientific name from its feet; the family title, *syndactyla*,[1] means "toes together," because the second and third toes of its hind feet are united under the same skin up to the nails. The generic name, *macropus*, or "big foot," is given because of the enormous length of the hind feet. In truth the fore-paws of the kangaroo are rather hands than feet. At first sight of this animal it is the re-

[1] Pronounced sin-*dak*-tilla.

markable disproportion between the shoulders and fore-legs and the hind-legs with their enormous haunches, which chiefly impresses the beholder. It is as if the head and shoulders of a rabbit or hare had been united to the hinder part of a creature as large as a pony.

"This must be a very ill-shapen creature" we might conjecture from such a description. But no; the remarkably large tail, the strong, active motions, the thick fur, the bright and gentle expression of the eyes, the erect posture of the kangaroo, unite to make it a very attractive animal. The kangaroo does not go on all fours except when it lowers itself for grazing; it holds itself up; its fore-paws hang before it like arms at rest and it moves by rapid leaps. When standing quietly, it supports itself upon its long, strong tail as well as upon the hind-legs.

That ancient lizard, the iguanodon, which used his two hind-legs and his strong, pointed tail as a tripod whereon to seat himself, set the fashion, it seems, to some of those little marsupials which were crawling and jumping around his feet, and might have been crushed under his mighty tread. But these frail and unpromising families of mammals have survived the iguanodon and his race by countless generations.

The adult kangaroo weighs some two hundred pounds; but of kangaroos there are a number of species, and these differ in size, one species being no larger than a hare and weighing less than four pounds. This little creature is called the hare kangaroo and is the most agile of the family, making without difficulty, jumps eight or ten feet high. Fossils of the kangaroo type have been found in Australia, which suggest that the family formerly had monstrous members. Some were perhaps as large as the mastodon. When the kangaroo is spoken of in general, reference is had to the distinguished and most common variety, *Macropus giganteus*, "the giant big foot."

The kangaroo was entirely unknown to the civilized world until 1770, when Captain Cook put into the river Endeavor on the northeast coast of Australia. While he was delaying there to repair his ship which had been damaged by a storm, a number of large and singular animals appeared from the woods and stood erect, gazing at the men and ship with mild curiosity. They were too timid to permit approach, and darted away in long bounds across the grass when people went toward them. The natives, when asked about them, replied with a strange word which the Englishmen pronounced and spelled kangaroo, or kanguru. Such a word is now unknown in any native Australian dialect, and it is uncertain whether it was intended as the name of the creature in question, or merely signified "Don't know." However, the word has come into general use among all nations as the common name of this animal. Finally one of Captain Cook's party, Mr. Gore, went out gunning and shot one of the strange creatures. Then several more were killed, and Captain Cook took home the skins. These were examined by naturalists of different countries, and Schreber, a German, pronounced them animals more closely allied to the American opossums than to any other creatures; for at that time opossums were the only known pouched animals. In his work on mammals Schreber called the kangaroo the gigantic didelphys. In 1791 Dr. Shaw, being better informed about the kangaroo, called it the giant macropus, or big foot, and that has since been its scientific name.

The kangaroos are vegetable eaters, thus differing very greatly from the carnivorous opossums. They feed on grass, roots, and nearly all green herbs. Sometimes as they browse they get down on all fours and move slowly about in this position, which is as awkward to them as creeping is to a full-grown man. But while browsing in this posture, they frequently raise themselves on their hind-legs and look about to see if enemies are approaching; for they are exceedingly timid. When alarmed they take refuge in flight, being almost as inoffensive in their dispositions as sheep.

The fore-feet of the kangaroo have five toes, each furnished with a large, strong nail; the hind-feet are exceedingly long and have but one really well-developed toe; this one corresponding to the fourth toe of a human foot. This toe is very large and strong and has a long curved nail, furnishing the kangaroo's chief weapon. There is no great toe on the hind-foot; the second and third toes are very slim and small and are enclosed in a common sheath up to the nails. They are used only to scratch and clean, comb-wise, the animal's fur. Just outside the large fourth toe is a smaller one which is serviceable in walking, and also in fur-cleaning.

While usually mild and timid the kangaroo, especially the adult male, or the mother with a little one in her pouch to fight for, will arouse herself to great courage and give battle. At such a crisis the kangaroo will seize a dog in its fore-paws and squeeze it to death, or tear it to pieces with the large toes of the hind-feet. A kangaroo is also able to wield its tail with the strength and precision with which a man uses his arm. When chased by dogs the kangaroo will sometimes, with this long, heavy tail, strike its pursuer a blow so severe as to stun or kill it.

Occasionally adult male kangaroos will have a battle or duel. They stand face to face, bracing themselves by their tails, and simply claw at each other until they have satisfied their anger.

Sometimes when hunted by men or wild beasts the kangaroo is brought to bay, and defends itself in a peculiar fashion. It secures a position against a tree, or some object high enough to rest upon, clasping it with its fore-paws; then it braces itself firmly by its tail and lashes out with its hind-legs, armed with the immense toe and nail. In such circumstances an angry kangaroo is a very dangerous animal to approach. The place to lean upon while showing fight in this fashion is indispensable, because the kangaroo lifts both its hind-legs at once. It cannot make a stepping motion, lifting first one leg and then the other; nor can it rest upon one leg and kick with the other: the motion of the two legs must be similar and simultaneous.

The kangaroo differs from the opossum in the number of its teeth, having but thirty-four instead of fifty. These teeth are formed entirely for cutting and grinding vegetable substances.

The kangaroo differs from the opossum as much in the number of its family as in the number of its teeth. At the most two little ones complete the litter, and these when born are almost the tiniest of quadrupeds, are blind, helpless, and with bare skins instead of such warm fur coats as furnish forth little kittens. These feeble babies are snugly tucked in the fur pouch of their mother, and there, kept warm and well fed, they grow rapidly. The mother meantime rambles around, feeding and attending to her affairs with all the indifference of an Indian squaw with her pappoose tied to her back. The squaw's pappoose is hung over her shoulders, so that it looks out on the world from her back; the kangaroo's far older style of pappoose is carried in a front pocket, where it is always within reach of its mother's hands and under her eyes. When the kangaroo pappoose has been for some weeks tucked snugly away, it finally gets its eyes open, is covered with a lovely, soft coat, and begins to feel an interest in the world at large. Then it thrusts from the pouch its head, which is a funny little copy of the maternal head above it. Like its mother it has large, erect ears, bright eyes, and an intent expression.

The sight, smell, and hearing of the kangaroo are extremely well developed, and, owing to its timidity, the creature is always on the alert to discover if enemies are near. It stands a picture of attention, its eyes gazing steadfastly, its ears erect and set toward the wind to catch the first note of danger, the flexible nostril quivering as it scents now here, now there, for warning of a foe.

This timidity also causes the kangaroo to avoid solitude; they neither go singly, nor in pairs; but in little groups, each group or herd under the charge of some strong and wise old male kangaroo. These bands are often made up of an old father and mother kangaroo and their children. One, and sometimes two, little ones are born at one time, but as they attain their growth they linger about their parents. Thus the adult pair will be followed by a train of eight, ten, or twelve children of all ages and sizes, from full-grown specimens, seven or eight years old, down to the keen-eyed little creature peering out of its good mamma's fur pocket. It was formerly the custom of that nearly extinct animal, the bison, to go in herds, led by the oldest and strongest fighters.

Kangaroos prefer to graze in the vicinity of woods; for they are good climbers, and given to taking refuge in trees. When the jump, for which the kangaroo is famous, is made, it is by muscular contraction of the great hind-legs, and with this effort they droop the head and shoulders, and balance them by the long tail, which during the jump is held horizontally backward.

When full grown the coat of the kangaroo is silky on the head, shoulders, and tail, and woolly on the body. The skin, especially of the legs and haunches, is thick and tough, and makes good leather. The avidity with which these animals are hunted in Australia will soon make them as scarce as bison have become from the same reckless slaughter; and unless means for their preservation are taken, the nineteenth century is likely to see the extinction of this remarkable, ancient macropus family.

The kangaroo is so easily acclimated that some effort is being made in Europe to breed kangaroos. As they are readily kept it is thought that, domesticated and carefully reared, they would be as useful for hides and flesh, as cattle or sheep.

LESSON XXVI.

LOW DOWN IN THE SCALE.

"Parts relate to whole;
One all extending, all preserving soul
Connects each being, greatest with the least;
Made beast in aid of man, and man of beast;
All served, all serving, nothing stands alone;
The chain holds on, and where it ends — unknown."
— POPE.

CAREFUL and pains-taking observation has lain at the beginning of most great discoveries; the busy miner, not the careless idler, finds the gold. A course of accurate study in some particular department of science has often opened up new views, and afforded new data in some very different and equally important subject. Thus diligent investigations in the flora and fauna of various countries have not only revealed facts connected with plants and animals, but have unfolded new chapters in the history of earth-building.

A very minute study of the plant and animal life of Australia, New Zealand, South America, and some of the South Pacific islands has made clear the fact that certain types are common to all those localities, and are not found elsewhere. Does some one say, "What is curious about that? That is nothing!" To the ardent disciple of science, whose mind is keenly at work on the problems of nature, this fact means much. The first deduction from such a fact is that these lands must once have been very nearly united, while widely separated from the rest of the world, and that over them plants and animals have spread from a common centre.

Following the hint thus given, it has been concluded after more extended observation, that at some former time there was around the South Pole a great Antarctic continent, or a vast archipelago with its islands closely strewn upon the South Polar sea, which then was not a desolate waste of ice-floes, diversified by glittering icebergs, but was mild and beautiful as the Pacific.

We have seen that once the North Polar lands enjoyed a temperate climate and abundant vegetation. No doubt the South Polar regions were blessed with a similar golden age. Since this Antarctic continent stretched out to join, or nearly join, Australia, New Zealand, South America, and certain of the South Pacific islands, its fruits, flowers, birds, beasts, and fresh-water fishes were distributed among all these countries. When climatic changes came to the Antarctic land; when, perhaps, much of its shores were submerged; when deep and icy waters flowed where reefs and shallows had been: when whole islands sank beneath the waves never to rise again, — then Australia and New Zealand were for long ages parted from the rest of the world.

The attention of explorers has been directed to the Arctic, rather than to the Antarctic regions; thrilling adventures at the north have provoked ardent minds to seek adventures yet more thrilling. The search for sperm whales and for a Northwest Passage has diverted interest from the Antarctic land, where marvels as great and rewards as rich, no doubt, await the explorer. Now that interest in these unknown regions has been roused it may not be long before we learn the secrets hidden for ages in ice-caskets in the south.

The tide of modern civilized life set but slowly toward those great continent-like islands which lie far to the south of Asia. Thus it happened that the plants, animals, birds, and insects that follow the progress of civilized man across the world were long unknown in these localities, while their own plants repeated themselves seed-time after seed-time, and the helpless, clumsy, old-fashioned fauna kept their race intact, living undisturbed in the methods of their earliest ancestors. The hunter's dog and gun were unknown: the teeth of hogs turned loose to revert to the manners of wild boars, and the claws of cats relapsing from domestication to the state of savage feline tribes, did not molest the defenceless ancient families of Australian beasts. So it has happened that this country and New Zealand have preserved some marvellous types of life.

When travellers first described the curious creatures that they had found living in the Antipodes, their accounts were met by that disbelief which has often waited upon the first proclamation of truths.

The facts that the world is round; that, with regard to the earth, the sun is stationary while the earth moves; that far to the north the sun continues for weeks above the horizon in a long day without a night; that one can pass the Straits of Gibraltar — then called the pillars of Hercules — and sailing south can circumnavigate the extremity of Africa, — were long ago received as idle tales unfit for belief. In fact, some of these statements were thought to be so false that the very announcement of them was criminal.

The poet tells us that the discoverer of the North Cape, the Norseman Othere, went to the court of King Alfred to relate to him the wonders of the far north and the mighty walrus hunt held there. King Alfred could not believe the tale.

"'Four days I sailed to eastward,
Four days without a night:
Round in a fiery ring
Went the great sun, O King,
With red and lurid light.'

"Here Alfred, King of the Saxons
Ceased writing for a while;
And raised his eyes from his book,
With a strange and puzzled look,
And an incredulous smile.

"'There were six of us all together,
Norsemen of Helgoland;
In two days and no more
Walrus we killed three score,
And dragged them to the strand.'

"Here Alfred the Truth-Teller
Suddenly closed his book,
And lifted his blue eyes,
With doubt and strange surmise
Depicted in their look."[1]

Such doubts from honest souls have attended the declaration of new truths, and strangely enough, extraordinary fictions have usually been more willingly received than extraordinary facts.

When the early travellers in Australia declared that they had there found animals like none other in creation, mammalian

[1] Longfellow, "The Discoverer of The North Cape."

creatures that laid eggs and suckled their young; four legged, fur or quill-wearing animals, that were toothless, had duck's bills, were aquatic in their habits, built nests, and had webbed feet, the description was received with a howl of derision. When skins of the marvellous creatures were sent home for inspection doubt still remained, and it was said that by some skillful manipulation the "head of a new kind of duck had been fastened to the body of a new kind of beaver to deceive science with a new kind of animal!"

Wider zoological knowledge might have suggested that these creatures which were esteemed mere myths not only existed but were exactly what was to be expected. For as "Nature makes no leaps," it was in entire harmony with the plan and progress of creation, that the order which was lowest in the scale of its class should share the characteristics of the next lower and less highly organized classes.

The new world had already surprised the old with the marsupial opossums, and later Australia had contributed many other families of pouched animals. These had been placed in the lowest order of mammalian life. But here was a new type evidently lying still lower in the scale; and whereas some others of the newly discovered creatures bore some of the traits of ancient reptiles, these seemed to ally themselves to birds. It was hard to be believed.

When at last the disputed animals had been caught, tamed, and sent to England and Germany for examination, great was the amazement of the scientific world. Articles were written, pictures were made, and for a time the new beasts were the theme of general discussion. The first name given to the first specimen was the platypus, and duck-billed platypus was the common designation for a time from 1799. The colonists in Australia meanwhile named the duck-billed and beaver-like animal a "water-mole," from the fashion of its feet. The name platypus, however, was dropped because it had already been conferred on another creature. Then more learned heads were put together, and a name was produced so long and hard in Latin, that I dare not quote it. It meant, however, "bird-beaked-paradox."[1] Probably the reason the poor thing has survived such a name is that it knows nothing about it.

The finding of these curious animals made it necessary to erect another order in the mammalian class, an order that should embrace creatures lower in the scale than the marsupials. Four species under this order have been found, and probably there are no others. The duck-bill and the echidna, or "thorny" creature, are the two most interesting, and with most marked characteristics; to them we will now devote our attention. We shall see that no name more apt than that of "paradox," could be given to creatures with such apparently contradictory characteristics.

[1] "*Ornithorhynchus paradoxus.*"

LESSON XXVII.

THE MALLANGONG.

"I'm truly sorry man's dominion
Has broken nature's social union,
And justifies that ill opinion
Which makes thee startle." —BURNS.

ENGLISH settlers had not been long in Australia before they were told by the natives of a very curious animal, the description of which seemed rather that of an imaginary than of a possible creature. The animal was called by the Australian natives a mallangong, and was said to be very shy and secretive in its habits. The traders who heard these stories concluded that they dealt with some fabulous beasts, such as appear in the folk-lore of nearly all countries.

But one day a trader who was interested in natural science was standing on the bank of a pond, when suddenly a new animal rose to the surface of the water and swam noiselessly about. The creature had the soft thick fur of a beaver or otter, now apparently black, as it was wet and clung closely to the skin. Four legs the trader counted, and as the feet came to the surface they showed that they were webbed and pink-palmed like a mole's feet. Stranger still, the small, pointed head appeared to have neither eyes nor ears, yet bore above the water a large, flat duck's bill.

As the excited trader looked, the beast sank noiselessly out of sight. He realized that he was the first white man who had seen a mallangong, and that the strange tales were true tales. The Australian wonder must be taken from the domain of folk-lore and handed over to the investigations of science. But you must first catch your mallangong.

He consulted the people who came to his trading-house, and they told him that he must find a regular hunter of the mallangong; for the beast was wary and scarce. At last an old native was brought to him, who said that he knew how to get the desired prey; and at once a hunting party was organized and armed under the old man's direction. What weapons did they take? Guns and knives? Not at all. The old hunter had for his equipment a long, tough, slender stick, pointed at one end. This was for prodding, not the mallangong, but the ground. Two or three others of the party were given drills and shovels, or pick-axes, and so prepared they set out, the old man leading the way to the bank of a little stream.

As he slowly moved along he thrust his rod into the ground and twisted it about. The others of the party considered this very dull hunting.

"I have found him!" cried the old man. "Dig! dig! Behold the mallangong!"

The shovels soon laid bare a little tunnel, which the guide said was made by the animal and led to its nest. With some eagerness the men followed up this tunnel, digging carefully. The process was long. The tunnel wound about and seemed to have no end. At last, with a cry of triumph, the guide laid open a small circular chamber, and picked up a ball of fur. "Lo, the mallangong!"

The animal was rolled up, its long, flat bill being turned about so that it rested on the fur-clad back. The feet were drawn up under the body so as to be invisible, and the captive seemed either dead or very sound asleep.

The trader carried his prize home, and soon it became lively and friendly. Almost all creatures like sugar and milk; very few disdain bread. The prisoner accepted kindly the novel food offered to it; enjoyed the sunlight; lost all fear of humanity when it was not treated with inhumanity; recognized the voice of its master; came at his call; and when he seated himself in a chair promptly climbed to his shoulder and surveyed its new surroundings with great interest.

Now that it was out of the water it was found to have nostrils in the extremity of its bill, small, bead-like eyes shining from the mass of fur, and ears acute enough, though they were merely holes hidden in the depths of the fur. The hind-feet, while webbed like those of a duck, were palmed like those of a mole, and spurred like those of a rooster.

While it enjoyed the warmth of the sunshine, in which it would lie curled up in a ball, as we sometimes see a cat or a dog, it preferred darkness for its explorations. At night it crawled about the room, worked its way up the wall by bracing against the furniture, and rummaged everywhere with its busy feet and broad bill. Perhaps it was searching for its friends, its native stream, and some soft earth wherein to burrow.

A pile of shavings or raw cotton and straw afforded the nearest approach to an earth bank that it could find in the warehouse, and in such a heap it would dig until it reached the wall, and then it would curl itself up and take some comfort in being securely hidden. A rat or squirrel in such a case would have gnawed through the wooden wall and departed without taking formal leave; but the mallangong could not break prison in this fashion, because it has no true teeth, only several horny protuberances on each jaw.

Examined at leisure, the marvellous animal was found to have cheek pouches something like those of a squirrel, and evidently very convenient as baskets for carrying food through the long tunnel which led to its room. The temper of the creature seemed gentle; it made no noise either for joy or pain, but a low whining sound, or, if irritated, a soft growl. At first its owner thought it entirely defenceless, but the old native showed him the spurs, and gave instances where when angered the animal kicked out with its hind feet and inflicted a long deep scratch, which was followed by symptoms of poisoning. On examination it was found that the spur was traversed through all its length by a tiny canal, which led to a gland or sac at the upper part of the leg; the whole arrangement being very like the poison gland and fang of a snake. This spur is present in a rudimentary state in all young mallangongs; in the grown females it disappears, and in the males it very greatly enlarges, no doubt because they are expected to do the fighting for the entire family.

This animal, popularly called by foreigners a "duck-bill," and by scientific people a "bird-nosed-paradox," is about twenty inches in entire length; it has its bill covered with tough skin, and finished where it joins the head with a fold or ruffle of skin; the fur is soft, fine, thick, deep-brown above, and paler on the under part of the body. The web in the hind-feet falls short of the strong toe nails, but on the front feet it extends beyond the toes, so that when the feet strike upon the water a broad surface is produced, enabling it to swim and dive swiftly and silently. The duck-bill is entirely aquatic in its habits and never lives far from water, making its tunnel with the round chamber, in the bank of a pond or stream, so that it can come from its front door and betake itself instantly to its favorite element. Its manner of digging is like that of a mole. While digging it contracts or folds back the superfluous skin or web of its fore-feet. The burrow has two doors, one just above, the other below the water-line. The tunnel is from twenty to fifty feet long, and the room at the end is lined with dried grass and leaves, affording a soft bed for the young, which are there reared until they are able to swim and forage for themselves in the water.

The food of the duck-bill, or mallangong, is generally found in the bottom of the stream or pond; the animal dives, turns over the stones with its spade-like bill, and finds in the ooze worms, small crabs, the larvæ of beetles, and water insects. Filling its cheek pouches with this prey it ascends to the surface and swims quietly about, while it carefully grinds its food into pulp with the bony, tooth-like projections of the jaws. In this careful mastication the lowest of the mammals sets some of the highest of the mammals a fine example.

The tail of the duck-bill is short, thick, and pointed; it is of very little use in swimming, and for that matter the hind-feet are also little used in the water, the broadly webbed fore-feet being the chief paddles.

For almost three quarters of a century the question of the young of the duck-bill paradox was undecided. Report was that the creature laid eggs; but then it was a mammal and fed its little ones with milk: how could any mammal lay eggs? In 1884 the matter was finally settled by indisputable proofs. The duck-bill mother lays two eggs, less than an inch long and cased in strong but flexible shells. When the little ones emerge from the shell they are exceedingly small, and are fed with milk from milk-glands in the skin of the mother, to which they attach themselves. They grow rapidly, and when they are weaned are given insect-food. Shortly after this they are led out of the tunnel, and at once swim with ease.

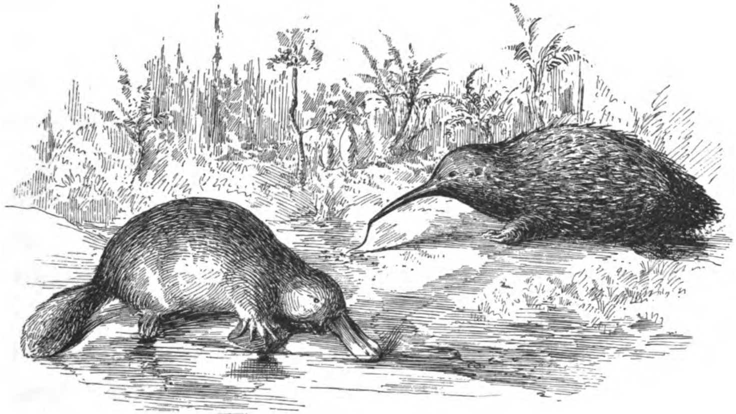
LESSON XXVIII.

BESIDE AUSTRALIAN RIVERS.

"He can behold
Things manifold
That have not yet been wholly told —
Have not been wholly sung or said."— LONGFELLOW.

THE famous mallangong has a cousin almost as marvellous as itself. Its common name is the porcupine ant-eater; its scientific name is Echidna. When first the habits and anatomy of the duck-bill had been investigated the question arose: Was this a lonely species, having resemblances to many animals and close relationships with none; sole representative of its order; as isolated as the hatteria? A search among the animals of Australia brought to light another relative.

The new animal inhabited the rocky districts and was plentiful in New South Wales. There, among the mountains, it burrowed in loose sand brought down by the water-courses, or hid in crevices of the rock. It wore the quill overcoat of



"LOW DOWN IN THE SCALE."

the sea-urchin, and when coiled to sleep looked not unlike a large specimen of that remarkable star-fish.[1] In size the echidna is about like the European hedge-hog (not our porcupine); it wears spurs like a rooster; it has the toothless jaws and the long flexible tongue of the ant-eater. It is entirely insectivorous in its diet, and from that and its quills, like a porcupine, it has its common name, "the porcupine ant-eater."

[1] See Nature Reader, No. 2, Lesson 40.

The head of the echidna is small and pointed, its eyes are nearly hidden under its quills; so are its ears, which are merely holes without external appendages. The frontal bone of the skull is prolonged into a slim snout not unlike a slender bill. Near the end of this snout are the nostrils. This snout is mostly covered with thin skin. The mouth orifice is small, but large enough for all the creature's needs; its manner of eating is to thrust out a long, flexible, delicate tongue covered with a glue-like substance. To this insects adhere, and the tongue being drawn in, the insects are swallowed. The echidna has no teeth; as its food is ants and small flies it needs none. The tongue and palate are covered with fine spines which no doubt crush the insect food.

On account of its diet this creature was formerly called the ant-eater, but that name has been dropped, as it belongs to a very different creature, the true ant-eater of the order Edentata.

The legs of the echidna are short and strong. The feet are not webbed, but are furnished with very powerful claws, and are admirably fitted for digging. The hind-feet have such a spur as was described in the chapter on the duck-bill.

The body of the echidna is covered with a close short fur; among this fur grow long spines thickly set, which project above the fur and entirely hide it. These spines are directed from the head backwards, but along the upper part of the body a large number of spines are also turned inward; thus they cross each other, and form a thorny, nearly impenetrable covering. The tail is very short, and is entirely hidden by projecting spines. When the echidna rolls itself up the spines stand out like a bristling thorn hedge all over the ball which it forms, and this sharp armor is ample defence. The mouth of a dog, or the hand of a man endeavoring to seize the curled up echidna would be speedily withdrawn, pricked and bleeding.

The echidna seems quite aware of the defensive quality of its coat, for when alarmed it tranquilly curls up and defies attack. Sometimes, however, it prefers to take refuge in burrowing, and it will disappear as quickly as a mole or a razor-shell clam.

The echidna is less easily tamed than the mallangong; it is restive, and constantly tries to burrow out a path of escape. On the other hand it seems of a hardier constitution; it has been carried across the sea, and has lived for some years in foreign zoological gardens. The mallangong has never survived an ocean voyage, and has been seen in captivity only in its native country. When travelling at sea the echidna is deprived of its natural insect-diet, but lives very comfortably on sweet liquids.

The habits of the echidna are nocturnal. It generally sleeps most of the day, and comes out at dark to prowl for insects. We might at first consider this strange conduct, as the insects on which it feeds fly or crawl about during the day and hide by night. But this is just what our prickly hunter wishes. He is not content to pick up a toiling ant here, and another there. When the ants are snugly housed after sundown the echidna searches out their hills, tears open a hole in one side, thrusts in his long nose, and then running out his slim, limber tongue he twists it here and there, and the ants and their white larvæ[1] bundles are collected by scores on its viscid surface.

Having gone from one ant-hill to another until its hunger is satisfied, or the morning dawns, or it grows weary, the echidna retires to its burrow or rock crevice. On the road it takes a drink of water, and makes a dessert of a liberal quantity of sand and mud. As fowls need some sharp bits of stone or shell in their gizzards to help grind up their food, the echidna seems to need in its stomach gritty material to grind the oily, insect bodies and keep them from packing. This need of some coarse substance with food is not confined to fowls and the echidna. Any sheep farmer will tell you that his sheep must be given what he calls "roughness" with their food. The "roughness" is ground or finely cut straw. If this is not given with corn and wheat, the sheep, however well fed, will become thin and weak, because their food is too rich to be well assimilated.[2] When sheep are grazed and not fed, they gather their "roughness" for themselves, in dry leaves, roots, stems, and little twigs.

In disposition the echidna is sluggish; seems to have no playfulness; does not object to having its nose gently stroked, but makes no friends, and except for its wonderful construction is not an interesting creature.

In Tasmania there is the short-spined echidna, which has

[1] Nature Reader, No. 2, Lesson 2.

[2] Cows fed entirely on grain and roots will gnaw at fence-posts and palings in an effort to get the woody, coarse substance supplied by coarse grass stems in their ordinary hay food.

much shorter and weaker spines and much thicker fur than the one just described. In 1877 a new species living on a mountain thirty-five hundred feet high was discovered in New Guinea. It also had fewer spines and thicker, rougher fur. This mountaineer of the echidna family is much larger than his relatives of lower regions.

No fossil remains of any great age have been found to prove that these animals are of distant antiquity. We cannot tell in what age they entered into existence. No remains of types connecting them with lower vertebrates on the one hand, or higher mammals on the other, have been discovered. The only fossil portion of an echidna that has been thus far secured is a shoulder-bone, found in a bed of bones belonging to extinct species of marsupial, or pouched animals. This shoulder-bone indicated an animal larger than any living echidna.

One echidna, called the tachyglossus of Van Dieman's land, eats grass and tender leaves as well as insects. It lives less among rocks, as it is very fond of burrowing. This specimen of the echidna is a marvellous digger. If disturbed it begins to make a great tearing of earth with its five-toed feet, and sinks out of sight almost as if it went down in water. Perhaps you have seen a crab perform this feat, keeping its eyes fixed on you until, presto! it has vanished as if by enchantment.[1]

The echidna, like its relatives, is a milk-giving, egg-laying animal. Only one egg is laid at a time, and that is very small. The egg is tucked into a fold of the mother's

[1] Nature Reader No. 1, Lessons 1–5.

skin, not a pouch such as the marsupials have, but a long fold. Here it is kept warm until it hatches. Until it has attained over one-third of its growth the mother nourishes the young creature with milk.

The Echidnidæ have all very quick tongues, which dart in and out of their tube-like mouths rapid as the play of a snake's forked tongue. Their mouths are very soft and delicate, and in burrowing the nose is carefully shielded, while the claw-armed fore-feet do most of the work. Owing to the quick movements of the tongue some naturalists have abandoned the name echidna, which refers to the thorny coat, and give the name tachy-glossus, "quick-tongued," to the entire family.

LESSON XXIX.

A WALK AMONG WONDER TREES.

"The groves of Eden, vanished now so long,
Live in description and look green in song.
These, were my breast inspired with equal flame,
Like them in beauty, should be like in fame." — POPE.

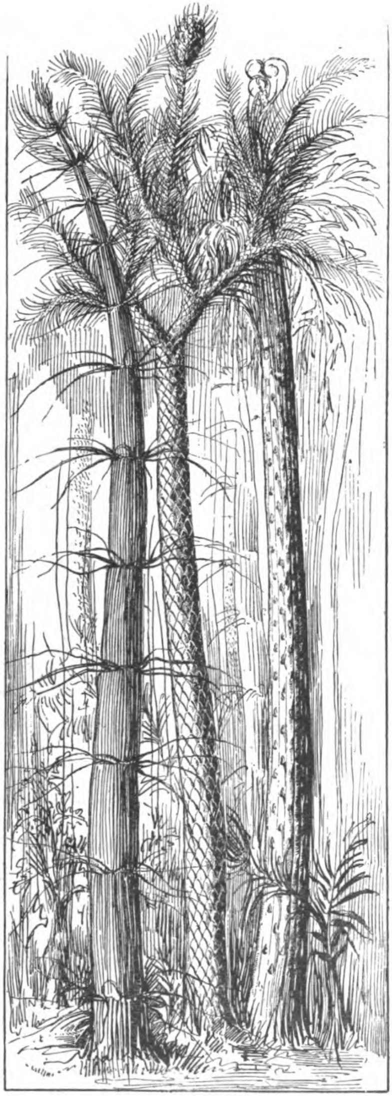
WE know that vegetable life has accompanied and probably preceded all animal life. The long successions of animal existences have been attended in their march through time by an equally long succession of plants. All those ancient and wonderful living creatures which we have noted have been and are now matched by equally wonderful vegetable organisms.

A few of the wonderful plants of the world we now propose to set as in a garden, and walk forth among them in fancy, and note their marvels. Come then, let us take a walk among wonder trees.

Who is there that enjoys the strange, the unique, the rare, the grand in nature? Let him come and walk slowly through this wonder grove with us, and his passion for the strange and the unexpected may be satisfied.

Our first wonder tree is notable only for its great age and vast size. It is the Cowthorpe oak of Yorkshire, England. John Evelyn, the pleasing writer and true gentleman of Charles Second's time, celebrates this oak in his book called "Sylva."

This noble tree is fully fifteen hundred years old.



BEFORE BLOSSOMS.

Not the oldest tree in the world then, for some of the olives in Gethsemane, near Jerusalem, are supposed to be older than that by several hundred years. The girth of the Cowthorpe oak at the ground is seventy-eight feet. Forty persons can stand inside its hollow bole. One of its main branches broke off in a gale, and being cut up, yielded five tons of timber. In Evelyn's time the branches shaded half an acre of ground. The circumference of this tree is greater than that of the Eddystone light-house. That famous light-house was modelled after an oak tree, as giving the best pattern of a well-rooted, firmly resisting column.

This Cowthorpe oak is not the largest tree in the world. There is a tree in South America with a girth of one hundred and twelve feet, and a California red-wood is known that measures one hundred feet around just above the ground. The red-woods belong to an ancient order of vegetation, and doubtless it could be said of the trees of the Carboniferous, and next two or three world-building periods, "There were giants in the earth in those days."

Australia is a land of wonders, animal and vegetable, and one of its curiosities stands next in our grove — the bottle tree. The name is given because of the shape of the tree, which resembles a gigantic bottle. This tree is sixty feet high; the bark is brown, smooth, shining, like thick glass. The girth of the tree is greatest just above the root, where it is forty feet in circumference; it tapers very little until about forty feet above the ground, where it narrows suddenly into a shape like the neck of a bottle; and in this neck the branches have their base. The branches are rather the long, pliant stems of compound leaves than real branches; and the slender, numerous, small leaves give a light, feathery effect to the foliage. This leafy crown forms the fantastic cork, or stopper, of this quaint bottle. The leaf-stalks rise and then bend over in a dome, or umbrella shape. The bottle trees grow in groves of about thirty each, and stand a hundred feet apart, as regularly as if planted by the hand of a gardener.

Be careful and do not tread on our next tree, the very pigmy of trees; perfect in root, trunk, branches, leaves, flowers, fruit, — a dwarf cherry tree from Japan. Are the trees of Japan then even more diminutive than the little, olive-skinned, and almond-eyed people? How did the skilful Japanese gardeners succeed in making this tiny tree? For it is dwarfed not by nature, but by the art of man.

I once saw one of these dwarfed cherry trees. It was a foot high and had a trunk about as thick as a lead pencil. The leaves were as small as those of the clipped box plants which bordered the flower-beds in my grandmother's garden. There were perhaps twenty or thirty small, red cherries upon it; but the cherries were large in proportion to the tree. This is a curiosity merely, and artificial; we admit it for the sake of contrast, and pass it by for a mighty tree that stands next, — bo, the "god tree" from Ceylon.

The bo tree is famous for its long life and the reverence paid to it by its Ceylonese worshippers. Perhaps it was the vigor and stately beauty of the bo tree which suggested to the Ceylonese that it was either divine, or the especial dwelling-place of a divinity. Alone the bo tree stood, and for two thousand years had been the idol of tree-worshippers. In 1887 a tremendous storm swept the island of Ceylon and prostrated the ancient idol tree. The fragments were gathered by the people and cremated with all the pomp awarded to dead kings.

The next specimen in our wonder grove comes from Africa, the famous and beneficent rain tree. This is a tall and beautiful tree, with widely spreading branches, gifted with the astonishing power of extracting water out of apparently the driest soil and atmosphere. While the earth seems absolutely parched, and the air is like the breath of a furnace, the blessed rain tree draws from somewhere abundant moisture, which it distills in a heavy shower from its leaves, saturating all the earth beneath.

What could be more grateful to a hot and thirsty traveller than this tree, bringing moisture from the very air of the burning desert?

Closely allied to the African rain tree is our next tree, brought to our grove from Ferro, the smallest island of the Canary group. This island is so dry that scarcely a rivulet or spring is found there, but on its rocks grows a tree with narrow leaves that are green all the year. A constant dewy cloud surrounds this tree, and is condensed, dripping from the leaf points like the swift patter of a summer shower. Under the branches the natives place cisterns and great jars, which are kept always full by the copious supply provided by these trees.[1]

[1] This tree, called by the natives the Til-tree, has almost entirely disappeared.

Coming from the South Sea Islands, where there are so many marvels, see next in our wonder grove the bread tree. The tree is of moderate height, with large glossy leaves. The fruit is of about the size of a Hubbard squash, and tastes like bread that has a little sugar in it. It is eaten raw, and is also cooked in various ways. The natives usually roast it in the ashes, as the negroes of the South roast yams. The bread fruit forms the most important food staple of the South Sea Islands, but is not so nourishing as the yam, wheat, or corn; children fed entirely upon it lose flesh and strength. The bread tree never finds an "off year" in bearing, nor a dull season; it is laden with good fruit every year and all the year. From the timber the natives can build their boats, and they make cloth from the bark. So with a rain tree, a milk tree, and a bread-fruit tree one could do very well for food, drink, shelter, and clothing.

As we have here in our wonder grove a bread tree, it is proper to put a milk tree close by its side. Water, bread, milk, these three trees of our collection afford all that is needful to support life. But the milk-producer, the cow tree, is not a native of Africa; it grows in South America, on the dry plains of Venezuela, where food and drink are alike hard to obtain. Blessed then be the shadow of this admirable tree, the hope of the perishing. The cow tree rises to a noble height. Its straight smooth trunk lifts into the air seventy or eighty feet before a branch springs from it. Then the wide arms extend in fair proportions on every side, until the topmost twig is more than a hundred feet from the ground. Tap the trunk anywhere, and an abundant sap, having the appearance and taste of rich new milk or cream, flows to revive the thirsty. The sap of our sugar maple runs freely only in early spring, the sap of the cow tree is always ready.

What more appropriate than to place the butter tree beside the milk tree? So we have placed it in our wonder grove, but nature planted it elsewhere, for the butter tree grows in Africa. The butter of this tree does not flow spontaneously. If people want butter it seems they must take the trouble to make it, even if it comes from a tree. The butter tree produces a fruit with a very rich kernel. When this kernel is ground, the oil exudes and hardens into a fine quality of butter, which will keep sweet for a year. David Livingstone, the celebrated missionary traveller, made known to the world the virtues of the butter tree.

Next let us have a tree that produces a fashion of confectionery. The manna tree grows in Calabria and Sicily. In August the tree is tapped, and the sap slowly exudes, hardening under the hot southern sun to the consistency of fig paste. The flavor of the manna while sweet is sickish to those unaccustomed to it. A taste for it seems to come by habit. The product of the manna tree is by no means so rich and useful as that of our beautiful sugar maple, but the sap of the maple must be prepared for use by boiling.

Next to the confectionery tree let us place in our grove a medicine tree. Who has not seen camphor, the clear white aromatic gum, so useful in medicine and in the arts? This is the product of the camphor tree of Japan. In Borneo, China, and the Malay Peninsula, the camphor trees have the gum formed in the trunk in large lumps. The camphor of other countries is obtained by boiling the wood of the camphor trees, and then crystallizing the camphor so obtained.

LESSON XXX.

STILL IN THE WONDER GROVE.

"Thus the seer
With vision clear
Sees forms appear and disappear;
In the perpetual round of strange
Mysterious change." —LONGFELLOW.

THE wonders of our grove are not yet exhausted. Indeed we might spend a lifetime here, if we studied thoroughly its curiosities. We can only look cursorily at a few more marvellous plants.

Here is a tree from Jamaica, called the life tree because it grows so readily, and is so tenacious of existence. The life tree will grow in a wet place or in a dry one; it cannot be killed by cutting down, for every fibre of its roots seems to possess power to renew the tree. Cut the leaves from the plant one by one, and where you drop them on the ground they grow, sending forth a root from any one of the severed ribs or veins. Cut the leaves into fragments and the fragments will grow.

This power in leaves to send forth rootlets and start a new plant, is not confined to the life tree. Gardeners will tell you that the plants of the begonia tribe are grown by cutting off a portion of one of the large handsome leaves which distinguish the begonias, and sticking it in a little damp sandy soil. It soon roots and sends up vigorous leaf-stems.

Beside the life tree behold its complement the death plant of Java, called by the Javanese the kali-mujah. This is a beautiful plant, growing nearly four feet high, with long, slender stems having upon them thorns an inch in length. These stems are crowded with broad leaves, thick, smooth as satin, heart-shaped, on one side a delicate emerald green, and on the other a vivid crimson marked with cream-color. From the midst of the leaf-stems rise the flower scapes, well guarded about the blossom with fine, briar-like thorns. The blossoms are milk-white, about the size and shape of a large cup. These beautiful flowers pour out a strong perfume, which, though agreeable, is overpowering and has poisonous qualities. If persons inhale this fragrance for several minutes, they become faint, and then unconscious; if shut up with the plant in a close room even a strong man would soon die.

Insects that hover about the flower fall dead, and birds that come, attracted by its red, white, and green splendors, wheel dizzily about it and drop unconscious. Even at a distance of three feet the breath of the kali-mujah will kill a bird or insect, and will give a man a severe headache with convulsive twitching of the muscles of the face. Other plants seem to avoid the kali-mujah, for none will grow in its vicinity.

But here is a more cheerful specimen. It should be the joy of all boys, — the whistling tree from Nubia. Day and night, year in and year out, this merry tree whistles tunes of its own composing — chorister of trees! The leaves and stems are so constructed that this tree becomes a shrill musical instrument, whistling loud and clear, even when no wind seems to be stirring. We have all noticed the shiver and murmur in a grove of pines, even in the hot stillness of a summer noontide; the whistling tree like the pine never ceases its peculiar music.

Our next wonder plant grows in water; it is a cousin of our white pond-lily, it is the *Victoria regia* which grows in still pools in the Amazon region. The leaves are round, and are from six to eight feet in diameter. They are sharply turned up at the edge to form a rim, so that each leaf is like a plate, the under surface is crimson, the upper surface green with fine lines; on this elegant plate the flower lies.

Let us watch a blossom open. About half-past eight in the evening the bud has slowly lifted itself above the pond, where it had grown submerged. Once free from the water it shakes and quivers, as if endowed with conscious life, and presently from the folded flower one petal flies open; then for a little it rests; then is again agitated, and a second petal expands. Then the agitation continues, the bud flutters and trembles, and petal after petal spreads out; then a dozen at a time are released from their close clasping, and at last behold the great flower, two feet wide across its snow and gold centre, a hundred snow-white petals composing the perfected bloom. From the whole blossom exhales a delicate, rich, delicious perfume, harmless as the breath of violets. The sun rises; the white petals bend together, and, rocked on the parent pool, the *Victoria regia* sleeps.

But as night draws on again the royal lily awakes. Now it is in its perfection; the perfume is more subtle; the petals take a flush of the palest pink; it rocks on the water and queens it through the night. And so with a few waking and sleeping nights and days, the royal lily's life is done.[1] When the splendid blossoms and the vast green leaves have perished the seed boxes or pods of the plant rise above the water and ripen, and the Indians call them water maize, and eat them.

Next to the lovely Regia let us place the century plant. The old notion was that this "American aloe" bloomed only after one hundred years of growth. *Agave Americana* is its true name, and when growing in a cool climate it is very slow in attaining maturity. At any time between ten and seventy years of age, it may send up a very tall flower stalk, covered with large greenish yellow blossoms, which continue open for several months. As soon as it has finished flowering it dies.

There are many members of the cactus and orchid families which might appropriately be planted in our grove of wonders, to light it up with their beauty, and amaze us with the marvels of their structure. But for that matter not a plant that grows lacks mysteries and marvels.

Of all strange, abnormal plants the carnivorous, or flesh-

[1] Some of the highest authorities state that in its native waters the Regia blossom lasts but one day and two nights.

eating, are the most singular. Several members of this family were described in Nature Reader, No. 3. Those were all small and pretty plants, green with dull red or yellow marks or tinges, and fatal only to little insects which were lured by the glittering bait of honey drops spread out for them.

Now let us introduce a native of Australia, called the stinging tree. No wasp, or hornet, ever had a sharper sting. Dreaded by all who know it, the stinging tree is yet a beautiful object. It is only twelve feet high and has dark, glossy, green leaves, and large bunches of scarlet berries. The tree grows always in a cone shape and reminds one of a Christmas-tree lighted with red candles. But at the tip of each projection of the green, saucer-shaped leaf grows a deadly thorn. The least touch of one of these thorns fills a man or beast with a terrible pain. Beasts act as if seized with hydrophobia; human beings stung by this tree are partly paralyzed, and suffer agony for days, or even weeks. The dry leaf, wind-blown, is able to effect as serious a sting as the leaf still on the cruel tree. Dogs and horses that have come in contact with one of these thorns must be killed at once, as in their pain they become dangerous.

Let us turn from this cruel stinging tree to one more useful and pleasant, the soap tree of Chili. This is a large, handsome tree with dark green leaves, casting a delightful shade. When the rough, outer bark is stripped away, behold under it a smooth, white bark, which, ground to powder, affords a soap nearly as good as any that you can buy. Who need have dirty hands or soiled clothing when a soap tree grows close beside his door? "Odd bark that," do you say?

Come to this next tree and we will show you a yet more wonderful bark.

Have you any jugs or bottles to cork? Do you want some cork soles? Here is the tree on which they grow. This is the great cork tree of Spain. It is found in many parts of South Europe and on the North African coast, but Spain is the land where cork collecting is a chief industry. When you take a cork in your hand, let it be as the enchanted stone, to carry you away to the warm hills of Spain, where you may see the laughing, black-eyed Spanish boys and girls running about to help the cork gatherers.

Our cork tree is thirty feet high, with well-spread branches, and a trunk very stout in proportion to the size of the tree. This trunk is covered with a thick, tough, elastic bark, which is constantly increased from within, growing thicker and thicker. When the trees are between fifteen and twenty years old, the bark is stripped off for the first time. This first bark is coarse and is used only for tanning, and for rough work. After eight or ten years the bark is stripped off again, and this time it is finer, and good enough for net-floats, and other coarse work, as life-preservers and buoys.

However, in eight or ten years more another coat can be stripped off, and this is fine and beautiful cork that will bring a good price. A cork tree will live for one hundred and fifty years, during which time the bark may be regularly stripped at intervals of eight or ten years. The stripping is done in July and August by making a cut entirely around the stem, just above the ground, and a second cut just below the branches, then three cuts are made length-wise the tree, and the bark is taken off in long strips. The greatest care is used to avoid injuring the inner bark. These slabs of bark are heated and slightly scorched; this causes them to flatten, closes up the pores, and gives toughness to the whole material. What should we do without cork for jackets, cork legs and arms, cork apparatus in life-boats, and other appliances for saving people from drowning? Our cork tree with its marvellous bark is by no means the least valuable specimen in our wonder grove.

What is this beautiful tree, tall and stately, with delicate oblong leaves, lovely flowers, and fruit like a plum? It is the tree from which our gutta percha comes, and without that valuable product what should we do for many instruments, for piping, and for a good covering for telegraph wires? As the Chinese and Malays always cut down these noble trees to get the juice which hardens into gutta percha, sometimes three or four millions of the trees are killed each year. At that rate they will all soon be gone.

What next? Why, the tree that bears india-rubber toys, overshoes, and water-proof coats. By good luck the people of South America, Central America, Asia, and Africa, where the varieties of india-rubber, or caoutchouc, producing trees are found, have learned to tap the trees and take care of them and do not kill them for a single harvest. The rubber is the hardened juice of the tree; when it first runs out it is like milk or cream, and hardens very quickly. It is sent to market in flat cakes called "biscuits." Trees producing various kinds of "rubber" abound in most tropical countries.

Now, finally, here is yet another specimen in our grove, a small shrub, only a tree by courtesy, but one of the wonders of the world, nevertheless, and happily a harmless curiosity, — if let alone! This is the electric plant.

We have long known of the electric eel, and the electric fish, that can give a powerful shock to anything touching them. A French naturalist has found and investigated, in the forests of India, a shrub endowed with amazing magnetic powers. At a distance of six yards it affects the magnetic needle.

If you break a leaf from the plant, you receive a powerful shock. Touch it with the tips of your fingers, and you receive a shock as from an induction coil. No birds or insects light upon it, they know the result too well; it would be certain death. How do birds and insects learn what is safe and what is dangerous for them to do? I cannot tell you.

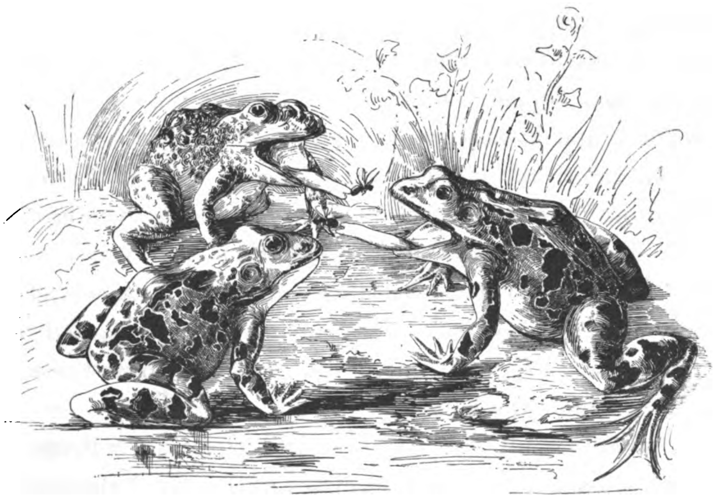
No electric metals are found in the vicinity of this shrub. The electricity belongs solely to the plant. At two in the afternoon the electricity is at its height; at night the plant nearly loses its curious properties. This is no doubt owing to the dewy dampness of night; for during a rain the electricity is also lost, and one can then break off a leaf with impunity. During an electric storm its intensity redoubles, so that the shrub becomes nearly as dangerous as an electric wire.

LESSON XXXI.

A NOISY FAMILY.

"When the hounds of spring are on winter's traces,
The mother of months in meadow or plain
Fills the shadows and windy places
With lisp of leaves and ripple of rain."
— A. C. SWINBURNE.

PASSING one day beside one of those shallow basins that are dug out of the clay soil of the west, to collect the rainfall and to serve as watering-places for stock, I saw a strange



BROTHER HOP 'O' MY THUMB.

sight. Above the brown and turbid water projected a row of green and yellow roundish knobs. These were placed at intervals eight or ten inches apart, nearly around the edge of the basin. Looking closer, I saw that at the base of each knob were two bright, prominent eyes. I laughed, as who would not, considering this living wreath encircling the pond. I had never before seen frogs drawn up in such orderly array.

For frogs these were, silent and alert. Whether fear or the heat of the day had driven them to this position I could not tell. Presently one of the bronze-green knobs elevated itself a little, became evident head and shoulders, rose above the surface of the water with a hop, and paused on the muddy edge of the basin for further observations. Watching carefully I saw that all the knobs moved now and again with a quick, bobbing motion. Connecting this motion with the sudden and final disappearance of numerous insects flying low over the water, I discovered that the neatly ambushed frogs were taking their supper. Presently I tossed a stone lightly into the pond, and at once, with a plash all the noses vanished. A little later, as twilight fell, a loud clangor of dissonant voices told that my frogs were engaged in their evening concert. A family of vocalists are these frogs.

The other day I passed this same pond. A winter of sunny weeks, with neither rain nor snow, had caused the water to dry away until only a few inches lay over the mud in the centre of the hollow.

"Where are all our frogs?" asked Hermie. "Frogs hibernate," I said. "As winter closes in they bury themselves in masses in the mud under the water. Some degree of moisture is needful to them at all times, and the mud affords all the dampness and warmth necessary. If the pond dries away, and the mud hardens about them, so that they cannot get out, they may live in their imprisonment for a number of months."

"I have heard," said Hermie, "that frogs have lived shut up in lumps of coal, in rocks, and in trees, for a great many years. Do you believe that?"

"I should want more reliable witnesses and more accurate information than have ever yet appeared in behalf of these tales. Experiments have shown that frogs and toads soon die if entirely shut away from air and food, though with a very little air and food they can live a long time shut up in wood or clay. An old man told me he had seen a frog taken out of a rock, where it had been buried five hundred years, and when it came out it *howled*. Now I know that a frog cannot howl,[1] and I concluded that one part of this marvellous tale was as untrue as the other."

The frogs, whose scientific name is Ranidæ, belong to the lower vertebrates, and are the largest family of their order. They are scarcely known in Australia and South America, and reach their highest state in the East Indies.

Among the best known of the Ranidæ in England and North America is the bull-frog, noted for his large size, his noisy voice, his green coat laced with gold, and his silvery vest. The most curious forms of frogs are found in South America. The Oceanic Islands usually have very few examples of the order. Frogs can endure great changes of heat and cold, and can live on land as well as in water, provided they have the amount of moisture needed to preserve the suppleness of the skin; but salt water is fatal to the frog in any stage of its existence.

[1] Frogs and toads sometimes squeal or cry with pain or terror.

For the study of the Ranidæ let us return to the representative best known to us, the lusty croaker of the summer pond. The frog dressed in green, silver, bronze, and gold is an expert swimmer, a mighty leaper, an ear-splitting vocalist, aquatic in his tastes, never wandering far from his native pond except when sent to market, and thence served up at the table as a dainty. But on the table we should not know him for our frog; only his hind quarters appear, and these skinned and fried are much like the legs of a spring chicken.

A most harmless, timid, and interesting beastie is the frog, and often most unfortunate, being considered a legitimate mark for all the stones that can be thrown at him by urchins wandering around his native pool. Moreover, he is filled with mortal terror when with stately progress a swan or a goose sails over the water or searches in the herbage where he hides.

What can we do to give this victim of geese and small boys a certain human interest, and win for him from the boys respect and friendship, rather than pelting? Let us look at him. We have described the colors of his skin, which is smooth, having no scales or plates. The yellow color is laid upon the bronze-green ground in stripes and spots, the stripes extending from the nose to the end of the back with a shorter stripe on each side. The front feet or hands are divided into four fingers, and the front legs are much shorter, smaller, and weaker than the hind ones, which are largely developed, and are used in swimming and leaping. The feet of the hind legs are webbed and have five fingers or toes.

The frog has a backbone, but no ribs. As he is ribless he cannot expand and contract his chest in breathing, so that he must swallow what air he wants. In swallowing air he must close his mouth and take the air in only by the nostrils; therefore, oddly enough, if his mouth is forcibly kept open he may be smothered.[1] The frog's breathing is partly through its skin, which gives off carbonic acid gas; and moisture is as needful to a frog's skin as to the gills of a fish.[2] The frog likes damp, rainy weather, and is as fond as a child of playing in a puddle. As soon as rain falls out come the frogs. The frog's skin absorbs moisture, which it stores up in an internal reservoir. When a frog is alarmed by being suddenly seized, it ejects some of this water. People have fancied that such water was poisonous, but it is not. Frogs have no poison sacs, and no weapons. Toads also give out a fluid from the skin.

Open our frog's mouth. There are a few tiny teeth on the upper jaw and palate; these are for partially grinding up horny insects. See this odd tongue; it is fastened at the front end to the mouth, and the hinder part is free and hangs down the creature's throat. This tongue is covered with a glue-like secretion, and when an insect is to be captured the tongue is snapped forward from the mouth, and the insect adheres as to bird-lime. Some frogs have cheek-pouches, and some drum-like throat-plates, wherewith to make their loud croak.

What is the life history of our frog? From seed to seed

[1] As these animals respire also through the skin they may live sometime without breathing through the nostrils.

[2] See Nature Reader, No. 3, Lesson 40.

is plant-life story; from egg to egg is frog story. The eggs of the frog are deposited in roundish masses attached to sticks lying in water, or to the stems and leaves of submerged water-plants. The creature which comes from this egg is no more like a frog, than a caterpillar is like a butterfly. It has a big head and no limbs, and what of it is not head seems to be tail. In fact, in this stage the creature is more like a fish than a frog, and has branched gills. The gills are nearly covered by a fold of skin. Have you seen it? It is a tadpole. This tadpole can live only in water, and swims and feeds from the first instant of its free life. Change in its shape begins almost immediately: the branched gills are drawn within the neck and hidden; a pair of fore-legs begin to bud, and then a pair of hind-legs bud and push out faster than the fore-legs. As the legs grow the tail is gradually absorbed and disappears. Meanwhile the interior of the body changes; the lungs and heart become like those of a reptile. When first the tadpole emerged from the egg it ate the jelly-like egg cover: then, by means of a pair of little horny jaws, it ate soft animal or vegetable matter. When its gills and tail are gone, and its legs are fully formed, it hops out of the water a perfectly formed frog.

Tadpoles feed on insects and also on each other. They are admirable preparers of small skeletons. Try the tadpole at this trade; drop into his pond a dead mouse, or bird, or frog, or squirrel. Soon you will find a clean, white skeleton, nice enough to put in any museum.

The food of the adult frog is chiefly insects. Less hungry than when in the tadpole state,—for the tadpole like the child must not only eat to live but to grow — the frog is not often tempted to vary his diet.

The frog, seated in cool leaf shadows, watches with his great, black, gold-ringed eyes for such insects as good fortune shall send past his retreat. As one hovers near, out flies his limber, sticky, notched, ribbon-like tongue, true to its mark. The insect adheres to the viscous surface of the projected ribbon, and is gently deposited in the open throat. During this process the frog maintains a calm, superior, self-satisfied expression, as if in this still hunt he not so much satisfied an appetite, as fulfilled a mission of ridding nature of superfluous insects. He seems to have no malice toward the insects; he is merely giving them an honorable burial, and saving them from the further perplexities of life.

The common frog attains a length of three or four inches.[1] He has glandular ridges down the skin of his back, and these, with his colors, singularly fit him for his home: the darker ridges imitating plant-stems; the green coat, leafage; the silver vest, the glimmer of water; the brownish feet and markings, the moist earth; while the yellow markings add to the protective display, in being like the stamens and pistils of surrounding flowers, and of the hue of many buds and blossoms. Thus the frog in his native haunts is protected by his garments, and is little likely to be seen unless he moves, or is betrayed by his full, bright eyes or the palpitations of his breast.

[1] Our large bull-frog is eight or twelve inches long. Frogs even one or two feet long (Holder's Zoölogy) have been found, but such a size is very unusual.

While the common frog represents the aquatic Ranidæ, his cousin, the wood-frog, represents a branch of the widely distributed family which prefers dry dwellings, except in the breeding season, when the eggs must be deposited in water. The wood-frog is smaller than the bull-frog, and is dressed in olive-green and shades of brown, like the colors of dead leaves and dry twigs. There is a large black patch on the side of the head around the big ear-drum. The wood-frog takes such enormous leaps that it is very difficult to catch. It is shy, and makes a prodigious jump at the first hint of danger. When it drops to the ground it is scarcely discernible from the dry vegetation about it. The wood-frog maintains the moisture of its skin by hiding in damp moss or in decayed logs, and in little hollows in the ground. It avoids the sunshine, and keeps close to the earth.

The tree-frog is another curious frog. Smaller than its cousins, it is dressed in bright green, spotted with black, and has a membrane stretched between its toes, which gives its feet a broad, flat surface, and helps to sustain it as it leaps from branch to branch, somewhat in the fashion of a flying squirrel. In tropical lands, where many trees are decked with gorgeous blossoms, tree-frogs appear very gaily colored, the splendor of the coat being protective in such surroundings.

The swamp-frog is dressed in black and light brown, and lives in marshes in the Eastern United States. Its voice is a prolonged croak. The clamata, or "bawling-frog," lives about cold, damp springs, and is very noisy. The resounding roar of the bull-frog is a well-known sound. No wonder that Horace, the Roman poet, wrote that "the noisy frogs from the marshes drive away sleep."

Cats, geese, owls, vultures, hawks, otters, and other creatures eat frogs, and the luckless creatures can hardly appear without finding an enemy. To balance this destruction of their forces they produce great numbers of eggs. When tadpoles first reach the frog state they are black. I have seen hundreds of them together, so that the pond mud seemed alive and crawling.

LESSON XXXII.

THE FROG'S COUSIN.

"Sweet are the uses of adversity,
Which like a toad, ugly and venomous,
Wears yet a precious jewel in his head."

—*As You Like It.*

BELONGING to the same class of vertebrates as the frog, to the same order also, but to a different sub-order, are the toads, the cousins of the frogs. As the frog is well known about the ponds, so the toad is a constant inhabitant of our groves and gardens. We introduce the frog to an admiring public as Mr. Rana, the toad as Mr. Bufo. The order to which the frogs and toads belong is divided according to the structure of the base of the skull and the shape of the shoulder girdle. In general anatomy the frogs and toads are alike. The eggs and young are closely similar, and the stages of growth from egg to the adult form are nearly identical. When the adult form is reached the frogs and toads are yet very tiny creatures, but small as they are the most casual observer can distinguish them from each other by the shape of the snout, and by the far larger development of the hind-legs of the frog.

The chief differences to be noted between Mr. Rana and his cousin, Mr. Bufo, are these: the toad has no teeth, but the frog, as we have seen, has teeth on the upper jaw and palate. The attachment of the tongue is the same, but the free end of the frog's tongue is forked, and the toad's is not. The toad's skin is usually warty, the frog's is smooth; the toad has a rounder body, shorter hind-legs, and its feet are less fully webbed; its snout is more rounded than that of the frog.

We find, let us say, a toad and a frog in our morning ramble. We notice the soft, moist skin and say, "These are amphibians." We see that they are tailless, and we say they are anurans, or tailless amphibians. Then having placed them together thus far, we note their differences, and we say of the frog, "This belongs to the Ranidæ," and of the smaller cousin, "Here is one of the Bufonidæ." Of the two, we may find the toad the more interesting animal, as among its kinsfolk are some very remarkable families.

Mr. Bufo is a citizen of the world, except of the severely cold polar regions. He hops through the tropics and the temperate zones, and goes pretty well up into the polar regions; an inoffensive, gentle, humble, useful, and generally utterly silent creature. No person is faultless, and Bufo is not superior to humans in that no evil may be laid to his charge.

He does eat bees. Happy is Mr. Bufo when, brigand-like, he can stand by the highway of the bees returning laden with wealth of honey and entering their waxen city. He holds his captives for no ransom, he scarcely stays to kill them, but swallows them alive and whole, and digests them later.

As far as we know, this bee-eating is Bufo's one fault; to counterbalance it he devours millions of harmful insects, and so assuredly saves the world thousands of bushels of fruit and vegetables. We will not say that Bufo is greedy in eating. It is true that he swallows insects ceaselessly and swiftly, so much so that a grasshopper's legs, or some other creature's antennæ, may sometimes be seen sticking out of a toad's mouth, while the carcass is well down his throat — but we will not be hard on him; we call this — zealous attention to business. The French gardeners appreciate Bufo's usefulness, and he is brought alive to market to be sold to those who need his help in their gardens.

Bufo can be tamed and taught to eat from your hand. He can be beguiled with sugar, and with bread soaked in milk. As to this last dainty, like a captious child, he eats out the middle of the slice and leaves the crust!

There are three myths about the toad: first, that he can live during centuries shut up in clay or stone; this is no more true of Bufo than of his cousin Rana. The second myth is that his skin when handled causes warts, and that the fluid he discharges is poisonous; this is an idle tale. The third allegation is, that he has a jewel in his head. This has been believed from very ancient times; perhaps the story rose from the beauty of his eyes, with their iris of flame-color.

The eggs of the toad are deposited closely set side by side in a long transparent tube which is dropped into water, and sinking to the bottom coils up until the eggs hatch. The young tadpoles are jet black and very active. They make all their changes very early and in the same manner as the frog, and are quite small when they arrive at the perfect toad-shape. As soon as they have produced four legs and their tails have been absorbed, they leave the water and set off on long journeys; for the toad is a born vagrant, and not, like the frog, a home-stayer.

Avoiding the sun's heat they travel chiefly by night, and by day hide under stones or herbage. If clouds cover the sky they take heart and hop forth on their pilgrimage. During a long drought they disappear, but if a rain comes they suddenly swarm out by hundreds, and thus have arisen the tales of a "shower of toads."

Going one day into my garden, I saw under my favorite rose tree a little hollow in the loose earth. It looked just like the cup-shaped impression made by an egg half buried in the ground. An hour later, I found a toad seated in this place, which he had evidently fashioned for himself in order to preserve the moisture of his body, while he hunted for his dinner. His keen, black eyes were fixed on the drooping stem and leaves of the rose-bush, and out and in played his little ribbon-like tongue, capturing an insect at every dart.

The toad feeds on worms as well as flies, and when after a rain the worms and toads are mutually inspired to take their walks abroad, many a luckless worm finds its way into the toad's maw. He never eats a dead insect.

In winter the toad hibernates like the frog, and since the young toad reaches its adult size in the autumn, it passes the first period of its grown-up life in a sleep, or coma, in some hole or burrow which it has found or fashioned in the earth. Sometimes toads creep into rock-crevices or into hollows in logs and trees, and being found in these places early in the spring, are hastily supposed to have been prisoners for many years.

The toad, as well as the frog, casts its skin in the process of growth. When the skin has become too small, and the shedding approaches, the white, green, and brown colors of the coat become dull, and a peculiar dryness appears. A new skin is forming under the outgrown one, which presently splits in half down the middle of the back and the under part of the body. The toad now begins to twist and twitch, and the old skin wrinkles and folds along the sides. Then the toad tucks a hind-leg under his forearm, and gives a good pull, and lo, he is out of that leg of his trousers. Then the other leg comes off in the same style. Next he puts one of his hands in his mouth, and giving a jerk, off comes the covering of that hand and arm, like a discarded glove. Then off with the other. Now then, what? Why, he rolls the outgrown skin into a neat ball and swallows it. No second-hand clothes sold or given away by Mr. Bufo. The frog strips off and disposes of his skin in the same way.

Toads and frogs can change to some extent the color of their skins to suit their homes. Toads kept in the dark with dark surroundings become dark in color; and those kept in light with white or light accessories become lighter;

but the color of the toad changes more slowly than that of the frog. The arrangement of the color does not alter; the change is merely from light to dark.

Let us now look at some curious specimens of the Bufonidæ. The pipa, or Surinam toad, does not lay its eggs in water. The mother toad places the eggs on her back, and a fold of skin rising up encloses each egg in a separate cell, until the young have not only hatched, but have passed through all their metamorphoses, and come out fully formed. Another toad, common in Europe and Asia, is largely colored with bright crimson, and the father toad carries the little ones in separate cells fastened to his hind-legs like chains. In these cells the little ones change to their perfect shape, when the cells wither away and the young toads hop out able to take care of themselves.

We said that toads were generally silent; a little toad about three inches long, called a "natter-jack," is common in England and is a noted singer, for a toad. His "gluck-gluck, gluck-k-k," can be heard any night. The "green toad," well known on the continent, is not so noisy as the natter-jack, but has a low, moaning cry.

All the true tree-toads, or Hylidæ, have clear, shrill voices,[1] and are fond of singing serenades. Like tree-frogs, tree-toads have the ends of the toes dilated into flat plates, or disks, which render their footing more secure as they hop among the branches. Our American Hylidæ are small, green-colored

[1] In the spring the common toad takes to the water and there sings loudly. The loud continuous trill that we hear in swamps in springtime is made by toads, not by frogs, as is commonly supposed.

with brown markings, but in Asia they are often brightly colored, One very pretty little Hyla lives near ponds, and seated on the hard leaves of water-plants sings its shrill monotonous song.

All summer, from early April, the Hylidæ trill and sing, but as the autumn frosts come, their songs begin earlier and last longer. As the red and yellow leaves fall in showers from the trees, and the golden-rod and asters begin to faint and die among the sere grasses, the Hylidæ seem to be singing their requiem, and bewailing the coming of winter.

Another toad with a voice is the spade-foot. This toad is rare though widely distributed; it is remarkable for its feet, shaped for digging, its subterranean habits, and its curious way of appearing and disappearing very suddenly. After a rainy season the spade-foot will come out from some hiding-place, attract attention by loud cries, swarm by hundreds about ponds, lay innumerable eggs,—and vanish. But while thousands of eggs are laid, scores only hatch, for most of them perish from being laid so near the water's edge that the subsidence of the water leaves them to dry up. While scores hatch, only tens grow up; for the spade-foot tadpoles devour one another, and are so greedy that very few survive. These few are most ravenous in their appetites. A spade-foot tadpole will seize a grasshopper, and being too small to swallow over half his prey, will calmly lie waiting for the swallowed half to digest in order that he may gulp down the remainder. As soon as a spade-foot tadpole becomes a "hopper," getting four legs and losing its tail, it leaves the pond and indulges its digging instincts. It scrapes out a house for itself, from eight inches to two feet in length, and cheerfully takes up an underground residence.

Thus we find that toads have three different methods of life, some being arboreal, or tree dwellers, seldom appearing on the ground; some subterranean, or underground dwellers seldom appearing on the surface; some dwellers on the ground, hiding among grass and other herbage when asleep, or when the sun is too hot for their comfort. But all toads, except the two varieties mentioned above, which carry their young on their bodies, go to the water to drop their eggs, and the young live in the water until they reach the adult state.

LESSON XXXIII.

THE SALAMANDERS.

"The rarest things with wayward will
Beneath the covert hide them still;
The rarest things to break of day
Look shortly forth, and hie away."

—Joanna Baillie.

Frogs and toads belong to the class Batrachia, a division of vertebrates which stands intermediate between fishes and reptiles, partaking in the different stages of their lives of some of the characteristics of both these classes. The eggs of batrachians are generally laid in water or damp places, and the young breathe, not through lungs but through gills. To the class Batrachia belong not only frogs and toads, but sirens, mud-fish, "water-dogs," and salamanders, all of which are interesting animals. Among them there is a species of salamander which is distinguished from all other batrachians, because its young ones are born alive.

I remember reading when I was a child, of a very remarkable beast called a salamander, which could live in fire; and one of my books had a thrilling description of one of these little animals which had come forth from a burning log in the midst of a blaze, and ran cheerfully about in the flames, sporting and enjoying itself. This myth of the superiority of the salamander to fire is wide-spread and ancient. It is a common saying that a person who is not easily affected by heat is "a perfect salamander." The stories of some old-time naturalists about the salamanders are amusing. We are told that the creature can not only live in fire, but is born in it; that passing through a fire it extinguishes it; that smiths finding the forge fires going out, always knew that a salamander was playing therein, and mended the fire by killing the animal. Another myth was that the salamander was the most poisonous of all creatures; if it crawled over a person's foot that person's entire body was poisoned, the hair fell out, and lingering death was the result; wood, over which a salamander had crept was poisonous; the creature's breath was a deadly poison. Some thought the animal wore hair, others that it wore feathers or fur, but all agreed that cloth woven of its coat was fire-proof. Belief in these fantastic stories long survived.

What is the truth? The salamander is not at all poisonous; on the contrary, like most other batrachians, it is harmless and helpless, and obtains its bad name no doubt from its general lack of beauty, of either shape or color. It is ugly and therefore venomous, is the reasoning. This is hard. What if we should reason that a person is unhandsome and therefore vicious? The skin of the salamander is glandular, and is capable of secreting much fluid, and when the creature is terrified or excited this secretion increases, and the fluid covers the skin. Owing to this fluid, a salamander which by any means finds itself in a fire, might move about for a minute or two looking for an exit from the flames, and get out scatheless, thanks to its watery coat. Besides, these cold-blooded animals are to a certain extent insensitive upon the surface of the body, and would suffer little pain in a brief sojourn in a flame. The stories of salamanders suddenly appearing in a fire as if born there, can be explained by the fact that they hide and sleep in decayed logs, under stones, or among dry, dead sticks, and so might be very likely to wake up in a fire kindled out of doors.

The largest of all the salamanders belongs in Asia, and is found in Thibet and Japan. It is the largest of the batrachians, and is about three feet in length. I once saw perhaps the largest specimen ever found, the giant of salamanders. It was two feet, five inches high, from its soles to the top of the arch of its back, and three feet, five inches long from nose to tail tip. Its color was a rusty black, and its skin was covered with thick knobs or granulations, making it look as if dressed in very hard and old embossed leather armor.

The head of the salamander is large and rounded; the tail is stiff and elongated; the legs very short; the hind feet are five-toed, the front feet have only four toes. The legs and feet are thick and clumsy, and the larger salamanders are heavy and inert in their motions. Far from finding fire their native or preferred element, the salamanders like cold, damp places; their eggs are dropped in water and hatch there, except those of the spotted salamander of Spain.

The young of these Spanish salamanders are at birth about half or three quarters of an inch long, with branched gills. They look like tadpoles or "pollywogs," and at once take to the water and remain there until they reach the adult form. The salamander larvæ grow to considerable size before they make their final change of form. Their gills are very large, and as they swim about they look as if they had trimmed their necks with foliage. In the water they find themselves very comfortable until they approach the adult period. Then they become restless and dig holes for themselves in the mud or sand of the streams or ponds where they live. These lairs exactly fit their bodies, and are so placed that as they lie there with their heads out of water every slight rise or ripple of the water will overflow them and keep the lairs well wet. Thus they breathe in the water by their gills, and at the same time practice air-breathing; for their gills are now shrivelling away, and they are progressing toward the air-breathing condition of the true salamander state.

A salamander much like the spotted one, but having no lighter spots on its skin, lives in high lands where there are no stagnant waters fit for a resting-place for its eggs. This black salamander's young ones are born two at a time, and are in all respects except size, precisely like their parents.

The ash-colored salamander is common in the woods of the Eastern United States. It is only a few inches long, but is not so small as its cousin the "microscopic salamander," a native of the Mississippi Valley, a lithe, brisk little creature, of a gray color, fond of hiding in logs and under bark or stones. Black, gray and dust-color are the usual shades of a salamander's coat, but in the Rocky Mountains some may be found adorned with red, yellow, and green spots and stripes.

A very common variety in the United States is the red-banded salamander, distinguished not only for the red band down his back, but for his activity in climbing. Shut him in a room and he darts up the wall lightly as a sailor goes up a mast. Put him in a glass case, he runs up the glass with the ease of a fly, and hangs from the plate at the top back downward, moving his dumpy head from side to side. You almost fancy a grin on his wide mouth, and a leer in his bright, black eyes, as if he said, "How does this strike you?" The secret of these feats is, that he can adhere to smooth surfaces by means of a moisture diffused over the lower part of his body and the soles of his feet.

The red-banded salamander may sometimes be found in the woods lying coiled on the tip of a branch or a large fern frond, the red line on his back showing like a coil of scarlet ribbon. If he is alarmed this coil snaps out straight, and by that motion he has cast himself several feet distant, and is gone among the grass. Commend us to a red-banded salamander or a wood-toad for a sudden and effective jump. Nothing is more curious than to see this dainty little red-banded beast climbing up a rush, or a long, stiff spear of grass, or the graceful, plumed stalk of a golden-rod.

The very prettiest of all the salamanders is found in the red-wood forests of California; it is of a vivid salmon-color and has very prominent, bright eyes. Salamanders are found from Mexico to Siberia, and in general it may be stated that those of the warm latitudes are smaller, more active, and more gaily colored; those of colder climates are larger, duller, dark colored, and very slow in motion. In the British Islands there are no salamanders.

The red-woods of California belong to a very ancient class of tree-vegetation: the salamanders are of an ancient class of living things. I have sometimes wondered looking at one of those little, brilliant, salmon-hued salamanders, with its staring bright eyes that see everything, whether it has received by tradition from its elders, tales of a time when intrusive mammals with man at their head were unknown, and they and the red-woods had their world to themselves.

LESSON XXXIV.

A DENIZEN OF THE MARSH LANDS.

"But the cold-blooded snake in the edge of the brake
Sits amid the rank grass, half asleep, half awake;
And the ashen white snail, with the slime in its trail,
Moves wearily on, like a life's tedious tale." — R. S. NICHOLS.

IF the question "What is a siren?" were suddenly put to a class of pupils, I think it probable that the boys would reply, "a steam whistle," and the girls, "a fabulous monster with a beautiful voice, which she used to lure people to destruction." Possibly some few observant lads from Georgia, Texas, and South Carolina, might say: "An animal something like a lizard; it lives in the marshes." The girls would be right, and the boys right, but this last would be the answer wished for in natural history. A siren is an amphibious animal closely allied to the salamanders.

There are four families of amphibians, or batrachians, which are so closely connected that in some of their stages of development they can scarcely be told one from the other.

In these the young of some present almost exactly the adult conditions of the others, and the larvæ of the lower forms have been known to undergo transformations that have changed them from the likeness of their parents to the fashions of the allied species. Thus the adult sirens are scarcely distinguishable from the aquatic larvæ of the salamanders. Siren larvæ have developed into the condition of adult salamanders, while the young of the salamanders greatly resemble tadpoles, or larval toads and frogs.

The adult menobranch has a skull like that of a tadpole, or a salamander in the larval state. In fact, wherever the young of one of these families diverge from the form of their parents, it is simply to trench upon the form of some of the allied species.

We have noted that frogs and toads have the tongue fastened at the front of the mouth, and hanging free down the throat. Some of the salamanders have the tongue fastened in the middle of the under side, so that it resembles a broad, flat mushroom on a short, thick stem, while the teeth are set in a fine brush above it on the roof of the mouth. In the sirens the tongue is free in front; there are no teeth on the jaws, and the jaws are cased in a horny sheath like a beak; but down the throat there are two patches of sharp little teeth pointed backwards.

Let us take a look at a siren. At first one might call it a fish or an eel, wearing queer plumes at the back of the head, and also endowed with little legs and feet. This is the "lizard-formed siren," and the largest specimen ever found was about three feet long: most of them do not exceed twenty inches in length. The body is long and slim, like that of an eel; the skin is smooth and nearly black, besprinkled with little white dots. From the shoulders, near the head, come a pair of small, feeble legs, the feet being divided into four fingers. These feet aid the movements of the creature on the sand or mud when it emerges from the water, and serve to elevate the neck a little in catching and swallowing prey.

The motion of the siren in the water is sinuous, like that of an eel; the legs may help a little as paddles, but the action from side to side, such as we have all noticed in a water-snake, is that by which it progresses. Well, let us look for the hind-legs, now that we have seen the front ones. Where are they? Gone altogether! Nature seems to have concluded that a little beast which would let its front legs dwindle away from want of use, might as well be deprived of the hind ones entirely.

The head of the siren is small; it seems to have as little use for brains as for feet. The snout is short and broad, with the nostrils near the tip; and as for eyes! — they are the tiniest little dots; evidently our siren does not depend much on taking observations of its surroundings. On the other hand the mouth of the creature is disproportionately large, opening across the entire head. The beastie lives to eat, and his mouth is, it seems, his chief organ. This ugly head sits close on an eel-like body which finishes up in a point at the tail, where there is a fin, as a fish has.

The most conspicuous feature of the siren is the appendage placed branch-like on each side of the neck. These appendages have three divisions, each one with a separate attachment, and under each one is a small slit or opening into the siren's throat. What are these branches waving like plumes? They are external gills, and very pretty they are, the only pretty things about a siren; these gills are of a pale rose-color shaded with gray, and waving and catching the light as the creature swims, they redeem him from absolute ugliness.

I have often wondered why this animal has been named a siren, after the beautiful and fatal creature of fable. Beauty, song, malice; these were the three characteristics of the sirens of which old Homer sung, and not one of these endowments belongs to the siren of the marshes, — ugly, silent, harmless. He is hungry, and he eats, and his food is toads, frogs, insects, any animal organism he can find in the water. He merely opens his mouth and takes his prey in; he neither lulls it nor lures it with music.

A first cousin of this lizard-formed siren, is the striped siren of Georgia. This has only one gill branch, and is distinguished by a broad, yellow band on each side, and a narrower one on the under part of the body. "A mud-eel" it is popularly called. It is very scarce, and valuable accordingly. Few of the museums or zoölogical gardens have specimens of this siren. No doubt ignorant and careless people, finding this odd and helpless creature in its native haunts, ruthlessly kill it, just because they can, and leave to decay specimens which, if taken living, or carefully preserved in alcohol, would have been of great value.

The siren sometimes suffers the loss of its pretty gills in a queer way. Fishes, attracted by their roseate color, nibble them off. In such cases the siren can breathe by coming to the surface of the water, and taking in mouthfuls of air, which it suffers to escape through the slits at the neck. This method of breathing is evidently inconvenient and difficult to the creature, but allows it to maintain life until new gill-branches grow, a process which requires some eight weeks to accomplish.

Some sirens wear a little gold-colored band about the lips and face, which band shines like molten metal in the water, and gives them a gay appearance.

The sirens are quiet and hardy animals, and small ones could be easily kept for pets in a glass aquarium box, if provided with a little mud and sand under the water, and with some stones upon which the creatures could crawl when they wished to be above water. Like all the carnivorous amphibians the sirens will eat bread and milk and raw veal, instead of their usual food.

While chiefly confined to marshy places or still waters of the South, occasional specimens of the siren families have been found as far north as Illinois,[1] and no doubt could live in any locality in the United States, if protected from their enemies. For their own part they are helpless, and fall a prey to whatever attacks them. Their teeth are far down in the throat so they cannot bite; their tails are weak so they cannot strike; they have even no nails on their toes wherewith to scratch. Instead of nails they have a little horny cap on each of the toes, rendering it broader, and so less likely to stick fast in the mud when they crawl out upon a bank.

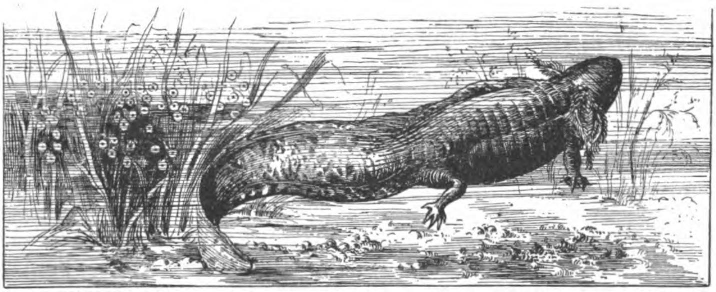
[1] The menobranchus abounds in all the "five Great Lakes," especially in Lake Michigan. — O. S. WESTCOTT.

LESSON XXXV.

A STRANGER FROM MEXICO.

"And he banned the water goblin's spite
For he saw around in the sweet moonshine,
Their little wee faces above the brine,
Giggling and laughing with all their might,
At the piteous leap of the fairy wight."
— DRAKE.

ONE day when I was studying in the Brighton Aquarium, England, I had been examining fish-scales through a powerful microscope, and turned to lay my paper of notes on a glass case near at hand. As I did so I remarked "that there



PEARL CRADLES.

were three fish in the case swimming around some kind of a leafless plant, on which hung a few round, small pods."

When I returned to the microscope I found my mind obstinately fixed on the contents of the glass case. "That was surely not a stiff sea-plant, but the dead branch of a land-plant." "I wonder what fish those were?" "Those were very odd-looking little pods!" So I thought, until I concluded to take a second look at the objects so obtrusively present to my mind. Lo! the branch had not merely a few little pods, but some pods were on every one of the numerous fine divisions of the branch, except one long one near the bottom. These pods were pearly, flat, semi-transparent, of the size of shirt buttons, and in the centre of each was a black dot answering to the button's eye.

As I observed them, the three "fish" kept swimming round and round the branch, in and out, and I noticed that this piece of dry plant was securely fastened to the bottom of the tank. But what! The lately bare lower twig had now four pellucid pods upon it! Surely the fish were placing these upon the twigs! The pods were then egg-cases.

So, my good fish, I said, you are hanging your babies upon a tree-top, are you? That very bad mother, the dog-fish, does the same.[1] But her cradles are black and horny; yours are like pearls! Who are you? Whence do you come? What is your place and name among all the fish families?

Stop: What is this I see growing from each side of your neck, like enormous whiskers? By this I perceive that you are not fish at all, but batrachians. These plumes are your external gills. And what are these? Why, truly, small legs and feet neatly drawn back as you swim; five webbed toes on the hind feet; four webbed toes on the front feet. Ah, but you are an interesting animal! Kindly stop swimming for a little until I count up your gifts and graces. A blunt head, shaped like the end of an ear of maize; a wide

[1] Nature Reader, No. 3, Lesson 44.

mouth; nostrils close to the lips; two little eyes also set close to the upper lip. Ah! I know you now — bone of contention among the scientific, most unexpected in your behavior, specimen of the order Urodela, spotted Amblystoma, oh, why cannot you have at least one simple and easy name, Mexican axolotl!

A curious little child of Mexico is this denizen of the lakes of that warm southern land — a mild, silent, unhandsome, small beast, given to surprising people. The chief peculiarity of the creature is that it obstinately refuses ever to grow up, and remains in the larval state, instead of properly putting on the form of an adult. Nature's perpetual child! And when it does grow up by chance, as, to be more surprising, some individuals do grow up, why then, it is no longer itself — but something else!

Now my interest was greatly quickened in this creature, and I began to admire it. Its scaleless skin was of a dark drab or steel color, of a velvet-like softness; the gills were three on each side of the head, finely divided into soft, thick plumes, which waved to and fro, expanded, closed, half-folded, spread wide. No Spanish belle ever handled a fan more beautifully than this little swimmer used its gill-branches.

Observe now the method of placing those translucent pearl cradles, the egg-pods. Twice about the twig the axolotl swims, eying it closely, as if considering of its fitness. Then she takes the twig, or the long, lithe stem of water-weed between her little webbed hands to steady it, and glides softly up the stem, and as she goes attaches the little pearl balls like seed-pods in a row. Nothing can be prettier than a long withe of green weed set with these pearly cradles shimmering in the sunlight; for not only do they hang as fair round pearls against the green in the water, but they are powdered all over with gold dust. This is a combination of green, pearl, and gold that any artist might envy.

The egg itself is the dark dot in the centre of that gold-besprinkled cradle. At first the inclosing jelly is but a small rim, but it expands immediately, remaining firmly attached to the stem. The little axolotl comes out of the egg perfectly formed, a minute copy of its parent; for we must remember that this parent is never grown-up, but remains always in the incomplete or larval state of its existence. The newly hatched axolotls grow rapidly to six or eight inches in length, and except for the branching gills closely resemble their near cousins, the salamanders.

Until 1865 the axolotls had never been closely studied. In Mexico they are abundant, are sold as an article of food in the markets and are eaten, "no questions being asked." They are to the Mexican buyers, axolotls, and that is enough. When taken to European museums the axolotls were supposed from their imperfect development to be larvæ, which one day would metamorphose into their adult form.

For several years the first specimens in Paris remained just as when they had been brought from their native lakes. Then, a change being made in their tank giving them more healthful conditions, what did they do but select some spears of grass and weed and decorate them with egg-cases! For thirty days the egg-cases adhered to the twigs, then the little ones hatched out, larvæ, like their parents.

After this curious circumstance had been discussed for a time, some scientific people thought they would try and force these axolotls to grow up. They were gradually removed from the water and accustomed more and more to breathe in the air. As this process continued, some of the creatures died, some made no change in their state, but some began to accommodate themselves to air-breathing without the help of water; the gills began to wither or waste away, as often happens to unused members of a living body; after a time these external gills dropped off entirely and the axolotl breathed through the slit at the bottom of the branchial stump. As soon as this was accomplished, behold, not an axolotl at all, but a salamander, for meantime the legs also had developed and strengthened.

A German lady secured in this way the change of young axolotls to salamanders, or at least to salamandral form and habits. It has therefore been held that axolotls may be a class of salamanders, which from the conditions of their life have never dropped their gills or accustomed themselves to a land life. Others think that as the young salamanders and axolotls are so alike, mistakes have been made in handling the larvæ, and that those which developed as salamanders were hatched salamanders. So little is really known of the habits and life history of these creatures that they offer a pretty clear field for observation and experiment. It would be easy for some of our scientifically inclined young Americans to secure specimens from Mexico, and rearing the young from the eggs, note all their changes. Nothing is more attractive than original investigation.

Some call the axolotl the "fish-formed siren," as it has a fin-like membrane down the middle of the back, around the tail, and so on along part of the under portion of the body. This fin enables it to balance itself admirably in the water. Axolotls eat worms, snails, tadpoles, insects, bread-crumbs, bits of meat, or any small larvæ found in the water.

LESSON XXXVI.

SOME MERRY LITTLE FRIENDS.

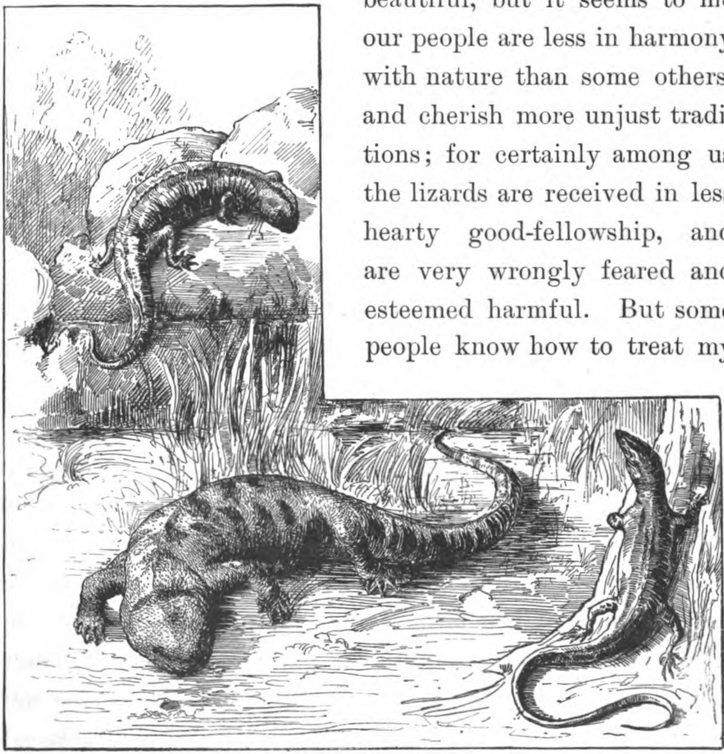
"The heedless lizard in his gambols, peeped
Upon the guarded nest, from out the flowers,
But paid the instant forfeit of his life."— MONTGOMERY.

IN calling the hideous and ill-tempered alligator *el lagarto*, the lizard, I think the Spanish explorers were guilty of a crying injustice to the lizard family, many of the members of which are the most delightful little creatures imaginable.

How often in Italy, seated by some ancient ruin or on a stone wall draped in rose vines, I have watched the merry little lizards, dressed in crimson, orange, or green, darting among the gray stones like flashes of living light, or running along the trailing vines like animated blossoms.

How often in the warm fragrant silence of the Tuscan hills, have I seen, thrust from the chinks of a pile of crumbling masonry, a pert little head, with a pair of diamond-bright eyes, watching me with intent interest. Friendly, graceful, entirely harmless, these little lizards seem to suit the beauty-loving Italians. I have never seen the smallest or rudest Italian boy throw a stone at one of them, or try in any way to hurt them.

The lizards in our own country are no less friendly and beautiful, but it seems to me our people are less in harmony with nature than some others, and cherish more unjust traditions; for certainly among us the lizards are received in less hearty good-fellowship, and are very wrongly feared and esteemed harmful. But some people know how to treat my



KNIGHTS ERRANT.

dear lizards with courtesy. A young friend in Florida has made pets of sundry emerald-green lizards. No creatures are more capable of maintaining an absolute stillness if they are suited with their circumstances. Like most of the cold-blooded reptiles, they delight in warmth. My young friend often placed a little green lizard in the knot of lace at the throat of her evening dress, where, delighted with the softness and warmth of the lace and its owner's neck, it would lie motionless for an entire evening. It was often mistaken for a piece of jeweller's work in rich green enamel, upon the beauty of which her friends sometimes commented. One of these little lizards would remain for hours, twined bracelet-wise about my young friend's wrist.

Inoffensive in disposition and unprovided with weapons of attack as lizards are, I have often admired nature's protective methods in their behalf. Walking once in a wood in New Jersey, I was surprised to observe a fragment of the bark of a tree some two feet from me, run round the tree and appear on the farther side. Here was a little lizard of the exact color and markings of the bark of the tree which it frequented; it was only by its motion that it could be discovered when it clung against the trunk or branches. When at rest its little, bright, jet-black eyes were the only noticeable part of it. In that same wood I was equally startled by seeing a dead leaf run away from a heap of leaves as I approached, and a little twig in my path darted out of danger just as I was about to put my foot upon it. These also were lizards, with their slender bodies dressed in gray and brown, with little markings of black and white, a coat closely simulating the colors of dry and decaying vegetation.

While capable of lying for hours in entire quiet, still as if fashioned out of gems or metal, the lizard, when it moves, is remarkable for the swiftness of its motions: it darts with the rapidity of an arrow; it seems to have no hesitancy, no after-thought, no change of mind; its spring is with the precision of entire certainty. Perhaps its sure-footedness has something to do with this; on wall or wood, tree, stone, grass, who ever saw a lizard slip or lose its footing?

In the lizard family there is a large variety in habits and appearance. We say that they are quick of motion — but then, what is more dull and sluggish than a hatteria? We assert that they are pretty and attractive, but what is more undeniably ugly in appearance than the horned toad of Texas, which is really a lizard? While in general the body of a lizard is slender and long, supported by four legs, in some species the legs are mere rudiments, and in others gone altogether. When present the feet and legs are sometimes weak, so that the body drags upon the ground.

The chameleons have their feet designed for grasping and climbing: the geckos of Asia have their feet changed into sucking disks, by which they can run up smooth walls; other lizards, which are chiefly aquatic, have feet formed for swimming; others still live in the ground and have hands fashioned like those of a mole, for digging.

As for homes, some lizards are tree-dwellers; others live on the ground, hiding in stone or rubbish heaps; some live in the ground in burrows; others abide by rivers, and spend most of their time in the water.

The lizards are citizens of the world, and are found in nearly all lands, but are most numerous and most brilliantly colored in hot countries. Wherever they are, some have so evidently the lizard characteristics that one who has ever seen any of the family would not fail to recognize their relationships at once; but others, as for example, the horned toad of Texas, might be thought at first sight to belong to some quite different order of animals.

Some lizards have scales; others have no scales, but thick, granulated skins: some have no eyelids; others have eyelids, but their eyelids differ, some are nearly transparent, admitting light when they are closed; while yet other lizards, as the chameleons, have lids surrounding the entire eye, so that they can be drawn together and admit light at merely a tiny opening.

In cold and temperate lands lizards lie dormant during the winter months; this is called hibernating. At the return of spring they come forth from their hiding-places. In tropical countries, while there is no cold to drive the lizards to a state of torpor, they still sink into a long sleep, or half-conscious condition, which lasts for some weeks.

Nearly all lizards lay eggs, which are warmed into life by the sun, and the young ones are able to take care of themselves as soon as hatched. But even in this part of its life-history the lizard shows the changefulness of its race, — as variable in all things as a chameleon's coat. Some lizards have living young, which they nurse with assiduous care.

A description of curious lizards would fill a volume; we can note only a few of the less well-known varieties. The geckos are a very interesting family, living chiefly in Asia. The "croaking gecko" is a lizard which distinguishes himself by breaking the spell of silence which lies upon his order, and making a loud noise almost as unpleasant as that raised by a frog. The "flying gecko," like the flying squirrel, has a wing-like expansion of the skin, and widely webbed feet, which enable it to support itself in the air as it leaps from tree to tree.

Another Oriental lizard is named "the frilled," because he wears a large quilled collar, or ruff, all around his neck; upon his head is a crest deeply indented, and down his back from head to tail-tip a full ruffle like a cloak close folded, or a court train. In fact, whenever I have seen a frilled lizard I have had a laugh, not only at its truly pert and comic appearance, but because he seems such a jolly little caricature of stately Queen Bess in her head tire, ruff, farthingale, and court train. Then, too, other ideas come to heighten my mirth over a frilled lizard.

You must know that lizards' tails are very brittle and not infrequently break off; when this happens the organ grows again just as a crab's claw does. I wonder if the tail of the frilled lizard is apt to break off, and how long it takes such a cumbersome appendage to grow. Then, again, here is my other little joke over him: all lizards, as they grow cast their skins; toads and frogs do this also, and crabs cast their shells. The process is far from unusual, but the lizards like the toads swallow their worn-out garments, and how can my frilled lizard swallow such an amount of frilling and furbelow and flouncing! I should say he must choke! It would be as bad as being obliged to eat a birthday cake, candles, wreaths of flowers, and all. But when I stand before a frilled lizard, and laugh at all these queer notions concerning him, what does he do but bob and move his head and neck, until all his ruffles quiver and curl in a most threatening way, as if he meant to alarm me by his ferocious appearance. But he is really a timid creature, and would rather fly than fight. If you persecute him and drive him into a corner he will now and then turn at bay, and bite with some sharp little teeth that he has.

The "flying dragon" is another odd lizard, provided with an extended membrane to serve as a parachute, and by which he flies — a little. But why call the dear little beast a dragon? His colors are wonderfully beautiful, as if he had been dipped in a melted rainbow, or in the stuff that peacock's plumes are made of. We think that dragons are fierce creatures, but this "flying-dragon" lizard lives in trees and daintily feeds upon gay-colored insects, as pretty as itself.

Another lizard is called the "horrid Moloch" from an ancient idol-god. This, with perhaps the exception of the "horned toad," is one of the most hideous creatures known. It is covered with large conical projections over the entire body; its feet are clawed, and the projections develop into horns on the top of the head and neck. These projections are merely a thick growth of the skin, each tipped with horny plates, and entirely intended for defensive armor, but they give the creature a formidable appearance.

Still another variety of the lizard tribe is the pygopus of Australia, a lizard with only one pair of legs, and these are scaly and footless. Indeed they look merely like fleshy fins, and as the animal is very long and slim, and is covered with scales, at first sight it is almost impossible to consider it a lizard at all; it looks more like a snake.

The iguana is a lizard of tropical countries: it is large, harmless, perhaps we had better say it is useful; for the natives of the countries where it lives are fond of its flesh for food, and think as well of a fried or roasted iguana as we do of roast chicken.

Perhaps of the entire lizard family the most famous is the basilisk, about which much has been said and sung. The ancients had as many odd myths about the basilisk, as they had about the salamander. They said it was the king of all reptiles and wore a crown of gold: from its body diffused a poison which filled the air and killed not only animals but plants: the glance of its eye was so terrible that all living things fled from it — unless they fell dead on the spot, infected by its poison. The basilisk was afraid of only one living creature, and that creature was — a cock. The crowing of a cock filled the king of all reptiles with an awful terror.

But what is the truth about the basilisk? The creature has been investigated by modern science. What does science report of it? Science says the basilisk is one of the prettiest and gentlest little creatures known. It is crested, and that crest is the famous "golden crown" of the ancient story; it is clawed, because it is a tree-climber; its eyes are large, gentle, lustrous; its skin is striped; its toes are much like the toes of a bird; its food is insects; it has no poison, and as for a cock's crow — it pays no heed to it whatever.

The Hilas are another family of lizards, embracing one with an ominous title, "The Gila monster." This is not inaptly named, for it is uncouth in appearance, large, and, unlike most lizards, has a poisonous bite. Though this bite is painful, it is not fatal.

The skinks are earth-burrowing lizards, not prettily shaped but handsomely colored, and especially noted for wearing vivid shades of blue, a tint unusual in reptiles. The ancients had myths about the skink as well as about the poor basilisk. They said it poisoned cattle, and was ever on the alert to do harm to man or beast. The fact is the skink is alert only for slugs, insects, and worms which it eats. Nearly all lizards are insect-eaters, though in captivity they will eat cake and bread.

LESSON XXXVII.

THE ANCIENT MONSTER.

"The various terrors of that horrid shore,—
Those blazing suns that dart a downward ray,
And fiercely shed intolerable day;
Those matted woods, where birds forget to sing,
And silent bats in drowsy clusters cling;
Those poisonous fields, rich with luxuriance crowned
Where the dark scorpion gathers death around."

— GOLDSMITH.

THE word reptile seems to be in such bad repute, and to raise such disagreeable associations in the minds of many people, that in introducing a few specimens of the class reptilia we began, not by describing the characteristics of the class, but by introducing some of its most pleasing members — the lizards. Let us now turn for a little to the distinguishing features of the class, and then to the animal which is its leading representative.

The class reptilia stands next to the class batrachia. Reptiles are cold-blooded, vertebrate animals, which breathe by the means of lungs. The form of the body is generally like that of the batrachians, between which and the birds, the reptiles find their place in nature. Thus the horned toad and the "horrid Moloch" are lizards, — reptiles which look very much more like toads than like their reptile brethren, — while the "frilled lizard" and the "flying dragon," gayly colored tree-dwellers, are more suggestive of birds than of some other lizards.

The body of most reptiles performs the chief part in locomotion, moving with an undulatory action from side to side. The spinal column is therefore strong and stiff, and the tail is long, while the head and shoulders are comparatively small and narrow. Some of the reptiles, as the serpent tribe, have no feet, but the tortoise family have well-developed feet, and move by means of them, and not by serpentine undulations of the body. Most of the reptiles are voracious feeders, and are well provided with teeth. The skull is always depressed, with a small cavity for the brain, and the standard of reptilian intelligence is comparatively low.

No class varies more greatly in the size of its representatives. We find tiny chameleons and lizards but a very few inches long, and great crocodiles many feet in length. There are snakes no longer than one's little finger, and boa-constrictors large enough to swallow a man or a cow. There are little turtles of the diameter of a twenty-five-cent piece, and huge turtles that weigh eight hundred pounds. When we name these species we are reminded what a wide variety there is in the families of the reptilian class.

There are four methods of securing safety, or life-preservation, known among the reptiles; the most common, — because the small creatures to which it pertains are happily the most numerous of their group — is imitation in form and color. We have noted this in the lizards. The second method is the wearing of natural armor, by the thickening of the skin or hide. Thus, in the serpents, the skin is often covered with scales; the scale-plate of crocodiles and alligators is generally bullet-proof; in the turtle family the body is protected by a hard, solid box of united plates neatly and closely put together. A third means of preservation is found in weapons of defence, as great teeth and huge, lashing tails, as in the crocodilia; or violent poison in fangs, as in many snakes. Lastly, the greater reptiles have often no weapon but their vast strength, as most of the boas; no creature desires to cope with them or go within reach of their mighty coils.

To make closer acquaintance with the most prominent and notable of all reptiles, we must go to the torrid zone. The hot breath of the desert smites us, as the sun's rays are like fierce thrusts, the noon-day is scorching, still, breathless; the green of summer seems to have been burned away, as in a furnace blast. There, stretched his lazy length on the black ooze, beside the famous river of Africa, lying in the full glare of the sun, his little eyes sleepily shut, heedless alike of the insects that cluster about him, and of the birds which dart down to carry them off, lies the monster that was in ancient times often worshipped as a god — the crocodile.

The crocodile gives his name to his order, crocodilia; which order, happily for human convenience, has but few representatives. The characteristics of this order are, aquatic habits, firmly planted teeth, skin thick and furnished with armor-plates, a long tail, four short legs, and feet with toes. The crocodile's limbs are muscular and active, well articulated or put together, and end in fingers or toes, whichever we may choose to call them. The strong, bony plates are chiefly on the creature's back. A peculiarity of the teeth is that they are cone or wedge shaped, and a pair on the lower jaw are much longer than the others, and fit into notches in the upper jaw when the mouth is closed. What is the use of these big teeth? It is to seize and hold firmly the prey of the monster, so that by no struggles can it escape when held by these cruel prongs.

The crocodilia are all inhabitants of hot countries, and are found in Asia, Africa, Australia, and tropical America. We chiefly associate them in our thoughts with the Nile and the Ganges rivers, where they particularly abound, and were once paid divine honors.

The gavial, or crocodile of India, often reaches twenty-five feet in length, and is the giant of its order.[1] It is distinguished from the true Nile crocodiles and the alligators by its very long and narrow snout, the jaws of which are set with fifty-

[1] Specimens even longer than this have been noted.

four teeth above and fifty-two below, presenting the appearance of a terrible pair of huge double saws. Each of these great cone-shaped teeth has beneath it, slowly growing for future use, two or three other teeth, which, as the tooth in use is worn out, grow up and displace it, and so continue the perfection of the entire set.

The shape of the nose or snout of the crocodile changes with its age; a young crocodile's snout is depressed, and the animal cannot remain under water so long as an old one. The male gavials have a large, prominent swelling in front of the nostril.

Africa is the original home of the true crocodile, and there it has been feared and deified from remote antiquity. Pictures and sculptures of it are to be found on the oldest monuments. With the terror of the crocodile the African mothers frighten their children into obedience, and often in the end the crocodile gets both mother and child if they venture too near the water. In the Upper Nile region the beasts abound, and are seen lying basking in the sun, "placed side by side like rows of felled tree trunks," says one traveller. They abound thus because the number of eggs deposited is enormous. No creature is more subject to enemies: men, turtles, and fish, besides wild animals, seek out and devour the crocodile eggs. As soon as the little monsters are hatched, fish, wild beasts, birds of prey, and the large male crocodiles, wait to devour them. A baby crocodile has no friend or defender but its mother, and through all its life it is the foe of nearly every living thing, and consequently hated and attacked by everything that is capable of doing it injury.

The crocodiles are entirely carnivorous in their habits. They prefer putrid flesh to fresh, and thus they are valuable river scavengers, eating every carcass that appears. Travellers tell us that in attacking prey the crocodile prefers to give first a good blow with his tail, and so render the victim unconscious. Then he drags it under water and devours it; or, if not pressingly hungry, buries it in the mud until it partly decays. The monsters lie in wait at fords, or at the drinking places where cattle and wild beasts come at evening to drink. Then they seize the stooping prey and pull it under the water. Antelopes, cows, and human beings seem to be the crocodile's favorite food. The creature is cowardly and will draw off if a person shows fight when it appears.

Owing to its habit of eating putrid flesh, the eyes, mouth, and throat of the crocodile are infested with swarms of large meat flies. The "Nile bird," an agile and pretty insectivorous bird, follows the crocodile about, and, dashing even into his open jaws, picks off the flies. The brute seems to understand the good offices of the bird, and never snaps at it or closes his mouth upon it. Thus the Nile bird is the only friend of the crocodile, and the only living thing that does not fear him. The tongue of the crocodile is attached all round to the bottom of the mouth, and cannot be protruded. The neck is so formed with rib-like processes that it can be moved but little, so the giant reptile has no means of ridding itself of its persistent insignificant torments, the flies, and is at the mercy of the Nile bird's appetite to get relief.

The mother crocodile lays her eggs in the sand, which she heaps over them, and leaves the sun to warm them into life.

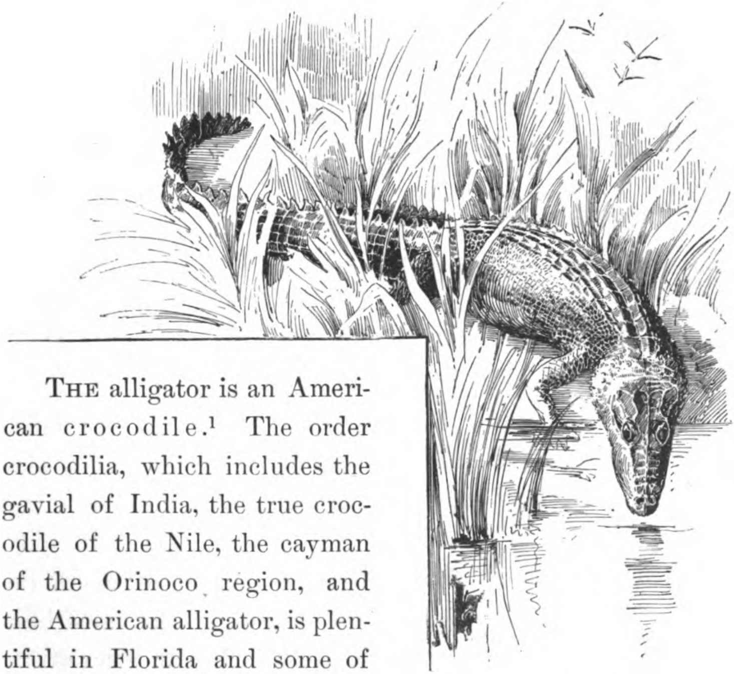
A recent traveller says that he took seventy-nine eggs from a crocodile's place of deposit near the bank of an African river. There was no effort to make a nest, but the mother had chosen a spot a few paces from the bank of the river, and had made it clear of plants in a circle of several yards in diameter. To do this she had placed herself on the spot and wheeled her heavy body round a number of times, making the earth clear. Then she had laid down a few branches, as if to prevent the eggs from rolling away. Next she dug out four pits, each about two feet deep, obliquely set. The eggs were laid twenty or twenty-five each day, until a hundred had been placed in the pits, one pit being dug and filled before another was made.

After the eggs are laid the mother crocodile remains asleep near them a great part of the time, basking in the sun, and leaving the place of deposit only to go to the water and seek food. The egg-laying occurs but once a year, about the opening of January. It is two months before the young hatch out, and about the time they appear the rainy season sets in. As they come from the hatching place they take to the water by instinct, and there the mother is waiting to give them what defence she can, for the male adult crocodiles are ready to devour them, and wild beasts of various kinds make them a prey. The young crocodiles show their fierce disposition at once, fighting, biting, and making themselves generally disagreeable as soon as they get into the water.

LESSON XXXVIII.

EL LAGARTO.

Basking upon a log he lies;
Around him skim the dragon flies;
Above the squirrel drums his tune;
The rabbit steals along the brake,
And trembles lest his footsteps wake
The tyrant of the still lagoon.



LURKING.

THE alligator is an American crocodile.[1] The order crocodilia, which includes the gavial of India, the true crocodile of the Nile, the cayman of the Orinoco region, and the American alligator, is plentiful in Florida and some of our other Southern States, and

[1] A true *Crocodilus Americanus*, long overlooked or mistaken for an alligator, has been discovered in America.

takes its scientific name from the Mississippi River,[1] one of its favorite homes. The name alligator is of Spanish origin, *el lagarto*, the lizard, and was given by the early Spanish explorers of our Southern States because this was the greatest lizard they had ever seen.

This American crocodile, the alligator, is one of the best-known creatures in the world. Being easily caught, and easily reared, it is seen in the cheapest shows, museums, and menageries, and in many public aquariums and zoological gardens.

For my own part I never felt a deeper sympathy with any wretched beast than I did with a pair of alligators in the Brighton Aquarium, England. Lying in a grotto, where all that could be done in the way of providing them with a few inches of water, and a certain amount of damp heat had been done to testify to the general good will of their keepers, were those miserable exiles from their hot, native lagoons. I fancied that among the mists and raw cold of "John Bull's tight little island" these creatures longed, as I did, for the vivid blaze of a southern sun.

While an alligator basking on a log in hot sunshine, deep water close at hand to slip into for safety, is a picture of intense lazy enjoyment, an alligator blinking at an electric light in an aquarium, a chilly beast stretched upon wet stones, seems in his stillness a picture of apathetic misery. I doubt if either of the beasts in the aquarium could have roused to enough interest in life to snap at its favorite food, a puppy, had one ventured near. They did not even show appreciation of the fact that a person like

[1] *Alligator Mississippiensis.*

myself, with a toleration for dog-days, and a hearty longing for palmettoes, trumpet-creepers, magnolias, and red-birds, was looking at them with sympathy and a gleam of kindness!

The adult alligator is easily taken prisoner by being seized from behind as it lies basking; its legs are securely bound, its mouth muzzled, and then—away to a showman's cage! The Orinoco cayman and the Mississippi alligator are often captured in the following curious fashion. A hook baited with some small animal, which the alligator especially likes as food, is dropped into the water, and when seized by the alligator, the hook which is not sharp, but blunt and double, is arranged to expand and fill the creature's throat, but will not pierce or tear it. Then by pulling at the chain or rope attached to this hook, the brute is drawn ashore. A strong man next leaps on its back, grasps its fore-legs and draws them bridle-wise back to serve as reins. Thus mounted the captor maintains his seat as on a fractious horse, during all the creature's plunges and tail-lashing, until finally it succumbs, fairly worn out by its own battle. Once entirely exhausted, it becomes weak, mild, and obedient.

The food of the alligator is squirrels, rabbits, water-rats, water-fowl, fish, hares, and young dogs, but it will attack men and kill children if it has opportunity. Its method of preying is much like that of the Nile crocodile; the victim is first pulled under the water and drowned, and then eaten at leisure.[1] The alligator seems to know that while he is merely enjoying a little agreeable change under the surface of the water, his prey will drown.

[1] The alligator, like the crocodile, can close the nostril opening and remain under water for some time.

Why does not the water rush into the lungs of the alligator, and so smother it, as the alligator is a lung-breathing animal? Because it has at the base of its tongue an interior collar which expands and guards the passages to the lungs when it is under water. When it wants a mouthful of air it elevates its head above water while its hands hold its victim below the surface.

The alligator is a smaller animal than the crocodile, its length being from five to ten feet; its head is shorter and broader than that of the crocodile, and its snout is more obtuse. The large, long teeth on the lower jaw do not, as in the crocodile, fit into external furrows on the upper jaw, but into pits made there to receive them. The hind legs and feet of a crocodile have a jagged fringe which the alligator does not have; the alligator's hind feet are webbed only about half way up the toes, and the crocodile's hind feet are webbed to the very tip.

Despite the strong musky odor of the alligator's flesh, it has sometimes been eaten: so also there are people who will eat crocodile's flesh and eggs. To a civilized appetite no flesh could be more loathsome.

The alligator's bill of fare is not confined to the living creatures we have just mentioned as furnishing its favorite food. Alert for its breakfast, this pirate of the lagoons and bayous gathers up fish, flesh, and fowl for its table, but swallows, as a condiment, whatever comes handy. An old rubber shoe floating in the water, an empty soda-water bottle, a lost jack-knife, a battered tin can, a stone as big as an orange, part of a broken lamp, — any of these are welcomed as serving to fill the yawning vacancy in its stomach, and to aid in grinding up more digestible food. Similarly an ostrich will swallow a horse-shoe, a table-knife, a spoon, a leather strap and buckle, a few spools of thread, or any other trifle left in its way, seeming to consider its stomach, as a school-boy does his pocket, a general receptacle for almost anything that comes to hand!

Baby alligators make rather amusing pets for a number of months, before they begin to exhibit hereditary traits, when they at once fail to be agreeable. They will eat eggs, raw or cooked meat, rats, mice, birds, frogs, toads. They learn to come when they are called, enjoy hearing a whistle, and, on rare occasions, show some slight degree of gratitude and affection, amiable characteristics which they speedily outgrow. When these baby alligators are a few months old, they must be killed or put back into the water where their relatives live.

Alligators are usually silent animals, but in the spring, when the eggs are being laid, they all become noisy and excited, and bellow like buffaloes. A number of adult alligators roaring together make a sound like distant heavy thunder.

The mother alligator builds with her front feet a mound of mud, or sand, though if she finds a mound just to her taste, she takes that, and saves herself trouble. In the mound she places her eggs, and in due time the sun hatches them. The eggs of reptiles are not enclosed in hard, brittle shells, as those of birds, but in a thick, tough, elastic skin, as if the white skin that lines a bird's egg-shell had grown parchment-like and served instead of shell. The eggs are the size of hen's eggs, but more pointed.

As soon as the little alligators come from the egg, they scuttle off to the water and are ready to fight their enemies and begin their predatory lives. As they are smaller and less fierce than the gavials, caymans, or true crocodiles, they are far less destructive. An alligator of twelve feet long is a giant of his kind. Not only are the alligators smaller than crocodiles, but they have fewer teeth, and are "less handy with their tails," not being able to strike out quite so vigorously.

The alligator is among the animals that are disappearing before perpetual hunting and the presence of men about their old haunts. They are still numerous, but fewer than they were some years ago. They will die out speedily unless people undertake to raise them on alligator farms. And why should people do that? For the sake of their skins. Alligator skins make a strong and handsome leather, very beautiful for bags, portmanteaus, purses, boots, portfolios; and for the sake of their skins they should be reared.

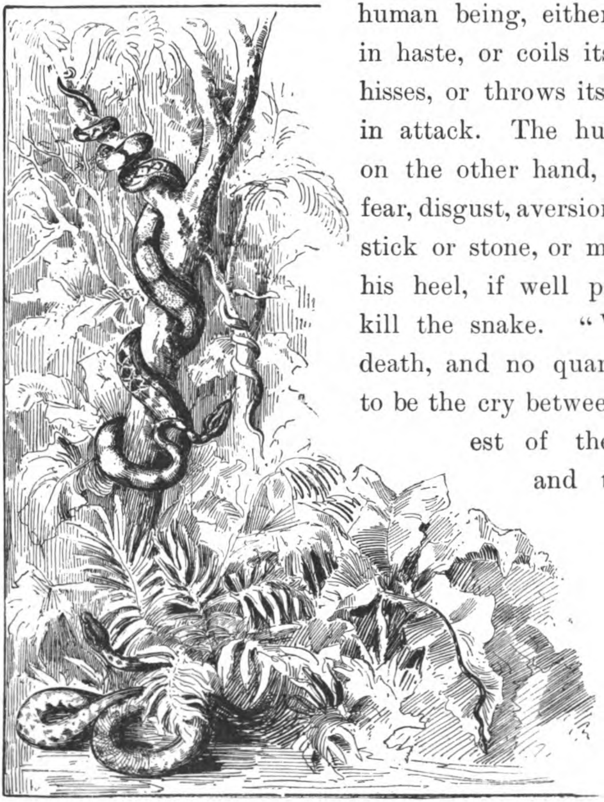
LESSON XXXIX.

WISER THAN ANY BEAST OF THE FIELD.

"Beyond the shadows of the ship
I watched the water snakes;
They moved in tracks of shining white;
And when they reared, the elfish light
Fell off in hoary flakes."

—COLERIDGE, *Ancient Mariner.*

BETWEEN man and the snake there seems to be placed an instinctive and unappeasable enmity. The snake, seeing any



OUR NATURAL ENEMY.

human being, either glides off in haste, or coils itself up and hisses, or throws itself forward in attack. The human being, on the other hand, experiences fear, disgust, aversion, and seizes stick or stone, or makes use of his heel, if well protected, to kill the snake. "War to the death, and no quarter," seems to be the cry between the highest of the mammals and the serpent tribe.

"As hideous as a snake" is a common phrase, born of the hatred between man and the ophidian order, but in point of fact, were enmity left out of the question, the creatures of the serpent tribe are not hideous. A lithe, long, cylindrical body, coated with glittering scales, and splendid with all the colors of the rainbow, elegantly arranged in rings, lines, or dots; bright eyes; graceful motions; a tongue that plays to and fro like lightning in an open throat, often of vivid flame color; a head sometimes crested as if bearing a royal crown,—these are some of the characteristics of that serpent family, which instinctively we call "hideous" and "hateful."

To the above briefly noted particulars we may add that the eyes of snakes are lidless and the sight somewhat feeble; the sense of smell is better developed, and the nostrils are placed close to the mouth. The mouth is large proportionately, and opens widely; the tongue is the organ of touch; there are no external ears, and snakes seem to be deficient in hearing. Snakes have no external limbs, except in two or three species, where there are mere rudiments of hind-legs visible. The snake's body is elastic and capable of enormous distention. It is furnished with a spinal column, and with numerous ribs. The ribs and scutes, or large scales, are the chief organs of locomotion.

The method of crawling shown by the worm, as described in Nature Reader, No. 2, is very much like that of some snakes. There are three ways in which snakes make their progression. First, they may glide forward with a perfectly straight motion, by pushing with the scutes, or large scale-like plates of the under part of the body, to which the ends of the ribs are attached. Second, these scutes may open out as the scales of a fish when scraped backward from head to tail,[1] and on the edges of these opened scute-plates, the snake may walk. Third, they may go forward by pushing; stretching out the body, and then contracting it, and making the same motion over again, these motions being sinuous, or wave-like, from side to side.

The light, smooth body of the snake, provided with nu-

[1] Nature Reader, No. 3, Scales and Teeth.

merous small, powerful muscles, renders its progress by any of these methods exceedingly rapid. Water snakes swim, waving the body from side to side, and using the tail as an oar is used in sculling. No serpent can move on a perfectly smooth surface, as glass; it must have some ridges, or roughness to resist the motions of the scales and ribs.

Serpents are dumb except for their hiss, which is produced by driving the air swiftly from the lungs. In some snakes the hiss is varied to a whine or hum.

Serpents, like the batrachians, cast off their skins and come out in gleaming new skins which have grown under the old ones. If the serpent for any reason cannot cast its skin at the proper time, it sickens and dies. The cast coat is perfect in form, but is generally turned inside out. Cast snakeskins are sometimes found in the woods by sharp-eyed boys. Sometimes the lucky boy finds a whole skin; at other times the cast skin has been partly destroyed by ants, beetles, or the effects of the weather. Some snakes swallow their cast-off skins.

Snakes usually move about and hunt in the day-time, and sleep at night. They hibernate, or take a long winter sleep, as the lizards do. For hibernation they retire to caves, to holes in logs or in the ground, and may be found torpid, a number rolled closely together. At such times the most poisonous snakes, as the viper and rattlesnake, may be handled without danger. In the spring they begin to revive with the first warm weather.

I remember that when I was a little girl a very beautiful hollow or cave in the river-bank not far from Niagara Falls was called "The Rattlesnake's Cove," because so many snakes lived there. In summer the place was carefully avoided. In early spring, before the snakes awoke from their sleep, this cove was a favorite place for picnics, and the school-boys often went there armed with knives, hatchets, picks, and hoes, and hunted for the torpid snakes and killed them by scores.

In hot countries, where there is no winter to send them off to sleep, the snakes are for some part of the year stupid and drowsy, and lie for several weeks in a nearly comatose condition. In this state they are too dull to be either timid or ill-tempered. On the other hand, when casting their skins, they are exceedingly nervous and vicious.

All snakes are flesh eaters, and have very hearty appetites. They drink a large amount of water, and when a captive snake is well supplied with water, it can live for several weeks without food. However, it is doubtless hungry, and the experiment is a cruel one to try even on a snake.

The serpents have many teeth, sharp, cone-like, and pointing backward. These teeth grow constantly; when they become at last old and worthless, they are at once renewed. Lucky snakes! no toothless gums, no worn-out, broken teeth, no aching teeth, no dentist's bills. Nature keeps their teeth perfect from infancy to old age.

Snakes lay eggs, and with the one exception of the python, which carries her eggs in a fold of her body, they deposit the eggs in safe places, leave them to hatch by sun heat, and let the little ones take care of themselves as soon as they come forth from the eggs. There are also a few species of snakes which have their little ones born alive, not in the egg. Snakes' eggs are enclosed in a leathery skin like those of turtles. There is a widely spread story that the young of some kinds of snakes accompany their mother, and in time of danger she stretches open her mouth, and they take refuge in her throat, where they remain safely until the danger is passed. The keepers of the "snake-house" in the London Zoological Garden told me they had never known a case of the kind, and the best scientific writers have found no proofs that such story is true. Therefore this tale is open to grave doubts.

The snake is a creature about which fables have been gathering from the earliest times. The snake was one of the first objects of false worship; coiled in a ring with its tail in its mouth, it was taken as a symbol of eternity. The Magi of the East used it as the emblem of their order and their arts; a serpent twined on a stick was also the emblem of physicians, and of the art of healing. It is strange that a creature exhibiting so many deadly varieties should have been chosen as the insignia of the physician, and not less strange that to the serpent should have been attributed great wisdom. Snakes exhibit fear and anger, but almost no wisdom or anything that seems like reason. Nearly all domestic animals — ants, bees, spiders, and many fishes — show far more forecast, ingenuity, architectural ability, than any snake. And yet "crafty as a snake," "wise as a serpent," are frequent expressions.

Snakes vary greatly in their habits: there are snakes which live on the ground, hiding under stones, leaves, or brush, and in rock crevices; other snakes live chiefly in the water, making their holes in the bank below water-mark; others live in trees, and some others almost entirely underground.

To this tribe surrounded by enemies, nature has given abundant means of self-preservation,—swiftness of motion; instinct of instant flight; poison, sometimes deadly to its enemies; vast size and strength, as in some boas and pythons, and especially colorations, which closely imitate their surroundings. Thus ground snakes have, especially on the back and sides, brown, gray, black, and white in spots and markings, which together look much like earth, twigs, pebbles, and dead leaves, so that the snake can scarcely be distinguished from its bed or home. Tree snakes, and snakes that live in grass or mosses, are usually green, marbled, or streaked with black and brown. Snakes from the marshes or muddy banks are nearly black; among the abundant flowers and gayly colored shrubs of the tropics, snakes take very brilliant hues. Snakes of temperate climates are also often tricked out with scarlet, or white or orange stripes and bands.

Snakes are largest, most numerous, and most brightly colored in hot countries. Like all the cold-blooded vertebrates, they delight in hot sunshine, and will lie motionless, basking for hours. In taking a position for this sun-bath, they select a place where they will not be conspicuous. I have often noticed that while a gray snake will stretch itself out in the sun on a bare rock, a green snake never chooses such a post. Instead, the green snake extends itself on a bed of moss, or close, short grass, or if slim and light of body, will crawl up the midrib of a big leaf, or the stalk of a fern frond, where its color is scarcely discernible from the vegetation about it. A dark brown or black snake seems to know that it is tolerably secure lying upon a fallen, decaying tree-trunk. So a gray, or black and white snake, may often be seen sunning himself on a fence-rail, or on the top of a stone wall.

There seems to be a common notion that because a creature is a snake, it must be dangerous and poisonous. This is quite wrong, for in point of fact, very few of the numerous serpent families are venomous. The greater number of their species are quite harmless. One of the most dangerous of all snakes, the boa-constrictor, does not kill its prey by poisoning, but by crushing it. In general, the head of the harmless snake is rounded and oblong, while the poisonous species have heads flat and triangular.

Snakes prey upon birds, toads, rats, mice, frogs, gophers, and destroy much harmful vermin. The common snakes, called "milk snakes" and "garter snakes," which frequent barns, are not at all poisonous, but, on the contrary, are useful, destroying rats and mice. Nearly all snakes are very fond of milk, and will glide up to a bowl of bread and milk, especially if it is warmed, and eat it with great relish. Black snakes are seldom harmful to people, but are cruel enemies of birds, devouring the young and the eggs, and tearing up the nests.

Snakes seem to be able to "charm" or mesmerize small animals, and sometimes even human beings, by fixing their gaze steadfastly upon them. The victim appears to be smitten dumb and motionless with terror, and a bird thus charmed will presently flutter straight toward the open mouth of the snake. I have seen one case of a snake so charming a bird, but I had a better opportunity to study a cat charming a bird, and probably the process is much alike in both.

The cat placed itself on the outside sill of my window, near to a pine tree. A bird presently alighted on the pine tree, no doubt not observing the cat. The cat fixed its attention on the bird. The cat's eyes were widely opened, and shone with a peculiar brightness; its head was raised and intent, the fur on its neck and about its face slowly stood up, as if electrified. Except for this rising of the fur, and a certain intensity of life in the whole attitude of the beast, it was as still as if cut from stone. The bird quivered, trembled, looked fixedly at the cat, and finally, with a feeble shake of the wings, fell toward the cat, which bounded to seize it.

LESSON XL.

OUR COMMON ENEMY.

"Within the shadow of the ship
I watched their rich attire,
Blue, glossy green, and velvet black,
They coiled and shone, and every track
Was a flash of golden fire!" —COLERIDGE.

ONE day while sitting at dinner I heard a loud outcry from some bluebirds, especial pets of mine, which had their nest in a little grove of dwarf oaks near my house. Hurrying out to inquire into the troubles of my favorites, I saw the mother bird sitting on a twig, her wings dropped wide and slack, her tail drooping, her head stretched forward, quivering with fear; the father bird was flying about crying wildly, while on a limb of the oak, and approaching the nest, was a large black snake. The nest was full of nearly hatched eggs.

To throw a big stone at the snake was the first performance. Then some one ran for a cane to beat the monster; but the snake had concluded that discretion was the better part of valor, and waited only to receive one good blow, before he glided off among the bushes so swiftly that we could not find him. Where these big climbing snakes are numerous, the birds have a hard time to raise a brood, for the snakes destroy the nests, and devour alike parents and fledglings.

Except for their attacks on the birds, tree-climbing snakes are usually of the harmless kind, and are sometimes even useful. There is, however, a tree snake in hot countries, which seems to have a spiteful disposition, and darts from the branches at the eyes and faces of passers-by, often inflicting a sharp, though not poisonous wound.

I once formed the acquaintance of a girl who acted as "snake-charmer" in a museum. She astonished the public by going into a glass cage filled with snakes, which she handled and played with. She held the snakes in her lap, twined them about her neck and arms, and made free with them in many ways. She told me confidentially, that while these snakes looked as if they were terrible monsters, they were the most of them fangless and of harmless varieties. Those which were of poisonous species had been rendered safe playthings by having their fangs cut out.

The poisonous snakes have a poison sac or bag, which empties into a little duct or canal running along each side of the jaw to a large tooth or fang; by an action of the throat muscles, the serpent presses poison from the sac through the canal, and ejects it through the tooth as it bites. By cutting out the fangs the snake is rendered harmless, but only for the time being. The poison apparatus reproduces itself, and unless the process of growth is watched and the fang again cut out, the lately harmless snake may suddenly become harmful, and the snake-charmer be fatally wounded.

"The poisonous ones do not keep from biting because I charm them, or because they like me," said the snake-charmer frankly. "Snakes never know or like anybody, so far as I can see; it is only that they can't bite, that's all. Folks think the snakes love me because they coil about me. It is only because I am warm that they do that. They are cold creatures, the snakes, and they like the heat of my arms, neck, and lap, that's all."

Among the snakes without poison glands are the pythons, the species that watches over and incubates its eggs. The mother python coils herself round and over the eggs, and for three months retains this position, until the little ones are hatched. She seems to be very fond of her young, and is the model mother of all the snake tribe. The larger pythons eat birds, cats, rabbits, hares, frogs, and dogs. They seldom meddle with human beings in any way. The sand snakes are nearly related to the pythons and are also non-poisonous.

The largest of all snakes, the boa-constrictor, belongs to the same sub-order as the python, and would be harmless if it were not for its rabid appetite, which tempts it to devour every living thing which it sees, while its great strength enables it to master almost any prey. Thus it will wind about a man, an ox, or a horse, and crush such victims to death, and feed upon them at leisure. The boas and most of the pythons are natives of hot countries.

A man who had long been a sailor gave me an account of the capture of a boa-constrictor, which is now in the London Zoological Garden. This sailor wanted to go to the interior of the island of Java, to see the country. When he landed in Java he met an English gentleman, Sir Henry ——, who was fond of travel and hunting, and had come to Java intending to capture some wild animals to present to the Regent's Park Zoological Garden. A rajah of Java had invited Sir Henry to go to his bungalow in the central part of the island, and have a big hunt. Sir Henry offered to take the sailor along to aid him. They caught a tiger and several other beasts, and I will describe to you the way in which they captured a boa-constrictor.

They found a place in the forest, where the crushed grass and brush showed that a boa frequently passed by. Then at evening, they fastened a goat to a tree that its crying might attract the big snake. For two or three nights something carried off the goat, or it managed to escape. Finally they chained the goat. The hunters were watching and waiting some way off. At last they heard cries from the goat, which cries the natives said meant that a snake was coming. Then all was still, and they said that meant that the boa was eating the goat.

Accordingly they hurried to the spot. There, stretched out his full length, lay a huge boa; he had swallowed the goat, which distended the front part of his body so that he would have had hard work to move, even if he had not been held by the chain attached to the swallowed goat. This chain was fastened to a plane tree, and held the boa fast, as he could not disgorge the goat. The boa does not dismember or chew its food; it crushes it, and swallows it whole. Then it lies quiet, and waits for the mass to digest. Thus the boa was captured by the chain down its throat.

Several strong natives now leaped upon the monster's tail and held it down. Others laid a long, thick bamboo on each side of the boa, from head to tail. Then with strong, new ropes they wound and bound the snake to the bamboos until he was stiffly imprisoned. Next they released the chain from the tree, and left the end dangling from the snake's greedy mouth. Then a dozen or more strong natives picked up the bamboo sticks, with the great serpent between them, and marched off to the coast, where a cage had been prepared for it on an English ship.

The sub-order which includes the greatest snakes in the world, as the boas, pythons, and anacondas, includes also some of the very smallest, tiny creatures not over an inch in diameter and a few inches in length. These snakes exhibit every variety of color and marking, — green, gold, crimson, white, black, brown, violet, yellow; they gleam in the splendors of the rainbow.

I remember once on a crest of the Lehigh Mountains I was looking up some of the lower vertebrates, when, happening to glance over the side of a big stone on which I was sitting, I saw the most beautiful little snake that I could imagine. It was coiled up in the sun, and was only about ten inches long, and less than one inch in diameter. It was of a vivid emerald green color, and as the sun touched its tiny scales they seemed bordered and powdered with gold. The under part of its body paled to pea green and silver white, a few dots of red glittered about its neck and shoulders, like coral beads. Its wide-open mouth was reddish and bordered with yellow. Its tiny tongue played like lightning to and fro, caught the sunshine, and gleamed as if dipped in gold. Alarmed at seeing me, and afraid to leave its retreat on the sunny side of the stone, it erected its head with a low hiss, darted it from side to side, and seemed to try to frighten me away.

Almost as pretty as this little dweller on the mountains are some of the water snakes, which are often iridescent, and change in tints of red, purple, crimson, orange, and green. Good swimmers and fishers, they pass a happy life among the lily-pads.

LESSON XLI.

WITH A HOUSE ON HIS BACK.

And through the mossy wood-paths slow
I see the silent tortoise go.
The flecks of light, the shadows dim,
The springing flowers, are naught to him;
The dry pine needles are his bed,
His house is always o'er his head,
The fungus is his table spread.

SEVERAL years ago, walking one morning in a wood in Pennsylvania, I surprised a wood turtle or box tortoise, eating his breakfast. The season had been rainy and many varieties of large fungus had attained a prodigal growth. The woods were full of what are popularly called toad-stools; many of them were of the diameter of a tea-plate, and stood five or six inches high. As I walked through the wood I observed that many of these fungi had been gnawed off evenly, as if cut by a knife, leaving only the central pillar intact. What had done this? I soon discovered; for moving noiselessly over the mossy earth, I came to a little opening, where grew one of the finest of these toad-stools, and there was a wood turtle taking his breakfast.

The animal had already made one or two rounds of his plate, and was eating with praiseworthy deliberation. He would bite off a mouthful of toad-stool, chew it carefully until he had extracted all the juice, then open his mouth and drop out the chewed fibre, and take a fresh mouthful, not biting inward toward the stem, but breaking off the morsel next beside that which he had just eaten. He paced round and round the fungus as he took his bites, eating his plate like Æneas and the other Trojans,[1] and as the fungus decreased in regular circles, the circle of chewed fragments increased. In three-quarters of an hour he had eaten all the disk of the fungus to the stem part, and then he walked slowly off to look for another.

I found the crumbs that had fallen from his vanished table quite dry, nothing nutritious being left in them. Why

[1] The harpies, we are told, frightened Æneas by saying he would be so hungry that he would eat his plate. But as the Trojans at one of their meals used big cakes of bread for plates, the prophecy was harmlessly fulfilled.

he rejected the central part of the fungus and the stem, I could not imagine, but he left it in every instance. If he came upon a decayed or wormy portion of the toad-stool, he did not "bite round it," but abandoned it altogether, and went for a fresh one.

At another turn in this wood, I found, under a pine tree, the shell and entire skeleton of a turtle, from which every particle of flesh and muscle was gone. The animal had died on his bed of pine needles, and his decaying body had been devoured by ants, which had left a delicately white skeleton. The little horny jaw had a very close resemblance to the beaks of certain birds.

The turtle is a four-legged reptile, with a short, stout, oval-shaped body, encased in a bony frame or box, from which the animal is able to protrude its head, legs, and tail, and into which it can withdraw them at pleasure. In different varieties of turtle, the size and shape of the box-like covering varies. The box tortoise can retire into its shell and close the under part into a groove of the upper edge, and thus form for itself an impregnable retreat; but there are varieties only partly encased by the shell, which cannot bring their heads and feet under cover.

The turtle wanders about with its house on its back as the snail does, and against its enemies it can close its doors and be emphatically "not at home." Turtles have keen sight and hearing; they have no teeth, the jaws being simply cased in horn, like those of birds. Many of them are capable of making loud sounds.

Turtles lay eggs which are buried in earth or sand, and left to themselves to hatch. The sea turtle is the largest variety, and will sometimes lay as many as two hundred eggs in a single heap. Sea turtles weighing a thousand pounds have been caught in tropical lands. Turtles of five or six hundred pounds weight have been captured on the United States coast.

In the four species of marine turtles, the feet are flat and fin-shaped. In one the shell is rather leathery than horny. Some of these marine turtles are carnivorous, living on fish, mollusks, and crustaceans; others are strictly vegetarian, feeding only on roots and various sea-weeds. The flesh of some of the sea turtles is rich and delicious, and a favorite and costly article of food; but of some others the flesh is coarse and strongly flavored, so as to be quite uneatable. The eggs are always sweet, good, and wholesome food. The shell of the sea turtle is a valuable article of commerce, boxes, cases, handles for knives, jewelry and other delicate ornamental things being made from it; it is susceptible of a high polish, which brings out clearly its rich brown and golden shades and markings.

Next to the marine turtles, come the fresh-water or river turtles. These eat both animal and vegetable food. They enjoy lying in a bed of mud, their heads lifted above the surface of the stagnant water, their long necks moving snake-like to and fro as they take mouthfuls of air. The fresh-water turtles are generally gregarious in their habits, large numbers of them being found together. They are fond of lying in the sun on logs or banks, near the water, into which they promptly slide at the first hint of danger. They are timid creatures, but if caught will snap and bite furiously.

Salt and fresh water terrapins are a variety of turtle. Some scientists distinguish the turtle from the tortoise thus: the turtle is a marine animal, does not hibernate, cannot draw its head and feet inside its shell. The tortoise never goes to sea; can draw itself entirely within its shell, though only the box tortoise can close the shell fast when so withdrawn, and finally, the tortoise hibernates. Some of the best and latest writers on the subject call all these animals turtles, giving the name tortoise to the box tortoise of the wood.

Clumsy as turtles appear in their box-like covering, they can walk rapidly on land, are climbers of some distinction, and all of them can swim. The head, neck, and legs of a turtle are of a uniform color, — bronze, blackish green, or deep brown. The shells or boxes are beautifully marked, glossy, ribbed, ridged, or carved, and made up of closely united many-sided plates, fitted upon a thickened, lighter-colored, uniform plate. This shell is not brittle and lime-like, as the shells of mollusks, but is more like horn.

In general, the shell or flat covering of the under part of the body is of a lighter color than the upper case, being light brown, yellow, or cream color, with yellow lines dividing the plates, and bordering bands of red, yellow, or purple. The upper shell is usually of a very dark color, marked and lined with darker and lighter tints, and often with a bevelled yellow edge.

The painted turtle receives its name from the beauty of its many-colored shell. The spotted turtle, often called the wood turtle, is distinguished by fine yellow spots sprinkled over its black back. The turtle which I saw feasting on the fungus was the common box tortoise. This box tortoise prefers dry woods, and dislikes the water. It is a long-lived creature. Some specimens have been known to live over a hundred years. A box tortoise that I had, ate meat, insects, and bread and milk from my hand, but if I put berries in its mouth it wiped them out with its front foot used hand-wise, in a very funny way. When it wanted to get away from the balcony, it crawled along the edge looking over, its neck outstretched; when it seemed to decide to go over it suddenly drew itself close into its shell, and making some quick jerk while quite shut up, over it went, came down safe in the grass, and walked away. I watched it do that many times and was never quite sure how it flung itself "overboard" after it was safely shut up.

The snapping turtle is a common variety. It has a box or shell too small to close over it and hide it completely. To make up for this lack, it has a bold and hasty temper, and snaps vigorously when disturbed.

The gopher is the turtle of the southern pine countries. It is a large, strong animal, with a shell fifteen inches long. These gopher turtles live in troops, a number of families digging their dens or burrows near together. The entrance to the den is about four feet long and expands into a spacious room. In each burrow lives a single pair of gophers. Gophers' eggs are as large as pigeons' eggs, and the eggs and flesh are prized by the negroes as food. By day gophers stay at home, by night they wander out and devour yams, melons, corn, and other garden produce. They dislike wet, and go in doors when it rains.

A near relative of the gopher is found in Europe, and is often kept about the house for a pet. If it can find its way into a garden in the autumn it digs a hole and hibernates, coming forth in the spring. A friend of mine in London had one of these animals which lived in the kitchen. It was fond of creeping into the fire-place and getting under the grate, where it would lie until the hot coals and ashes dropped upon its back and burnt its shell. When winter came this little animal wanted to take its long sleep, and dug so persistently into boxes, baskets, drawers, and closets that finally a box of earth was given to it, into which it worked its way until out of sight, and there stayed until April. It ate potatoes, carrots, turnips, and bread and milk, which it specially liked.

LESSON XLII.

A REAL LIVE MERMAID.

"The waters pushed, the waters swelled,
  A fisher sat near by,
And earnestly his line he held,
  With tranquil heart and eye;
And while he sits and watches there
  He sees the waves divide,
And lo! a maid with glistening hair
  Springs from the troubled tide." — GOETHE, *Trans.*

WHEN I was a child I was greatly fascinated with tales of mermaids, fabulous damsels who lived in the ocean. They had beautiful faces and arms, and long, pale green hair, which they combed with golden combs, and decked with seaweeds and pearls. They swam like fish, and sang most sweetly. When I learned that mermaids were only creatures of fancy, and did not really exist, I felt as if I had been robbed of friends. A few years later a bronzed, wrinkled old fisherman restored to me my mermaids as real creatures, even more interesting than the sea maids of myth. And so there is a real live mermaid!

Where shall we find her? My old sailor said he first met her some miles out at sea, in the latitude of Florida. She was swimming along at ease, her head held above water, and she carried on her arm her baby, whose head she stuck up above the waves.

Was she beautiful? Had she large, lovely eyes? No; her face was something like that of a cow, but instead of the large black eyes of a cow, she had tiny eyes, smaller than those of a pig. But were not her arms beautiful? No; her arms were flat, short, somewhat of an oval shape; in fact, they were flippers rather than arms, though she had free use of the elbow, shoulder, and wrist joints. She had no hands, no fingers, but at the end of each flipper were three small, flat nails. Had she long, waving hair? No; she had a few coarse hairs about her face, and a scanty covering of very fine, short hairs over her body. Could she sing? Unfortunately all real mermaids are dumb. Finally, was she of a sea-green color? Not at all; her skin was very thick, and of a dark gray, finely wrinkled all over, very like the skin of an elephant. Her upper lip was divided into two deep lobes, and she had no lower limbs, but instead a tail, with a wide, strong fin.

Oh, an ugly, horrible creature! By no means; on the contrary, as amiable, mild, gentle, playful, kindly a creature as ever drew breath. A fish, of course! Indeed not: a mammal; a mammal of the sea.

The class mammalia has orders of animals that live in the sea; other orders of creatures that live mostly in the air, and very many other creatures that live on the land, and some that spend their lives under ground. Any animal that suckles its young is a mammal, whether a swimming, flying, walking, climbing, or burrowing creature. The sea mammals are the whales, dolphins, porpoises, dugongs, and this mermaid.

Our mermaid is called by sailors a "sea cow" from the shape of its head and face; a "river calf" from its size and habit of living in rivers; the most common and best name for it is that given it by the early Spanish colonists, the manatee, or handed animal, because it can so skilfully use its fore limbs or flippers.

Once there were manatees in many different parts of the world. They were numerous in the Indian Ocean and in Behring Sea; but they have been so recklessly slaughtered that now the creature is nearly unknown, except a few in Africa near Cape Verde and the Cape of Good Hope; some few along the coast of South America, and those that inhabit the rivers of Florida. The manatee, like the buffalo of the Western plains, is likely soon to be extinct.

The manatees of the Eastern hemisphere seem to have been much larger than those of Florida.[1] Eight or ten feet

[1] The rhytina and dugong are not, as some suppose, manatees, but animals closely allied to true manatees.

is the usual length of the American manatee. Efforts have been made to raise the animals in captivity, but they do not thrive. One was kept sixteen months in the aquarium at Brighton, England, and was fed on lettuce, cabbage, turnips, thistles, and dandelions. Let us now look at the animal in its favorite home, the Santa Lucia River in Florida.

Manatees live in droves or herds, and prefer shallow to deep water. When they move up the river they keep well to the centre of the stream, as they are very timid. They rest near to the banks where they find plenty of grass and lily-pads to shelter them. Manatees come from the West Indies and Central and South America to the Santa Lucia River, to rear their young among the thick vegetation. They arrive early in May and remain until late in the autumn.

Here is our manatee; let us take a good look at it. It has a gray wrinkled skin; no fin on the back; a stiff, thick, shovel-shaped tail, with a flat tail-fin; a moderate sized oval head with small eyes; a very small under lip. The nostrils are two slits of a half-moon shape; the ear is a little orifice, set not far behind the eye. The sight of the manatee is good, but its hearing is something extraordinary. Probably no other animal has ears so acute. If a blade of grass or a leaf drops into the water the manatee hears it and darts away, for it is as timid as it is harmless.

To the shoulders of the manatee are attached the flipper-like arms, which it uses so readily. When in shallow water the creature supports itself on the ends of the flippers and the tail, and thus raising its body it moves slowly about the sandy river bottom. Its food is purely vegetable, and it is interesting to watch it eat. If you notice a caterpillar, or a silkworm feeding on a leaf, you get a notion of the method of the manatee in eating, and its use of its odd double lip.

Hold out a cabbage leaf to a manatee which has been kept in a tank as a pet — for though timid they are affectionate when kindly treated; the gentle beast extends its head toward the leaf, and in so doing parts the lobes of the upper lip, leaving a wide gap. As soon as the leaf is within this space, the lip lobes come together and hold the leaf firmly with their bristly surfaces. Then the lobes draw backwards, and the leaf is thus pushed into the mouth where there are some twelve teeth to chew it. The mermaid has in all twenty-two teeth, but some fall out before others come, so it generally has twelve in its mouth at one time.

While the manatee lives constantly in the water, it breathes air through its nostrils into its lungs. To secure air it comes to the surface of the water once in every three or four minutes. When it thus rises it will blow like a whale and send a spout of spray and water twelve or fifteen feet into the air. It seems to enjoy this blowing; it also enjoys rolling itself on the sand and fine pebbles in the bottom of the stream. It rolls and plunges to cleanse its skin; it is its way of making its toilet. After a roll the manatee rises to the surface, parts its lip lobes, gives a good blow, draws in all the air it can, and returns below.

Lily pods and pads, bananas,[1] a coarse river grass called manatee grass, are its favorite food. A large manatee will eat three bushels of lily-pods in a day.

[1] When in captivity.

The manatee is a strong, swift swimmer, and dives with wonderful agility. In its favorite haunt, the Santa Lucia River, the mermaid's babies are born among the lily-leaves, and in that green and pleasant nursery, the clean white sand for their bed, the fragrant lilies rocking on the water, the butterflies and dragon-flies darting out and in among the shadows, and the birds singing and sporting above them, they live for several weeks. When they are quite small their mothers carry them around in their flippers if they seem tired or do not go fast enough, but the manatee baby can swim as soon as it is born.

Being now very scarce, the manatee is largely increased in value. One fifteen feet long would cost two or even three thousand dollars. A large skeleton is worth a thousand dollars. The hides and flesh have been so much sought after that the creatures have been hunted nearly out of existence. Formerly the Indians made light, strong, and handsome canoes of manatee skins.

The manatee is very hard to kill; being timid, it darts away at the first alarm, and its swimming speed is exceedingly rapid if it is frightened; its thick skin, remarkably large, strong bones, and a thick layer of fat under its skin protect it in a great measure from injury by a bullet. The general method of securing the animal is to drive it into a very large, strong net. One side of the net is sunk to the river bottom, the other rises to the top of the water, and is then drawn about the hiding-place of the manatee. After a little training it will come when it is called, will eat from one's hand, and likes to be petted and to have its head rubbed.

LESSON XLIII.

GREAT WHALES ALSO.

"So far I live to Northward
No man lives North of me;
To the East are wild mountain chains,
And beyond them meres and plains;
To the Westward, all is sea." —LONGFELLOW.

MANY people think that a whale is a huge fish, the largest of the fish class. This idea is entirely wrong; a whale is not a fish, but a mammal. It belongs to the same class as the cow, sheep, horse, lion, monkey, and man, because all these widely differing creatures are born alive, and not in an egg, and when young are nourished by their mothers' milk. The mammalian class, distinguished in this way by suckling the young, is divided into many orders, and to one of these, the cetacean, or whale order, the whales give their name.

The whale is the largest of all living mammals; it is a mammal of the sea, and has a fish-like body because its home is constantly in the waters. A whale is entirely helpless when cast upon the land; it is unable to move itself, or to find anything to eat. Out of water it will soon die, but not because it is unable to breathe air, as is the case with the fishes.[1]

The whale breathes air through its nostrils into lungs; it does not have gills, and therefore while in the water it must constantly come to the surface for air. Thus the principal

[1] See Nature Reader, No. 3, pp. 243–4.

motion of the whale in the water is up and down, coming to the surface, and then seeking the depths. To aid it in this motion the whale's tail expands sidewise or horizontally, and not up and down or vertically, as do the tails of most fishes which chiefly swim straight forward, or in large curves.

Let us look at a whale. Its body is cone-shaped; the head is very large, sometimes one-third of the animal's entire length; there is no notch of the body to mark the neck;[1] the body tapers to the tail, which is widely expanded on each side into what are called flukes, and thus becomes a very strong propeller. Just behind the head we find a pair of fore limbs, called paddles or flippers. These are flat and oval, and have externally no marks of joints, fingers, or nails. But if you examine the skeleton of a whale, you will find that this limb is divided into arm and hand bones, very much like those of your own arms and fingers. There are no external signs of hind limbs, but in some kinds of whales we find in the skeletons some small, soft bones like a hint of legs.

The skin of the whale is smooth, of a dark gray or black color, and without hair except a few bristles around the mouth. Under the skin is spread a layer of several inches of fat, called blubber. This layer of blubber serves to keep the whale warm, and also to render its huge body light, so that it will float easily; it also keeps it from being readily injured. Most whales have a low, narrow fin down the centre of the back, to aid them in keeping a proper position in the water.

Let us now examine more particularly the whale's big head; it has small eyes, and a pair of tiny holes for ears.

[1] Neck or nick, or notch. Notice etymology.

These ears are close behind the eyes, but the nostrils are usually placed on top of the head. In nearly all varieties of whales we find teeth inside the large mouth. In one very important species there are no teeth, but instead, we find a large number of horny plates. The whale's mouth opens very wide, and the lips are stiff and immovable, not soft and flexible like our own.

Most people have read of the *blowing* or spouting of the whale, when it sends a double stream of water from its nostrils up into the air. The general idea is that the whale takes this water in at the mouth, and then spurts it up into the air through the nostrils, as a matter of amusement. This is not true. When a whale comes to the surface he takes in a large amount of air, and returns below; most of this air becomes changed to steam or vapor, as the animal remains below for some time. Then the whale comes up for more air, and the first thing is to free his lungs of the heated, vaporized air that is already in them. The animal drives this air violently from its lungs through the nostrils, and rising into the cold atmosphere it is at once changed to spray by condensation. The whale frequently begins to blow before it reaches the top of the water, and so drives surface-water up with the vapor which it expels from its lungs.

Fishes, we know, have very little red blood; reptiles are cold-blooded animals; but whales have plenty of warm, red blood. They are very strong and active creatures in spite of their unwieldy size. The lightness afforded by their blubber, or sheath of fat, and the large amount of air they can contain in their great lungs, and the strength of the tail with its wide flukes,[1] enable them to dash through the water with amazing swiftness.

Most of the "true whales" are flesh-eaters, with very fierce appetites. They devour fishes, mollusks, crustaceans, and even seals or other whales. They need enormous quantities of food to support such large bodies, for a Greenland sperm whale is sometimes seventy feet long, and from twenty to thirty feet thick through the shoulders. To secure the needed amount of food, the vast mouth opens wide. In some whales a man can stand upright between the extended jaws.

In the "right whale," which has no teeth, the mouth is lined along the upper jaw with long, narrow plates or flakes called baleen, of which whalebone is made. Every piece of whalebone is a strip of this baleen, from within the mouth of a right whale, and every such piece has a wonderful history behind it, for it has been floating, perhaps for many years, through the cold Arctic seas. It could tell us rare tales if it could speak.

These plates of baleen are sometimes seven yards long, and the mouth of one whale has about seven hundred plates. The chief food of this right, or whalebone whale, consists of very small brown crustaceans, one of the numerous crab family. These creatures are so abundant in the northern seas that they lie in banks many leagues long and several feet thick. The whale feeds on these beds of living animals, as a cow browses on grass or hay.

Whales are mild and inoffensive in disposition, unless greatly irritated by wounds and attack. They seldom quar-

[1] A *fluke* is either half of the tail of a cetacean, so called from the resemblance of the tail to an anchor, as the teeth of an anchor are called flukes.

rel among themselves, but are playful and affectionate, while the mother shows intense fondness for her young. Whales are social animals, and go in herds, or groups; one is seldom found alone.

In the spring the whales pair, and move off together to find some place where they may rear their young. As they travel together they seem very lively and happy; they stop to feed, and indulge in frolics, leaping out of the water, tumbling over and over each other, turning somersaults, and striving to show what they can do. As they come to inlets or deep, quiet bays, which may afford them a safe home, the male whale goes to explore their fitness, or to see if the spot is already taken by some other couple. This is the spring house-hunting of this famous family, and while Mr. Whale enters to make inquiries, Mrs. Whale waits outside. Finally, an abode is selected, and here the mother remains, until in autumn, one, or at most two, little baby whales are born. Compared with their big mother they are small, but compared with human children they are giants.

To her little ones the mother whale gives devoted attention. She suckles them for about two months, at the end of which time they are able to feed on crustaceans and small fish. Then the mother sets off with her family to complete their education by taking them abroad in the water-world. The baby whales can swim as soon as they are born, but not so fast as their big mother, and she carefully accommodates her pace to theirs. If danger threatens, she places herself between it and her child, and hastens the little one's flight by pressing against it, and so shoving it through the water.

If there is need to go still faster, she sometimes grasps the young one between her flippers and her neck, and so swims with all her might, carrying the little one off. If attacked, she will sacrifice her life rather than abandon her baby. When the baby whale is attacked, the usually mild mother shows great fury.

A male whale also will defend his mate if she is attacked, swimming round and round her, blowing, lashing the waves with his powerful tail, and trying to overturn boats with his mighty head; he will die rather than desert her. Such noble, loyal qualities shown by these animals deepen our regret that through promiscuous slaughter, they are rapidly diminishing in numbers, and are likely to disappear from the Northern hemisphere. Sharks, narwhals, and white bears are enemies of the whale, but none of these brute hunters are as reckless and destructive in their warfare as men.

The sperm whale is more nearly allied to the porpoise than to the right whale. From the sperm whale, oil, ivory, ambergris, and spermaceti are obtained, but no whalebone. The spermaceti, from which this whale derives its name, is found in a cistern-like reservoir over two yards deep, placed near the brain cavity at the back of the whale's head. This reservoir contains many gallons of spermaceti.

Dolphins, narwhals, and rorquals, all belong to the whale family. The rorquals have larger fins than the other whales. The blue whale is the largest of all the family.[1] The hump-backed whale is shorter and thicker than the other varieties, has a queerly shaped back fin, and large flippers.

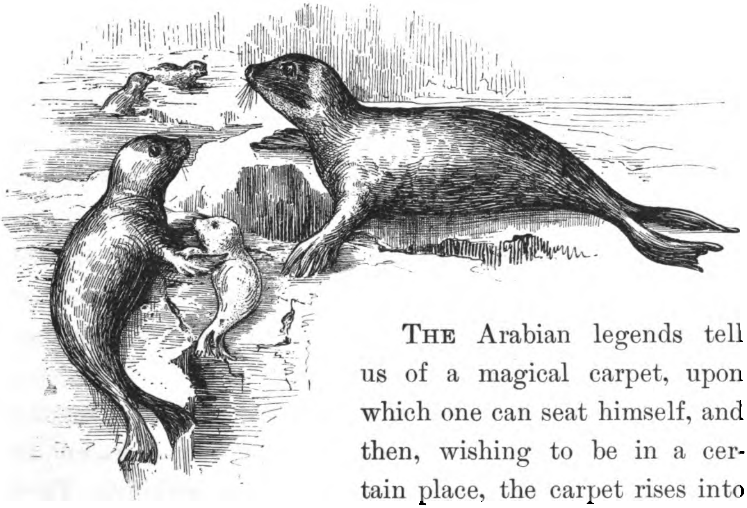
[1] This *Balænoptera sibbaldii* gets its common name from its bluish gray color; it is supposed to be the largest of living animals.

LESSON XLIV.

THE STORY OF A SEAL-SKIN COAT.

"And there we hunted the walrus,
The narwhal and the seal.
Ha! 'twas a noble game!
And like the lightning's flame,
Flew our harpoons of steel."

— H. W. LONGFELLOW, *in The Discoverer of the North Cape.*



GARMENTS OF PRICE.

THE Arabian legends tell us of a magical carpet, upon which one can seat himself, and then, wishing to be in a certain place, the carpet rises into the air, and safely and swiftly carries him where he would be. When Catherine showed to me a costly seal-skin coat, her Christmas gift, I proposed to her that we should use it as a magic carpet, and flying to the home of the fur seal, should trace the coat through all the changes of its history.

"Let us go at once!" cried Catherine.

"If we go now," I said, "not a seal shall we behold, for they are now far off at sea. It will be useless to make our trip before the fifteenth of May."

On the fifteenth of May, accordingly, Catherine and I spread out the seal-skin coat and began our journey. We went northwest, crossed the high Rockies, left behind us the new State of Washington, moved still west by north, and finally arrived at three small islands in Bering Sea, called the Pribylov Islands, from a Russian who discovered them in 1786. "Our fortune is good," said I to Catherine; "this is just such weather as seals like. They delight in cool, moist, foggy days, so that the sun is obscured, and casts no shadows. This is the usual weather on the Pribylov Islands, where the sun shines clearly but few days in the year. Seals spend about eight months in the water, and four months chiefly on the land. When they land they choose a dry locality of hard sand and pebbles, shelving toward the sea, so that no water or slime shall be left on the ground, for if their fur becomes matted with mud it falls out at once."

"Here we are at St. Paul's Island; date, May eighteenth; day, mild and hazy. We stand on a ledge of rock, and to the left of us we see five or six giant seals walking. They come up on the rocky beach and calmly take their places on large rocks and sit looking seawards; they are watching for their mates, friends, and neighbors to arrive. We need not fear to approach them; unless attacked, even the largest seal is entirely gentle. His eyesight is good, but only for moderate distances, but his sense of smell is as keen as the hearing of a manatee. If we keep on the side to which the wind is blowing, so that he cannot detect us by his sense of smell, we may approach close to him.

"Look at him now. He is seven feet long, and weighs four hundred pounds. He has a small, round head, the skull bones are thin and light, and the brain fills almost the entire skull cavity, for the seal is a highly organized and very intelligent animal. The eyes are large, of a bluish hazel, and very beautiful; the nose is like that of a Newfoundland dog, but the mouth has not loose skin like the dog's mouth, but firm, well-outlined, human-like lips.

"Open the mouth and there are large, sharp, dog-like teeth. A gray moustache ornaments the upper lip, outdoing Victor Emmanuel's in length, and sweeping down upon the breast. At the back of the round head are two small, pointed, drooping ears. The neck and shoulders are very large and heavy; the tail is merely an apology for a tail, being but four inches long. The seal has four limbs or flippers. The front flippers are hairless, blue black, ten inches broad at the body, eighteen inches long, and taper to a point. There are no fingers, and the arm and the forearm are embraced in the body, and hidden under the skin and blubber. In fact, the flippers are only hands, the arm part remaining enclosed in the covering of the chest. These fore flippers are used as feet, the seal stepping on them with alternate up and down movements, and carrying his head three feet from the ground, in an erect and graceful attitude.

"The hind flippers are very odd. They are much longer than the front ones, light, slender, and ribbon-like; they look like a pair of empty, wrinkled, black kid gloves. They are twenty-two inches long, and at a little distance from the ends have each three strong nails. The heels are horny and projecting, and on them the seal rests the hinder part of the body, for the upper part of these hind flippers, bones, and joints are embraced in the body, as are the fore limbs. At every other step the seal pauses and gives his hind flippers a sidewise fling, as if to keep them out of harm's way.

"Having slowly walked up the beach, this seal, who is an adult male, seats himself and surveys the ocean, his front flippers hang idly down, but he fans himself in the most comical style with his long, ribbon-like, hind flippers. He is exceedingly fat; under his skin lie several inches of blubber, and well it is for him that he is so provided, for now that he has come out of the water, he will not return there nor taste food or drink for the next three or four months.[1] All the time that he is on land he maintains an absolute fast. In the water his food is fishes, crustaceans, and squids,[2] of which he eats enormous quantities."

"But the fur!" cries Catherine, "the fur! I see nothing on this beast like my lovely, soft, dark cloak. This creature is covered with coarse gray hair."

"Step a little closer, my Catherine, and let us examine into this important matter. The seal wears two coats: the outer one is this coarse, grizzly hair, the inner one is a short, close, soft, elastic, silky fur. This fur is darkest on the back and shoulders, lightest on the flanks and breast.

[1] See U. S. Govt. Reports of the Pribylov Fisheries.

[2] A kind of cuttle-fish.

This adult male seal does not have that glossy nut-brown, or that delicate light gray or cream-colored fur which belongs to young seals, and to the females, and which presently we shall see prepared for your use.

"These big seals have come out of the water to make ready for spring housekeeping. Each one selects a dry, sloping place which will suit the mothers and their little ones, and this home he is prepared to defend against all intruders. About the fifteenth of June the mother seals begin to come out of the water. They are obliged to come out and nurse their little ones on land, as even a human baby will not be more helpless in water, or drown more quickly than a baby seal.

"As we watch the mother seals swimming toward land and walking up the beach, we shall see that they are only about one-sixth of the size of the big seals we have been examining. They are of a much more slender and graceful make, have remarkably handsome heads and necks, and are not encumbered with the mass of blubber under the skin. They do not need the blubber, for they go regularly into the water to feed, and even remain away two or three days, leaving the male seals to keep house and defend the children. Meantime these big seals fast and use up their store of blubber to maintain their vitality.

"The big seals meet the mothers coming up the beach, and escort them to their homes and to comfortable seats among the rocks. The mother seals sit down and fan themselves with their flippers, and croon or sing. They turn their pretty heads artlessly from side to side, and croon to each other.

No mother seal will stay alone for a minute; from six to fifty mothers always keep together in one home.

"The big male seal has four distinct calls or notes. He has a chuckling whistle whereby he converses with the mother seals; a loud, angry roar for any other big seal who meddles with his family; a low growl, with which he talks to himself; and a sound like a cat spitting, when he is alarmed. Mother seals have the crooning song for their mates, and a bleat like a sheep for their little ones. Baby seals cry just like little lambs.

"A mother seal seldom has more than one baby or "puppy" at a time. These mothers are exceedingly gentle, patient creatures, and very quiet. On shore they fan themselves, croon, and curl up for cosy naps, but the big seals are nervous and restless, and never sleep when ashore more than a few minutes at a time.

"Baby seals cannot swim. They make their ba-a-a-ing cry all the time that they are awake. Their eyes are wide open at once; they are not blind at first, like kittens and puppies, but they do not know their mothers from any other seals. The mother seals know their own children by their cries, though to human ears their looks and cries are all exactly alike. No matter how far off the puppy may roll, no matter how many scores of puppies are heaped into a warm, furry ba-a-a-ing heap, the good little mothers can find each her own. Perhaps the sense of smell aids them as well as the bleating cry.

"The mother seal is not a very anxious nurse. She pays no heed if any one picks up her baby, carries it off, or treads on it. She leaves it for two or three days at a time, while she is off in the water enjoying herself; meantime the little one sleeps and ba-a-a-s, and does not seem to suffer from hunger. When the mother returns from her excursions she curls down by her baby and gives it plenty of rich milk. These baby seals have dark blue eyes, but the eyes become browner after a while. All seals have long, thick eyelashes.

"As the baby seals grow older they begin to roll about the shore, which from much trampling has been worn into hollows filled with tide-water. These hollows are muddy and the seal mothers do not wish their babies to get into them. The naughty little seals, like frolicsome children, trot to the puddles and go into them a dozen times a day, and their mothers pull them out.

"As the little ones reach the age of three months they go nearer the water's edge in their rambles and venture in. At first they cannot swim, and clamber out, sputtering and spitting and crying ba-a-a at the top of their lungs. Still, after a little nap, they go back and try it again and again, and in a few days they know how to swim; but they are a full year old before they know how to dive, swim, fish, roll, and sleep in the water, as well as the adults.

"In swimming the seal carries his long hind flippers stretched backwards to serve as a rudder, and uses the fore flippers for propulsion. When the little ones can swim they are weaned, and they betake themselves to the water to stay, and are able to catch squids and crustaceans for themselves. They are three or four months old when they thus go to the water to find a home, and they do not come back for two years. A seal can sleep as comfortably on the water as on shore. To sleep it turns on its back, holds its nose and feet above the surface, and takes a profound nap, gently rocked by the waves.

"While the young seals are on shore the big seals defend them and take care of them so long as they keep at home. If they wander away, even though they do not go out of sight, they pay no attention to them.

"By the middle of September the homes are broken up and the seals return to the water to remain until May or June. Now, my Catherine, that we have thus observed the seals in general, let us look after the making of your coat. The fur came neither from a big male seal, a baby seal, nor a mother seal. Then from what seal did it come?

"Let us, on a July day, turn our eyes from the crowded rookeries, or seal homes on the rocks, and at some distance off on the shore we shall see thousands of other seals which the Indians call 'bachelors.' These are seals from two to six years old, young males fresh from the water, but not allowed by the big adult seals to approach the homes on the rocks. They do not seem troubled by the decree of exile; they are in good temper and high spirits, and they have very jolly times at play. They roll and tumble and gambol as do kittens and puppies. They lie on the grass, shut their eyes, and roll to and fro; they sit and fan themselves; they stretch out and gently comb themselves with the nails on their hind flippers; they take naps; they run races; they play leap-frog over each others' backs, and snort and roar with great hilarity.

"These young seals have the long, coarse over-hair, less gray than the big seals, and the soft, rich under-coat is silken and of a delicate brown color. The down and feathers on a duck's breast are arranged much as the hair and fur on a seal. In August seals begin to shed and renew their coats; in June and July they are at their best. These, then, are the seals from which the skins for commerce are to be taken, and in June and July it must be done. They are so docile and gentle that it is very easy to kill them.

"The seal-killers are Indian natives of the islands who understand their work. A number of these natives go to a herd of bachelors, and passing around them just at day-break 'cut out' from one to two thousand, just as a shepherd 'cuts out' a drove of sheep from a great flock. Surrounding and gently driving them, they turn them to the slaughter-houses. Seals walk easily and quickly, and they go as they are driven with the docility of sheep. Arrived at the houses, they are allowed to lie down and rest and cool for half an hour.

"Then an expert man goes out with several others armed with clubs. The expert points to different seals and says: 'Don't kill him, he is too young.' 'Don't kill that one, he is shedding his coat.' 'Don't kill that one, he is too old.' 'Let that one go, he is sick.' And so on. When he has thus pointed out the exceptions, the men with the clubs lift the clubs high and bring down a crashing blow on the skull of each seal, killing it instantly. As the seal is killed it is dragged from the group, laid on its back, and bled at once. If this is not done immediately the body heats very soon and the fur falls off.

"Then expert skinners strip off the skin, making cuts around the snout, tail, and flippers. Next the skins are carried to the salt-house, piled on each other in bins, 'fur to fat,' in layers like piles of paper; salt is thickly strewn on them, and they are held in place by heavy planks. In two or three weeks they are taken out, rolled in bundles, two skins together, corded tightly, and shipped to London to be dressed. Now, my Catherine, we must leave the Pribylov Islands, and go to London to follow the fortunes of your seal-skin coat.[1]

"In the seal-skin dressing establishment the skins are carefully heated to loosen the coarse hair and not disturb the fur; then the hair is very carefully combed out, leaving the soft, silky fur, which is at once dyed to a rich, even brown color. The difference in the price of seal-skin garments arises chiefly from the greater or less labor and skill expended in combing and dyeing them.

"The process of preparing the skins is this: they are stretched on frames or beams, and the flesh side is well scraped; the skins are next washed to remove grease, and are then dried, tacked on frames to keep them smooth. When dry they are again soaked and well cleaned with soap and water. Next the skin is dried by heat, and while still warm the coarse hair is combed out, the skin being kept warm and pliable, so that the hairs will not break. Once more being dried, the surface of the fur is shaved evenly. Then the skins are made soft by a fulling mill, or by being covered with sawdust and then trodden upon until pliable.

"After all this the skins are examined, mended where torn,

[1] Many seal skins are also dressed and dyed in Germany.

and two skins are laid together fur to fur, with paper fastened between. In this way they are shipped to the United States. It requires three skins to make your coat, my Catherine; if the style demanded very long coats it would require five. Being safely at the furriers in the United States, the skins are cut into coats and muffs and collars of the latest fashion, beautifully lined with quilted silk, and you, my Catherine, walk forth defiant of the cold, clad in the soft, warm garments which a year ago were swimming, rolling, plunging, feeding, sleeping in Bering Sea.

LESSON XLV.

A FLYING MAMMAL.

> "Silent they rest in solemn salvatory,
> Sealed from the moth and the owl and the flitter-mouse."
>
> —JEAN INGELOW.

WE have been studying together these wonderful creatures, the manatee, the whale, and the seal. These are not the only mammals that live in the sea; the sea-lion, porpoise, dolphin, and others are also sea-mammals. In a book like this we cannot discuss all the animals of any large order, and now we turn from these huge citizens of the sea, to learn something about a small but equally curious flying mammal, a citizen of the air,—the bat. It is a little beast, universally disliked, even feared; let us hope to clear away some of the foolish notions which surround it, and place it where it belongs, among harmless and interesting animals.

One evening last summer, as we sat on the veranda, a dark, winged creature with an uncertain, zigzag flight swept above us. "Oh! Oh! the horrible thing," screamed Mabel, putting her hands to her head; "he will get tangled up in my hair. Bats always do that."

"Mabel," I said, "I don't think you ever saw a person in whose hair a bat had become tangled. I never did. It would be as unusual an incident as to find that a toad had hopped into your pocket."

A few minutes after we saw in the moonlight, on the gravel walk, a small, dark object, moving in the most clumsy, hobbling fashion. "It is that bat," shouted Rex. "Where is a stick? Let me kill him."

"Let him be," I said. "I can tell you some very delightful things about him." In fact, I told Rex such wonders that he became interested in bats, and happening the next day to find a young, half-grown bat in the smoke-house, he concluded to take it to school, to ask for further information from his teacher. To do this, he put it in a pasteboard box, with the cover left partly off to give the creature air. The little bat cried, and the mother bat came flying in haste to her child. As she could not get into the box to her baby, she clung to the outside with her head to the opening, making little encouraging squeaks; and thus Rex actually carried both bats to school. The teacher put them into a small cage, and fed them bread, milk, and sugar for several days; then one evening they were set free.

Now let us see what Rex learned about bats. The bat has a number of names; the English peasants call it a "flitter-mouse," from its jerky, uneven flight. The Germans and Dutch give it the same name; the Swedes call it a "leather-mouse," from its parchment-like wings; Goldsmith used to call it "a mouse with wings."

The bat is a four-legged, hairy creature, with teeth set in sockets in the jaws; it suckles its young; in addition to these characteristics of a mammal, it has wings and truly flies. Were it not for the wings it would have been put in the order of insect-eaters, but its wings have secured for it an order for itself. The name of this order is the "wing-handed," or "hand winged," and to it belong the bats, vampires, and flying foxes, all of them truly bats, under varied names.

The lemurs, flying squirrels, and a few other animals have extensions of the skin mantle-wise along the body and legs, to bear them up for a little in the air, as they make long leaps; but they do not really fly. The bat, on the contrary, has good wings, and flies. The bat reminds us a little of that winged reptile which was in the ancient world long before men appeared on the earth. That was a reptile with a large, skin-like wing; a bat is a mammal with two skin-covered wings.

The structure of the bat's wing is very different from that of a bird.[1] The bones and muscles of a bird's wing are set with stiff feathers, which can be folded together as a fan is furled. When spread they form an elastic instrument for beating the air, and sending the bird forward, upward, downward, wherever it may choose to direct its flight.

The body and head of the common bat are very like

[1] Compare Nature Reader, No. 3, Lesson 28.

those of a mouse; it has bright black eyes, a mouth full of tiny white teeth, a covering of gray or reddish hair over all its body. A mouse has a long, scaly tail; a bat has a very short tail; the ears of a mouse are small and pointed; the bat's ears are large. The nostrils have a fold or ruffle of skin about them, which is supposed to improve the sense of smell.

The fore legs, or rather the arms, are very wonderful. If we had the skeleton of a bat we should see that the bones of the arm and forearm are long and slender, and instead of two bones in the lower part or forearm, there is but one which represents the smaller bone in the human arm. The bat's hand has five distinct fingers. The first of them, the thumb, is short, but the other four are very long, much longer than all the rest of the bat, and they are also very slim. Upon these fingers, as upon a frame, the thin, leather-like double membrane of the wing is stretched on each side of the extended hand, enclosing the finger-bones, thus the two arms have become a pair of wings.

This membrane is extended from the fingers to the sides of the body, then passes back to the hind legs, and covers them up to the ankles, and so round enclosing the little tail. Thus the bat has an enormous spread of wing for its size. The long forefinger of the hand extends to the tip of the wing, and the middle finger runs close to it, making this part of the wing strong. When the bat closes its wings the bony frame shuts together like the wires of an umbrella, and the skin hangs in folds as the covering of the umbrella hangs in folds between the closed wires. The thumb of the bat's hand is left free, and the nail is a large, hooked claw.

The flight of a bat is strong and tireless, but it is not in straight lines, nor in easy curves or sweeps like that of a bird; it is restless and flitting, with sharp turns and jerky motions.

When the bat alights on the ground, as it but seldom does, it shows itself a genuine quadruped. It draws its fingers together, throwing the membrane of the wing into folds, and so the free, strongly clawed thumb projects, and on this claw, and the hind feet which are free to the ankles, the bat walks, but as you might expect, its gait is very awkward.

The bat is a night-flying creature. Its sight is better suited for night than daylight; it prefers twilight, or dark caverns. Like the owl and the moth it sleeps by day, and comes out after sunset. As it eats insects it frequents shady places where insects can be found; during the day it rests in cool, dark places where there is some rough surface to which it can cling. Thus, dark woods, hollow trees, old barns, abandoned houses, church towers, and caves are the choice haunts of the bat.

From its habit of hiding, its night-flying, its uncouth motion, its mouse-like body and unfeathered wings, which are so unhandsome that artists have copied them when they wish to show demons, witches, dragons, harpies, and evil angels with wings, the poor bat has derived its unlucky reputation, and the general dislike with which it is regarded. In truth, there is scarcely any creature so frail, defenceless, harmless, friendly, gentle, and timid as a bat. It has no weapons, and its only hope of defence lies in its quick, erratic flight.[1]

During the day in its dark shelter, the bat sleeps in a

[1] When alarmed by being caught and held, bats sometimes bite, but the bite is not very severe.

strange fashion. It hangs itself up on some projecting stone or twig, as you would hang a cloak on a peg, or an umbrella by the crook on the handle. It hangs head down, using the large hooked claws on the hind-feet to cling by, and queer as the position is, it seems to suit very well. Bats are social in nature, and live in large flocks or bands. A cave or tower may have its walls quite covered with them, hanging close together. Sometimes, especially in winter, they cling one to the other in a curious, compact mass.

Bats hibernate, or sleep, through cold weather, hiding themselves in tree-caves or other dark places early in the autumn, and coming forth when the spring is fully opened and has brought their insect food. When the bat goes abroad it spends all its time in hunting for insects. Our common bat is a most useful creature, destroying thousands of insects which would be harmful to our garden and fruit trees. In a season, a bat eats myriads of gnats, midges, moths, beetles, cockroaches, crickets, and grasshoppers.

The great bat, or noctule,[1] has a spread of wing of twelve or fourteen inches, while its body is only three inches long. Its mouth can open with a wide gap like that of a swallow. When it catches a beetle, it has to hold it to its mouth by its thumb claw while it eats it, as a boy would eat a pear. To bring the thumb around to its mouth the bat must partly close the wing; as it does this it drops a foot or so; then it gives a stroke or two of its wings as it chews the bite it has taken, and rises again; then it takes another bite of beetle, and so on. All the time it is hunting it gives shrill squeaks or cries.

[1] Common in England.

Not only is the free thumb of the bat's hand useful for holding food, but it is of great service in walking, as its method is to extend the arm, catch hold of the ground by the claw of one free thumb, and pull itself forward; then make the same motion with the other arm and thumb, the free feet following these movements. Thus it proceeds in a zigzag, moving first to one side and then to the other. Although this is such an awkward method of progress the bat can run rapidly.

Bats are not great travellers; they haunt the same locality year after year. The mother bat has seldom more than one young one at a time, and this is born early in the spring, before the bats begin to fly abroad. The baby bat is smaller than a small bean, is blind and hairless. The mother bat folds up a part of her wing membrane into a cradle or nest for this tiny creature; she seems very fond of it, smooths and brushes it, and keeps it warm and clean.

The little creature has from the first strong claws, and uses them to hold fast to its mother. For several weeks this little one clings to its mother, is fed by her milk, and when she goes out to hunt she carries it along and never lets it fall. Even after a young bat can fly and catch insects for itself, it keeps near its mother, and she watches over it, and timid as she is by nature, she will die in its defence.

Bats are found in nearly all parts of the world, and may be divided according to their food into insect-eating and fruit-eating bats. The insect-eating bats belong generally to cold or mild climates, and the fruit-eaters to the tropics. The fruit-eating bats are much larger than the insect-eaters, and they are destructive and troublesome, while the common bats are useful.

The four most famous bats are the common bat, which we have described; the long-eared bat, which has ears so enormous that they are as long as the creature's entire body; the flying-fox, a bat of India, very lazy, and having a fox-like face. Flying-foxes are found in India, Africa, and the Oceanic Islands. In Java the fruit trees must be protected with bamboo nettings, to prevent the depredations of these creatures. The fourth notable bat is the vampire of Southern and Central America. These are very large bats given to blood-sucking, and while their bites and blood-sucking do not occasion death, they are very troublesome to both men and beasts.

One of the most wonderful things about the bat is its ability to guide itself in flying in perfectly dark places, and even when it is blind. A blind bat flies just as swiftly and safely as one with good eyes. It seems that the sense of touch is remarkably acute, so that even without contact, they can tell when a solid body, even of small size, is near them. Although the bat does not seem to need its sight to direct it in flying, its eyes are remarkably keen, as is shown by its insect-catching. So the phrase "as blind as a bat" is a poor comparison.

Bats can be easily tamed and become very friendly, eating insects from one's hand, coming when called, perching on an extended finger, and seeming quite at home in a room. In captivity they eat insects, raw meat, sugar, cake, and bread soaked in milk.

LESSON XLVI.

ORDER OUT OF CONFUSION.

"O, mickle is the powerful grace that lies
In herbs, plants, stones, and their true qualities,
For nought so vile that on this earth doth live,
But to the earth some special grace doth give."

— SHAKESPEARE.

WE have now studied some of the mammals of the sea, and a family of mammals which spend a large part of their time on the wing. Let us look next at a species which lives entirely underground, — the mole. In describing the mole-cricket [1] and the "duck-bill," we noted certain resemblances between these creatures and the moles, taking it for granted that moles, being common and widely distributed creatures, were well known. But in point of fact, what do we know of the structure and habits of this interesting little animal?

The mole is very nearly as unpopular as the bat. Gardeners complain bitterly that the moles destroy their lawns, by raising long furrows which disturb the grass, and that they ruin vegetables and cereal crops by eating the roots. I think the mole must plead guilty to the first charge; it does injure the lawns by raising its unsightly furrows, but it does not eat roots or other vegetable food. It sometimes draws down into the ground stalks of oats, wheat, or barley, to line its nest; it also serves some long-stemmed vegetable in the same way; it also cuts off the roots of vegetables, now and then, if it

[1] See Nature Reader, No. 3, p. 123.

finds them in its way as it digs its underground galleries. But the food of a mole is animal — earth-worms, beetles, larvæ and pupæ of insects — and thus the mole offsets its errors and turns the scale of opinion in its own favor, by being exceedingly useful as a destroyer of insects harmful to vegetation.

Looking out on my lawn one morning, I saw that it was badly marred by mole ridges. Tom, the gardener, went over them with the roller, but the next day they were as bad as ever. "Tom," I said, "you must catch that mole." That afternoon Tom came into the library, carrying something which looked like a pretty fur purse, held by a short cord.

"I've caught him," he said, "and as you like such things, I have brought him in alive." So the pretty drab purse was the mole. Alive! He did not look it. Alarmed at his situation, as Tom carried him by his short, nearly bare tail, the little beast had drawn his head, hands, and feet closely into his soft, silky coat, and exhibited only a rigid, fur-covered cylinder. I watched him a few moments, Tom keeping perfectly still, and presently I saw a little red nose and a pair of pink hands stretched out from the fur, as if feeling for something to take hold of. Tom laid his prize on my table, and I proceeded to examine him, as we shall now do.

The common mole, which claims the short and pretty name of *talpa*, has a cylindrical body about six inches long and three inches thick. There is no apparent neck. The head tapers quickly off from the line of the shoulders to a little snout of the shape of the tip of a blunt lead-pencil. This snout is about a quarter of an inch long, flexible, of a deep red, tough skin. Under this snout is the mouth, which is very wide and furnished with twenty-two sharp white teeth on each jaw. The two upper and two lower front teeth are long and lap over; the others are smaller and pointed.

Once people said that the mole had no eyes, and needed none, as it lived in the dark underground. But it has two very small, jet black eyes, deeply hidden in its lovely thick fur and covered by a fold of skin. The nostrils and ears of the mole are almost as closely hidden, but internally well developed. We may say then that the creature has sight, somwhat limited and imperfect, but sense of hearing and smell very keen. We can see how wise it is that these delicate organs, the eyes, ears, and nostrils, should be well protected by the thick fur, as the mole burrows underground.

The body of the mole is entirely covered with soft, close, even, fine fur of a deep drab or mouse color, nearly black. No lady dressed in plush was ever more richly arrayed than this little burrower. The tail is short and scantily covered with hair; the legs are very short and strong, and set close to the body. The fore limbs or arms are furnished with broad, flat, five-fingered hands, set with the palms turned outward, so that as the mole digs, it throws the earth to the right and left. The palms of these hands are very singular; they are somewhat callous, of a rose pink, and the fingers are webbed up to the strong, curved nails.

When the animal is removed from the earth the snout and palms soon become peculiarly dry, and this evidently causes pain and irritation. The hind-feet are only about one-quarter the size of the hands. They are webbed, but are not so strong, and have more slender nails. The broad front feet, or hands, fitted for digging, indicate the underground life of the mole; the webbing of the hands and feet suggest, what we find to be true, that the mole is a good swimmer. Indeed, it often goes from the mainland to islands in lakes, rivers, or ponds to dig out its home.

Wet or stony land does not suit the mole, because it cannot dig its rooms and galleries in such soil. Fertile fields that have been cultivated and loosened by spade and plough are its favorite haunts. It is very wonderful that such a small, soft creature can move and disturb so much earth.

Every mole lives alone and builds for itself an elaborate and comfortable home. This house consists of a central dome, where the earth is well packed and beaten to prevent the percolation of water. A bed made of leaves, grass, and vegetable stems is placed in this room. Around this dome wind and radiate seven or eight long galleries or tunnels, which break off and pass into each other in a curious fashion, so that there is no direct line of approach to the dome. It is evident that this labyrinth of galleries is designed to make the dome safe from intruders, and to enable the mole to elude pursuit.

The mother mole has from four to six little ones at a litter, and she has two litters each year, one in April and one in August. Thus we see that moles multiply rapidly. The mother mole is very careful of her children. The large domed room is their nursery, and she makes them a soft bed. The little moles grow quickly, and in a few weeks are weaned, as they have become able to feed themselves. When they leave their nursery the digging instinct develops in them, and they at once set about making a dome and galleries, and going to housekeeping each one for itself.

While the fur of the mole is exceedingly pretty the skin is so small and delicate that very little use can be made of it, though sometimes it is used for gloves, purses, bags, caps, and mittens. In England, where moles abound, men called "mole-catchers" go about with spades and traps and catch and kill the moles.

The mole is the most hungry and ravenous in proportion to its size and weakness of all mammals. Hunger seems to be a madness with it. Moles eat snails and are very partial to frogs, but oddly enough they will not touch toads. A mole will eat the dead body of a bird, mouse, or small snake, if it finds these in its rambles. If two moles are shut up together without food one will kill and devour the other. Moles drink very freely.

These creatures seldom appear at the surface of the ground. Now and then they will come out of their galleries by night, but strong light is painful to them.

Except for attacking each other when imprisoned and very hungry, moles are quiet and gentle in disposition. No creature, however, is harder to tame and keep in captivity, not because of any violence or uneasiness of disposition, but because of its dislike for daylight, and its need of darkness, coolness, and the slight moisture of the earth below the surface. A mole shut up in a room or box seems seized with a terrible homesickness for its underground haunts, pines away, and soon dies.

It has been stated that a mole will die if left without food for ten or twelve hours, and that moles eat only animal food, refusing all vegetable substances. Though individual moles may have been found of which this is true, the statements are incorrect as applied to *all* moles. The mole which Tom brought me, I put into a thick pasteboard box with some air-holes cut in the cover. I put in the box a little flat pan of water, and Tom insisted upon giving the animal some grains of corn and wheat. The mole did not touch these grains, but drank some water. After it had fasted sixteen hours, I gave it boiled rice, which it refused. In two hours more I gave it bread soaked in milk, and of that it ate a little.

After twenty-four hours of captivity, I gave it cracked oats, uncooked, but soaked in milk. This it ate heartily. After it had been thirty-six hours in the box, I let it out in the room, and it at once ran about looking for some place to dig. I threw a large woollen mitten on the floor, and that it soon found, crept into it, thrust its head into the thumb, and remained quiet for some hours. I kept it for several days, during which time it drank water, ate oats soaked in milk, and also took a little raw meat. It pulled and tore at the carpet and upholstery, seeking for places to burrow, but remained for the most of the time in the mitten.

A mole's skeleton is a nice curiosity for a museum, and is easily prepared. A mole can be quickly and painlessly killed by a sharp blow just back of the head. After it is skinned, lay the carcass near a large hill of ants, or at the edge of a pond, where there are plenty of tadpoles, and soon only the clean white skeleton will remain. Wash this in hot water and ammonia, and dry it in the sun; then mount it carefully on a little board covered with black, which will set the small white bones in good relief.

These studies of swimming, flying, and burrowing mammals suggest to us the diversity which exists in the great class of mammalian animals. On the ground, and under the ground, in the water, in the air, on the trees, we find the mammals, and at first it might seem impossible to bring order out of this confusion, and divide these almost innumerable creatures into their proper groups. But a careful study of these varied forms has enabled scientists to divide them according to their most peculiar characteristics, putting orders, sub-orders, and families together according to their closest relationships. So, when we study these animals, we are able to decide upon their names and places in the class mammalia. And like all else that is orderly, this classification becomes presently clear and simple.

Let us now set the various divisions of the vertebrate animals in a table which can be easily understood, and will be found convenient for reference. The vertebrate or backboned animals are divided into —

Fishes,
Amphibians,
Reptiles,
Birds,
Mammals.

The mammals are divided into various orders beginning with the monotremes, the lowest form of mammalian life, and closing with man, the highest form. So our table stands —

Monotremes: duck-bill, echidna.
Marsupials: having a pouch for the young — kangaroo, opossum.
Edentata: having no teeth on the front of the jaw; sloth, etc.
Cetacea: fish-like creatures, eating animal food — whales, dolphins.
Sirenia: fish-like creatures eating vegetable food.
Insect-eaters: mole, hedge-hog, etc.
Hand-winged creatures: the bats and vampires.
Rodents, or gnawers: with chisel-like front teeth; rats, beavers, etc.
Ungulates or hoofed { even-toed; as cow, sheep, deer, etc.
uneven-toed; as hog, horse, elephant, etc. }
Carnivora or flesh-eaters { seals, sea-lions.
dogs, cats, bears, lions, foxes, tigers, etc. }
Primates { Quadrumana, or four-handed, as apes and monkeys.
Homo (man). }

LESSON XLVII.

A REMARKABLE FAMILY.

"He prayeth best who loveth best
All things both great and small,
For the dear God who loveth us
He made and loveth all." — S. T. Coleridge.

In our last lesson we enumerated the orders into which the mammalian class has been divided. Of six of these orders we have already studied representatives. We have found in the duck-bill and two other animals, the only species of the order of monotremes; the opossum and kangaroo furnished us examples of the pouched animals. The third order mentioned is that of the edentata, or tooth-lacking creatures, and some of its families we will now discuss.

The name toothless is only partly descriptive of this group of mammals, because while some of them are really without any teeth, there are others that have the enormous number of ninety-eight. But all of the edentata are destitute of any teeth on the front of the jaws; there is always a vacant space there; and besides this, all the teeth are more or less imperfect, and have only one root. That vacant space in the front of the jaws, and the peculiarity of all the teeth being exactly alike, are constant characteristics of the edentata.

All of these animals are slow and clumsy in their movements, show very little intelligence, and have sharp, strong claws on all their toes. They are all natives of warm countries, and are most numerous in South America. None of the living edentata are more than four feet long including the tail, and some are no larger than rats. But from rocks and shell-beds, deep in the earth, have been taken fossil remains of this family, showing creatures which lived far back in the early periods of earth-building, some of them as large as an ox, or a rhinoceros, or an elephant.

The first of the edentata which we shall examine is called the sloth. It is a South American animal, and was for a long time classed among the monkeys, on account of its tree-climbing habits, and the long hair which covers its body. On the ground, to which it seldom descends, the sloth is the most ungainly of beasts. Its hind legs are very short, and its arms or fore legs are very long; its claws are strong and curved, and the toes are buried in the skin up to the nails, so that they can make no separate movements. Their leg joints turn outwards, and when the creatures try to walk on the ground, they are compelled to double up their fore legs and go on their knees. Moreover, these sloths cannot bear strong light. When placed on the earth in the sunshine they seem to be crippled and blind.

The sloth has no tail, and no external ears. The eyes are small and sleepy; the motions of the creature are slow; its intelligence is very limited; in length it is about thirty inches, and the body has the general proportions of a monkey. Is this beast, then, a poor deformity? Or, in the noble plan of nature, is there some place which it exactly fits and fills? Let us see.

Now we shall place this queer little animal on its native trees. At once all is changed. Why, this sloth is all grace! You could not see a more beautiful climber. The short hind legs, crooked claws, long forearms, are just suited to tree life, for clambering safely and lightly from bough to bough. The sloth, thanks to its claws, is as safe hanging back downwards as a bird is safe in its nest. Those weak eyes are suited to the soft shadows of the leaves; the subdued light on the tree is just right for it.

The sloth is a vegetable feeder; as it climbs about the tree it nibbles off the sap leaves and the delicate new bark and twigs; hanging by the feet and one hand, it reaches out the other long arm, and picks fruit as dexterously as any schoolboy; then holding the fruit to its mouth it eats it daintily. In museums or zoological gardens the sloths are furnished with a tree to climb upon, and are fed on fruit, vegetables, and bread and milk.

The next of the edentata which we shall observe is the armadillo, one of the most singular of animals. At first sight you would feel sure it was not a mammal, but a reptile of the lizard or turtle family, for instead of being covered with hair or fur, it wears a heavy case or armor of large scales. These scales, or bony plates, are arranged in close bands about the body. The plates over the head, neck, and tail are immovable, but those on the centre of the back will lap, so that the creature can roll itself into a ball, bringing the nose, feet, and all parts of the body under protection of its horny armor. The under part of the body has no scales, but is covered with hair.

The armadillo has short legs with five-toed feet, each toe being furnished with a strong claw. The ears are very large; the eyes are small; the nostrils are set at the end of the long, pointed snout. The smallest of the species is about the size of a rat; the great armadillo is a yard long, and has in its widely opening mouth ninety-eight teeth.

Instead of living on trees like the sloth, it burrows in the ground; the rooms and galleries which they fashion for themselves are like those of the mole, only larger. The strong, curved claws are used to tear up the ground, and they do this so effectually that the animal will disappear beneath the surface in a very short time.

When undisturbed, the movement of the armadillo is a slow, a dignified march, suited to its short legs and heavy armor. When pursued, if it does not have opportunity to dig a burrow, it can run, and has been known to outstrip a man in a race. When attacked the creature prefers to tear up the earth and sink away out of sight; if it cannot do this, it rolls itself into a ball, and trusts to its armor.

As it paces about, it feeds daintily on vegetables and fruit; it waits under trees for the fruit to fall, and then nibbles at it very contentedly. Still it does not reject animal substances, not even carrion, for when it discovers a decaying carcass it feeds upon it; it also devours insects whenever it can get them.

A third curious specimen of this order is the ant-bear, which is chiefly found in Brazil and Guiana, but is not unknown in the other parts of South America. The ant-eater or "ant-bear" is sometimes a yard and a half long not including the tail. The most conspicuous part of this creature is its tail, which is plume-like, and carried over its back like that of a gray squirrel, but is very large, so that it overshadows most of the body, like a great canopy of fine, loose, waving hairs. The body is covered with long, coarse, dark hair; the legs are long and very strong, and the claws are deeply hooked and singularly powerful.

The ant-bear's head is small, and tapers from the neck to a long, curved snout, at the end of which are the nostrils. The ears are small and placed far back on the head; the eyes are small and set half-way down the snout. This snout is well worth looking at; it is really a tube, with a small, round hole at the tip, through which the ant-eater can thrust out his tongue. The tongue is long, slim, round, worm-like, and covered with a sticky secretion. The ant-bear has no teeth.

The chief food of this odd animal is ants, and let us see its method of feasting. During the day, while ants work abroad, this animal sleeps; but it wanders out at night when the ants are in their hills. The ant-eater puts his long snout into a hill, and thrusting his sticky tongue into the rooms and galleries, gathers upon it ants and pupæ. Then he draws his tongue into the tube, swallows his prey, and repeats the performance. In like fashion the ant-eater will capture upon his slimy tongue other small insects.

This animal is mild in disposition, slow and listless in its motions. It prefers damp forests, or reedy marshes, for its home. Though quiet, it is not timid, and if attacked by a fox, wild-cat, or jaguar, it will defend itself, and often squeeze the enemy to death, or tear it to pieces with its powerful claws.

Owing to its lack of teeth and its tube-shaped mouth, it is evident that the ant-eater cannot chew food, but in addition to swallowing insects whole, it can take food by sucking the juices, as beetles and some other insects do. In the London Zoological Gardens were two ant-eaters, which not only ate insects when they could get them, but sucked up raw eggs and bread and milk, and would also suck the blood from raw meat.

The mother ant-eater is a fond and attentive parent. She has but one little one at a time, and she carries it about seated on her back. She never leaves it for a moment.

There is one variety of the ant-eater which lives on trees. This animal seldom comes to the ground; it eats fruit and the insects which frequent trees, and drinks the dew and rain from the leaves. It is a pretty creature of about the size of a small squirrel. This tree ant-eater does not carry her baby about on her back; instead, she finds a hole in the tree where she makes a nest of leaves, and there she puts her child to sleep while she hunts about for food. Every few minutes she returns and puts her little head into the hole to see how her baby is coming on.

In India, China, Java, and the Malay Islands, there is one of the edentata called a pangolin, which wears an extraordinary coat, from which it is sometimes called "the scaly lizard." This coat is composed of large, leaf-like, pointed scales, set in the skin much in the fashion of the nails on your fingers. These scales lap over each other like roofing-slates, and extend from the nose to the tip of the tail. A strip on the under side of the body is bare of scales.

Like the armadillo, the pangolin can roll itself into a ball if it is in danger. Also like the armadillo, the pangolins have short, strong legs, strong, curved claws, and dig burrows. But they are not so fond of burrowing as the armadillo, and if they find a hollow in a tree they take that for a home. While the armadillos are short and thick in body, and much like a tortoise in shape, the pangolins are slender and lizard-like.

The pangolin has no trace of teeth, and its method of feeding is like that of the ant-bear. The head is short and the tongue less slim than the ant-bear's, but the manner of procuring food is the same. It has the largest and brightest eyes of all its order. There is no external ear, but hidden under the scales on the head there is an ear opening.

When the pangolin wishes to defend itself, it can erect its scales as the porcupine does its quills, and so it looks very fierce. All the motions of the pangolin are slow except the play of its tongue, which darts in and out with great rapidity.

From a study of these animals we see, that while the edentata differ remarkably in many respects, they are alike in these particulars: There are no teeth on the front of the jaws; their toes have strong claws; their motions are very slow; their intelligence is small; they are inhabitants of South America or the eastern part of Asia.

LESSON XLVIII.

THE GNAWERS.[1]

"And the grumbling grew to a mighty rumbling,
And out of the homes the rats came tumbling:
Great rats, small rats, lean rats, brawny rats,
Brown rats, black rats, gray rats, tawny rats,
Grave old plodders, gay young friskers,
Cocking tails and pricking whiskers!"
— R. Browning, *Pied Piper.*

In our chapter on the whales we have given examples of the fourth in our list of the mammalian orders. The manatee stood as the representative of the next named order, that of the sirenia. Then came the order of the insect-eaters, or insectivora, and little Mr. Talpa, the mole, was described, though perhaps he is not more interesting than his relations, the shrews and the hedgehogs. The seventh order in our list is that of the wing-handed creatures, which is occupied entirely by the bats, with their first cousins, the

[1] Chapters 48, 49, and 50 give but brief glimpses of numerous well-known mammals. The object has been merely to call attention to peculiarities of structure and other points of interest, and thus encourage the pupil to seek more extended information in larger works.

vampires and flying foxes. These animals might have been set with the edentata, if they had not indulged in the peculiarity of wings.

Our eighth order is the rodentia, or gnawers. No order of animals is better known, or has more common examples. Hark! in the stillness of the house at night you may hear a rush and a scuttle through the walls, or a fine nibble in a corner; these sounds proclaim the presence of two very unpopular rodents, the rat and the mouse.

As I was sitting one day last summer in the shelter of a great rock, a little animal appeared from a maple wood some hundred yards distant, and with long hops came over the hillside towards me. When about thirty yards from me, he stopped — he had just discovered me. This was our most beautiful rodent, the large gray squirrel. I concluded that bright as his eyes are he could not see so far as I could, or he would have noticed me when he came out of the wood. A little while after, as I still sat silent and motionless, another beautiful rodent came from an adjacent tree, and, deceived by my stillness and the color of my linen gown, he came and sat down on the hem of the gown, and holding himself erect on his haunches began to eat a nut. This last was the pretty chipmunk, wearing a reddish coat, and having black velvet stripes down his back.

In introducing these four animals, I have already indicated the creatures to be found in the order of rodents, or gnawers. One of its most famous and ancient members, the beaver, we have already described in a chapter by himself. The order of gnawers is one of the most extensive of the mammalian class. All of its members are small, or of moderate size. They are distinguished by having only two kinds of teeth, incisors, or cutting teeth, and molars, or grinding teeth.

The incisors, generally two or four on the front of each jaw, are long, stout, and curved. They are covered with enamel on the front only, and so the back part of the tooth wears away faster than the front part, and thus constantly preserves a sharp, knife-like edge, which is as serviceable as the best tempered chisel in cutting any kind of wood. The incisors never wear out. They grow from the base just as fast as they wear off at the tip.

The rodents are furry, four-legged animals, with nails or claws upon their toes. They have large bright eyes, sharp, well-set ears, and all their senses are very acute. They are also distinguished for intelligence, and generally for amiable dispositions. Among them are to be found the rat, mouse, squirrel, rabbit, hare, musk-rat, dormouse, jerboa, chinchilla, porcupine, ground pig, marmot, and many others. The porcupine and his family offer an exception to the other rodents in wearing quills among the fur.

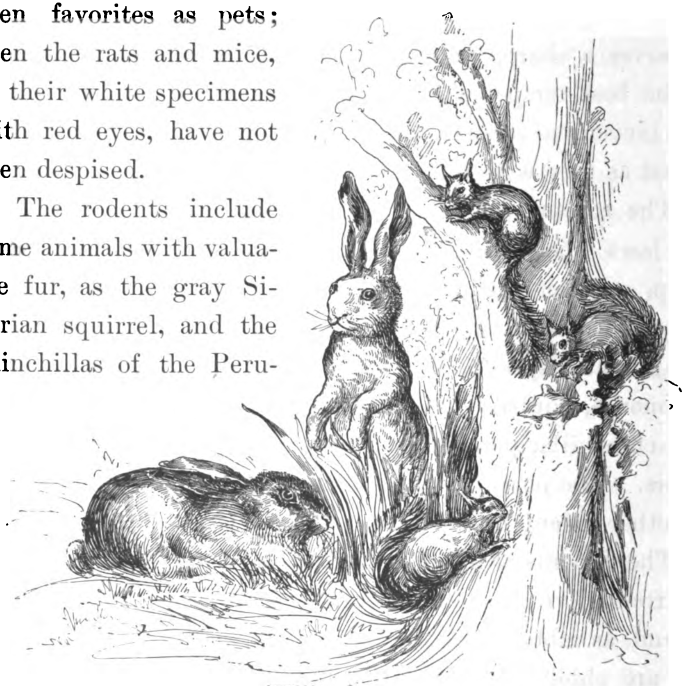
The rodents differ widely in their homes; some, as the squirrels, live in trees; others in forms or lairs on the ground, as rabbits and hares; some, as the beaver and musk-rat, are chiefly aquatic. The rodents also differ in their mode of life. The squirrels, rabbits, hares,[1] and some of the mice, work and eat by day and sleep at night; others, as the rats, guinea-pigs, and porcupines, are principally nocturnal animals, coming forth from their homes about sunset.

[1] Hares are given to wandering about at night, and porcupines often feed and travel by day.

In general the rodents feed on roots, vegetables, seeds, nuts, bark, leaves, or fruit; but some of them, as the rats, are fond of meat, and indeed devour anything in the shape of food, and are as ready to eat carrion as fresh diet.

All rodents are easily tamed, and are often kept in captivity. Rabbits, squirrels, and guinea-pigs have always been favorites as pets; even the rats and mice, in their white specimens with red eyes, have not been despised.

The rodents include some animals with valuable fur, as the gray Siberian squirrel, and the chinchillas of the Peru-



THE NIBBLERS.

vian and Chilian mountain ranges. The rodents are generally very prolific, and to the great number of their progeny is due their continuance, in despite of the multitudes of them killed every year by their enemies. The hunter, with his trap and gun, seeks the rodents for fur or for food; hawks, vultures, and owls prey upon them; dogs, cats, and foxes constantly lie in wait for them. Rats also fight among themselves, and prey upon each other, for the victor feasts upon the vanquished. Rats are also hunted for their skins, as thousands of dozens of kid gloves have been first on the backs, not of kids, but of rats.

As instances of the rapid increase of rodent families we may note that the mother rat has several litters of young each year, and ten or twelve at a litter. The fieldmouse has twelve little ones a year, but all of the same litter.

The harvest mouse is the smallest and perhaps the prettiest of all the rodents. Its back is tan color, brightening on the sides and legs, while all the under part of the body is snow-white and silky. It is not much over an inch long, has bright eyes, and a long, hairy tail; it lives upon grain, and constructs one of the prettiest of nests for a home. Laying together, with their long leaves, three or four stalks of wheat, oats, or barley, the harvest mouse weaves of grass and leaves a round, beautiful nest, about as large as that of a titmouse. The nest is shaped like a ball, and has a small opening on one side. In this nest the tiny mother places her little ones. She climbs up the wheat stems by means of her sharp claws, but comes down as one slides down a rope, holding on by one hand. This round nest is the summer home of the harvest-mouse. By the time the grain is ripe, some wise instinct teaches her to remove her household to a new dwelling. She either makes a burrow in the ground, or builds a nest in a corn-crib or hay-rick.

Another curious mouse is called the economic mouse, because it lays up grain and seeds for winter use. In this it resembles certain other rodents, as the beaver, which lays up a store of bark, the squirrel, which hoards nuts, and the hamster, which lays up grain, beans, peas, and seeds. Sometimes fifty or a hundred pounds of grain and dried seeds have been taken from the burrows of these animals. The squirrels, and the "pouched," or earth-rats, are provided with cheek pouches for carrying home their winter store of provisions. Others convey their booty in their mouths.

I had at one time a pair of chipmunks, which made their home in the foundation wall of my house. A row of wild cherry trees stood near the lawn, and I found that the chipmunks laid up a large store of the cherry pits, making many journeys daily to and from the trees, and carrying off in their cheek pouches a number of pits each time.

The season was dry, and one morning I had poured a pitcher of water over some plants near my porch, when one of the chipmunks passed among them on his way to the cherry trees. He stopped, sat on his haunches, took one of the wet leaves in his hand, pressed the sides together to make a trough for the moisture, and holding it to his mouth drank the water in the most comical fashion possible. He drank from five or six leaves, while I stood watching him. When he went his way, I filled a large saucer with water and placed it near the plants. This was presently discovered, and both my little chipmunks hereafter drank and washed regularly at this dish.

I made a practice of testing these pretty little fellows' knowledge of nuts. When I gave them cracked hickory nuts, they at once sat down, picked out the meats, and ate them. Cracked nuts were evidently not fit for storage. Sitting on their haunches, holding the cracked nuts to their mouths with their hands and using their incisors for nut-picks, these creatures were a pretty sight. When I gave them whole nuts, they tested them, evidently by weight, to see if they were sound. Sound nuts were promptly carried to the store-house; poor nuts were dropped. I never knew these animals to make a mistake. I cracked the rejected nuts, and never found one of them good.

When walnuts or other hard-shelled nuts that have been emptied by squirrels are examined, and the cleanness and accuracy of the cutting is noted, we get some notion of those beautiful cutting tools, the incisors. Likewise the wood chiselled by the beaver bears witness to the excellence of the tools bestowed upon this order of animals.

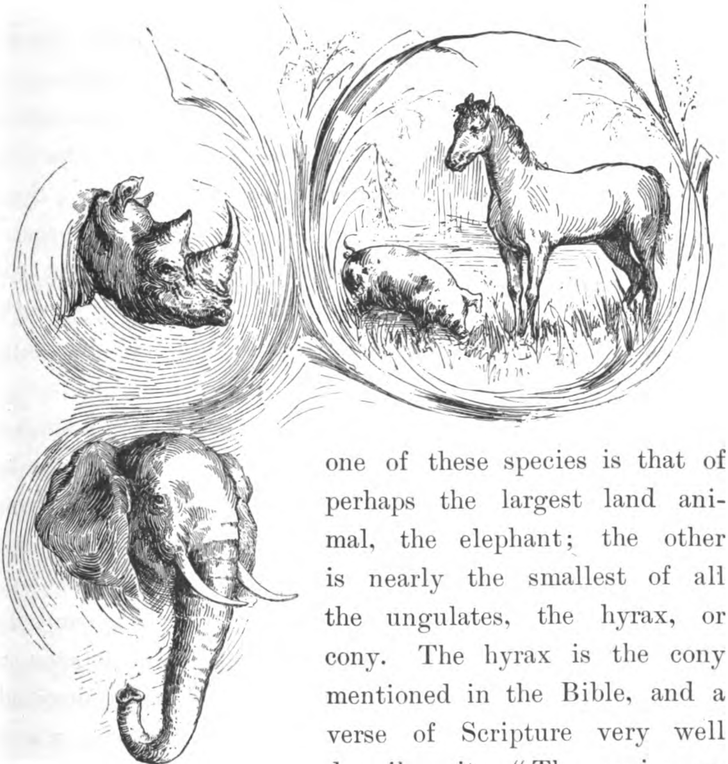
The gnawers are found in most parts of the world; the deep snows of Siberia are tracked by the agile feet of the squirrel, the hamster, and the economic mouse. Cold Norway has hordes of rats, as well as squirrels and rabbits. Italy is the only country free from the ravages of the field-mouse. In English gardens the dormice love to make their homes. Rats and mice live wherever men live. Africa possesses the sand rat and the brilliant mole rat, which wears a scarlet coat shining with the iris tints of the rainbow. The jerboas, with their short fore legs, and their curiously long hind legs, jump about in Tartary, Russia, and the African forests. South America has a monopoly of chinchillas and guinea-pigs. The porcupine is an inhabitant of three-quarters of the globe. Once the beaver built its dams and burrows over nearly all North America, and now every woodland abounds in squirrels and rabbits; almost every river-side has its musk-rats; every barn and nearly every house is infested with rats and mice. Thousands of hares are every winter brought into the English markets. In fact, wherever you go you can hear the busy teeth of the rodents, gnawing their way through the world.

LESSON XLIX.

ODD TOES.

"A thousand horse, and none to ride!
With flowing tail, and flying mane,
Wide nostrils never stretched by pain,
Mouths bloodless of the bit or rein,
And feet that iron never shod!" —BYRON.

ONE great order of mammals, is called the ungulata, or hoofed-order. The ungulates are animals well fitted for terrestrial life; they are vegetable-eaters, though now and then one of them, as the hog, may display some appetite for animal food, and sheep and cows will eat fish, especially if salted. No order is more familiar to us, as it contains all our best-known domestic animals, and those wild animals most popular in all menageries or zoological gardens, as the elephant, camel, and giraffe; and finally all those animals most ardently pursued by hunters, as the deer, antelope, and chamois. The order ungulata embraces two animals so widely different from the others, that they have been classified as sub-orders by themselves;



THE THICK SKINS.

one of these species is that of perhaps the largest land animal, the elephant; the other is nearly the smallest of all the ungulates, the hyrax, or cony. The hyrax is the cony mentioned in the Bible, and a verse of Scripture very well describes it: "The conies are a feeble folk, they have their dwellings in the rocks." For a long time these little animals were a puzzle to zoologists, and finally Professor

Huxley set them off in a sub-order all to themselves. Why were they so difficult to arrange? Let us see.

In the first place there are very few of them, and they are all found in Africa, near the Cape of Good Hope, except one species living in Syria. They are small creatures, rabbit-like, about eighteen inches long, covered with thick fur interspersed with bristles. First, they were classed with the rodents, because of their rabbit-like appearance. But their teeth turned out to be like those of a rhinoceros, and their skeletons like those of the hippopotamus family, and therefore they were placed among the ungulata. Soon there were other claims made upon them; their ribs and backbones were like those of that famous insect-eater, the sloth. These queer little beasts seemed to belong everywhere, and to fit nowhere, and they were set up by themselves.

The conies are gregarious animals; they live in colonies. They have no means of offence or defence, and so they make their homes in holes in the rocks, and stealing out from their stony citadels, they eat grass, fruit, seeds, and roots. As they go forth to forage they leave a sentinel perched on a high rock, to watch for danger and give the alarm. In Africa the lions are their greatest enemies, and as soon as the warning of an approaching lion is given, the conies dash off swift as the wind, to hide in small crevices, where their foe cannot follow them.

The other peculiar animal among the ungulates, which demanded a sub-order all for itself, is the elephant. Of this creature there are but two species now living, the Indian and the African elephants. They are classed by themselves on account of the proboscis or trunk, which no other animal possesses, and which a little boy described as a "big be-front tail, so that the elephant could walk backwards or forwards all the same." But this is a most unhappy description of an elephant.

The African elephant is the larger species, being sometimes eleven feet high. Its ears are much larger than those of the Asiatic species, are differently set, and there are also differences in the structure of the head and teeth. The tusks of the elephant are two large curved, bony appendages, projecting from the mouth on either side of the trunk. What are they? Why, *teeth* to be sure! Teeth? Yes; they are the two incisors such as I told you the beavers have, but the odd thing about these teeth is, that, beginning to grow in the second year of the elephant's life, they keep on growing as long as he lives. Of course they are soon too long to be kept within the shelter of the mouth, and so they project and grow and grow, until sometimes they become so enormous as to weigh from one hundred and fifty to two hundred pounds each. But these are exceptions; from thirty to eighty pounds is a more usual weight. Sometimes the tusks turn upward; sometimes they grow almost straight, or with a downward inclination.

Besides these huge incisors the elephant has six molars or grinding teeth on each side of each jaw. As these molars are its only teeth useful in eating, we see at once that the food of an elephant must be grass, hay, grain, and fruit. The tusks of the elephant are almost entirely the purest of ivory, and as they are our main source of this valuable material, thousands of elephants are slaughtered to secure the tusks. As the elephant has the fewest young of any known animal, the race of elephants cannot keep up with the rapid destruction produced by the ivory hunters, and there is great danger that it will become extinct.

In Africa elephants are not tamed and trained, but in India for many hundred years they have been kept as beasts of burden, as war animals, and as ornaments to the state of kings.

The most notable characteristic of the elephant is its proboscis. What is that? As the tusks are two overgrown teeth, so the proboscis is an overgrown nose and upper lip. The nose and upper lip of the elephant are prolonged into a tube, often six feet long, tapering almost to a point. At the extreme end of this organ the nostrils are situated, and elephants often swim entirely under water, by simply carrying the end of the proboscis above the surface. The proboscis is composed chiefly of muscles, four thousand of them we are told, together with many nerves. Thus it is exceedingly strong, flexible, and very sensitive, and an injury to it gives the animal intense pain.

The proboscis of the elephant is used by its owner with all the ease and skill of a human hand. Through it, it can draw up water and pour it over its back, or squirt it whereever it chooses; it can use sand in the same way, and by an arrangement of valves near the air-passages, the water and sand while thus drawn up are kept out of the nostrils and air-tubes. The tip of the trunk is prolonged into a finger and a thick knob which serves for a thumb. With these the elephant can pick up even so small an object as a cherry or a pin. With this hand-like extremity of the trunk, the animal conveys food to its mouth.

To the elephant its proboscis is indispensable and invaluable; clumsy in its motions, with a very short neck, which does not permit the head to bend to the ground, and thick, pillar-like legs, difficult to bend, what would it do without this long, flexible appendage? With it the elephant collects food and drink, tears off fruit and leaves from the trees, and taking a branch for a fan, drives off the teasing insects which settle on its vast body. A horse switches off insects with its tail, but the tail of the elephant is small, slim, and bare, very like that of the pig.

With the proboscis the elephant strikes down its enemies, pumps water for its bath, lifts a burden to or from its back, defends its young, and shrieks and roars, as if braying through a trumpet when hurt or angry. From this trumpeting noise, the French have called the proboscis a "tromp," or trumpet, which we have corrupted into that senseless name for a proboscis, a trunk.

In a fight with a lion or tiger, the elephant keeps its proboscis held aloft, out of harm's way, waving it like a banner, and sounding an alarm, and uses its tusks for a weapon, wherewith to gore or toss its foe. It also tramples on its enemies, and crushes them with its enormous weight. With its tusks the elephant also uproots trees when it wishes to secure dainty leaf-food, too high up to pull down with its proboscis.

The skin of the elephant is bare, exceedingly thick, much wrinkled, and of a dark lead color, nearly black. The head is large, the eyes are small; the mouth is set under the thick upper part of the trunk, and is guarded by the tusks. The legs are enormously large and clumsy, and so are the feet, which have five toes enclosed in a cushion of thick skin up to the nails.

Elephants live from seventy-five to one hundred and thirty years. The baby elephant is woolly about the head and shoulders. It sucks its mother's milk not through the proboscis, but with its mouth. The mother is very fond of her big baby, and is valiant in its defence. Elephants are enormous feeders, consuming half a bushel of grain and two hundred pounds of green herbage a day.

The sagacity of the elephant has been the theme of many stories, which have also celebrated its affection, gratitude, its sensibility to kindness, its revengeful memory of affronts, and its treacherous disposition, given to sudden bursts of rage. White elephants, of which so much is said, are not a separate species, but albinos.

We have now seen the greatest of the ungulates. With him in a menagerie we often find the tapir, remarkable for its long nose, and as being one of the oldest species of living mammals, therefore of an ancient dignity of family to which the king-crab, hatteria, opossum, and beaver may make their best bows.

The hippopotamus is a hoofed animal, next in size to the elephant. It is a hideous and dirty-looking animal, but one that in a menagerie or garden moves our compassion, for it is by its nature an amphibious creature, born to live in the rivers, and to spend the most of its time diving or swimming, or standing neck deep in water; and nothing can be more wretched than its appearance as it chews dry hay, and panting waits for a keeper to throw a few pailfuls of water over its fevered skin.

The hippopotamus is a tusk-wearer like the elephant, and while the ivory of its tusks is not quite so good as that furnished by the elephant, it is yet in great demand. The hide is also used in the manufacture of boots, trunks, and many instruments.

The rhinoceros is another big specimen of the ungulates, with a bare, smooth hide. It is an aquatic animal, wearing a single horn on the front of its snout. In its native home, this horn serves to root up river-plants, on which it feeds; it is also the weapon of war. Given in its natural haunts to spending hours in rolling in the mud or wading in water, the rhinoceros suffers severely in confinement. Usually of a mild, quiet temper, it seems sometimes filled with homesickness and despair, and with loud moans dashes its head against the walls of its prison as if wishing to end its miseries by breaking its skull.

No hoofed animal is better known, whether dead or alive, than the pig. The pig is the direct descendant of the wild boar, and owes the various changes in its appearance and conformation to ages of domestication. The wild boar is an animal with long legs, long bristles, lean body, a long snout, and a pair of big tusks formed by the elongation of two canine teeth on each side of the mouth. The two canine teeth on the lower jaw are much larger and stronger than those on the upper. The boar has fiery little eyes, a fierce and active disposition, and great courage.

It has been said of the common pig, that it is an animal "manufactured by man, and he makes it take such shapes as suit his wants best." By careful feeding and breeding the tusks are lost, the bristles decrease, the head and legs diminish, the body and haunches greatly develop. Fed and sheltered, the pig is mild and lazy. Turned loose in the woods, for several generations, the snout and legs lengthen, the body grows thinner, and many of the characteristics of the boar return. Various famous breeds of pigs take their name from localities where they are reared, as the Berkshire, Suffolk, Norman, Pyrenean, and Perigord varieties.

The horse is the most noble of all the thick-skins, and indeed of all brutes. Its immediate relatives are the ass, quagga, and zebra. The curious stages and changes in the development of the horse have already been given.[1] Docile and quick to learn, the horse has been trained and used by men from the earliest antiquity. Only one of this species remains superior to domestication, the wild ass of the Himalaya regions. The zebra also is restless and intractable, and is not often reduced to a domestic state. Why of all the horse kind should the gentle, tractable, humble, strong, patient, easily-fed donkey have been chosen as the constant recipient of scorn; abuse, and hard fare? Scant food and plentiful kicks and curses are the portion of one of the most useful and gentle of brutes. Much more

[1] Lesson 5.

hardy than his cousin, the horse, demanding only a little water and the coarsest fare, the poor donkey gets many blows and few thanks for tireless service. Hats off to the donkey, who always does the best he can.

LESSON L.

EVEN TOES.

"Then bend your gaze across the waste — what see ye? The giraffe
Majestic stalks toward the lagoon, the turbid lymph to quaff;
With outstretched neck, and tongue adust, he kneels him down to cool
His hot thirst with a welcome draught from foul and brackish pool."

— F. FREILIGRATH.

THE order of ungulate has for its second sub-order the even-toed animals. This group is distinguished by the power and habit, which all its species have, of bringing back into the mouth, food already swallowed, in order to re-chew it thoroughly. This habit is called ruminating or chewing the cud. We have all observed it in sheep, kine, and camels.

The most notable characteristic of these animals is the formation of the stomach, which is divided into several compartments of different construction. The second of these stomach compartments is small and lined with cells of a honey-combed appearance. The slightly chewed food, on reaching this receptacle, is gradually moulded into pellets or small masses, which, instead of passing into the next lower division of the digestive apparatus, rise into the throat, are re-conveyed to the animal's mouth, and are slowly chewed into a fine pulp. Any one who has watched a cow or sheep lying at ease, calmly and steadily chewing the cud, has seen a picture of quiet enjoyment.

The lowest division of the stomach of a cud-chewer is called the rennet-bag, from a fluid called rennet, which it contains, which digests all the food. Rennet has the property of curdling milk, or rather of making it partly solid without rendering it sour. It is used in making cheese. This rennet, mingled with the well-masticated food of the cud-chewers, completes the process of digestion. All liquids swallowed by these animals find their way at once to the rennet-bag.

All cud-chewers feed upon vegetable substances, and chiefly upon grass, of which they eat the stalks and fibrous portions as well as the blades. In a former lesson we spoke of the need of sheep for "roughness," as stock men call it — a need which is shared by all ruminants. This roughness is the coarse and innutritious portions mixed with the richer parts of their food, to enable them to chew the cud, and to prevent indigestion, which would be caused by too rich and compact diet.

The teeth of cud-chewers are especially formed for grazing; there are no incisors or cutting teeth on the upper jaw, except in the camel family. The teeth are of two kinds, incisors (on the lower jaw) and grinders, or molars. These grinders are wide teeth, and as the jaws move, the molars act upon each other from side to side, the lower jaw grinding against the upper one. Watch a cow as she eats, and you will observe this motion.

Now let us look at these even-toed feet. You will say that these animals have hoofs divided in the centre, while the hoof of a horse is not divided at all. The pig, which does not ruminate, has a hoof centrally divided, like that of a sheep; and the hare, which chews the cud, has several separate toes, and belongs to the rodents. Amid all this diversity there is this constant characteristic, that the cud-chewers of the ungulates have the toes of each foot collected under what is called a cloven hoof, as if a solid hoof had been cleft into two.

There are four families of even-toed ruminants — the hollow-horned, including kine, sheep, goats, and antelopes, the deer tribe, the camel tribe, and the camelopards.

To the hollow-horned family belong our most useful domestic animals, and those earliest associated with man. The cow family affords us beef, our principal meat food, also butter, cheese, and milk; while the hides furnish our chief supply of leather. The bones are used for making buttons, combs, knife-handles; the hair is used in plaster; glue and gelatine and calves' foot jelly are made from the hoofs. Oxen are largely used for draught purposes. What, then, should we do without the bovine race?

The sheep was no doubt the first domesticated animal; its gentle nature, and the ease with which it can be reared, made it an early associate with the homes of men; its wool furnishes probably our chief clothing supply; its flesh is a favorite food; many nations drink its milk, from which they make also cheese and butter. Thus we have in the sheep an animal indispensable to our civilization.

The goat is a third hollow-horn, the flesh and milk of which are much used in many countries, while the goat's long and silky hair is in demand for woven fabrics.

Finally among the hollow-horns we find the famous animals of the antelope family, the beautiful, timid gazelle, the fleet chamois, the fierce, untamable gnu, the graceful ibex. If we had time to describe all these, we should find before us some of the most charming creatures in the world. They live in high mountain districts, and the Swiss is never more happy than when he pursues the chamois over the steep crests and among the crags of his native land.

The largest and most untamable of the hollow-horns is that cousin of our patient, useful ox, the bison, or buffalo,[1] an animal rapidly becoming extinct through cruel and wanton slaughter. While few of us have seen the bison himself, his shaggy pelt is well known in the buffalo robes of our sleighs and carriages, and in the heavy overcoats made for northern travel. Next to the elephant and the rhinoceros, the bison is the largest of land-mammals.

If we lived in Arabia instead of America, we should set beside the sheep, as the special ally of men, the camel. We have all seen this creature in menageries and zoological gardens, — a tall, awkward beast, with long legs, a shambling gait, one or two humps on its oddly shapen back, a small head, the upper lip split in the centre, a long neck, small

[1] The animal called a buffalo in America is not a buffalo, but a bison. The buffalo of India and Italy is the *Bubalus*, the buffalo of the Western plains is the bison. The large, wild bison of Germany is called the Aurochs. All these animals belong to the family Bovidæ.

ears, a dusty, shaggy coat, and a demeanor of patient endurance. Buffon says that "the camel is the chief treasure of the East."

Gentle and hardy, demanding but little food, and that of the coarsest description, — a few dates, a few handfuls of grain, — capable of going for days without water, a strong beast of burden, this is one of the most important members of an Arab family. The milk of the camel affords the Arab cheese, and also a nourishing drink; of the animal's long hair is woven cloth for clothing and for tent covering; its flesh is used for food; and across the long, hot, arid stretches of his desert land, the Arab rides in safety, seated on his tent and household goods piled upon the back of this "ship of the desert."

From the earliest times the camel has been the only means of conveying travellers and Eastern commodities across the desert. It travels thirty or forty miles a day, under the hot sun, carrying a burden of five hundred or six hundred pounds.

Camels have broad, callous soles over the bottoms of their feet. These enable them to tread firmly without sinking in the desert sand. There are also callous knobs on their knees and breasts, which protect them as they kneel to receive burdens, or sleep in a kneeling position. The training of the young camel begins when it is but a few days old, and it is taught to get along with the smallest possible allowance of food, drink, and sleep.

The stomach of the camel is provided with numerous little sacs, called water-cells; these drain off a considerable quantity of water when the camel is drinking, and retain it for several days, restoring it gradually to the stomach. The camel seems to prefer coarse, unsucculent, dry food, and burning sunshine; it never seeks the shade. It is perhaps apathetic, rather than gentle; it seems little impressed by kindness, and, like the elephant, has a long memory for injuries.

Following the camel in our menageries usually comes a very strange-looking beast, the tallest of all animals. With its long neck, small head, and its habit of browsing off the tree-tops, it reminds us of what we have read of that fossil beast, the iguanodon. This is the giraffe, often called the camelopard, which name is given it because it has a somewhat camel-like form, and the beautiful spotted skin of a leopard.

If we watch a giraffe in a menagerie, we shall remark the beauty of its silky, spotted coat, the gentleness of its large, eager eyes, its two short horns covered with skin, its ears turned backward, its long, dark tongue, with which it constantly licks its lips and nostrils. Timid and mild, the giraffe shows vexation only by pawing the ground rapidly with its fore hoofs; it will bend its stately head to accept an apple or a carrot from a little child, and seems to forget the days when it wandered through the African forests, and browsed on fruit and leaves from the tops of the trees.

The giraffe is one of the swiftest of animals, and it is almost impossible to take an adult alive. They are generally captured while very young, and brought up on camels' milk, until old enough to eat grain and green fodder.

The Western hemisphere gives us no animal corresponding to the giraffe. In South America the llama in some measure represents and takes the place of the camel; but the tall and beautiful giraffe stands alone of his kind.

We now turn to the fourth family of the ruminants, distinguished by the fact that they shed and renew their horns. The horns of the cow, ox, sheep, antelope, and goat are permanent. If by any accident they are lost, they are not renewed; but the deer family shed their horns, which indeed, are not properly called horns, but antlers. Antlers are a horny growth, large and branching, divided into what are called tines. Up to a certain age these antlers grow, fall off, and are renewed every year, and there is no mammal peculiarity more wonderful than the rapid growth of these large frontal ornaments. In many of the deer species the male alone wears the antlers. In the reindeer family both males and females have these huge horny branches.

The deer family is distinguished for grace of movement and beauty of form. They have smooth, close, hairy coats, but on the breast of the male deer the hair grows long and is called a beard. The eyes are large, clear, and bright, full of gentle eagerness, and furnished on the inner corner with a curious hollow, or gland, called the tear-pit. They have small, pointed ears, and short tails; their legs are slim, and their hoofs are small, the whole animal being built for lightness in running. Even the antlers are not nearly so heavy as they look, for they are porous and full of air-cells.

The deer family is distributed over the entire world.

Deer vary in size from the large elk or moose, the royal stag, and the magnificent wapiti, to the small roe deer, not so large as a sheep, and the pigmy deer, which is the smallest of all ruminants, and indeed, is not larger than a hare.

Deer are vegetable-feeders, and in the coldest climates are capable of living on lichens, and the scantiest fare. In the far north reindeer or caribous furnish the chief wealth of the people, and serve instead of cows, horses, and sheep, their flesh and milk being the chief food-supply, and their skins furnishing clothing and bedding. They serve also as draught animals, and pull sledges over the snow with incredible swiftness.

Deer generally live in herds; the mother is a most vigilant and tender parent, devoting herself to her twin children with tireless care. Deer are distinguished for the perfection of their senses of sight, smell, and hearing, and as soon as one of a herd discovers anything that indicates danger, the alarm is given, and away they go. The deer mothers, while feeding, are constantly alert, and hurry their little ones off at the first hint of danger. The general disposition of the deer is amiable, but the old males sometimes fight furiously together, and if brought to bay by hunters, defend themselves valiantly with hoofs and horns.

Passing now from the ungulates, we reach a very well-known order of mammals, called the carnivora, or flesh-eaters. This order is divided into two sub-orders, the pinnipeds, or "fin-footed," and the fissipeds, or "slit-footed." In our study of the seal we have had the best example of the fin-footed, or aquatic carnivora. Bring up your dog or your cat for a sample of the slit-footed flesh-eaters. Ponto, set your foot down firmly, and let us look at it. All the toes are of equal length; the foot looks as if a roundish foot had been deeply slit into toes, which are hairy up to the nails. The feet of web-footed animals would look like this if they were not webbed.[1]

These slit-footed, or fissiped creatures, are divided into several species, and there is considerable difference in their way of treading; some, as the cats, walk on their toes. Come here, kitty, let us see your feet. Kitty can draw her claws close into the "velvet," or fur, of her paw so that you would not know she had sharp nails. As she does this she curls her foot up into a cushion, and walks on the ends of her toes. Look at her foot when she stretches it; how well you can see the slit-foot arrangement and the clawed toes. Kitty is a mild and domestic representative of the great, feline race, at the head of which stands the lion. Ponto, on the other hand, is a civilized and educated specimen of the canine race, which numbers among its members the wolf.

While kitty draws in her claws and walks on her toes, the bears are what is called plantigrade carnivora, for they walk on the flat soles of their feet. These carnivora are all flesh-eaters, but when educated and refined, like Ponto and Kitty, they will eat any kind of food.

Among the carnivora we enumerate lions, tigers, bears, cougars, hyenas, panthers, wolves, jackals, leopards, cats,

[1] If we examine the toes of the cat and dog, we shall see that the skin extends web-like partly up the toe bones.

dogs, badgers, and many more. You see they embrace all the fiercest and most dangerous wild beasts, as well as our domestic friends, the cat and the dog. If you will open Kitty's mouth, or Ponto's, you will see what style of teeth these carnivora have; they are made for tearing flesh, and are accompanied by sharp claws for holding fast the living prey. All the carnivora are singularly strong, agile, and tenacious of life. The carnivora are so varied and interesting, that we leave them to be studied elsewhere, and indeed so we must serve the final order of mammals — the primates.[1]

These primates are divided into two sub-orders, the quadrumana, or four-handed animals, and the human race. Many scientists, instead of the order primates, with these two sub-orders, give us the order quadrumana, or monkeys, and the order bimana, or man, and that is the better division.

The quadrumana, or ape families, contain a large number of curious and interesting animals, all natives of tropical regions. They are hairy creatures, with three kinds of teeth, and are adapted for eating nearly all kinds of food. They are well known to us in menageries, and are frequently seen on our streets, fancifully dressed, and in company with a man and an organ, surrounded also by a group of admiring children.

"How many children are there in your family, Pierre?" we one day asked a bright little Italian boy.

[1] It has been impossible in so small a book to discuss with any minuteness the subjects noticed in the closing chapters. It is hoped that the hints given will incite pupils to study and observe the domestic animals of which we see so much and know so little.

"Four, and the monkey, signora."

"But the monkey, Pierre, does not count with the children."

"O signora! for care and trouble he counts more than the children! He must have the warmest corner and the best food. At night, for warmth, he sleeps in my father's arms. He gets cold ten times as often as we do; and if he gets a cold he must have the doctor, for he is likely to die. If he dies, away go all our saved dollars for more monkey! Gracious! O signora! do you think our father would let our monkey run round in the streets and look out for his own dinner as Marie and I do? The thing is impossible!"

THE END.

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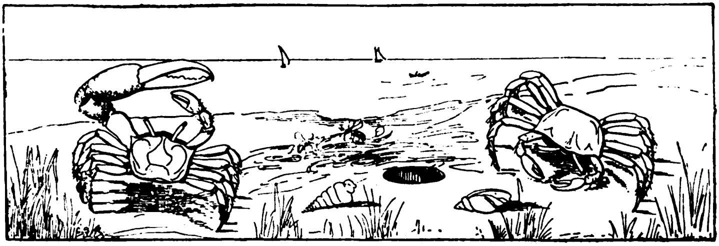

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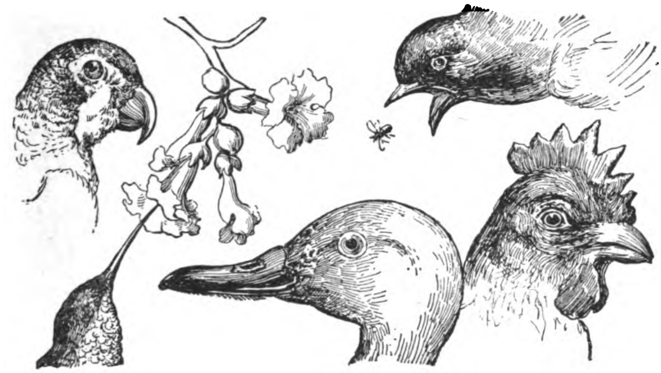

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