

Stories of
Rocks

NATURE SERIES

SELECTED AUTHORS

Stories of Rocks

Selected Authors

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Stories of Rocks

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Stories of Our Mother Earth

By Harold W. Fairbanks

Introduction

Nature study is deservedly attracting more and more attention in the schools, but the most of the aids for teachers and pupils have been limited to a presentation of organic nature, while the wide and fully as important field of inorganic nature has been very much neglected. With the hope of supplying, to some extent, the existing lack, this little book is presented for the use of grammar-grade pupils.

It has been the opinion of some educators that children are not as quickly or as easily interested in rocks, minerals, and the processes which are changing the surface of the earth, as in plants and animals. I believe, however, that where the experiment has been well tried, all phases of nature with which the child comes in contact, have been found to be equally interesting and instructive.

It is undoubtedly true that the study of specimens by themselves is largely devoid of interest. Children want to know the relation existing between things in the world about them. I am thoroughly convinced also that they are capable of understanding many of the processes involved in the shaping of the earth, but

because of the idea that the subject is too difficult, or from lack of proper familiarity with nature on the part of the teacher, these inorganic nature studies are more often neglected.

The majority of children leave school at, or before, the completion of the grammar grades, and for these the great realm of inorganic nature has too often no meaning. We must reach these and give them at least some correct ideas of the origin and meaning of the common things about them.

In mountainous regions especially, where mining is often such an important industry, and physical nature seems to work more energetically, it is particularly desirable that the children should go out from school with some living knowledge of their surroundings. They should know something of those aspects of nature with which they have to deal their whole lives.

I do not wish to unduly emphasize the economic aspect of education at the expense of the so-called cultural, but I do maintain that the education of the child should bear some relation to his life's surroundings, and if, as is the case with nature studies, this education is cultural as well as economic, then so much the better. Those who pass their lives in the

mountains with the rocks and minerals all about them, and the processes of disintegration, erosion, etc., actively at work, should be able, on leaving school, to interpret the more simple of these phenomena in a rational manner.

Nature study from books cannot be a success. Books should only direct to nature herself. Neither should nature study be an addition to already crowded courses but should supplant, especially in geography, much which is still too often taught irrationally and mechanically.

It has been my purpose in the preparation of the following chapters to present in a simple manner, some elementary conceptions in geology, mineralogy, and physical geography. While the different topics are illustrated by examples from the Pacific Coast, yet the most of them are of such a nature as to be applicable to any section of the country.

The Pacific Coast is particularly rich in illustrative material for the study of inorganic nature, but up to the present time little of this material has been put in such shape as to be available for the use of schools.

If the subjects presented here should prove helpful, even in a small degree, to teachers and pupils, and arouse in them a desire to know more of the

processes of nature going on all about, the purpose of the book will have been accomplished.

HAROLD W. FAIRBANKS,

May 15, 1899. Berkeley, California.

This Home of Ours

The earth is our home. Ever since we can remember we have been living upon it, and moving about here and there. We have slowly become acquainted with some of its nooks and corners, but our rambles still bring us to many things which we do not understand. As we climb the hills, or follow the rippling streams, or wander along the beach, we feel that this is a very pleasant place in which to live. For some of us the growing plants and flowers are the most attractive. Some like best to watch the strange behavior of the little animals and insects, while others think the smooth and brightly colored pebbles are of the greatest interest.

As we grow older, the world seems to widen out faster than we can explore it. We travel farther, and catch glimpses of a great range of snowy mountains, at the foot of which are broad fertile valleys, and beyond them the shining Pacific Ocean.

As we have a chance to examine this country closer, we find new things. The streams from the mountains are led out over the valleys, and keep them

moist through the long summers, so that almost everything people need grows here.

In the mountains there are deep canyons through which, in the late spring, flow dashing streams of muddy water. In the fall they are quiet and clear, and we can count the pebbles over which they ripple. In some places they plunge over great walls of rock, and in others they run quietly under drooping willows.

High on the mountains there are no trees; only bare rocks and snow-banks. From a tall peak, we can see over the range to a very different region beyond. In that direction there are no green fields, no houses, nothing but a stretch of parched ground, for on that side of the mountains it seldom rains, and there are few running streams.

If we turn our footsteps to the ocean, we see in some places long ridges running out into the water. Where the waves have washed off the soil from these ridges there are jagged rocks, perilous places for the ships.

Behind the cliffs we see the bays, where the broad valleys come down to the ocean. The rivers wind sluggishly through these valleys, as though they did not know which way to go.

We enjoy seeing all these things, and by and by we begin to wonder about them, and to ask questions. The world becomes to us something more than a mere playground made for our especial benefit.

We begin to realize how large the world is, and how many things it contains which we shall have to study to understand. We see that life itself depends upon these things. If it were not for the great oceans from which the breezes carry moisture to the mountain tops, there to be condensed into rain, and water the thirsty land, no plants or animals could live, and our homes would become a parched desert.

We see that in choosing our homes we cannot go where we please, for we cannot grow our food in the desert, or upon the rugged mountains. We must choose the fertile valleys, if we would be farmers. We must leave the valleys and seek the mountains, if we would be miners.

Great cities do not grow up at any point. They are located in the protected harbor, behind the rocky headland, where the river and the valley meet the ocean, where the ships can come and take the produce. Manufactories must be built where dashing streams roaring among the bowlders, or pouring in

cascades over the rocky cliffs, furnish the necessary power for running machinery.

It is clear then, that our lives, as well as the lives of the animals and plants, depend upon the oceans, the position of the mountain ranges, and the direction of the winds.

We question the mountains, and the rivers, and the ocean. We wonder if they have always been where they are now. The mountains look so firm and solid it seems as if they must always have stood where they do now. But some day we find shells upon a high ridge far from the ocean. This puzzles us, for these shells must have lived in the ocean once.

We finally come to the conclusion that before we can know all about the plants; why one kind grows on the hillside, another by the brook; why the animals are distributed as we find them; why cities grow up as they do; and why in one part of the country people till the ground, and in another part dig deep for the minerals, we must know a little more about the foundations of our home.

We must know how the rocks and the soil were made, how the mountains grew, and why the rivers run as they do. We must understand how Nature is shaping the earth about us.

In order to do this, we shall study what the rain and the frost are doing upon the mountain tops. We shall trace the river's course, and find where the mud which it carries to the ocean comes from. We shall try to understand how this mud is spread over the floor of the ocean, and what the waves are doing as they continually beat against the land.

We shall go beneath the rich soil upon which our grain grows, and find out what is going on within the earth. We shall want to know about many things which are dug from the earth, how the coal was formed, and where the petroleum comes from. The gold, quicksilver, borax, and salt, will also interest us.

Nature has many forces at work, some great and some small. They have worked a long time getting this home of ours ready for us. If we can understand how Nature works, our home will be more dear to us, and we shall be happier.

The Rock Floor

Below the loose earth upon which we walk there is a rock floor. This floor forms the crust of the globe, and stretches all around it. It is what makes the globe solid and firm.

When the rock floor was formed, a long time ago, it was very rough and uneven. Nature covered a part of it with the great oceans. Over another part she spread a dark carpet of soil; but she has not yet succeeded in covering the tops of the mountains.

Along the ocean cliffs the waves have washed away the carpet of soil, and we can see how rough and hard the floor is. We can also see the rock in the bottoms of all the little gulches in the hills; but in the valleys the floor is hidden very deeply. How would the world look if there were no soil, and everywhere we went we had to scramble over the rough rocks? It may be that we can learn something by a visit to a lava field where Nature has not yet stretched her carpet of soil. Lava is a part of the stone floor which was so hot at one time that it melted and flowed up through cracks in the crust of the earth.

Hundreds of years ago, near Mono Lake, in Eastern California, some of this red-hot lava ran out and spread over the surface, killing and burying all the plants, and the animals that could not run fast enough to escape it.

It looks as if some giant had poured out there a large kettle of thick pudding; but instead of being good to eat, it was made of melted rock, which, as it cooled, became so hard that a hammer was needed to break it.

It is a long trip across the mountains to the lava-field, but at last we come in sight of it, an immense stretch of bare rock with green forests all around.

We climb up the precipitous side of the lava, and find, on reaching the top, an immense rough plain of jagged rocks extending away in front as far as we can see. There is not a tree nor bush to break the desert-like character of the surface. As we climb over the rough, sharp-edged rocks we can hardly avoid tearing our clothes and cutting our hands.

It is the most lonesome place imaginable. There are not even any little blades of grass growing out of the cracks. All that we see are some patches of gray moss, clinging here and there. Even the birds and ground squirrels are absent, for there is nothing here

out of which they could build their nests. Everything looks fresh and clean, as if it had just come out of the shop.

In spite of care, we do sometimes slip and cut our hands; and at last, tired of prying around, we sit down on the edge of the lava and look at the large pines growing in the soil of the valley below.

We begin to wonder at the meaning of what we have seen. It seems that the earth must be hot inside, where this lava came from. If this is so, then our whole world was hot once, even the outside, where the grasses and trees are growing. It must have crusted over at last, just as our breakfast mush cools on the outside first, or as the skim of ice forms upon the pond during a cold night.

The rock upon which we sit certainly must have been in the fire, for it looks just like the slag which we have picked up about the furnaces where iron is being melted. We try to imagine how the whole country would look if it were covered with such lava. We would find only hard rough rocks wherever we went. There would be precipices, deep holes, caverns, and cracks, into which we would be in continual danger of falling.

It would rain as it does now, and the streams tumble over the rocks, as they hastened to the sea. The mountains would be white with snow in the winter time, but we would miss the spring, the green spring with its flowers, and the fall with its brightly tinted leaves. It would make no difference how much it rained; nothing could grow without soil.

The picture is such a dreary one that we stop thinking about it, for we could not live in a world of bare rocks and stones. Without the soil there could be no pretty little meadows, and without the plants which grow upon the meadows, no animals could live. It would be a dead world.

The whole world once looked just like our lava field, but that was so long ago that a great many changes have taken place. The stone floor which we now see is not all lava. Along the ocean beach, and in the beds of the rippling brooks, we see pebbles of many colors, telling us of the different kinds of rocks in the hard floor under us. There are so many that it would take a long time to learn all about them.

The stone which is used for the walls of buildings comes from this floor. It is dug from large holes in the ground called quarries. All the beautiful stones which are used for jewelry also come from the rock floor.

They are rough, when first obtained, and have to be cut and polished.

Iron and copper are among the most useful of the minerals found in the rock floor, but we think the most of gold and silver. We should feel very awkward without many of these things which are dug out of the rocks, and we are glad that the soil does not cover them all up.

The mantle of soil furnishes the necessary things of life, and so makes it possible for us to live here; but the rock floor supplies not only many useful things, as we have seen, but, in the mountains, surrounds us with grand and beautiful scenery. It makes our lives more happy.

In the great plains of the Mississippi Valley, the rock floor is buried out of sight. The people living there do not know the pleasure of a home in the mountains, where the great rocks stand high in the air, and the rains and dashing streams have carved them into all sorts of grand and rugged cliffs.

In another lesson we shall see how the soil was formed, and at last covered up so much of the rock floor.

How the Soil is Formed

We learned from the lava field that there was a time, when our world was a good deal younger than it is now, when there was no soil upon its surface. The great oceans, and rivers, and bare rocks, were all there was to be seen.

Perhaps Dame Nature grew tired of such a barren world. However that may be, she at last covered up all but the roughest places with a smooth carpet.

It was such slow work that I fear we would have become weary if we had been compelled to watch her. Look out upon the pretty valley and see how smooth and level she made the ground, and then turn toward the mountains where the great rocks rise to the sky, and you will see where she has not yet been able to spread the carpet of soil.

How did she do this work, and where did she get the soil? It will help us to understand these things, if we look again, after many hundreds of years have passed, at the lava field near Mono Lake.

Generations of the great pines have grown up and died, when we again cross the mountains to the field of lava. How different everything looks. We have much trouble in finding the place.

The lava is no longer rough and bare, and only in a few places are there any rocks standing up from its surface. A soft, dark mantle of soil covers all the rest. Tall pines stand upon the soil, and send their roots down through it into the crevices of the lava below it.

In the side of a ravine we see what the soil is made of, and how it covers the lava. On the surface there is a dark layer of decaying leaves and stems, forming leaf-mold; and below it a dark, rich, clayey soil, with no fragments of the rock in it. Farther down it is almost a pure brownish clay, with only a few roots running here and there. This is the subsoil. Below the subsoil, and near the bottom, there are fragments of the lava which crumble as we dig them out.

Under the subsoil lies the lava, which is soft and crumbling at the top; but in the bottom of the ravine, where the water has washed off the decayed lava, it is as hard as it was upon the surface so many years before.

We can also see in the sides of the ravine how the roots of the trees have grown downward into the

cracks in the lava, and gradually shoved the pieces apart.

Year after year, ever since the lava first cooled, the rain and frost and air have been at work. For a long time they did not seem to accomplish much, but there are many things going on in the world which we cannot see.

The water ran into the cracks, and as it froze during the winter forced the masses of rock apart. The fragments finally crumbled and turned to a clay-like mass which formed a coating over the rocks.

Little by little, the seeds of different plants were carried to the lava field, either by the birds and squirrels, or borne upon the wind. Many of them, falling upon the crumbling rock where there was a little moisture, sent their tiny roots down into the cracks, and managed to live for a short time. When they died, their leaves and stems enriched the softened rock, and so, year by year, made the surface more fit for larger plants.

Trees grew up at last, and shaded the soil, so that the moisture did not dry out so fast, and when the trees died, they added their rotting trunks to the soil.

Then the ground squirrels came and burrowed in the soft material, turning it over and over, bringing

fragments of rock to the surface, where the frost made them crumble into still smaller pieces.

Many other animals made their homes in this gathering soil. Among them were the earthworms, which we see stretched upon the ground after a rain. They are stirring the soil all the time, and loosening it up so that the air can get into it.

The ants also are doing their part, as they tunnel through the earth, and bring the little particles to the surface. There are, in addition, some very small animals, which we can see only when they are placed under the microscope. They are called bacteria. Every handful of earth contains thousands of them. They are very necessary in fitting the soil so that the roots of plants can make use of it.

The soil which forms over the rock floor in this way is called residual soil. The brooks are washing away particles all the time, and this soil is what is left.

The soil in the valleys is formed in a different way. The tiny particles of sand and clay of which it is composed have, in many cases, been borne miles by the rivers, and ocean currents. All of the rock floor which we see in the mountains is softening and crumbling upon the surface just as the lavabed did.

The raindrops wash the particles from the mountain slopes into the brooks, and they in turn carry them to the rivers. The latter leave them at last either in the marshes near their mouths, or bear them out to the ocean.

This is what the Sacramento River is doing year after year, as it pours its muddy flood through San Francisco Bay into the Pacific Ocean.

We will dip up a glassful of the dirty yellow water, and see what happens when it becomes quiet. In a few hours the water is clear, while upon the bottom of the glass is a thin layer of mud.

Each spring the Sacramento overflows its banks, and covers the lowlands. When the river becomes smaller and the water runs off the meadows, there is left everywhere a thin layer of mud. In this way the soil of the level bottom lands has been formed. Grasses grow upon it, and animals burrow in it, finally leaving it dark and rich.

We have already seen how necessary the soil is to our existence. Plants cannot grow without it, and without the plants there could be no animals.

We have also seen that it takes Nature many years to cover the bare rocks with this rich carpet. These things should make us careful when we plough and

dig in it, that we do not leave it so the rains can carry it away. We should not permit the grasses and trees upon the hills to be killed, for their roots hold the soil. The soil in turn holds the moisture.

In the mountains of the desert there are few plants, and the soil is washed away as fast as it is formed, leaving the rocks almost bare.

A Handful of Sand

I have here a handful of clean, white sand, scraped up from the beach. It is the sand which the children so delight to play in, and which never soils their clothes.

It is the same kind of sand that they use to make mountains and hills in their geography studies.

Sand is not only nice to play in, but it is useful in many ways. Glass is made of it, and the plasterer mixes it with lime to form the mortar with which he lays the bricks, and plasters the walls of our houses.

What is the history of the little grains which the winds blow in our faces, and the waves wash up and down the beach?

Examine these grains with a pocket microscope and you will see that they are clear like glass and quite smooth. They have been thrown about by the waves, and rubbed upon each other, until all the sharp points are gone.

We will call them quartz grains and the sand, quartz sand.

Very long ago these grains of sand formed a part of a granite mountain. The mountain was high and rugged and stood upon the border of what is now one of the deserts of Southern California.

Now the mountain is nearly gone, and the little grains of which it was composed are scattered far and wide.

The picture before us shows a low hill in the desert. It is the heart of the old mountain, and is all that is left of it. How beautifully it tells the story of what Nature is always doing. She is tearing the rocks down in one place, and building them up again in another.

One lone granite pillar stands in the center of the hill. Lying about on all sides are the great blocks of granite which have broken off and tumbled down the sides of the hill.

These blocks are still hard, and if you should hit them with a heavy hammer they would not break. Those farthest from the hill, which have lain on the ground for a long time, are crumbling to little grains, which will form a part of the desert sands.

Scrape up some of the sand, and look at it carefully. It consists mostly of grains of quartz like those upon the seashore, only they have sharp angles instead of

being rounded. Among the quartz grains are some little black scales and particles of clay.

With a hammer you can soon crush a piece of the granite to sand. Nature did not go to work in that way. She is very quiet, and it takes her many years to make great changes.

Let us look at a piece of the granite, to see what it is made of, and then, perhaps, we can understand how it crumbles to sand.

The clear, glassy grains which you cannot scratch with a knife, are the quartz about which we have been talking.

The shining black mineral which you can dig out in thin scales with the point of a knife is called mica. You have all seen it in the windows of stoves. The mica is used there because it is not easily broken or affected by the heat.

You will notice also some grains of another mineral, which is nearly white, but not as clear as the quartz. This mineral has little faces, which reflect the light, and it can be scratched a little with the knife. It is called feldspar.

Now let us see, if we can, how Nature changes a piece of solid granite to sand.

When the mountain of granite stood where the hill does now, there were narrow cracks running all through it.

The rains soaked into the cracks, and the roots of the bushes and trees penetrated them. As the roots grew larger, they pried the masses of granite apart, just as a man would do with a bar. The loose pieces finally rolled down the mountain side.

As we have seen, every piece of granite is composed of three different minerals,—the quartz, the feldspar, and the mica. As the sun shone upon the granite it made it warm, and each grain expanded a very little. At night, when it was cool, the grains contracted. In this way they became loosened, and after a long time slowly fell apart, forming sand.

This is Nature's way of tearing down a mountain. It is very slow, but if you could live long enough you could see how much she accomplishes.

The little brooks which used to run by the granite mountain had plenty to do. As the granite crumbled, the feldspar became soft, and turned to clay. The brooks picked up the particles of clay first, but they made themselves muddy in doing so. They could not get rid of the mud which the clay made, and so had to carry it to the ocean.

The water also washed the scales of mica along very easily. Look in some brook on a summer day, and you will see the shining scales of mica moving along on the bottom with the current. Perhaps the brook is carrying them from some mountain which is now being torn down. The most of the little scales will not stop until they reach the ocean.

It was not so easy to move the grains of quartz, but the brooks did it when the rains fell, and they rushed along more swiftly.

The clay and the mica scales were carried far out into the ocean, where the water was quiet, and then fell to the bottom.

The quartz grains were not carried out so far, and the waves piled them up on the beach. The waves never tired of playing with the sand. They turned the grains over and over, and ground them together, until they were perfectly smooth.

You see now how the ocean sorted the different minerals in the granite. It put the clay and mica scales in one place, and the quartz grains in another. The work is not always done so well, for along some ocean shores the clay and mica and quartz are all mixed together.

When the waves have done with the grains of sand, and thrown them up high on the beach, the wind takes a hand. It picks them up and whirls them through the air as it does the snowflakes.

What do you suppose will become of the granite pillar which is all that remains of the mountain about which we have been talking? It seems to defy the rains and the frost, but by and by it also will fall, and crumble to sand. Then there will be nothing left to tell of the mountain but a small mound of sand in the desert.

The forces of the weather never rest. They are tearing down all the mountains around us. Although the carpet of soil in which the trees and grasses grow protects the rocks in many places, yet they are crumbling and decaying in spite of it.

After a time the mountains will all disappear, if something does not lift them up again.

We love the wild rocks, and do not like to think of their being torn down; but we must be content, because their materials are necessary to make the soil.

The Work of the Wind

There are many different forces at work around us. The world is never free from them, although they go about their business so quietly we cease to notice them.

The frost, the raindrops, the river, and the ocean waves are all doing something toward leveling the surface of the earth.

The wind also has a share in the changes which are going on. It is different from the other forces, in that it builds up hills as well as causes them to be worn away. When the trees are bending before the storm, and the great breakers are coming in from the ocean, we see what power the air has as it rushes along.

We realize still better what the wind can do if we try to face it. The grains of sand, and even small pebbles scattered over the ground, are picked up by the wind and thrown in our faces with such force as to make the flesh tingle with pain.

The wind does work then. It uses the sand to grind down the bare mountains in the deserts. When it is

through with the sand for a while, it piles it up into great hills, called dunes.

The most of us have seen the dust storms, when a "norther" is blowing. The sky is yellow, and the sun almost hidden by the flying dust and sand. It gets into the tightest houses, and settles on everything.

In the deserts the sand storms are furious things, for there is nothing to break the sweep of the wind. In the deserts of Arabia and Northern Africa, people are sometimes smothered and buried in the sand storms.

After feeling the powerful blows of the little grains upon one's face, it is not hard to understand how mountains can be worn away by them.

In the deserts the rocks have but little, if any, covering, and the winds blow much of the time. With the wind behind them, the little grains are forever chasing each other over the surface. If any rocks get in the way, they have to suffer. Each grain is a chisel in the grasp of the wind, and every time one strikes, it takes a very small bit of the rock away with it. The rocks are thus sculptured into all sorts of pinnacles and grooves.

The sand plays strange freaks sometimes. Along the railroad, in the Colorado Desert, it cuts into the telegraph poles until they are worn through.

The beautifully polished pebbles which are scattered over the desert owe their shining surfaces to the blows of thousands of grains of sand, which are always moving along the ground when the wind blows.

In some portions of the Colorado Desert the wind has piled the sand into great dunes. They do not stay in one place, as hills usually do, but move across the country in the direction in which the wind generally blows. They march in ranks, like an army, destroying everything in their path.

The dunes are formed in the same manner as snowdrifts, and are shaped exactly like them. The sand drifts upon the railroad tracks as the snow does in the winter in the mountains, so that trains are stopped until it can be shoveled off.

The work of the wind in forming dunes is most frequently to be seen along the ocean. For miles and miles the ocean waves break upon a cushion of sand. The rivers have brought some of the sand from the far mountains. Some of it the waves themselves have made, as they ceaselessly hammer the pebbles upon each other.

Each breaker lifts the grains of sand, whirls them around, and throws them up the sloping beach. Some

are left high and dry, above the reach of the succeeding waves. Then, as soon as they are dry, the wind takes them in charge. It rolls them over and over, or carries them bodily through the air, and finally piles them up in those great drifts, which we have called dunes.

Each dune is long and narrow, and looks exactly like a snowdrift, even to the little ripples upon its surface. The manner in which the dunes travel is as follows: the wind picks up the grains of sand on that side of the dune from which it blows, and carries them over the top. As soon as they reach a point which is protected from the wind, they are dropped. Thus they succeed each other, as the dune slowly moves inland from the beach.

Nothing can stop the march of the dunes. Bushes, trees, and green meadows are buried under the barren sand. The only way in which dunes can be held is to get bushes or grass to grow upon their surfaces. Then the wind can no longer get hold of the sand.

On some coasts, the sand-dunes have overwhelmed whole farms, and even villages. If a village stands in the way of the creeping dunes, the people have to leave. The houses are buried, and all traces of the village disappear for years. But, as the

dunes continually move, the houses may be uncovered in time.

What a dreary sight the deserted village presents, with the broken houses, and dead trees still standing in front of them.

A Curious California River

Some of our California rivers have strange ways. They do not act as rivers ordinarily do. They seem to flow bottom-side up. Ordinary rivers run upon the top of the ground and become larger toward their mouths.

These curious rivers are found in portions of California where the rainfall is light, and they have to run a long distance to reach the sea. The Salinas River is one of them. As we study the map of California, this river appears to be one of the longest and most important streams in the Coast Ranges. If you should start out in the summer time to look for this river you would be disappointed. You can find the Salinas Valley easily enough, but where is the river?

There, where it ought to be, is a winding channel of sand, reaching as far as you can see. High clay banks shut in the bed of sand, which is half a mile wide. It must be the river bottom, although there is apparently no water in it. Every few miles it is spanned by long iron bridges, so that it must be that water flows here sometimes.

What then, has become of the river? Its bed is so dry that the afternoon sea breezes which sweep up the valley and across its surface, blow the sand into great drifts.

The sand in the bed of this apparently dry river is very deep. If you should dig down a few feet it would become moist, and a little farther, you would meet water. Now you have found the river. How strange! The sand, which is usually at the bottom, is on the top. The river is actually flowing through the sand, instead of on the surface. Why does it do this? The reason is very simple.

During the long dry summers the hot sun dries up so much of the water that there is not enough to rise above the sand, which is piled deep in the bed of the river.

The sand is like a sponge, because it absorbs a large amount of water. As the little grains are not packed tightly together, there are little empty spaces about each one. Through these spaces the river slowly passes down its sloping bed to the sea.

In the winter the storms are frequently severe, and floods of water are brought by all the rivulets to the main river. Then the flood sweeps down the channel,

washing down its banks until it forms a broad sandy bed.

Far away in the gulches are hidden the little springs which feed the river during the summer. The grasses and ferns shade them, while overhead bend the pines and oaks, and the hot sun cannot get at them.

Farther down the slopes, the springs unite in the rivulets which run more slowly, and are in many places open to the sun.

These little streams at last unite in the main river which, for a time, runs over a rocky bed between the hills.

Soon the banks become more open; the hills leave the river, and a broad valley takes their place. The river seems to hesitate about going farther, for there are no longer tall trees and overhanging banks to protect it from the rays of the greedy summer sun. With what intensity they beat down through the long days.

The river seems doomed, for it would all be gone long before reaching the sea if it had to flow over the hard rock floor which it had among the hills.

But the sand comes to the rescue. The little grains of sand, which the river has been trying for so many years to wash out of its bed and carry to the sea, now

do the river a good turn. The sand was in the river's way, and blocked its channel, when it swept along so full and strong in the winter. Now the river is glad to accept its protection.

The sand has buried the rock floor all the rest of the way to the ocean. Gladly does the river creep in between the little grains, and hide itself from the sun. It looks a little selfish however, for now the thirsty cattle follow its bed for miles, hunting in vain for some water to drink. They are fortunate if they at last find a little spot where the sand is so shallow that the river has to come to the top. It peeps out for a few rods, and then disappears again in the sand.

How wise Nature seems in thus preserving the river, which would otherwise be entirely dried up by the summer heat. It furnishes water to the people who live along its banks, who would otherwise have trouble in getting it. Now all they have to do is to dig a hole in the sand of the river bed, and there they find plenty of pure, cool water.

Although the river flows upon the top of the sand for only a little time each year, yet the bridges are quite necessary. When the sand is full of water, it forms what is called quicksand. It is then very dangerous. A horse

team will sink into it almost as quickly as into water, and it is very hard to get it out.

Where the sand is very deep, as in the deserts, it drinks up all the water that falls and never gives it back. In our rivers the bedrock keeps the water near the surface.

As the days become cooler in the fall, the air does not take up so much of the water, and a little of it again comes to the top, and runs over the sand. It increases until the first heavy rains come, when the broad winding strip of sand becomes a muddy torrent.

Streams in South America which head in the high mountains, and flow across the deserts, have the same habit. When the snows begin to melt on the distant mountains, the people go out to watch for the coming of the river. When it does come running down over the dry sand they are happy, for without the water there would be no crops the coming year.

The Story of San Francisco Bay

Nature has been a long time making California. She has put gold in one place, and silver in another. She has lifted up mountains, and torn them down again.

She has buried the Coast Ranges under the ocean, and then raised them up again as though she enjoyed the sport.

She has turned things upside down so many times that we are not quite sure she will not do it again. How strange it would be if we should wake up some morning and find San Francisco Bay dry land. Stranger things than that have happened here.

Can you picture to yourselves how San Francisco Bay would look if there were no water in it; if the fertile valleys which surround it extended all over it?

There would be room for many farms, and quantities of vegetables could be raised. However, they might not find sale, for if there were no bay here, there would be no city of San Francisco. There would

be no Golden Gate, with the ships sailing in and out past the lighthouses and the foghorns.

This is the way it really was many years ago. The land was much higher, and the Sacramento River flowed where the bay now is. Did the river empty into the ocean where the Golden Gate is? We will answer the question by asking if it could have flowed anywhere else, if some giant had built a great dam across the mouth of the bay?

There is, indeed, another way. It is through the Santa Clara Valley, past the city of San Jose. This broad valley is only slightly raised above the level of the ocean, and extends south to the Pajaro River, which flows into the bay of Monterey.

The Santa Clara Valley is so nearly level that, as you ride through it on the cars, it is hard to tell just where the highest point is. On the north, the streams flow into San Francisco Bay. On the south, they unite with the Pajaro River and so reach Monterey Bay.

You can see now that if the mouth of San Francisco Bay were dammed up, the Sacramento could easily flow south into Monterey Bay. What a strange sight it would be to see this large river flowing past Oakland and Alameda, and through the Santa Clara Valley, where the city of San Jose now stands.

You know from the geography the shape of Monterey Bay, and where the Pajaro and Salinas rivers flow into it. It has been discovered by soundings that there is a great valley extending east and west through the bay, but entirely buried by the ocean.

It is believed that when the land was higher, and Monterey Bay was dry land, that a large river flowed through this valley. You can easily guess what river it was. It was that which we call the Sacramento.

Then a time came when the coast sank, and all the lowlands along the shore were flooded. The sea, of course, broke through the Coast Range of mountains at the lowest point, which is the Golden Gate. After this happened, the Sacramento River did not have to flow away round by San Jose and Monterey to get into the ocean, but could go directly through the gap made in the hills between San Francisco and Sausalito.

While the bay region was dry land, several hills rose in the fertile valley. When the ocean broke in and flooded the land, the hills which were not entirely covered up, formed islands. One of these we call Goat Island, another Angel Island, and a third, Alcatraz Island. Those hills which were just covered by the water, formed reefs. The reefs did no harm to the

canoes of the Indians, but when the great ships came some ran onto the rocks and were injured.

To make the Golden Gate more safe for ships to pass through, these rocks will have to be blown out.

The Sacramento River, and the smaller streams which flow into it, are continually at work trying to fill up the bay. They do this by the aid of the mud and sand, which the rains wash into their channels.

Many small arms of the bay are already so nearly filled that the bottom is exposed at low tide. The marshes back of the mud flats are high enough for a kind of grass to grow upon them.

The long wharves, which have been built out into the bay, break the currents of water which are carrying mud out into the ocean, and more of it settles to the bottom. In order to dig out this mud, which is settling all the time, machines called dredgers have been built. They scoop up the mud from the bottom, and so keep the water deep enough for the great ships.

Man is helping Nature fill up San Francisco Bay, and many years from now it will not be as large or as deep.

This is not all of the history of San Francisco Bay. Many other things have happened here. It was once so deeply buried beneath the ocean that only the tops of

the Berkeley Hills, Mount Tamalpais, and the Santa Cruz Mountains, rose above the water.

The ocean extended up through the straits of Carquinez, past Vallejo and Benicia. The San Joaquin and Sacramento Valleys formed large, deep bays into which ships could have sailed if there had been any people to sail them.

Now that we know something of the story of San Francisco Bay, we may wonder why the great city which bears the same name was built here. Did you ever think that we cannot build a city anywhere that we want to? We have to take advantage of the way in which Nature has arranged the mountains, valleys, and bays.

If California had been discovered and settled at a time when San Francisco Bay was dry land, you may be sure that no great city would have been built here. The city would have grown up where there was a harbor for ships. It might have grown up on Monterey Bay.

Where a number of inland streams and valleys unite in a deep and protected bay, that is the place for a great city to be built. So you see why the largest city of the Pacific Coast has grown up on San Francisco Bay.

The bay has a narrow entrance, and is well protected from the storms. It is broad and deep, and its long arms reach out into the many valleys which converge toward it. Nature has destined it to be the center of trade of a great region.

How much more interest the bay will have for us, now that we know something of its history.

An Ancient Oyster Bed

Near the summit of the Coast Ranges, far from the ocean, I found an oyster shell. There it lay in the sandy soil, looking so old and worn, I could imagine that hundreds of years had passed since it saw the ocean.

Did someone carry it there, or did a bird bring it from the seashore? It hardly seemed possible, for there are none like it upon the beach. Besides, there are no birds living now which could carry a shell of such size.

The one which lay before me seemed a giant in comparison with those in the market, and is properly named *Ostrea titan.* The oyster which once lived in this shell would have made a whole meal. A half dozen of the common oysters would hardly make more than so many mouthfuls.

If you had ordered some oysters in a restaurant, I think you would be astonished to see a waiter come in, carrying a single big oyster upon a platter. Just think of an oyster with a shell a foot and a half long.

Such a big fellow would have to be carved like a piece of roast beef.

Many such oysters must have lived once upon a time, for on looking about near where I had found the first one, I discovered a whole bed of them. They were sticking out of a layer of hard sand, which extended along the top of a low hill.

Where the rain had washed the dirt away, other and smaller shells appeared. There were scallops and periwinkles, and clams which looked very much like those now living in the ocean.

The layer of sand and fossil shells looked just like an old sea beach; but how did it come here, high in the mountains? Oysters do not live in rivers or lakes. They are found only in the salt water.

The Coast Ranges must have been under the sea a long time ago. As the earth was raised the water ran off, and the place where the shore was at that time is now many miles from the ocean.

Suppose you try to form a picture in your mind of that old beach where the oysters lived in the clean, white sand.

There were not many things to disturb the peace and quiet of the great oysters, whose shells were so thick that no animal could bite them open. Besides,

there were then no people living upon the earth. So that they were not troubled by picnic parties, or the men who hunt for oysters at low tide, in order to carry them off to market.

Many generations of the oysters lived there happily in the shallow water, among the islands where the Coast Ranges were to stand in the distant future.

The oysters had plenty to eat, and their shells grew so large and heavy that they could hardly open them. When they died, the waves buried them in the clean sand. The young oysters took their places, and in this way the bed of sand and shells became many feet thick.

The ocean tides rose and fell twice a day in those times, just as they do now. The oysters did not mind it. In fact, they rather enjoyed the little time during which the tide ran away and left them.

But one day something unlooked for happened. The tide went out farther than usual, and left the bed of oysters bare for a long time. After a few hours had passed, and the salt water had dried off from them, they became very thirsty. O, for a drink of the cool salt water. Why did the hot sun shine upon them so long? Why did not the tide come back? Their shells gaped

wider and wider; but alas, it was all in vain. In a little time they all died.

When it was too late the tide swept in again; not quietly as it had done so many times before, but with a rush of muddy, dashing waves. The water came in with such force that it did not stop until it had swept far over the land, uprooting the trees and washing away the soil.

The currents and waves washed mud and sand and rubbish from the land over the bed of oysters, and it was buried very deep.

The water kept rising, until it covered all of the islands, and there was no land in sight.

After ever so long a time had passed, the water began to go down, and the land where the islands had been, rose again above the water. The land continued to rise, and after a time the water all ran off. The islands became connected by dry land, and so were no longer islands.

This land which had been raised above the water was only bare rocks and mud and sand. It looked just as San Francisco Bay would look if the water were all drained off.

The winds and the birds brought seeds, and all kinds of plants sprang up where the sea used to be.

You may wonder what became of the bed of oysters. It was so completely buried that one would never suspect there had ever been one. Something was raising the land higher all of the time, and by and by it began to look a little like our Coast Ranges. The rains which fell washed out little ravines, which finally grew to be canyons. The rains also worked upon the hills, and washed away into the canyons so much of the rocks and soil that the bed of oyster shells at last stuck out of the ground in plain sight.

This is the history of these rough and worn oyster shells. What fun it is to dig them out of the sand where they have been buried all these years.

A Rainstorm in the Desert

You have all heard of the deserts of Eastern California. They are formed of broad, sandy valleys, with mountains of almost bare rock, lying between them.

The high mountains, between these deserts and the coast, cut off the cool breezes, and during the long summer days the air becomes so hot that when it blows upon one's face it seems like the breath from an oven.

It is not the heat, however, that makes this region a desert. It is so barren because there is very little rain. One would think that the lizards and the rattlesnakes would have such a country all to themselves. The desire for gold, however, draws men across the blistering sands to the far away mountains, and some of them are never heard of again.

Two prospectors once made their camp in a range of mountains in the Mojave Desert. They had been fortunate, and found a cool spring which no one but Indians had seen before. They built a cabin in the

canyon near it, for they intended to stay there and hunt for gold.

The canyon extended away back into the mountains, and some time, water must have flowed in it, but now it was perfectly dry. As rains so seldom fell upon the mountains the prospectors felt quite safe.

During the middle of the hot days little columns of sand were caught up by the winds, and moved slowly across the sandy desert at the mouth of the canyon. Fleecy clouds also gathered about the tops of the mountains, but disappeared as night came on.

Months passed quietly in the canyon, but one day the clouds gathered heavier than usual. They grew quite black, and a few rumblings of thunder were heard.

The miners looked at the clouds so far away, and longed for their cool shadows, but after a time, as the sun continued to shine upon them, they forgot all about the clouds.

In the meantime something was happening in the dark clouds. They settled down upon the tops of the mountains, and a few drops began to fall. As these drops cooled the air, the clouds sent them down thicker and thicker. Finally a perfect flood was pouring from them upon the barren mountain slopes.

There was little soil to hold the falling drops, and they quickly gathered into rills. The rills ran over the ledges of rock and into the little ravines. They poured from all sides, for the clouds seemed to have broken and turned all of their moisture into raindrops at once.

The floods of water tumbled and roared into the gulches. They became larger each moment, as every side canyon added its share. The torrents were angry and muddy looking. They had picked up what little soil there was and all the loose fragments of rock, besides, there were trunks and branches of the few stunted trees which managed to live upon the mountains.

It was years since such a rain had fallen here, and a large amount of rubbish had accumulated. Many fragments had fallen from the cliffs into the canyons, and one might think that the water would have trouble getting over or around them.

On the contrary, it did not seem to be delayed at all. It picked up and carried along all but the very largest ones, apparently as easily as it did the bird's nest which had been torn from a bush.

In a short time all the torrents reached the main canyon. There they united and went thundering down toward the little cabin of the miners. The men

had heard the sound of the coming waters, but did not know what it meant until a wall of water appeared sweeping around a bend in the canyon above them.

In an instant the men were out of the bed of the canyon, and climbing its sides. They were just in time to reach a point of safety as the foaming flood went thundering past.

At its front, huge boulders, almost as large as their cabin went rolling over and over. The water was thick with mud and sand and boulders.

The clouds had cleared away, and the rain stopped by the time the flood had reached the main canyon, and so the water went down almost as quickly as it had risen. After a few hours, there remained only a little stream of muddy water, hunting its way among the boulders which dotted the bed of the canyon.

The miner's cabin had escaped the torrent, but just in front of it was a dirty channel, many feet wide. The willows by the spring had been swept away, and all was dirty and desolate.

What had become of the great mass of water and rubbish? It swept down to the mouth of the canyon, and there spreading out upon the sandy floor of the open desert, soon spent its force. Some of the boulders were carried three miles out into the desert.

The water did not stop there, but with the mud and sand, flowed fully ten miles before it sank into the dry sand.

This is the picture of what we generally call a cloudburst. When rains fall upon the mountains of the desert they often come in torrents of this kind. As there is so little soil, the water gathers and runs off very quickly.

In places where it rains more frequently, soil collects, and the grasses and trees which spring up keep it from washing away.

We can easily see that the desert mountains will finally be torn down by such cloudbursts. The mountain tops are cool, and at times change what little moisture there is in the air into raindrops. When the mountains have been worn away the springs will dry up, and the desert become more barren still.

The Story of Petroleum

There was a time very long ago when there were no Coast Ranges in California. The waves of the Pacific Ocean rippled in the sunlight, where the cities of San Francisco, Santa Barbara, and Los Angeles now stand.

In this old ocean the hungry porpoise chased the little fishes, and many strange monsters swam to and fro. Sometimes the sailor thinks that he catches sight of some of these long, snake-like monsters playing near his ship. No one believes him, yet he may be right, for we know by the bones which have been found that there were once such animals in the sea.

You have read of the whales, those great animals which are hunted for their oil; but did you ever think that the petroleum in our evening lamps also comes from the sea, from the bodies of very small animals which lived long ago? It is a strange story, and you may be interested in hearing it.

The world did not look then as it does now, though the ocean was filled with plants and animals

swimming or floating in it just as at the present time. They did not know nor care that the bottom of the sea in which they lived was to be called California. All they wanted was sunlight, plenty to eat, and a great ocean in which to live.

In order to find out more about these little animals, and what became of them when they died, let us take an imaginary trip to the bottom of that old sea. We shall have to be dressed as divers are, with helmets on our heads, and heavy weights attached to our feet.

The bright sunlight follows us down many feet, as we sink through the clear water, but it gradually becomes dim, and, long before we reach the bottom, it is as dark as it is at midnight, when the stars are hidden by heavy clouds.

In the upper portion of this sea the water is full of animals and plants of every size, shape, and color. The fishes and their relations stare at us for an instant with their great round eyes, and then are gone. But the little animals, which are not much more than mouth and stomach, are not at all disturbed by our visit.

We see that each layer of water has its peculiar animals, just as each kind of bird has its own place in which to live, and build its nest. The bodies of the most of these animals are so small that, as they float

before our eyes, they seem like so many particles of dust. A cupful of water would contain thousands of them.

As the light grows dimmer, the animals are not so numerous, for they cannot make their homes where the light of the sun does not reach. There are some, however, with little lanterns like the fireflies, which makes it possible for them to live in the bottom of the sea. By the aid of this dim phosphorescent light, we can just make out what is going on around us.

At last, when about half a mile below the surface, we reach the floor of the sea, which stretches away in every direction like a great plain. The bottom is soft, and we sink deep into a slimy ooze which feels much like the mud in a stagnant pond.

This is a dreary place, for the waters are perfectly quiet, and the few animals move about very slowly. Our attention is attracted by little particles that are slowly sinking through the water. Most of them are so small that they look like tiny snowflakes. Has there been a storm above, and are these the little flakes of snow which disappear as they strike the water?

We hold out our hands and catch a number, and examine them closely. To our surprise we find that they are the bodies of the little animals which live in

the water far above. As they grow old and die, their bodies sink down through the still water, until at last they come to rest upon the floor of the ocean.

Dipping up some of the ooze in which we stand, we see that it is formed of the same material. Living in this ooze, and feeding upon it, are worm-like animals.

Perhaps you have already thought what we ought to call this place. It is the cemetery of the sea. Here the bodies of all the animals, which are not dissolved in the water, come to rest. Among their little skeletons and shells, which are not half as big as a pinhead, there are bones of the larger animals, such as the fish and seal.

In this soft, slimy material, which is so slowly collecting, there are particles of dust from the land. A north wind whirled them into the air, and out over the ocean, and then dropped them.

Year after year the bed of ooze increases, until thousands of feet of material are deposited upon the bed of the ocean. That which is undermost, as you will readily see, must be pressed upon very heavily by that above, so that the whole mass becomes constantly harder and more compact.

Thus things went on for an unknown time in the deep ocean, which then occupied the place where the

Coast Ranges now stand. Finally, these quiet times came to an end. Something strange was about to happen. There were queer sounds, and rockings of the earth, and all the animals which could, fled away.

The bottom of the sea was raised so that the bed of ooze, which during all these years had become quite hard, was raised nearly to the surface of the water. Then, from the nearest land, the ocean currents brought sand and mud, and spread them layer after layer over the surface of this old cemetery, of which we have been talking.

Long, long years passed by, and thousands of feet of sand and clay and gravels were washed on top of what was once the bed of ooze. The clays and gravels were hardened and became stone. Then another great earthquake took place, and the sea bottom was lifted high above the waters into a great range of mountains.

During the raising of the mountains, the bed of ooze was squeezed very hard, so hard that it became quite warm, and a strong smelling gas was formed from the materials of the little animal bodies. At last this gas, which is poisonous and invisible like that formed from burning coal, found some cracks in the rock through which warm water was flowing, and came to the surface. We can see it bubbling up in

many of the little springs which we find in the Coast Ranges. Many birds and small animals, coming to drink at the springs, breathe the poisonous gas, and drop dead before they can get away.

There was also formed in the bed of ooze a brownish or greenish liquid. This is petroleum just as Nature gives it to us. Before it is fit to use in our lamps, it must be refined.

The crude petroleum, which is made far below the surface, soaks into the pores and cracks of the surrounding rocks, and some of it at last reaches the surface, flowing out with strong smelling springs of sulphur water. The petroleum in some of these springs is thin, and dries up like so much water, but in other springs it is very thick like tar, and gathers in large springs. The bear and deer, coming down to drink of the queer tasting water, sometimes fall into the tar, and as it is so sticky, they seldom get out.

Prospectors found hills of sandstone filled with the thick black oil, or tar, and called the sticky mass bituminous rock. The tar which they found nearly pure, and dried out so that it was hard, they called asphaltum. They discovered that it was very useful for making street pavements, and opened large quarries

in different parts of the Coast Ranges, and shipped it to the cities.

Other prospectors found little streams of the thin oil flowing from the cracks in the rock, and putting up derricks, like those for windmills, they bored holes so that the oil would come out faster. The holes were made hundreds of feet deep, and sometimes they obtained one hundred barrels of oil in a day from a single well.

Over some of the springs of gas, tanks have been built for collecting it, and people have used it for lighting houses.

The oil we have used for many purposes. From one part is made naphtha and gasoline. Another part is used for burning in our lamps. From the thick portion paraffine is made, also the analine dyes, and oils for lubricating machinery.

As we look at the clear oil in our lamps, it is hard to imagine that it has had such a strange history. The little animals which lived long ago in the sea never dreamed, if they dreamed of anything, that they would be so useful.

The History of a Package of Borax

In the center of one of the desert valleys of Eastern California there is a group of men at work. The heat is almost unbearable, and they move slowly about.

What are they doing in this desolate region? They are gathering the crude borax, which forms a layer of almost dazzling whiteness over the ground as far as one can see.

We would hardly know how to get along without borax. It is useful for so many purposes. Our borax formerly came from Europe, and cost much more. Now it has been found in great abundance in the deserts of California and Nevada.

Borax goes through many processes before it is fit to use. It finally reaches us in the form of a white powder, put up in neat little packages.

The history of borax deposits, and how the crude material is purified and sent to market, is an interesting one.

There was a time, long ago, when more rain fell in these desert regions. The valleys had no outlets, being

shut in by the mountains on all sides. As a result, the water running down the mountain canyons, flowed out into the valleys and formed lakes.

The streams carried down sand and mud, while the waves spread this material over the beds of the lakes, forming a soft, but even floor.

The streams also brought other things, such as soda and borax. These they had dissolved out of the rocks over which they flowed. The mud made the waters dirty looking, but the salt and borax were invisible, just as the salt in the ocean cannot be seen.

A time came when the lakes began to dry up. The streams were smaller, and the heat of the sun, as it poured down upon the water, evaporated more than the streams carried in.

Every year the lakes became smaller and shallower. The streams had left so much borax and soda in them during the many years since they were formed, that the water at last became unfit to drink. If you will dissolve some borax and soda in a glass you can tell how the waters of the lakes tasted.

Now set the glass out of doors, and let it stand until the water has entirely dried out, or evaporated. The borax and soda will appear again as a white crust upon the bottom of the glass.

Something like this happened in these old lake-beds. When the water had all evaporated, there were miles and miles of mud flats. The borax and soda which had been in the water were left mixed with the mud.

As the mud dried upon the surface, the water which soaked up from below kept bringing the borax and soda, little by little, to the surface. After a time a white layer covered the mud flats.

It looked as if there had been a snowstorm, only the white deposit did not disappear in the hot sun.

What a change had come over the old lake bottom. As far as one could see, there was this white coating over the mud flat. It glistened so brightly in the sun as to almost blind one's eyes.

The borax deposits were not disturbed for many centuries; but at last a prospector in crossing the desert discovered them. Buildings were put up, and men went to work scraping the borax into piles.

It was then placed in large tubs of hot water until entirely dissolved. The dirt which was mixed with it settled to the bottom, and the water with the borax was drawn off into pans, where it was allowed to cool.

In the dry air of the desert the water soon evaporated, leaving the borax in the bottom of the pans.

To get the borax to the railroad it was necessary to haul it nearly one hundred miles. Several wagons were built which would hold half as much as a freight car. They had wheels seven feet in diameter, the tires being nearly a foot wide, so that they would not sink in the sand.

Three wagons were hitched together. Two were loaded with borax, and the other carried water for the mules to drink. What a long string of mules was needed to haul these wagons. There were twenty of them. When the mules were all hitched up, and the driver had climbed into his saddle, the sight was an interesting one.

It took them three days to cross the desert, over a road which was almost as smooth and level as a railroad.

There they went, slowly creeping over the desert. All that we could see of them at first was a great cloud of dust. As they came near, the heads of the mules appeared through the dust, and then the outlines of the wagon boxes.

The mules looked dusty and tired, and so did the driver. With the creak of the wagons, and the steady sounds of the hoofs, they passed.

As the sun went down they stopped, and unhitching the mules, made camp for the night. The precious water which the tired animals had been hauling all day was given them to drink, and they lay down to rest.

In this way the borax was taken to Mojave and placed upon the cars. When it reached Oakland it was purified farther, then ground and put in little packages for sale.

Borax not only helps in cleaning, but is useful in many other ways.

Where Our Salt Comes From

Among the most wonderful mines in all the world, are the salt mines of Austria. There, chambers larger than houses have been dug out of the solid salt. Salt obtained in this way is called rock salt.

Salt is found in California, but here we do not have to dig underground for it.

You all know how salty the sea water is. Sailors have to carry all of their drinking water with them. If it should be used up, they would be as badly off, with the sea water all around them, as those who are lost upon the desert.

The most of our salt comes from the sea. In some places Nature has collected the salt for us upon old sea bottoms, which are now dry. In other places, we make it directly from the salt sea water. There are many such salt works upon the eastern side of San Francisco Bay, near Alvarado. There the sea water is kept in ponds, and simply allowed to evaporate. You can try it yourself by placing some salt water in a basin and allowing it to stand until the water has dried up. There

will then be a coating of little salt crystals over the bottom of the basin.

A marsh over which the sea water flows at high tide is selected. It is then cut into square fields by shoveling up embankments. Gates lead from one field to another, and connect with the water outside. This permits them to be filled when the tide is high.

When a pond is full of salt water the gate is closed, so that it cannot run out when the tide goes down. It is then allowed to stand for weeks in the sun, and with the winds blowing over it. When the water has nearly evaporated, the gate is again raised at high tide, so that the pond can fill up again.

This process is repeated until the salt water or brine in the pond is very strong. The water, when it passes off into the air in the form of little invisible particles, cannot carry the salt away with it. Consequently, every time the water is let in, the pond is richer in salt.

Finally, the brine is as strong as it can be made, and the salt begins to separate from the water, and fall to the bottom. You can understand more clearly how this is done by dissolving all the salt you can in a glass of water, and then allowing it to stand until some of

the water has evaporated. Little crystals of salt will soon begin to appear around the sides of the glass.

When a thick layer of salt has gathered upon the bottom of the pond, the water is drawn off. Then the men go to work with shovels, and throw it out on the banks in piles.

Nature has made the great beds of salt in different parts of the world in very much the same way. We only imitate Nature when we make it by evaporating sea water.

Some of the salt beds have been buried deeply by sands and clays which have been washed over them. To get at the salt in these beds, we sometimes dig shafts, as is done in mining for coal. Men go down in these shafts, and quarry the salt. In some places, the salt water is pumped up from wells, and then allowed to evaporate as in making salt from the sea water.

When the old sea bottoms, upon which the salt lies, have not been covered up, the salt is very easy to get. This is the way the salt is found at Salton, in the Colorado Desert.

That portion of the desert which is below the level of the sea was once the head of the Gulf of Lower California, and was covered with salt water.

As the Colorado River built its delta out into the gulf, the water covering the desert became nearly cut off from the rest of the gulf.

Under the influence of the hot sun and dry air, the water was continually evaporating. To keep up the supply, the sea water flowed in from the gulf to the south. This process is, as you see, quite like that carried out artificially.

Thus the great pond or lake, for it was many miles across, at last came to form a very strong brine. After a time the delta of the Colorado River cut the lake off entirely from the Gulf of Lower California. Then the water began to dry up, and the salt to settle to the bottom, and mix with the mud.

When the clear water was all gone, the mud and salt formed a thick layer all over the bottom of the old lake. The air was so dry that the mud hardened on the surface, but it still remained soft underneath this crust.

How does the bed of pure salt form upon the surface of the former lake bottom, which is now white and glistening as far as you can see? It is in this way. You have all noticed the little salt crystals which appear upon the surface of a roll of butter when it is

placed in the dry, warm air. The salt was in the butter before, but it was dissolved, and you could not see it.

The dry air brought it to the surface of the butter. There the water in which the salt was dissolved evaporated, and left the little crystals of salt.

The same thing takes place upon the bed of the old salt lake at Salton. When a layer several inches thick is formed, it is scraped up. The Indians do the most of the work in this hot region. With plows and scrapers, many hundred tons of salt are gathered every day. When the salt has been scraped into rows, it is shoveled upon the cars and taken to the mill. There it is ground and put up in form for sale.

We think it would be a very hard thing to go without salt. Yet, during some of the wars, people have been shut away from the salt beds, and have had to learn to eat their food without it.

You know how the animals like salt. The hunter takes advantage of this fact, and waits for the deer when they come to drink at the salt licks.

Mono Lake

You have all read of Great Salt Lake, in Utah. Its waters are so salty that if you should fall into it, it would be impossible to sink. It is a good place in which to learn to swim, although the salt is very disagreeable, if you get your head under the water.

Do you know that there is a lake in California which is fully as interesting as Great Salt Lake? It is known as Mono Lake, and lies on the edge of the desert country east of the Sierra Nevada Mountains.

Common salt is the most important substance in the water of Great Salt Lake, but our California lake contains as much soda as it does salt. You all know what soda is. It is put into biscuits to make them rise, and if there is too much of it the biscuits are yellow.

There is so much soda in Mono Lake that if the water were all evaporated, and people could get it, there would be enough to last all the bakers in the world for many years, and give everybody the dyspepsia.

There are so many queer things to be seen around Mono Lake that I will tell you about some of them.

The lake lies in an enclosed basin, without any outlet. The barren desert lies all around it, except upon the west. On that side the snowy Sierra Nevada Mountains rise very abruptly. They reach a height of a mile above the lake, while the lake itself is more than a mile above the level of the ocean.

Several dashing streams of pure, cold water from the melting snows upon the mountains flow into the lake. Nevertheless, its basin never becomes full so that streams can run out.

Where do you suppose all the water goes to? It is taken up as invisible vapor by the thirsty air, and is carried out over the hot deserts. The water of the lake is clear, and it looks as if it would be good to drink, but one little taste is enough. It is so bitter and salty.

The brooks that flow into the lake are full of trout, but if any are accidentally carried into the lake, they turn over on their backs and die immediately.

It is delightful water to go swimming in, for it feels so warm and soft. But you must not forget and stay in too long, for it would eat into your skin, and leave it smarting and sore.

What a washtub this great lake would make. Every afternoon when the wind blows, the waves, as they break upon the shore, raise a bank of foam looking just

like soapsuds. The water is indeed very good for washing clothes, but the clothes must not be left in too long, for the water takes the color out and leaves them rotten.

Many years ago, when icy glaciers covered the Sierra Nevada Mountains, the water was higher in the lake than it is now. Pebbly beaches where the waves used to break, extend along the sides of the hills many feet above the present beach. The water then was not so full of soda and salt, and fish may have lived in it.

After the glaciers had melted, less water flowed into the lake, and it began to dry up. As the water became lower in the lake it grew more alkaline and salty. For you know that if a spoonful of salt or soda is dissolved in a pitcher of water it will not taste as strong as it would if the same amount be placed in a small dish, such as a glass.

If the water of the lake should entirely dry up, there would be left a white layer of salt and soda all over the bottom. The substances dissolved in the water do not go away with the watery vapor which the air takes up.

The water of the lake is now so strong that one would think nothing could live in it. But there is an insect which lays its eggs in this water. The larvae, when they hatch, are thrown up by the waves along

the shore, and give a very disagreeable odor. The Indians, however, think them a delicacy, and gather them in large quantities. After they are dried, they are packed away for winter use.

The region around Mono Lake is dotted with volcanoes. Although none are active now, it was different once. I am afraid we should have had as hard a time as the people of Herculaneum and Pompeii if we had lived near Mono Lake a few hundred years ago.

Streams of hot lava flowed over the country, and the volcanoes threw out clouds of pumice and ashes, which settled over everything. There must have been terrible earthquakes too.

We will visit the two islands in the lake, and see the effects of the volcanoes and earthquakes. We have to row several miles in the hot sun before reaching the first island.

There are many strange things upon these islands. Near the larger one springs of hot water come up through the lake, making a very nice place to bathe, if one does not get too near the springs. In the black lava nearby, are crevices through which steam is constantly issuing with a loud, puffing noise. On a

cool morning, the steam forms quite a cloud over the island.

On one of the islands is a group of craters, where explosions underneath the surface have blown the rock into fragments and left deep holes. The holes look much as they would if they had been blown out by giant powder.

In the center of the island there is a deep hole of a different kind. It certainly looks as if the bottom had fallen out.

The smaller of the islands is composed entirely of lava. It has almost no soil and only a few bushes. The island seems to have been pushed up from underneath the lake by some recent earthquake.

The rocks are shattered, and full of cracks. In the bottom of some of these there is water, and in their darker corners owls make their home.

We feel like walking lightly, for it almost seems as if the jar of our feet would send the island crumbling to the bottom of the lake.

Although the island has no springs upon it, a band of goats is kept there. They are very wild, and run like deer when we come in sight.

There are many other interesting things about Mono Lake. Many springs come up in the bottom of

the lake. They carry lime dissolved in their waters, and have built up strange looking little towers. Some of these reach above the water. They are hollow inside, and the water runs up through the hollow and out over the top just like a fountain. You may want to know where all of the salts in the lake came from. A little must have been dissolved in the spring water, but the most was brought in by the streams which flow down from the mountains. They are constantly removing a little of the rock over which they flow, and as no streams run out of the lake, everything that is brought in must stay there.

The Story of the Colorado River

Some rivers flow through broad valleys nearly their whole length. They hardly know what a cliff or waterfall is. Others tumble and foam between steep rocks, where there is not even room for a footpath.

Different rivers can tell different stories, but there is not one that can tell a more interesting story than the Colorado. For more than two hundred miles it flows in a canyon, which is more than a mile deep, and often so narrow that the sun reaches it but a little time each day.

This great river seems almost like a living thing. It never rests, but moves on just the same, year after year. It has a great work to do, and though it has been busy for thousands of years, it has made only a small beginning.

The task which has been given it is enough to discourage anything but a river. It is to carry away to the sea, grain by grain, the particles which make up the mountains and plateaus which form its basin. A river

basin, as you know, includes all the land sloping toward one stream.

After working all these years, it has done little more than cut this deep canyon. It has yet to carry away the material of the great plateau through which it runs.

The river does not have to work alone however, for it has many assistants. In the first place, there are the branch streams which flow into it. Each one of these grinds out a canyon for itself. As these tributary streams reach back toward the mountains which enclose the basin of the Colorado, each one in turn splits up into smaller ones. These in turn divide into little rills nourished by the springs and melting snows.

The raindrops, and the heat, and the frost are at work upon the mountains, breaking the solid rock into little fragments. These tumble into the rills, which bear them to the brooks, and the brooks give them to the rivers, which finally all unite in the yellow and muddy Colorado.

Sometimes the brooks bring more particles of sand and clay to the rivers than they can carry. Then their beds are filled up, and they overflow the valleys along their banks. But where they run swiftly, they

bear along all the rubbish given to them, and keep their channels clean.

If the water of the Colorado were clear, it would have nothing with which to do its work. The sand and pebbles, which its swift current bears along, are its tools. They are rolled and shoved along the bottom, and gradually wear away the solid rock. In this way the river slowly cuts deeper into the plateau.

Each tributary stream does the same thing, so that there is formed a perfect network of canyons, which makes it impossible to travel across the country.

Here, where the great walls rise so many thousands of feet, there is a good opportunity to learn something about the rocks of which they are made. They are not massive and dark, like the lava about which we have read, but are formed of layers of different colors. The layers lie perfectly flat, like the boards in a lumber pile, and extend up and down the canyon as far as one can see.

The dark layers we will call shale. They are formed of hardened clay. The reddish layers are composed of little grains of sand, colored with something like iron rust. We will call them sandstone. Rocks made of layers in this way are said to be stratified.

Before the Colorado River existed, what is now this great plateau was beneath the sea. A river, perhaps as muddy as the Colorado, flowed into this old sea. The sand and mud, which it brought down, were washed around by the waves and currents, and spread out in layers just as we see them in the walls of the canyon.

After a time this old sea bottom was slowly and gently raised, until it was more than a mile above the surface of the water. It formed a great plateau.

Rains fell upon the plateau, and the brooks in which the drops collected ran here and there, hardly knowing, at first, what direction to take, because the surface was so level. Finally, all those upon one slope united in a valley, and flowed toward the south west, at last reaching the Gulf of California.

In this way the Colorado River was born. It went to work at once carrying off the waste material from the hills, and at the same time cutting a canyon. It will continue this work for a long time to come.

What has the river done with all the little particles of sand and clay which it has taken from the mountains, and from the canyon? Let us follow it toward its mouth, and we may be able to learn.

When the Colorado leaves the canyon, it winds for long miles through desert hills and sandy plains. As it nears the Gulf of California, its banks become lower and more muddy. Now it enters upon a great plain, which gives place to a tidal marsh, and then to the open waters of the gulf.

This is where the river leaves its load of mud. A great delta has been formed, filling up nearly all of the northern end of the gulf. A long time ago, before the Colorado River had brought down so much mud, the Gulf of California reached north into California. It covered what we now call the Colorado Desert.

Gradually the mud from the river spread out over the gulf until the plains of the delta extended quite across it. The very northern end of the gulf was not filled with the mud, and being cut off by the delta to the south, a salt lake was formed.

The climate in this region is very warm and dry, and little by little, the water dried up, leaving a deposit of salt. In this way the basin of the Colorado Desert was formed. The center of the basin is now about three hundred feet below the level of the sea.

When the river is high it sometimes overflows its banks, and a part of the water turns back and empties into this basin of the desert. Then a large body of

shallow salt water is formed, called Salton Sea. The air is so hot and dry however, that it soon evaporates.

Little seashells are scattered at various places over the desert. The animals which once inhabited them crawled about in the mud, when this region formed a part of the Gulf of California. Around the edges of the desert one can also trace the ancient beach, where the waves used to break.

We see now what a great work the Colorado River has done. It is still busy carrying mud and sand, and may some time fill up nearly the whole gulf.

What We Saw in an Ocean Cliff

The picture before us represents a part of a high cliff on Point Loma, near San Diego. The shore here can be explored only at low tide, and even then it is difficult to reach.

The rocks forming the cliff are arranged in horizontal layers, and caves appear in them at different places. One of the largest of the caves is shown in the picture.

Boys always delight in exploring wild places, and Point Loma had the greatest attraction for us on this account. We discovered this cave on one of our expeditions. It was so interesting that we took a picture of it.

After exploring the cave, which extended into the rock more than one hundred feet, we sat down on the rocks. Dangling our feet in the water, which at ebb tide flowed back and forth very quietly, we studied the cliff and the cave.



We were interested in the regular layers of rock, formed one above the other, and wanted to know why the waves dug out a cave at this particular place.

Perhaps you would be interested, too, if we should tell you what we learned about them.

Each layer of rock is called a stratum, and the whole series is said to be stratified. Those layers which stand out sharply are harder than the others. They consist of grains of sand tightly packed together, and are called sandstone.

Those layers which have been worn away most are softer than the sandstone. They consist of clay which has been squeezed very hard. They are called shale.

These stratified rocks were formed in the bed of the ocean and then lifted up to the place in which we saw them.

You may be able to understand how they were formed if you should examine the mud flats when the tide is very low. A deep trench dug across the mud flats would show them to be made of layers like those in the cliff. They would be soft, but formed of the same materials, sand and clay.

The little particles which make up the flat have been brought by the waves and tides. If you turned a handful of soil into a pitcher of water the little grains of sand would go to the bottom immediately, but it would take some time for the fine particles of mud to settle.

This is the way it is in the shallow water of the flat. In the winter, when the weather is stormy and the currents strong, sand is washed onto the flat. During the long summers it is very different. The water is more quiet, and only the fine particles of mud are deposited upon the flat.

In this way, as year after year passes, you can see that a succession of layers of sand and mud would be formed in the water. The ones at the bottom would be squeezed and made hard by the weight of those above. The sand would be changed to sandstone, and the clay to shale.

Now that we have seen how the different layers in the cliff were formed, we want to know something about the cave.

The waves have dug in a long distance, and at every storm they go a little farther. At the back end of the cave is a beach of pebbles. These pebbles are the tools which the waves have been using to wear away the rock.

Study the picture carefully, and you will see a broad line upon the face of the cliff. It extends from the cave across the layers of rock, slanting upward toward the left. Along this line the rocks have been

broken and ground to pieces. This is called a fault, and was formed long ago, during a heavy earthquake.

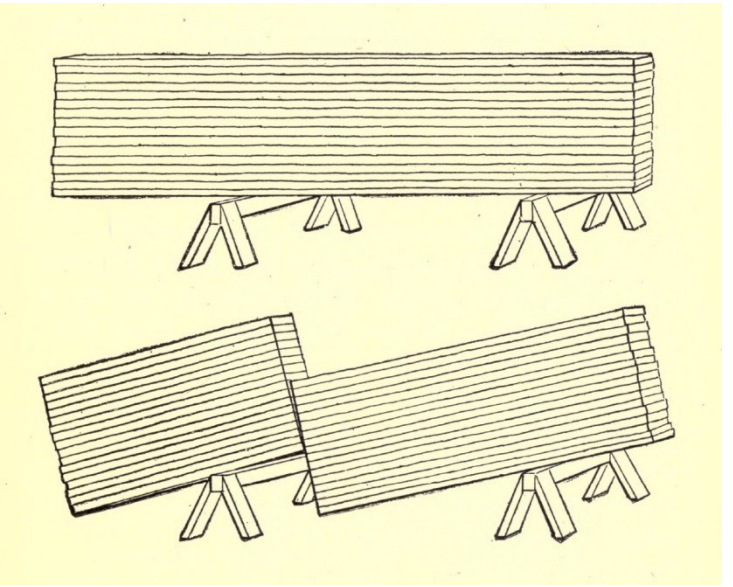
The sea bottom was being raised, when suddenly the rocks forming it broke, and those on one side of the crack slipped past those on the other. You can see from the picture that this is true, for the layers on one side do not fit those upon the other.

The waves, dashing against the cliff, found the broken place, and soon dug the clay and pieces of rock out of the crack. They kept on enlarging the hole, until the cave was formed.

Our picture teaches another very important thing. It is, that breaks of the same kind as that in the cliff have made some of the great mountain ranges of the world. Such is the origin of the Sierra Nevada, the most rugged range of mountains upon the Pacific Coast.

Perhaps you do not see how such a little crack could make a range of mountains. It is really quite simple.

Suppose you are watching a carpenter, who has stacked up a great pile of boards on two saw-horses. You can imagine that each board is a layer of rock which lies flat like those in the cliff.



Now the carpenter goes to work, and after measuring the boards the length he wishes, begins at the top of the pile, and saws it into two parts. There is nothing to hold up the ends of the pieces, and when the last board is cut they tip up, and one end of each part falls to the ground.

The line along which the carpenter has sawed the boards into two pieces you can imagine is a break in the crust of the earth. The end of one pile of boards slips down past the other, and forms a valley, while the parts which stick up form mountain ranges.

The Sierra Nevada Mountains are represented by the end of the pile of boards which sticks up. The great

desert basin of Nevada is represented by the end of the pile which fell down.

The earthquakes which we feel may mean that the rocks have slipped past each other along a crack. While the ends of the board pile have slipped past each other only a few feet, in the Sierra Nevada Mountains the slip is in some places two miles.

Our picture of the sea cliff has made clear some of the most interesting things in the formation of the earth.

How Islands are Formed

Islands are interesting things. What fun it is to discover an island, and play Robinson Crusoe. The island may be nothing more than a sand bar, or a little bare rock, but for the boys it is an island just the same. It calls up pictures of shipwrecks in some far away part of the world.

Islands are made in different ways, but if there were no water there could be no islands at all.

Suppose we try to imagine our globe without any water. Its whole surface would be made up of mountains, valleys, and plains. Now, if on this dry world it should rain torrents for years and years, the water would run into all the lowest places, and form the oceans which are spread out before us.

If more water turned into the oceans, they would rise higher, and cover up more of the land. There are mountains beneath the sea just as on the land, only they are not high enough to rise above the water.

The continents are the large bodies of land which stick up out of the water. The small ones are called

islands. You can easily see that if there were more water, many of the islands would be entirely covered and hidden from sight. If there were less water, new islands would stick their heads up.

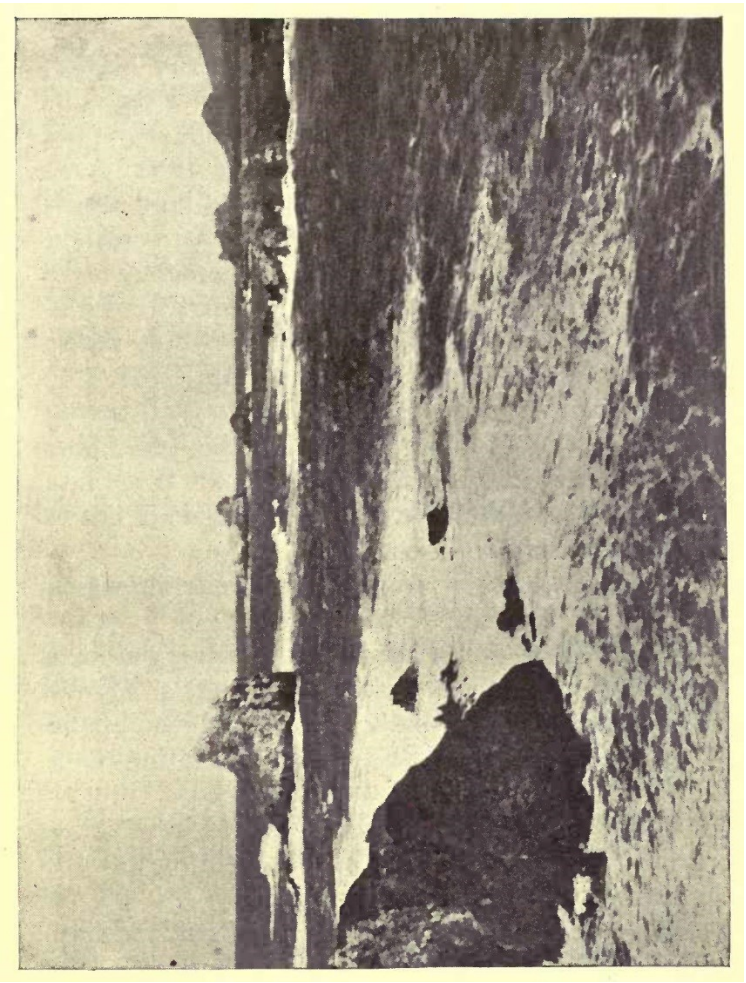
You have seen the same thing happen in the rivers in the summer time. As the water goes down, many little islands and sand bars come into sight, and some of these you can finally walk out to without wetting your feet.

There is another very different way in which islands are formed.

If you have ever visited the sea shore, you have seen how the waves are always beating against the rocks. Sometimes the waves are small, and break very gently, but in stormy weather it is different.

Water by itself cannot wear away the hard rocks. It is only when the waves have something to work with that they accomplish anything.

The tools of the waves are grains of sand, pebbles, and boulders, which lie along the shore. As each wave runs back you can hear the rumble of the pebbles rolling down the beach. When the next wave comes, it picks them up and hurls them with great force against the cliffs.



With each blow a little of the rock is ground from the cliff. When the waves have succeeded in wearing out a hollow at the bottom, the cliff caves down. Each new fragment of the rock cliff falling into the ocean is in turn used as a hammer by the waves. In this way

they slowly eat into the land. They grind it away little by little, in the form of sand and mud, which the currents of water then spread over the ocean bottom.

On some sea coasts the land is being destroyed so fast that houses, and even whole farms, are washed away.

But you may ask what has this to do with the making of islands. Look closely at this picture of a wild part of the California coast, and perhaps you can tell. The first thing which will attract your attention are some rocky islands, with the waves foaming all about them. At the right side of the picture is the mainland with which the islands were once connected. The broad strip of water in the front of the picture was formerly occupied by the land.

The waves hunt out all the soft places in the rocky cliffs, just as you would do if the same work were given you. They hurl the boulders and pebbles against the cliffs, and dig caves and passage-ways where the soft spots are.

After a long time the shore is dug into so far that bays are formed, where little boats may anchor safely. Bat the harder rocks remain as headlands, or capes, between the bays.

The waves continue to beat against the rocks, until some of the headlands are left entirely surrounded by water. This is the way the islands which appear in the picture were made. How boldly and defiantly they face the storms. At first, they are only a little distance from the mainland, but as the waves keep at work they are left farther and farther out in the ocean.

The waves have a long task ahead of them to tear the islands down. The water is quite deep about them, and the pebbles have been washed toward the shore.

Under the attack of the atmosphere and waves the islands will finally crumble away, and in the place of each there will be left only a reef upon which the waves will break in stormy weather.

New islands will be formed as long as the waves continue to tear down the cliffs.

Islands assume strange shapes sometimes. If you will examine the picture carefully, you will see that the island farthest away looks very much like a lion at rest. It is called Lion Rock.

What picturesque rocky hills these islands would make if the sea should retreat and leave them upon the dry land. I suppose that all children who know anything about the sea, and have wandered along the

shore, have wished that they could explore the bottom, and climb up on the rocky reefs and islands.

The sea birds use the islands for nesting places, and cover them with the white guano which is so valuable for making land produce heavier crops.

The sea lions and seals also make use of the islands, for they are more protected from hunters. At certain seasons of the year nearly all the rocky islands along the coast of California are inhabited by the bellowing sea lions.

The Story of the Yosemite Valley

The fame of the Yosemite Valley has gone all over the world. People travel thousands of miles for the purpose of spending a few days there, looking at the cliffs and waterfalls. What is there about this valley which makes it so attractive? There are cliffs and waterfalls in other places. We can tell best, if we see the valley with our own eyes. It is a long ride, up and down wooded mountains, and by roaring streams, into the very heart of the Sierra Nevada Mountains. We begin to wonder where the valley is, when all at once, passing a turn in the road, we come out on the edge of a great precipice.

Far below, so far that the pine trees look like little bushes, lies the beautiful Yosemite Valley. There are green meadows and forests, through which winds a shining river.

On every side of the valley rise walls of rock. In some places, they are almost a mile high. At several points little streams, flowing down from the higher mountains about the valley, tumble in streaks of foam over the walls of rock.

The valley seems like a picture in a frame of bare granite mountains, and you wonder how it came there.

Some people have thought that, during an earthquake a long time ago, the bottom fell out of the mountains, and left the deep hole in which the valley now lies. We do not think this is the way it was formed. We think the brooks and rivers can tell us more about how it was done.

A long time ago the Sierra Nevada Mountains were not so high as they are now. There were no deep canyons, and bare granite peaks, but in their places valleys and rolling hills.

Then something began to lift the hills higher and higher. They became colder, and it snowed and rained a great deal. This gave the rivers much to do. They could no longer play truant in shady ponds, as they used to do. They had to run more swiftly to reach the San Joaquin Valley, and dashed from rock to rock over their rough beds.

The streams said to themselves, if we can only wear the rocks away, and dig deep gorges between the mountains, we shall then not have to run so fast, and besides, we shall be hidden from the sun the most of the day.

They went to work with a will, and by the aid of the sand and pebbles, which the brooks brought them, they ground away the rocks over which they flowed, and in this way cut deep channels.

Those rivers, which were the largest, and flowed over the softest rock, accomplished the most, and at last hid themselves deep down between the mountain walls.

In this way the Merced got ahead of its brother rivers, and dug out the beautiful Yosemite Valley. It had to carry away much material, for the valley is eight miles long, and more than a half a mile wide and deep. But it did it, nevertheless, by taking the rock away, a few grains at a time. The most of this waste was left in the San Joaquin Valley, and it is this which makes the great valley smooth as a floor.

The Merced River had many tributaries, as it flowed through the Yosemite Valley, but they were small, and did not cut down into the granite rock as fast as the main river did. So, in order to get to the river, they had to jump over the great walls about the valley. In this way, the pretty waterfalls were formed. Some of them are so high that the water turns to spray before it reaches the bottom of the valley.

Now that the valley was cut out, the Merced River felt quite happy. Its work was almost done. But disappointment came to the river as it does to people. The climate continued to grow colder, and it snowed so much, that it seemed to the river that the whole world must be covered by the white sheet.

In the winter, the water of the river froze, and it could not run, but in the summer it had to do double work, because of the melting snows.

After a time more snow fell in the winter than could melt the coming summer, and it increased so much that it began to slide down the mountain sides and to fill up the canyons which the rivers had dug.

The snow became hard and icy like the snowballs which the boys have made on a warm afternoon and left out overnight to freeze. The valley of the Merced River was filled at last with the ice. It moved along so slowly that one would have had to watch it a long time to be sure that it did move.

You can imagine how the ice acted by watching a little stream of molasses on a cold morning, only that the molasses is sticky, while the ice was not.

Such a stream of ice is called a glacier, and this cold time upon the mountains the Glacial period.

How the glacier did tear the mountain sides as it moved down the valley! It broke off all the projecting points of rock and scraped them along, polishing the old bed of the river and the sides of the canyon.

For many years the ice filled the valleys, and they would surely have been forgotten if anyone had lived in California then.

The cold came to an end, however, and the ice melted away, giving the valley over to the river again.

The river hardly recognized its old home. Everything was greatly changed. All the trees and soil had been carried away by the ice, and there was nothing but barren granite. How the granite did shine in the sunlight! It was polished in many places as smooth as a mirror.

The river did not have as quiet a time in the Yosemite Valley as it used to. Great boulders, which the glacier had dropped, were strewn all over it, and the river had to hunt for a new channel.

The river went to work to make the valley smooth and fertile as it was before, but it was very slow work. The ice had swept every bit of soil from the mountain slopes, and it was some time before the rain and frost could pry the particles of the rock apart, and furnish sand and clay for the brooks to carry to the river.

At last the river succeeded in covering up the most of the boulders in the valley, and grass and trees sprang up. Innumerable bright flowers covered the bottom lands, and in the meadows the red strawberries grew without anyone but the birds to eat them.

What a happy valley this was, all shut in from the outside world! The wild animals made it their home, but there was no one to see the grand cliffs and beautiful waterfalls. The animals thought only of something to eat and a comfortable home in the winter. The brooks, as they jumped over the cliffs in haste to join the river in the valley below, sang to the empty air.

Time went on, until some Indians, hunting through the woods which had grown up on the surrounding mountains, accidentally came to the edge of the cliffs and looked over.

The valley seemed so inviting that they went back for their friends; then they all climbed down the steep walls into the valley, and made their homes there.

When the miners came to the mountains, the Indians frequently went out on stealing expeditions. They were often followed, but for a long time succeeded in escaping to their well-hidden homes.

One day they were less fortunate, and were traced to the valley, where a fight took place. The miners drove the Indians out and took possession of the beautiful valley.

It was so difficult to get into the valley, that for a long time but little was known about it. When the rude trails were replaced by smooth roads, many people went to visit it, and the story of the wonderful valley spread all over the world.

When the Mastodon Lived

Most of us have seen the elephant, with his curious trunk, great dangling ears, and stumpy legs. How alarmed we should be to meet someday a number of these animals roaming wild in the woods!

If we had lived here several thousand years ago, however, we should have become as used to elephants as the people of Africa and India now are.

We cannot realize how long a time a thousand years is, for even one year seems to pass so slowly. All that we can know is that a long time ago, when our Pacific Coast home was very different, many strange animals lived here. Among them was one great animal in particular, which looked much like the elephant, only that it was larger, had long shaggy hair and great curved tusks.

We have read of such animals having been found frozen in the snow of the far north, but what reason have we to suppose that they ever lived in California?

It came about in this way. One of the streams where we used to fish had been swollen by days of

heavy rain, and as it rushed along, it tore away the grassy bank in many places. Half a mile below the house it formed a cliff, about forty feet high. Here we went to hunt for the smooth and prettily colored pebbles which had washed out of the bank.

One day we found that the water had exposed something very different. There were some giant bones sticking out of the hard clay, some fragments of tusks, teeth as large as our heads, and leg bones fully four feet long.

We had never seen an animal which was as large as this one must have been when it was alive. Even the elephant at the show could not have stood more than half as high. We had heard stories of great animals which had lived here before people came, but they never seemed true. It was said that these animals roamed about our home in the foothills, eating the leaves and branches of the trees, and that when they died their bones were covered up in the gravel of the creeks or in the mud of the lakes.

We asked an old man, who seemed to know a great deal, to come and help us dig the bones out. When they were all lying on the bank we sat down to rest, and he told us many things about this animal and the time when it lived.

He said that these fossil bones belonged to a mastodon, and that it lived so long ago that we would grow tired trying to think how long. He said also that we would not have known the country around our home. The most of the plants and trees were different, and there were many other strange animals besides the mastodon.

This was all so new to us, and so interesting, that we wanted to know more about those times, and so he continued.

Before the mastodon lived here the country was warm, and the mountains not so high as they are now. But there came a time when the land began to rise, and as it rose the climate became colder, until snow, instead of rain, fell on all the hills and mountains.

Jack Frost, who loves cold weather, gradually extended his kingdom over all the high mountains of the Pacific Coast. Every winter it became a little colder and a little more stormy. The winter snows grew deep, and covered up all the bare rocks, and at last, even the tallest trees were completely hidden. The animals and birds who made their homes in the mountains, either died or moved into the valley, where it was still warm.

The country kept rising, until the shore of the ocean was farther west.

What a strange looking country it was. The mountains, so cold and white, rose above the valleys where trees and grasses abounded, and all sorts of queer animals chased each other through the brush or nibbled the grass of the meadows.

There were several kinds of elephant-like animals, of which the mastodon was the largest. The teeth that we have found show us that these animals were plant-eaters, for the surfaces of the teeth are flat, and fit for grinding the leaves and stems of plants rather than for tearing flesh.

We can picture to ourselves herds of these clumsy, shaggy creatures as they fed upon the brush in some shady spot. All at once, perhaps, they start to run, as a lion, as fierce as any in the African jungle, bounds into their midst, and the earth shakes beneath their great feet.

In another place might be seen a group of animals, appearing much like the camel, only larger. They were the ancestors of the llama, of South America, which the Indians use for pack-animals.

In addition to the sloth and tapir, which are not found now in North America, there were wild hogs

and wolves and deer. The ferocious looking buffalo may also be added to our picture.

Two kinds of wild horses wandered through the larger valleys. One of them was a third larger than any living now. We wonder what has become of them, for when America was discovered there were no wild horses here. The great bands of horses which used to roam over the plains of Texas and South America descended from the horses which the Spaniards brought over with them.

The ice and snow covered the mountains for many centuries. At last a change came. Not so much snow fell during the winter, and in the summer more of it melted, so that the rocky peaks began to appear here and there. The glaciers, which are only streams of ice, melted slowly, and the rivers were high and thick with mud.

The climate changed in the valleys. The animals of which we have been talking did not seem so numerous. Many of them were sensitive to changes, and as less rain fell, and the plants began to dry up, they disappeared one by one. Some of these animals went to other regions and some died. Many skeletons were scattered around in the sun; these soon decayed and disappeared. A few were preserved by being

buried in the swamps and river bottoms. These are the ones which we often find today.

The mastodons and other animals, as they fed here and there, had wandered out to the region of the Santa Barbara Islands. When the climate became warmer, it was because of the fact that the land was sinking. So, by and by, the sea again flowed in through the Santa Barbara channel and cut the animals off, so that they could not retreat to the mainland. They died there, and the rains washed soil over many of their skeletons. The waves are now at work tearing down the islands, and as they wash away the cliffs, the buried bones of these old animals are frequently exposed.

As the climate continued to grow warm, different plants and animals took the places of those that had died, for we know that every living thing is adapted to the place in which it is found.

The plants which had come down from the north with the cold of the Glacial period, for that is what we call the time when the mountains were so snowy, retreated as the snow melted. We still find a few of them living on the highest mountains, where the cold yet remains.

For many long years after the ice and snow left the mountains, they showed nothing but bare rock. Little

by little the soil gathered, the winds and birds carried seeds, and the trees, bushes, and grasses began to grow. With the new vegetation came the animals which are now living here.

Since the Pacific Coast has been settled, we have found large numbers of the bones of the animals which used to live here. Having the bones, we can tell a great deal about those ancient times. Do you not think it is interesting to know what happened on our earth long before we were here?

Summer and winter succeeded each other many times, and California came to look much as it does now. We are not certain that the Indians lived here with the mastodon, but they must have had their homes here for centuries before the early explorers came.

After what our wise old friend had told us, the great bones upon the bank seemed full of stories of the past. We imagined them alive again, and clothed with flesh, and the mastodon feeding in the valley, at the foot of the snowy mountains.

The Making of Mountains

We have learned from our study of the ocean cliff, that earthquakes and the formation of long cracks in the earth, have much to do with the making of some kinds of mountains. We have also learned how great volcanoes like Mount Shasta are built up.

There is still another way in which mountains arise, and we can understand it by studying an apple.

We have all noticed how wrinkled the skin of an apple becomes when it stands for a time in the dry air. The apple shrinks, because some of the juice evaporates. The skin is then left too large, and as it clings tightly to the pulp underneath, it is finally obliged to wrinkle.

Nearly all the substances of which the earth is made, shrink as they become cooler, and expand with increase of heat. The earth, as you have learned, was once hot all over. It has now become cold, and hard upon the outside, but it is still hot and soft inside. This inner part of the earth far below us is cooling all of the

time, and as it does so, it shrinks, leaving the hard crust upon which we stand, too large.

Now, what happens? The crust has to settle down, and in doing so, it forms folds, just as the skin does upon an apple.

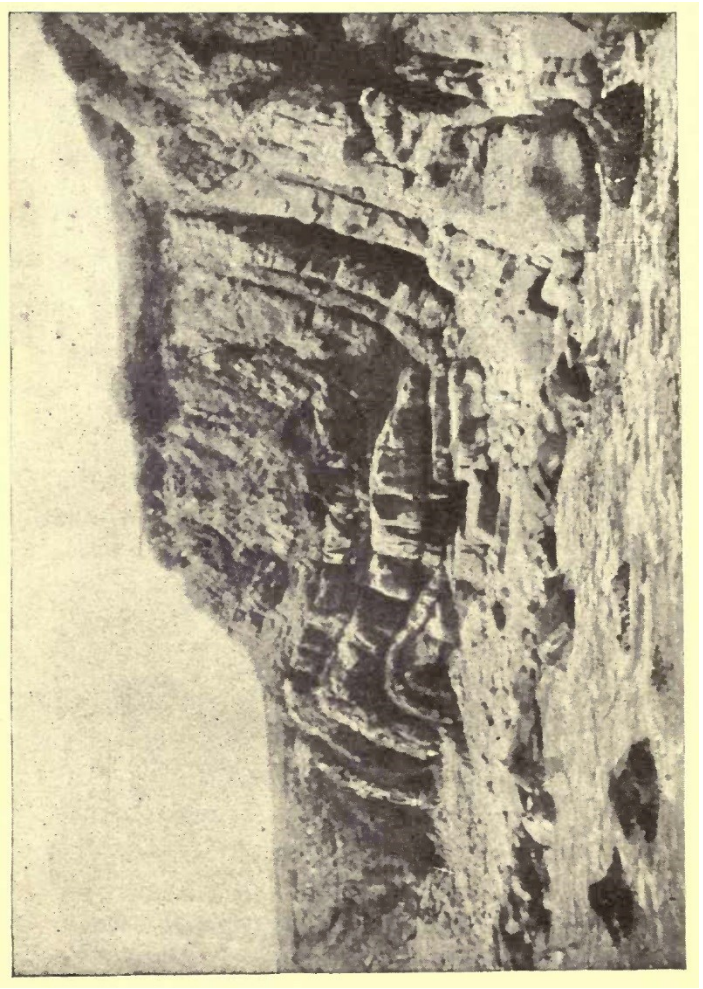
A large part of the crust of the earth is arranged in layers. There are layers of pebbles, sandstone, clay, and other rocks. These, when they are formed in the bed of an ocean or lake, are nearly level. When the crust of the earth folds, these layers are tipped up at all sorts of angles.

We cannot go into the canyons in any portion of the Coast Ranges without seeing these layers standing more or less steeply. It is easy to make some of the wrinkles or folds, in the same way that those upon the earth are made. We will take some sheets of paper, and holding the opposite sides in each hand, shove them together. The paper will bend in folds.

The folds upon the earth are sometimes so large that they form high mountains. We can often see the layers arching like a rainbow upon the sides of the canyons. Our picture shows some folded rocks upon the coast of California. These layers of sandstone, which are now folded into the form of a letter S, were once flat and even. We can hardly imagine what a

great force it requires to bend solid rocks in this manner.

If the skin of an apple consisted of layers, they would appear folded, just as the rocks are in the picture.



An Extinct Volcano

We have all been startled at some time or other by the sudden escape of steam from the safety-valve of an engine.

With a loud, explosive noise, the steam bursts out for a moment, and then stops.

The engine-boiler is made in such a way that, when the pressure of the steam inside has reached the limit of safety, some of it can escape. If it were not for the safety-valve, the boiler might be blown to pieces.

Did you ever think that there are mountains on our earth which behave much like the safety-valve of an engine? Such mountains are called volcanoes.

The ground over which we walk seems perfectly firm and solid, yet the earthquakes which shake it once in a while, and the volcanic eruptions, teach us that there are giant forces shut up within it.

Miles below our feet the heat is so great that the rocks are melted, just as the iron is in a furnace. There is steam in those regions also, and it is trying to get out

in the same way that the steam tries to get out of the engine-boiler.

Water soaks down through the rocks to these hot regions, and is there changed to steam. When the pressure of the steam becomes too great, it blows a hole through the crust of the earth at some weak spot.

The steam is mixed with the melted rock or lava, and when it makes a hole to the surface, the whole mass is blown high in the air. This is the beginning of a volcano.

Some of the lava is blown into pieces so small that they seem like dust, and float many miles before settling to the ground. These fine particles are called volcanic ashes.

The heavier pieces do not float away in the wind, but fall back around the mouth of the volcano. Some of them look like masses of slag from a furnace, and are known as cinders. Others are heavy and round like cannon balls, and are called bombs.

This material gradually builds up a rim about the opening. The basin-like depression thus formed in the center is called the crater. Mount Shasta is the most perfect of the great volcanoes upon the Pacific Coast. There it stands in Northern California, so tall and grand, a giant among the other mountains. Through

the long summer, its cap of pure white snow attracts you. Is there anything so wonderful as this great mountain rising three miles above the level of the sea?

Yet a long time ago this mountain began as a little volcano. If we could have stood then upon the top of the mountain, and looked down into the crater, we would have seen some interesting things taking place.

We would have seen the red-hot lava with the steam rising from its surface, once in a while settling down almost out of sight in the throat of the volcano, and showing a tube-like opening leading down into the earth.

Then the lava would rise again, bubbling with the escaping steam, just as a pudding does. As each bubble broke, a great cloud of steam would escape.

When more steam had formed than could escape in this way, it would gradually lift the whole mass of lava, until boiling and foaming, it would run over the lowest place in the rim of the crater, and down the side of the mountain.

If we had been there when the explosions took place, it would have been very dangerous. We should have had to crawl under some projecting rock, to escape being hit by the chunks of the falling lava, which had been blown into the air.

The heat, the steam, the poisonous air, and the glare of the lava at night, would have been terrifying. Then, when the explosions took place, it would have seemed as if the whole mountain were being blown into the air.

Just watch your mother make a hasty pudding someday, and you will get an idea of how the lava acts. If the bubbles of steam should blow some of the hot pudding in your face, it will seem all the more real.

A volcano not only acts like a safety-valve, but like a cannon as well. The steam blows the lava up through the throat of the volcano, as powder does the shot from the cannon. The comparison is all the more real, because the masses of lava hurled into the air are called bombs.

Some of the lava which flowed out cooled around the top. This, together with the chunks which were thrown out, slowly built up the top of the volcano. At last, it towered high above all the surrounding mountains.

How the ashes and lava desolated the country around the volcano! One stream of lava reached the canyon of the Sacramento River, and followed it for nearly fifty miles. The heat of the lava turned the river

to steam, and not until the lava cooled could the river flow there again.

The lava was so hard, that when the river did begin to flow again, it cut a new channel by the side of the old one, which the lava had filled up.

Mount Shasta now stands there so quiet, it is hard to imagine the exciting events of its history. All the volcanoes along the line of the Cascade Range, including Mt. Hood and Mt. Rainier, are now extinct. By that we mean that the lava in their throats has become cold and hard, and the openings far down into the earth, through which the steam hurled the lava, are closed.

Mount Shasta was the last of these volcanoes to become extinct. It has probably not been so, very many centuries, for there are several places upon its summit where the hot sulphurous gases still issue from the crevices in the lava. In fact, we are not quite sure that Mount Shasta is extinct. It may break out again some time.

You know that Vesuvius, that great volcano on the Bay of Naples, was supposed to be extinct nearly two thousand years ago. The people, who lived there, had no traditions of its ever having been in eruption. They built villages and set out vineyards on its slopes.

It broke forth again, without warning, in the year 79 A.D. Streams of lava flowed down the mountain, destroying everything in their path. Clouds of volcanic ashes also fell, burying whole cities, which remained there undisturbed for centuries until they were almost forgotten.

Near Lassen's Peak, which is also a volcano, there is a stream of lava which must have issued from the earth not more than two hundred years ago. The trunks of pine trees, which were killed by the falling ashes, are still standing.

If Mount Shasta is really a dead volcano, the rain, and frost, and little rivulets, will gradually tear it down. They are at work upon it now, but so slowly do they work, that it will be many centuries before they will succeed in affecting it very much.

Caves

What delights the boys most when they are climbing among the rocks is to find a cave. There is something very attractive to them about a hole in the ground. They want to explore it at once, and see where it leads to.

It may be that boys like caves so well because our ancestors used to live in them, and found them of great protection at many times.

In rocky countries, many animals make their permanent homes in caves. The greatest caves that we know anything about are in Kentucky. The largest is the Mammoth Cave, in which one can walk for miles without ever coming out to the light. Caves like these in the limestone are made by running water. The rain water soaks down through the soil and into the cracks in the limestone. Little by little it dissolves the rock, and after a time great caverns are formed, through which the streams run.

There are a few caves in the limestone upon the Pacific Coast, but no very large or interesting ones.

Many caves are formed in other ways. Ocean waves are interested in caves. They have slowly worn them out of the cliffs, against which they are perpetually dashing.

Ocean caves were years ago, the favorite resort of smugglers and pirates, and many interesting stories have been written about them.

Some of the caves into which the ocean used to dash are now above the reach of the waves. That many of them have been used as camping-places by the Indians, is shown by the smoked walls.

The most interesting caves are found in the lava-fields of the Northwest. The lava rocks which cover so much of Northeastern California, Oregon, and Washington are full of holes and cracks and underground passage-ways.

There are many things which make us believe that there are caves all over this region. In riding over the lava, the rock frequently sounds hollow under the horses' feet. Besides this, there is little surface water for miles. The water from the snow and rain, runs into the cracks in the lava and gathers in underground streams. In some places the caves have fallen in, and we can actually explore them.

These caves are very different from those in the limestone on the seashore. They were not made by water, but by the lava when it cooled, and the water has simply made use of them.

Some of the underground passages must be many miles in length. North of Mount Shasta there is one called Pluto's Cave. It was formed by a long, narrow stream of lava. A crust of solid lava formed on the outside of the stream while it was still hot and soft inside. What do you suppose happened then? It was a very strange thing. The inside flowed on and left the hardened shell. Thus a long hollow tube was formed, which looked on the inside something like a railroad tunnel.

This cave has been followed more than a mile without finding the end. It is very rough inside, and the walls, where they have not caved, show the hollows and ridges of the crust. The cave is in places eighty feet high and seventy feet broad.

It is a queer sensation to climb through one of these caves, where a red-hot and steaming lava stream once flowed.

In the Modoc lava-beds there are many such caves partly broken in. It is here, you will remember, that Captain Jack and the Modoc Indians took their stand

against the soldiers. The Indians took refuge in the caves, where there was plenty of water. They knew the country perfectly, and it would have taken an army to have driven them out.

The caves through which the underground streams flow are generally too small to explore, besides, one would be troubled with the water. Many of them are deep under the lava, and would never be known if it were not for the canyons which cross this region.

The canyons have been formed by the larger rivers flowing across the lava-beds. Many of the streams underneath the lava are thus exposed. Some of them are so large that we might call them rivers. A perfect torrent of water pours out of an underground passage in the canyon of the upper McCloud River. The volume of water is so great that it doubles the size of the stream.

Moss Brae Falls, in the canyon of the Sacramento River, has the same origin. It comes, under the lava, from Mount Shasta, fully twenty miles away. The water is pure, and almost ice-cold. It never sees the light of day after leaving the melting snows high on the slope of Shasta until it runs down over the fern-covered ledges into the Sacramento River.

Other large springs issue from under the ends of lava-beds. Springs of this kind form Fall River, an important tributary of the Pitt River. An interesting feature of rivers that are formed of such springs is that they flow nearly the same size the year around.

One of the springs which forms Fall River is so large that it has been used to run a saw-mill.

Other springs of equal size are scattered all along the base of the Cascade Range.

All these things show us that caves are among the most interesting features of the lava-beds.

Crater Lake

Our world is very old, and many things have happened upon it since it began moving around the sun. We would have opened our eyes very wide at some of these things if we had been there to see them.

The ocean now covers sunken continents, where wild animals once roamed and trees waved their branches in the wind. Sea shells upon the mountain tops tell an equally wonderful story of sea bottoms which have become dry land.

There was a time, long before people lived upon the earth, when central Oregon was beneath the sea. The ocean did not always remain there, however, for earthquakes occurred and great cracks opened in its bed. From these cracks flowed streams of melted lava, which slowly cooled, and as the years went on were heaped one upon the other, until the Cascade Mountains were formed.

On the summit of these mountains, and rising many thousand feet higher, were the great volcanoes

which we call Shasta, Mazama, Rainier, and Hood, besides many smaller ones.

All but Mt. Mazama you will find marked upon the maps. This was a great mountain, almost as high as Shasta; and you ask why it is not down also. Simply because no such mountain exists there today. In its place is Crater Lake. Listen, and I will tell you the strange story of Mt. Mazama.

For centuries Mt. Mazama poured out smoke, ashes, and streams of lava. At last, the fire nearly died out in the mountain, and only now and then a little steam issued from its top. The rough and jagged lava rocks upon its slopes grew cold.

The climate became cold, and the Cascade Mountains were covered with snow and ice all the year round. What is now the Willamette Valley was then a lake. Long streams of ice, formed from the hardened and partly melted snow, moved slowly down the mountains to the lake, and breaking off, floated out upon its surface.

The region all about Mt. Mazama was a desolate one. All the vegetation, even the tallest trees, were buried under the snow. No living thing was to be seen, except when some Arctic animal wandered over it.

After a time the climate grew warmer, and the snow melted away. Grass and bushes, and finally trees, covered the mountains again.

A family of bears, searching for a home, came to a deep cave under the lava on the slope of Mt. Mazama, and stopped there. The home was well chosen, for during the cold winters the bears retreated far into the cave, where the snow could not reach them.

During the summers they had the huckleberries, which grew in the meadows, a little farther down the mountain, all to themselves, for the most of the other animals, as well as the birds, seemed afraid of the mountain.

The years passed happily, until the bears began to be suspicious that something was going on within the mountain. Strange rumblings were heard, and the rocks often trembled. Once the mouth of the cave was nearly closed by a rock which had rolled down. In the winters the heat began to disturb their long sleep, so that more than once they thought spring had come, when it was still mid-winter.

Finally, one night, when returning from an expedition, they saw the sky above the summit of the great mountain on which they lived, lighted up

brightly, and shortly after, fine, suffocating ashes began to fall.

At last, when an unusually heavy earthquake shook the cave, our family of bears could stand it no longer, and started pell-mell down the mountain side to find a safer place.

In the days that followed the heat increased. There were loud, thundering noises, and earthquakes so severe that they broke the trees down. Even the most sluggish of the animals left their homes and fled away from the mountain.

After a time these disturbances ceased, and Bruin and his family wandered back up the mountain. But, somehow, things looked different. The trees and bushes were all dead, and the green meadows where the huckleberries used to grow were buried under a layer of soft ashes.

All at once they came out upon the edge of a great precipice. They could go no farther, for in front of them, where the mountain had risen so many thousands of feet, there was a hole nearly a mile deep and several miles across.

In the bottom there was a red-hot mass of lava, which bubbled up, and threw out great jets of steam.

What it all meant the bears did not know, but it seemed as if the mountain had been melted and fallen in. One look was sufficient, and then they turned and fled from the spot. Year after year passed, but the bears did not return. The lake of lava at last became cold. The rains fell and gathered in this old crater of the sunken Mt. Mazama.

Explorers discovered this beautiful lake hidden away in the forests which now cover the summit of the Cascade Range. The surface of the lake lies two thousand feet below the top of the circling cliffs which formed the old crater.

The water is nearly half a mile deep, and clear and blue it lies there in the quiet of the mountain woods. On an island in the lake there is a small volcano, but it is also covered with trees. Probably it has been centuries since it threw out ashes and lava.

The eagles build their nests in the cliffs, and the deer come down to drink. Will it always be so? We cannot tell. Some time the fire may be lighted again, and smoke and ashes fill the sky, but we hope not.

This is the story of Mt. Mazama, the mountain which fell in. Do you wonder that it is not located in the geography?

The Lava Plateau of the Northwest

If you want to get the juice out of an orange without peeling it, how is it done? Why, it is a very simple matter. Cut a little hole in the orange, and then squeeze it in your hands.

The great round earth on which we live is like an orange in some ways. It has a hard skin, or crust, on the outside, while it is soft on the inside.

Now, if there were a hole, or crack, in the crust of the earth, and some mighty giant should squeeze it, what do you suppose would happen? The soft material inside would come up through the cracks and run out over the surface exactly as the juice of an orange does.

Many different times in the history of the earth the melted rock inside of it has flowed out and over the green surface, making it rocky and barren. We must not think, however, that a giant really squeezed the earth, for there are no such things as giants. Instead of that, the lava was pressed out by the weight of the crust upon which we walk.

Our earth was once a fiery, glowing mass, like most of the stars, but now the outside has become solid and cold. At least, it seems solid, except when we feel it rocking during an earthquake.

Far below the surface it is still soft and hot. The crust is very heavy, and once in a while it settles down a little, and squeezes out some of this soft material, which we call lava.

You may wonder how we know that it is hot inside. In many parts of the earth lava can now be seen in the craters of volcanoes, steaming like some hot pudding. Many of the hot springs which are so abundant upon the Pacific Coast are caused by the heated rocks far below the surface. In some places mines have been worked that are nearly a mile deep. It has been found that the deeper the miners go the hotter it becomes. So we are quite sure that it is hot enough to melt the hardest substance not very many miles below the surface.

In portions of Oregon, Washington, and Idaho so much lava has been squeezed out that it has formed a high table land, or plateau, hundreds of miles in extent. It is called the Columbia Plateau, because the Columbia River flows across it. The plateau was originally almost as level as a floor, but since the lava

cooled, cracks have formed in it, and some portions have been raised to form high mountains.

How do you suppose this country looked before the lava flood buried it? It probably looked very much as mountains generally do. There must have been hills and valleys and running streams.

There came a time of terrific earthquakes. Great cracks formed in the rocks, and floods of fiery lava flowed up through them. The lava was very thin, and ran over the country, almost as easily as water would have done. It filled the valleys first, leaving the hills sticking up; but the heat must have been so great as to kill every living thing over many hundred square miles.

Then for many years no more lava came out. If we had lived there we should have felt safe again. The steaming lava became entirely cold. The winters and summers succeeded each other, until the hard rock crumbled a little on the surface, and trees grew up. Among them were pines and spruces, just like those we find on the mountains now. There must have been animals and birds also.

Then again, without warning, the crust was broken, and more lava came boiling out. It killed and buried the forests, and spread farther than it had

before. After a time it was quiet again. How many times this was repeated we hardly know, but at last the whole country, for hundreds of miles around, was completely buried.

These would have been terrifying sights if we could have seen them all. Steam, hot air, volcanic dust, and fiery lava were everywhere. It would have seemed as if the earth were turning inside out, and that everything upon it was to be killed.

Thus the Columbia plateau was made. After the lava had become cold, the rain water formed lakes at different spots upon its surface. Many interesting animals lived around these lakes. Their bones, which are still found, show that they were quite different from the animals living there now.

Far to the east of the lava plateau, were the Rocky Mountains. The lava had not covered them. The streams from these mountains flowed westward, and united in one large river, which we call the Columbia.

Ever since the Columbia began, it has been cutting its channel into the lava of the plateau. It has now the deepest and most rugged canyon of all the rivers of the Northwest.

The river has cut through the different layers of lava which flowed at different times. What we can see

now in the canyons enables us to tell what happened so long ago.

We might compare this plateau to a layer-cake. Each stream of lava would then represent one layer in the cake, and the soil between the layers the jelly. How boldly and clearly the layers of black lava stand out on the walls of the canyons. The thin layers of soil between them contain fragments of petrified trees and impressions of leaves. They tell the story of how the country was once buried by the lava.

Down in a Gold Mine

If it were not for the gold hidden away in the mountains of the Pacific Coast, this region would not contain as many people as it does. In the early days, when gold was first discovered in California, there were no railroads. When it was known that gold was to be had here for the digging, thousands of people started from the East for California. They had to encounter all kinds of dangers. They crossed the broad deserts, climbed mountains, in whose canyons Indians waited, or sailed half around the world.

After the pioneers reached California, they had yet to find just where the gold was. They explored the brooks and rivers of the Sierra Nevada Mountains, and discovered that in many places the gravels in their beds were full of grains of gold. This is placer gold, and digging for it is called placer mining.

The miners found little pieces of quartz with the gold, and soon discovered that both came from quartz veins, which appeared wherever the rain, or the streams, had washed the soil away from the rocks.

The little white pebbles, which we find in all the brooks, are quartz. They are so hard that your knife blade cannot scratch them, and often as clear and transparent as glass.

A quartz vein is a long, narrow band of quartz extending across the country. Quartz is so much harder than the other rocks that it often stands up in prominent points above the rest of the country.

All the children who live in the Sierra Nevada Mountains have heard of the Mother-lode. Those who live in other places would perhaps like to know something about it. The Mother-lode is formed by a line of quartz veins, which reach for more than a hundred miles through the foothills. These veins are very large and rich, and the miners called them the Mother-lode, because they thought the gold in the gravels of the streams all came from them.

Hundreds of mines have been worked here, and everyone who is looking for a mine, wants it to be upon the Mother-lode, because he thinks it is so rich. We must not think that all the quartz pebbles which we find in the brooks contain gold, for we would be greatly disappointed. The miner sometimes spends years hunting for a vein of quartz with enough gold in it to pay him for working it. He prospects the vein by

pounding a piece of the quartz to dust in a mortar, and then washing away the dust in a pan, or spoon made of horn. If there is any gold, it settles to the bottom, and appears as a string of little shining yellow grains.

An old prospector had lived for years in a log cabin in a gulch in the mountains. He had a mining claim upon the Mother-lode, but for a long time had not been able to find just where Nature had put the gold, for she does not sprinkle it in all the quartz.

The day came at last when he found some quartz with specks and threads of gold. The disappointed look in his face was changed to a happy one. He built a new cabin, and threw away his old clothes.

He had worked years, digging holes along the vein of quartz, in the hunt for gold. These holes looked like so many wells, only there was no water in them. He had raised the quartz from the bottom of the holes by hand. The windlass which he used, with its rope and bucket, looked just like that employed by well-diggers.

Now, in place of this windlass, there stands a large mill, from which comes, through all the day and night, the steady thump, thump, of the heavy iron stamps, as they pound the quartz to pieces, and set free the shining grains of gold.

We will go down in the mine, and see what he has found. At one end of the room is a dark hole, surrounded by a railing. It is called a shaft, and through it the quartz is raised to the surface.

A steel rope is running up from the shaft, and over a wheel on some timbers above us. A little behind stands the engineer, ready to stop the machinery at a second's notice.

As we watch, a great square bucket, or skip, as the miners call it, comes in sight, rising out of the dark shaft. It passes to the floor above, where the ore is dumped, and is then lowered for us. We climb in, but not without some fear. At a signal, the engineer moves a lever, and we seem to fairly drop into the dark hole.

Down, down, we go for some moments. The air becomes cold, and by the light of the feeble candles we catch glimpses of mossy timbers, and bare, wet rock, as we fly past. Several lighted stations, where men are at work, come into view, and quickly disappear.

Little streams of water run down the sides of the shaft, and drip upon us, but with rubber coats on, we do not mind it.

The bucket slackens its speed, and comes to a stop close to a platform, and we climb out. We are two

thousand feet down in the earth, and although it is cold, the air is not bad, for there are pipes leading to the surface, through which fresh air is constantly pumped.

The men began digging upon the vein of quartz at the surface, and followed it all the way down this shaft. They think it extends much deeper still.

To the right and left of the landing upon which we stand, tunnels, or drifts, as they are also called, extend away into the darkness.

We start out to walk to the end of one of them, where the miners are at work breaking down the quartz. The timbers which hold up the roof of the tunnel hide the most of the vein, but in a few places we can see it glistening brightly.

We meet a group of men at the end of the tunnel, and stop to see what they are doing. Here stands an iron car, holding about a wagon load of the ore. It is pushed back and forth between the place where the men are at work and the shaft.

Two men are loading it with chunks of quartz, which have just been blasted down from the vein, which we see sparkling overhead. Another man holds a short steel bar, called a drill, while his companion

strikes steady blows upon it. In this way a round hole is slowly cut in the solid rock. This is called drilling.

Holding a candle close to the vein, we can see little specks of gold scattered through the quartz. The foreman calls this rich ore, and we are ready to agree with him. A wagon load of it would make us almost rich.

It is nearly noon, and the men are going to blast down some more of the quartz, before going up to their dinner. Sticks of dynamite, which look like candles, only they are yellow, are placed in the holes which have been drilled. A dark, thick string, called a fuse, is put in the end of each, and left sticking out of the hole.

When all is ready, the fuse is lighted, and we hasten back through the tunnel, and enter a side-tunnel, or cross-cut. Here we are safe, and wait for the blasts to go off.

Suddenly, we hear a sharp click, seeming to come out of the wall of the tunnel. Then there follows an explosion, which shakes the solid rock.

It is very dangerous to work in some mines. If the rock is soft, it keeps settling slowly into the tunnels, breaking timbers more than a foot through. In some mines, there is so much water that the pumps have to

be kept going all the time, or the men would be drowned.

The men who work in mines get so used to living underground that they do not think any more about it than we do of going into a dark cellar.

We hasten back through the smoke, which has come from the blasts, and reach the shaft. Our guide pulls a cord, which gives the engineer the signal, and we are drawn up again in the bucket.

Where the Quicksilver is Made

Who has not seen the silvery substance in the tube of a thermometer, and noticed how it rises when it grows warm and falls when the cold comes again; or, if the bulb be broken, followed with wondering eyes the glittering drops as they rolled over the floor?

This substance, so heavy and bright, which behaves so strangely, is quicksilver, or mercury. When people first discovered it they called it liquid silver, because it looked so much like silver. It is the only metal which looks like a liquid at the ordinary temperature, but there are many others which become liquid if they are put in a furnace where it is very hot.

Quicksilver is useful for many purposes. It is mixed with tin to form the coating for the backs of our mirrors. The miner uses it to collect the little particles of gold as the water carries them away. Calomel is one form of quicksilver. We may have some time taken this white powder as a medicine, and can remember how badly it made us feel.

Did you ever think that we do not get many things without working for them? The hunter has to tramp often many long miles before he finds any game. Our lessons, too, cannot be learned without hard work.

Nature treats us in the same way. She has hidden away her most precious things in the rocks, and we have to hunt long and earnestly for them. She does not give us quicksilver in the pure condition in which we see it in the thermometer, but combined with sulphur in the bright red mineral known as cinnabar.

The prospector spends his life hunting for minerals. He goes through all the mountains, and looks carefully at the many kinds of rock, and perhaps at last discovers some that contain little specks of this mineral about which we are talking, the bright red cinnabar.

Opposite the Sacramento Valley, near the summit of the Coast Ranges, there were once, many, many years ago, some great volcanoes. We all know that volcanoes are mountains out of which come smoke and ashes, and sometimes fiery masses of melted rock.

The volcanoes at last became cold, but the springs about them remained hot for a long time. Some are warm even at the present time, and are used for

bathing and drinking, as they contain substances which are valuable as medicine.

Where many of these springs run out over the surface of the ground, prospectors have found deposits of cinnabar. The cinnabar was brought up by the water from deep down in the earth, where it is so hot that the rocks are almost melted.

In this region there is a little stream called Sulphur Creek, and along it, there are many hot springs and veins of cinnabar. One large spring, in particular, comes out of the ground on a hillside facing the creek, and here some miners have dug a tunnel hundreds of feet long. We will take advantage of their work to go under the ground, and possibly we shall find something very interesting.

In the story books one goes on imaginary excursions to the center of the earth, crawls through caverns, and is let down over precipices to the edge of boiling lakes, but here we are going to take a real trip away under the ground, far from the bright sunlight, and see with our own eyes what Dame Nature, who seems never to get tired, is doing there in her hidden workshop.

Hot, steaming water runs out of the tunnel, bringing with it a current of warm, choking air, which

smells much as a lighted sulphur match. However, we need not be afraid, for the miners work here all day, although they have to come out of the tunnel once in a while for fresh air.

Before entering, we have to take off our outer clothes, for our guide, who is dressed very lightly, tells us, as the sweat pours down his face, that it is rather warm inside.

Holding a lighted candle in one hand, and in the other a little hammer to knock off specimens, we start in single file into the dark hole. On first getting inside we commence to cough, and are almost choked with the hot, stifling air, but after a time we get used to it, and manage to keep up with our guide.

We tramp on with our dim candles for some moments, passing now and then a narrow cavern, from which comes the sound of gurgling waters. At last we reach the point where the miners are at work, and we stop and look around. What wonders meet our eyes! Deep, narrow crevices lead away, until lost in the darkness, in which we imagine strange shapes, as out of them come the steam and choking vapors from the unknown regions below us.

We hear running waters in every direction. They pour from some of the openings, almost boiling hot,

and drip upon us from overhead. The walls everywhere sparkle in the light.

The hot waters are bringing up many other things besides the cinnabar, and are gradually filling up the open caverns with the most beautiful specimens. In addition to the bright red cinnabar, there is the yellow sulphur, and if we look closely, a little gold will be found in some places.

Most beautiful are the little crystals of sulphur which form from the choking vapors which we are breathing. They coat the walls, and sparkle like thousands of gems whichever way we turn.

The sweat covering our bodies, the stifling and poisonous air, the boiling water at our feet, and the sparkling walls, shutting us in on all sides, make it easy to imagine ourselves miles below the surface of the earth.

We can remain no longer, and hurry back to the fresh air of the outside world. We have had a strange trip into the earth. We have seen one of the most wonderful quicksilver mines in all the West. In most mines the water is cold, and Dame Nature is taking a rest after her work. She is waiting for new earthquakes, new volcanoes, and new hot springs.

Let us follow the ore from the mine and see what becomes of it. A little car running upon a wooden track brings it to the mouth of the tunnel. There it is put upon wagons and hauled to the mill, in the valley, where it is placed in a furnace, over a hot fire.

There it is roasted for a long time. The quicksilver is driven off in the form of invisible vapor, and passed into cool chambers, where it is condensed in the same way as the moisture from the air condenses upon a glass of cool water.

Working with quicksilver is very dangerous, for if one breathes much of the gas from the furnace, or the dust from the ore, it will slowly poison him. The Chinamen who are employed in most of the mines and about the furnaces go with moist cloths tied over their noses and mouths.

The Autobiography of a Nugget

You must not expect me to tell just how I was made, or all the things that have happened to me. You would not understand it all.

Besides, I am a little puzzled myself to know who left me in the vein of quartz. However this may be, I lay for a long time deep down in the earth, with solid rock all about me.

It seemed for a time that I was to stay there forever, but as the years went past it began to be less dark, and I could see a little daylight coming down through the cracks in the rocks above.

The frost and the raindrops were at work with their picks and shovels, breaking the rocks apart and rolling the little grains down the mountain slopes to the brooks.

The brooks were tired of flowing so fast and tumbling over the rough boulders, and they were glad to help all they could in breaking the mountains in pieces. They picked up the grains of sand, and carried

them along, but the pebbles and boulders they could only roll over and over along the bottom.

They finally ground to pieces all the pebbles but those made of quartz. This interested me, because it was the quartz which held me so tightly.

At last the rock and quartz were broken away, and I rolled out upon the surface of the ground. How different everything seemed. Now I could enjoy life. I was upon a hill upon the western slope of the Sierra Nevada Mountains, but they were not as rugged and wild as they are now.

I had heard it whispered that there was a giant inside the earth, who slept the most of the time, but when he turned over he raised the mountains, and made them tremble. However that may be, it had been a long time since the mountains had been disturbed, and the frost and the raindrops and their assistants had almost, torn them down.

They were still at work, and did not want me to lie there in their way. They were jealous of my pretty yellow color. They need not have bothered, however, for there were then no men there looking for nuggets like me.

As I lay upon the mountain side I saw some strange animals feeding upon the bushes by the river.

There was a rhinoceros, and a large camel with a hump on its back. Farther away there were other large animals, which looked like elephants. Long after, when I was brought down to San Francisco, I learned that they were mastodons.

The raindrops wanted to roll me into the brook. They washed the sand from under me, and let me go rolling down the bank. Finally, after a long time, I was tumbled into the river, and sank in a deep hole.

The river washed sand and pebbles over me. Sticks of wood and some large bones were mixed up with the sand. The bones must have belonged to one of the animals I had seen.

The river flowed over me for a long time, and buried me so deeply that I thought I would never get out again. I was not alone, however, for other nuggets were scattered through all the gravel near me. I felt proud, for I was the largest of them all.

All this time the raindrops were bringing the little pieces of rock to the streams, and the streams were carrying them away to the sea. The mountains, after a long time, became so low that it did not rain so much upon them. Then the rivers became smaller. Their work was nearly done.

At last something happened within the earth, and volcanoes were formed. They blew out steam and ashes and chunks of lava. There were lightnings and heavy showers. The falling water washed the mud and pieces of lava from the sides of the volcanoes and into the rivers. The rivers could not carry it all down to the Sacramento Valley, and so their channels were piled full.

As a result of all this, I was buried many feet deeper.

After that the earth about me became very cold, and I concluded that the river above me was frozen. The cold continued for a long time, and when it went away it rained a great deal, and the river rose and swept along noisily.

The lava boulders and gravel which had been washed over me had by this time become cemented, so that the water could not carry it away. Then it went to work and washed out a new channel where the rock was softer. At this behavior of the river I lost all hope of ever getting out again.

For a long time the river kept digging its new channel deeper. It at last made a canyon more than one thousand feet deep, and I was left on what was now a high hill.

When the world had become ever so much older, and many more things had happened, some men came walking along on the ridge under which I lay buried. They had pans and a pick, and would here and there dig up some of the gravel and carry it to a little creek. There they carefully washed it, to see if there were any little particles of gold in it.

If that was what they were looking for, I could give them a great deal. But they could not see me hidden so far below. After they had prospected at different places on the hill, they found enough gold to satisfy them, and then went to work to run a stream of water over the gravel. They wanted to wash it away so as to get at the gold.

The men built a reservoir, and laid a pipe from it to the place where they wanted to wash the gravel. Then they made some long boxes, called sluices, with little cross bars in the bottom, to catch the gold when the water carried the gravel through the boxes.

When all was ready, they turned the water into the pipe. With what force it flew from the nozzle. It looked like a stream from a fire engine, only it was larger and much more powerful.

The men turned the stream against the bank of gravel, and it tore it down very fast. The gray boulders

were rolled around as though they were little pebbles. As fast as the water washed the gravel down, it was carried through the sluices where the gold was caught.

When they reached the bottom of the gravel they found what the miners call the bedrock. This is the rock over which the old stream flowed so long before. In the crevices of the bed-rock they found nuggets as large as walnuts, and felt very well satisfied.

What a surprise was in store for the miners who had worked so long. One day the stream of water washed the gravel from around me, and with a rush of the muddy water I rolled out of the gravel bank. How they rejoiced at the great yellow nugget.

I was so heavy that it was all one of them could do to carry me. After being admired for a long time I was put in a safe place. Every little while, however, they could not resist coming to look at me.

They said I was worth many thousands of dollars. I was taken down to San Francisco and placed in a window, but with heavy bars around me, to keep people from carrying me away.

This is my story. I had an interesting life. My end, however, was a sad one. I was sent to the mint and melted down, and made into many different pieces, which people carried around in their pockets.

Coal, Graphite, Diamond

Can we think of three things which are apparently so very unlike? The first is a piece of coal, which is burning brightly in the grate. The second is the black lead, or graphite, in my pencil. The third is a clear, sparkling diamond in my ring. Although they seem to have nothing in common, yet they are all formed of the same substance. This substance is called carbon, and it came from the plants which lived upon the earth a long time ago.

Graphite and diamond are pure carbon. Coal is not pure, for it gives off a suffocating gas when it is burning, and leaves some ashes. Does it not seem strange that the diamond, which is the hardest of all minerals, and which shines with such a beautiful luster, is made of the same substance as the dirty black soot which comes from the coal, and lodges in the chimneys?

The graphite is black, like coal, but otherwise, it is quite different. It does not burn, if placed in the fire, and for this reason it is used for crucibles to melt other

minerals in. It is soft and greasy, and besides being used for pencils, is valuable for lubricating machinery.

It will be interesting to know how each of these three minerals was made. We will study the coal first, because the others have been made from it.

We all know what swamps are. Perhaps, in trying to go through them, we have gotten into the brush, and have been scratched and tumbled into the water. In such places, the vegetation grows very thickly. The leaves, twigs, and trunks of the trees, when they fall, are partly buried in the mud and water, and so, when they decay, cannot dry up and blow away as they would in the open air. Year after year the dead vegetation accumulates, until a bed a number of feet thick is formed.

Now, if something should happen to the brook which flows through the swamp, and the water should become dammed up, the swamp would be turned into a lake, and the bushes and trees would be killed.

When the brook was high, mud and sand would be washed into the lake, and the old swamp would be deeply buried. This is the way in which the beds of coal originated. In some coal beds, miners have found the stumps of trees still standing where they grew, and impressions in the mud of pretty leaves and ferns.

After the vegetation in the swamp has been buried, it still takes a long time for it to be made into true coal. In some parts of the country, vegetation is now collecting in swampy places, which will some time make coal, if it is buried and preserved long enough.

The most of our coal beds were formed so long ago that we can have no real idea of the time. The surface of the earth was very different, and the fruit-bearing trees, and higher animals, as well as man, had not yet come upon the earth.

The climate of a large part of the earth must have been warm, and like that in the tropics at the present time. The ancient swamps, of which we are speaking, contained luxuriant growths of palms, tree-ferns, lepidodendrons, and many other plants.

After the swamps had lasted a long time, the earth's surface would sometimes sink, and permit them to be covered by mud and sand, either from a river or ocean. As the years passed, they would become so deeply buried and pressed upon by the earth over them, that the vegetable matter would change its appearance, and there would at last result a layer of black shining coal.

Years passed, and some new earthquake raised the beds of coal, and the layers of sand and clay, high in

the air, until they formed mountains. When people came they discovered the seams of this black substance sticking out of the sides of the mountains, or in the canyons. They found that it would burn, and were made very happy, for in some parts of the earth there are few trees which can be used for fuel.

All they had to do to get the coal, which showed upon the mountain sides, was to dig it out; but in some places, Nature did not uncover it, and they had to sink shafts hundreds of feet deep in order to get what they wanted.

We cannot tell how much of the heat of the sun is stored in the coal beds. We know that it must be a very large amount, for the rays of the sun were necessary to make the plants grow from which the coal was made. Some people have called coal solidified sunlight. We are not sorry that Nature has preserved the vegetation of the swamps which were upon the earth so long ago. It is pleasant to think that she did it for our especial benefit, but it may be that she would have done it just the same if we had no use for it.

There are many different kinds of coal. That which was made last is the poorest. It is called lignite, because it is nearest wood in its appearance.

Coal which is older, and contains more carbon, is called bituminous. The best coal is found in the rocks which have been heated and squeezed the most. This coal is called anthracite, and is almost pure carbon. The soot which coal leaves when it burns, is formed of little particles of carbon which were not burned.

Lignite and bituminous coal are both found upon the Pacific Coast. Nature has placed in the rocks of California, so many different kinds of minerals, that when it came to the coal she must have got tired, for there is not a great deal here. There were, probably, not many swampy places in this region for the coal-forming vegetation to grow in. Coal, in greater or less quantities, is found in nearly all parts of the world. The whalers have discovered it far north of the Arctic Circle.

Now let us see what the connection is between coal and the black lead of our pencils. Black lead, or graphite, is formed from coal. When coal is heated far below the surface of the earth, where there is no air to permit it to burn, it is changed to graphite. Ice does not seem at all like water, although it is only water under a different form. Thus it is with graphite, which is the carbon of the pure anthracite coal under a different form.

Now we come to the diamond. It hardly seems possible that this sparkling gem is made of the same substance as graphite.

When the diamond is heated very hot it disappears in the form of invisible carbonic acid gas. This is the deadly gas which comes from coal when it is burning. Our breath, as it comes from our lungs, is also laden with this gas.

Like the graphite, the clear diamonds were made deep in the earth, where it is very hot. The carbon came up through the rocks as an invisible gas, and condensed in little cavities, thus forming the beautiful diamond crystals.

You can understand how this was done by placing a small pinch of sulphur in one end of a glass tube, and heating it. The sulphur will be driven away as invisible gas, and condense again in little crystals in the cool part of the tube.

Diamonds have been made artificially upon the sides of furnaces where there was very great heat. These diamonds are no larger than a pinhead, and are not fit for jewelry. Nature makes the crystals of diamond as large as a robin's egg. They have shining faces upon them, but have to be cut and polished before they show all their beauty.

The most of our diamonds come from Africa and Brazil. A few have been found in California in the gold-bearing gravels of the placer mines. We sometimes hear people speak of California diamonds. They generally refer to clear little crystals of quartz, and not to real diamonds.

The Earth in Past Ages

By

Sophie Bledsoe Herrick

Chapter I

What is Geology?

Geology is the history of the earth and of the various kinds of plants and races of animals that have lived upon it. This history is not written in books—there were no human beings living to write them—but it is recorded upon the rocks in various ways. In places sand rippled by the tide has been covered over and preserved till it has hardened into stone. This is just as plain a story of some far-off day when a sandy beach lay along the sea and the incoming water threw it into ridges, such as you may see upon our seacoast today, as if someone had seen it and written down a description of what he saw. In other places a piece of sandstone is pitted with holes made by a pelting rain. It does not need any written word to tell us when we find such a bit of rock that there were rainstorms in those days. Here rocks are tilted up and broken, showing some great force underneath; and there they are rounded and worn, showing the action of water or ice. In the midst of a mass of rock laid open by the blow of a hammer we find delicate seaweed, with every marking on the leaves as plain as if they had been pressed; or we may find in such a layer of rock

laid open an exquisite shell or starfish. What need do we have of words to tell us that when that rock was only a sandy sea-bottom these plants and animals had sunk in the water, were covered over by new settlings of sand, and so preserved as you might preserve a shell in plaster of Paris, and that the sand had afterwards turned into sandstone?

There is this one thing that the world has learned very slowly to do, and that is to look honestly at nature to see what is there, and then to use their common-sense in finding out the true meaning of what is seen.

In the land of Egypt, for thousands of years, there have been lying, half-buried in the sand, curious rocks, and temples covered all over with markings that no one could read. Tall monoliths, with strange characters carved upon them, pierced the blue and rainless air, offering their riddle to be guessed, but no one was able to read it. If you ever go to the Central Park in New York, you will see one of these monoliths, called Cleopatra's Needle, that stood for thousands of years in Egypt unread. Less than a hundred years ago a Frenchman named Champollion made a study of these signs. He worked long over them, and by the aid of a famous stone called the Rosetta Stone, which had upon it an inscription in three different languages, he discovered the clue to the signs on the stones, and at

last could read them; and from what he found there he was able to write a history of the past in Egypt in a language that can easily be read.

In the same way these other strange writings upon the rocks, the shells and leaves and bones, left there by a lifelong passed away, had been noticed and thought queer, but had never been interpreted. Ovid, a Roman poet who lived in the days of Christ, tells us that he had seen shells on the mountain-tops, and land made by the action of the sea. The first person who ever gave to the world a true explanation of these things was the great painter Leonardo da Vinci. He lived four hundred years ago, and you have probably seen some engravings from his celebrated paintings, "The Last Supper" and "Mona Lisa." A hundred years later another artist, Bernard Palissy, published a book in which he said that the "figured stones," as he called them, were the remains of beings that had once been alive and had been preserved in the sea-bottom. It is rather curious that these two men were not men of science. They were artists, who had trained their eyes to see and their minds to think about what they saw. For two centuries after this clue was offered them, the so-called men of science went groping about in the darkness, making foolish guesses and still more foolish arguments.

Other people since the days of Ovid have found seashells upon the tops of mountains, and have explained their presence in various ways. For a long time the Deluge was made to account for anything out of place in creation. When the shells and sea-plants and animal skeletons were buried under hundreds of feet of rock, the Deluge was given up, and other ideas were adopted.

In Greece, elephants' bones were supposed to be the bones of their old heroes; and Ajax, one of the warriors whom Homer tells about, was calculated, from a fossil knee-bone, to have been twenty feet high. The early history of all nations is full of stories of dragons and giants and terrible monsters. These stories probably rose from the finding of immense or curious bones unlike those of any animal living at the time.

After these stories and legends came to be doubted, the bones still were there to be accounted for. Some writers called them "freaks of nature." One brought forward a very queer idea; he said that before God created the animals, he made a great many models and stored them in the earth (as models of machines are stored in the Patent Office at Washington). Among these models are as many "failures" as among the patents, apparently, for they

were never followed by living animals. Of the shells found far away from water, it was said, as late as a century ago, that they had been brought from Rome or the Holy Land by pilgrims, and dropped far inland or on the tops of mountain-peaks.

But the world was not to be hoodwinked forever by such foolish suppositions. As the facts became more and more in number, the common-sense view of the subject grew, and this nonsense became less believed. It was quite two hundred years after Leonardo had explained the meaning of fossils before the world generally accepted his explanations and learned to read the riddle of the earth aright.

Geology is not an old science. It is scarcely one hundred years old today. And some things are still unsettled and others unknown; but there are many things which are perfectly fixed and known, and about the rest we are learning every day.

What I want you especially to bear in mind is, that the causes which in the past have built up the crust of the earth, and have formed its continents and islands, systems of lakes and systems of mountains, are the very same that are working like changes now. Apart from the work of man, they are the same, though less violent, as time goes on. If you use your eyes, you can

often see yourself these causes at work the gradual washing away of land by the action of water, the crumbling of rock by the action of ice; and in parts of the world new islands have been thrown up by volcanoes, and new land formed at river-mouths. These you may not see, but they are going on now, and you may read the accounts written by people who have seen them.

In order that you may understand geology, I am going to try to show you the things that are happening now by means of the same forces that fashioned the crust of the earth, for a great distance down, in the past. The forces that raised up our continents out of the depths of the sea, that built our mountain-chains, hollowed out the beds of our lakes, ploughed the channels of our rivers, and built up layer upon layer our solid beds of rock, and then wore them down into powdered rock or earth on which the plants and trees can grow and animal creation live these forces in geologic times were what they are now, stronger and fiercer in the new-born earth, perhaps, but the same. And as we go along studying our present earth and its changes, we will look back to the past, and try to interpret the unknown by the known.

Chapter II
The Clue Found in the Rocks.

More than sixty years ago there lived in a fishing town on the north-eastern coast of Scotland a boy who afterwards became a very famous man. When he was only five years old, his father, who was a sailor, was lost at sea. His mother, though very poor, managed to send little Hugh to school, and there he learned a good deal from books; but if he had learned no more than to read and to write, he would probably have still been a great man, for in the meantime he had found something else worth more to him than many books. He had learned to read another language. He had found out that he had two eyes, and how to use them. The rocks about the Firth of Cromarty were waiting for just such a pair of eyes to read their open secrets. Thousands of boys had played about those rocks, and thousands of men had fished and spread their nets and loitered there, but no one of them all had read the writing on the stones till Hugh Miller came.

The boy used to go down to the beach with his uncle Sandy when the tide was low, and look at the ripples left in the sand by the water. He would gather

shells, half buried in the sand, and seaweed lying upon it. His uncle had eyes that saw, too—it seemed to run in the family—and he helped little Hugh to see the wonderful life of the sea-shore, and to think about what he saw. These lessons, far more than anything he had read in books, helped him in after-life, though he was a great reader of books too.

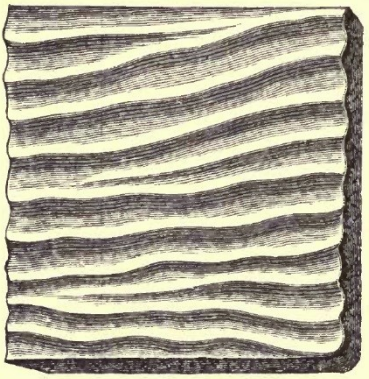


Fig. 1.—Slab of Ripple-marked Sandstone.
From Lyell's "Elements of Geology."

When Hugh grew to be a tall, lanky boy he chose his work in life; he chose to be a mason. His work lay in a quarry near Cromarty, close by his beloved sea. One day, as the men were lifting up the great slabs of sandstone, Hugh saw some markings on the piece of rock laid bare. These were the old familiar ripple-marks in the solid stone just such marks as he had often seen on the sandy beach (Fig. 1). He did not say, "How strange!" and then forget all about it. He began to think, and ask himself questions. Could it be that this was an old sea-beach?

How could it be, under those tons and tons of solid rock? The answer came to his questions after a while.

Strewn along the water's edge, washed up by the waves, were curious roundish pieces of limestone rock.

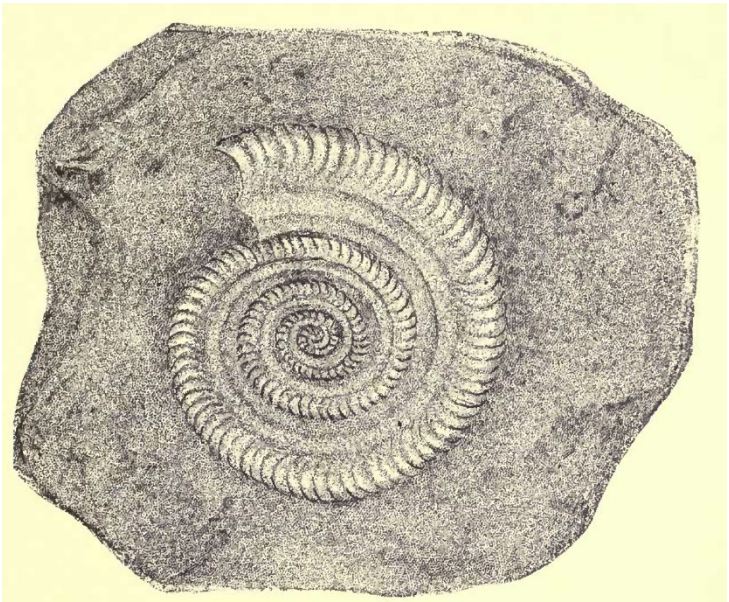


Fig. 2.—Shell in the Rock (*Ammonite*).

One day, hammer in hand, Hugh strolled along the beach. He struck one of these lumps, and it broke open, showing embedded in part of the stone a creamy-white shell, beautifully carved, and showing tints of color like the pearly lining of many of our shells. Another and another of these stones were broken open (Fig. 2). In some of them he found scales of fish; in others, fern-leaves (Fig. 3); in others, again, bits of decayed wood all in solid stone.



Fig. 3.—Fern-leaf in Stone.

Now he could answer his questions. These things had once been alive. He had spelled out one word from the tables of stone written upon by the finger of God himself. He had found the clue in the rocks, and he never rested until he had followed up this clue, and found, by examining the rocks themselves, and by reading about what other men had discovered, how the earth as it is had come into being.

If you have never carefully looked at the rocks of a railway-cutting as your car went through it, be sure that you do so the very first chance that you have. You will probably see that the rocks are in layers.

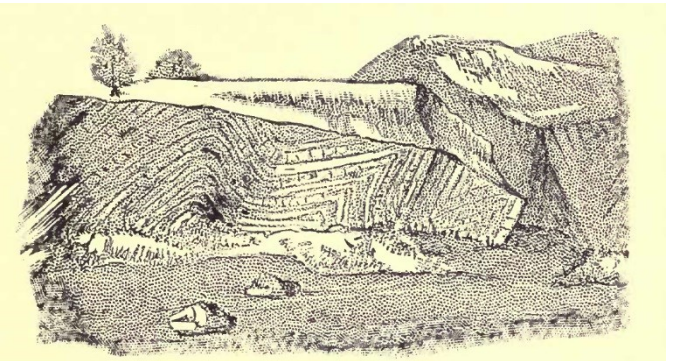


Fig. 4.—Tilted Layers in the Rock.

Sometimes these lie level with the ground; sometimes they are very much bent or tilted (Fig. 4).

To understand how these came to be so, we must understand some things which are very simple, but yet they are things that we would not naturally think of. What we call earth, or soil, is only rock finely powdered, mixed up with some of the dust from the dried parts of dead plants and animals. Earth is to rock about what the pulverized sugar you sprinkle over your berries is to the block-sugar your mother drops into your tea.

The surface of the earth was once rock which had no layers in it, like granite. Part of the round globe was covered with water, and a little of it was dry land. The beating of this old ocean's waves, the rain, the air, all helped to grind the rock to powder, and with it muddy the sea-water. Take a tumbler of water, and into it drop a teaspoonful of finely ground earth. Your muddy water is something like the sea-water was then. Now watch, and you will see what happened. The fine-powdered rock settled in the bottom of the sea-bed as the earth settles in your tumbler, and the first layer was made. Layer after layer was formed in this way. After a while "the spirit of God moved upon the face of the waters." A feeble life stirred in the bottom of the sea. Some very simple animals lived there, and

we can find the curious shells in which they lived in those deep-down rocks. We know that plants must have come first, because plants are the only fairies that can turn rock and earth and water into the food that all animals need to feed upon; but the soft, delicate sea-weed had died and left no sign. The early animals, however, had hard, glassy shells, and when they died these shells sank to the bottom of the sea, and the next layer of powdered rock settled over them and preserved them some of them until now.

You can see how this would be, and that when we lay open the rocks, as Hugh Miller did with his hammer, we might find the shells. Here is a drawing of a bit of such earth that was turned into stone, with its corals and shell lying thick in the layer, which is half broken away (Fig. 5). This was picked up just below my house, on the shores of Newark Bay.

The work went on through thousands of years, the sea laying one upon another these wonderful beds of rock of different kinds. All this was not an adding to what already existed, but only a new arrangement, with some change in the character of the old materials already there. How this great earth came to be is one of the secret things of God. The Bible begins with, "In the beginning God created the heavens and the earth." That is all we know. A guess here and there has

been made as to how it was done, but no one knows, and no one probably ever will know.

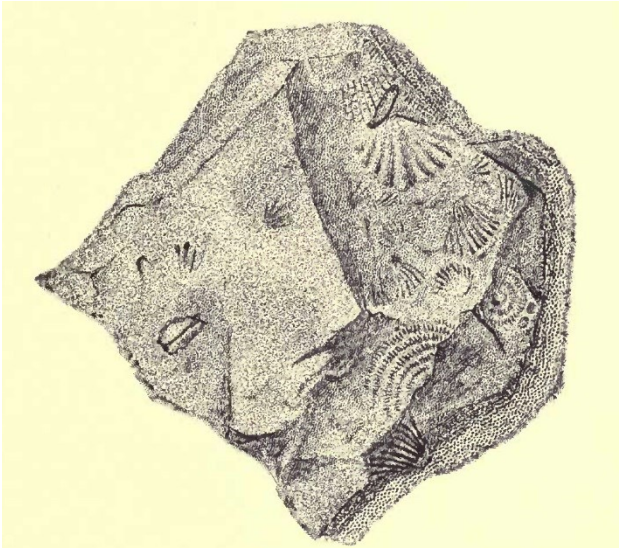


Fig. 5.—Shells in Broken Rock.

But we can tell the way the crust of layers was put on, because we can watch the same things going on now which went on thousands and thousands of years ago. At the bottoms of shallow seas and lakes, at the mouths of rivers, in the coral islands of the Pacific, the earth is still a-building.

About a hundred years ago men began to be interested in these strange things found in the stones. They hunted up pieces of such stone, and wrote out all they could find about it. They arranged the facts,

and called the new science geology, or the science of the earth.

It is very easy to see that if the seas had stayed all the while in the same place, with no disturbance going on, that the layers would have settled one on top of the other, according to age, the oldest being the lowest, and so on up. But you must remember that the earth was then, as it is now, part dry land and part water, though there was much less land in proportion then than there is now. It was only under water that the layers were formed. But there were other things at work besides this gentle wearing away of the rocks and building up of the sea-bottoms.

Long ago people believed that under the volcano of Ætna, on the island of Sicily, a giant was imprisoned, and that the trembling and cracking of the earth before an eruption were his struggles to get free. This had a meaning in fact, though it was only a fable. Under the whole earth the giant fire has been imprisoned. When the crust of the earth was thinner than it is now, the giant's struggles cracked and bent it; sometimes the bottom of the sea would be suddenly lifted up, and the dry land would sink and be covered with the waters of the ocean (Fig. 6). On the left side of the picture are the level layers of rock, broken up so that they look like a stone wall. After a

while we will see just why these are so broken. On the right-hand side you see the layers are lifted up by the

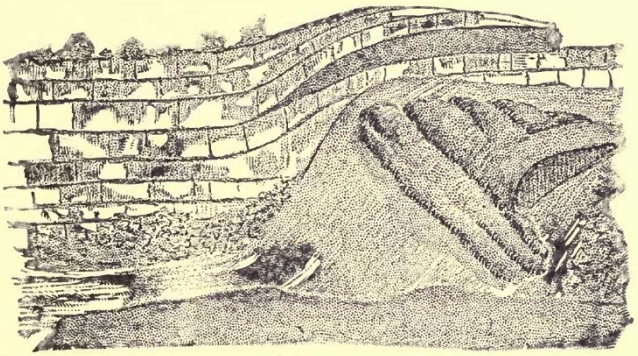


Fig. 6.—Level and Lifted Layers.

curious, curly-looking rock which boiled up out of the earth beneath as lava comes out of a volcano. Whichever part of the earth happened to be under the water would be covered up with layers of mud, and in them plants and shells, fish and animals, would be buried, and their hard parts preserved. The other part, the dry land, would not be very much changed; the plants and animals there would die, and mostly be blown away as dust.

This history of the earth written upon the rocks, you can see, is not a very easy history to read. Its leaves were all scattered and torn and twisted, and the writing on them often rubbed out, and many of them lost. It had to be gone over again and again, in many different places and by many different men, before

these stone leaves could be put together in the right order.

If these layers, or strata, as they are called, had remained just as they were placed, there would have been no way to reach them but to dig down to them, for twenty miles in some places, and that would have been impossible: nobody has ever been down, in the deepest mine, more than a mile. But the movements of the earth's surface, caused by the struggling fire underneath, would tilt and break through the layers, and so the broken edges would be on the surface (Fig. 6), and the geologist could in places study the very bottom layers without digging down to them.

Chapter III
Water

Geology has nothing to tell us about how the great mass of the earth was first created. There have been many guesses, but they have never been proved to be correct ones. What we hope to find out by studying geology is how the surface of our earth came to be as it now is, with its seas and continents, mountains and lakes, rocky peaks and sandy deserts. This was the work of the same forces still busy in changing the face of the earth the air above, the water on the surface, and the fires under the earth. So we will only go back to the time when the earth was a rocky globe, intensely hot inside, and covered with a universal sea, when the earth, as it moved round the sun, might be compared to a mighty drop of dew moving round a globe of glowing fire. We must get rid of all our notions of the world as it is now in order to go back in imagination to that time. The earth was not beautiful then, the land was not adorned with trees and grass and lovely flowers, the air was not full of humming insects or swift-flying birds, nor the waters of darting fish and delicate floating sea-weed. It was a desolate waste of waters, a shoreless sea, whose tides, instead of rising

and falling and breaking upon some sandy beach, followed the moon, sweeping unbrokenly around the globe. There were no blue skies overarching the wide waters, no fleecy clouds turning to gold in the sunsets. A heavy mass of leaden clouds covered the sky, and poured down into the hot seas hot rain-water day and night.

The only things in the world then were rocks and water, fire and air. But as the earth cooled, these forces, the moving water, the fire and the air, went to work and began building the continents and islands, and dividing up the waters into seas and rivers and lakes.

First came the fire and lifted up part of the earth's crust in its struggles; another part of the crust would go down, and into these low valleys the waters would collect, leaving the high, bare rocks standing up out of the sea. In this same way many islands and continents arose out of the sea. Next came the turn of the air in the work of world-building. The air around the earth then was like the air now, only that it had a great deal more moisture in it, and the gas that comes from burning--called carbonic acid gas--than our air has. Such air as this has a very peculiar effect upon some sorts of rock: it slowly dissolves them; the waves of the sea, or the rivers pouring over the rocks, soon carry

this dissolved rock, or earth, as it really is, away, and finally it settles in the ocean, forming layers of soil, which after a while become solid rock again. Then again these layers are uplifted, and again they become rotted partly away, carried off, and deposited. This is not mere guess-work. The world is not done yet; it is still a-making; just the very same things are happening now in various parts of the world as went on of old.

Islands have suddenly risen out of the sea, and men have seen them. At the mouths of great rivers and in the bottoms of ponds land is forming all the while. In some places, on the dry land, rock where it stands is rotted into earth, and gradually washed away by the rain; and where the weather is cold enough to freeze, this work goes on faster still. When you have an opportunity to examine a piece of brown stone, used so much to build houses of, or as facings to brick houses, look carefully at it. You will be apt to find that there are on the surface loose flakes which you can rub away with your finger. Brown stone is full of little cracks and crevices and openings the water soaks into these, and when it freezes it pries off the piece of stone above it; the ice, taking more room than the water, acts as a wedge. When the earth became cool enough to permit the rain to freeze, the rocks were in this way more quickly reduced to earth.

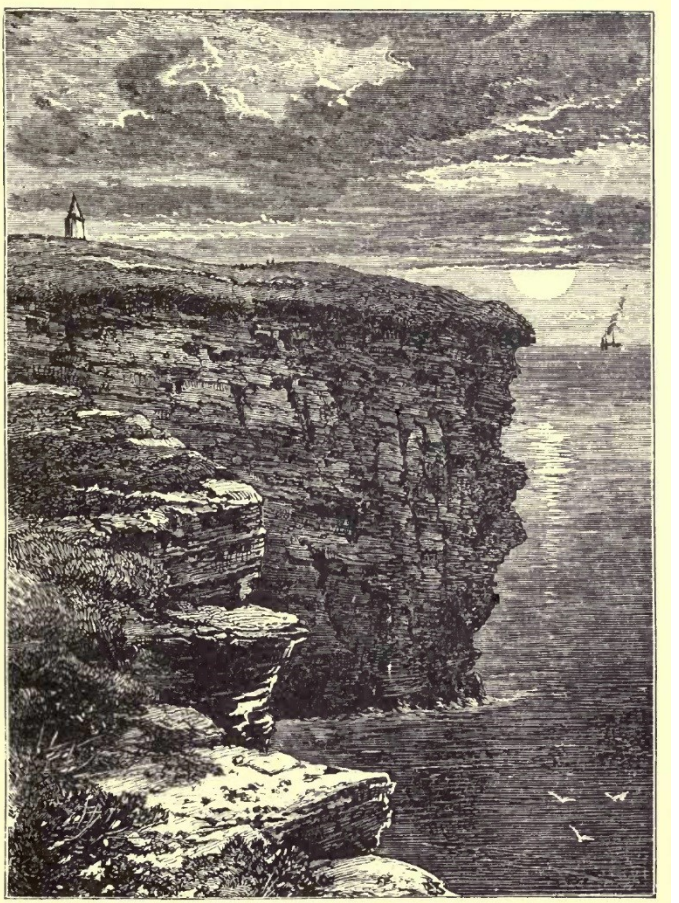


Fig. 7.—Stratified Rock Cliffs at Brough.

Just the same things went on in those days that go on now, only they were more violent. The cool crust of the earth was thinner; the inner fire, therefore, oftener succeeded in breaking its way out; the earth was more shaken; its crust was more torn and crumpled. There were, of course, more earthquakes, a

larger number of volcanoes, and greater quantities of rain fell into wider seas.

See the picture of the Rocks at Brough. These cliffs have been slowly deposited in layers, and then lifted up by the fire, tilted as you see, as they were raised, and then again they have been worn away by the waters. In one place an archway has been made directly through them.

When the layered rock is lifted up, it is of course very much strained and cracked; the water gets into these cracks, and so does its work much faster. The Clett (Fig. 8) is a single pillar of layered rock standing up in the sea. The layers in this rock correspond exactly to those on the cliff nearby, showing that it was once part of a great cliff reaching out into the sea.

Water does some very wonderful things when it falls over a precipice, and so makes a cataract. At Niagara the waters of the great lakes on their way to the sea fall over a high precipice of rock. This precipice is made of very hard rock on the top, while the layers underneath are much softer. The boiling of the waters, after tumbling over the high cliff, gradually wears away the softer rock below, then the upper layers stand out like a shelf, and over this the water falls. The rush and strain finally crack off the



Fig. 8.—The Cleit, Holborn Head, Scotland.

projecting shelf, and it breaks and falls; then again the softer rock is hollowed out; another shelf forms and is broken away. In this way the water-fall has worked its way backward for seven miles, as the rocks on each side of Niagara River show.

Great rivers like the Mississippi wash up earth where they flow swiftly from high land to low land; when they come to a more level country they "slow up," and begin to drop the earth. Anything which makes the current run slower causes this sort of a deposit. Where two currents meet, as where the Ohio flows into the Mississippi, the two jostling together hinder each other, and in the contest earth is dropped, and a sand-bar is formed, making the river very shallow there. No matter how many times such a bar is removed, it comes again. Where the Mississippi empties into the Gulf the current spreads out, and so slows very much, and a great deal of earth is dropped. The jetties made by Captain Eads, of which you have probably heard, are banks built into the Gulf to carry the river currents swiftly out into the deep water, and there allow the earth to be dropped where it will not make the channel too shallow for ships to pass through easily.

Some rivers in India have built up their beds by dropping earth in this way all along through the low plains, until the bottom of the river's bed is higher than the country around. When the river overflows its banks, the fields beyond the high bed are flooded. Then, when the river sinks again, the water cannot get

back into the channel, and it lies on the fields and kills the crop.

Certain kinds of rocks are more easily dissolved by water and carbonic acid than others. When layers of different kinds of rock are exposed to the air, they crumble away very unevenly, and so make curious-shaped rocks, sometimes standing up like monuments in the sea or on land.

In rocks which are not dissolved in this way the water sinks into the cracks and flows away, doing very little work; but in limestone rocks, which the water does dissolve, the crack is washed larger and larger, till a cave is hollowed out in the solid stone down under the surface of the ground. The water goes on trickling and dripping from the roofs of these caves, and decorates them just as the freezing water in winter decorates the edge of your portico roof with icicles. I am sure you have often watched icicles form. As the rain fell from the roof, drip, drip, drip, each little drop left a little bit of itself behind frozen, and so an icicle gradually grew from these many drops.

But perhaps you were too busy looking at the sky to see if it were going to clear, to notice what happened underneath the icicle on the portico steps or the ground. There each drop left a little of itself

again before running away, and a heap of ice was formed. Now, in the limestone caves just this sort of

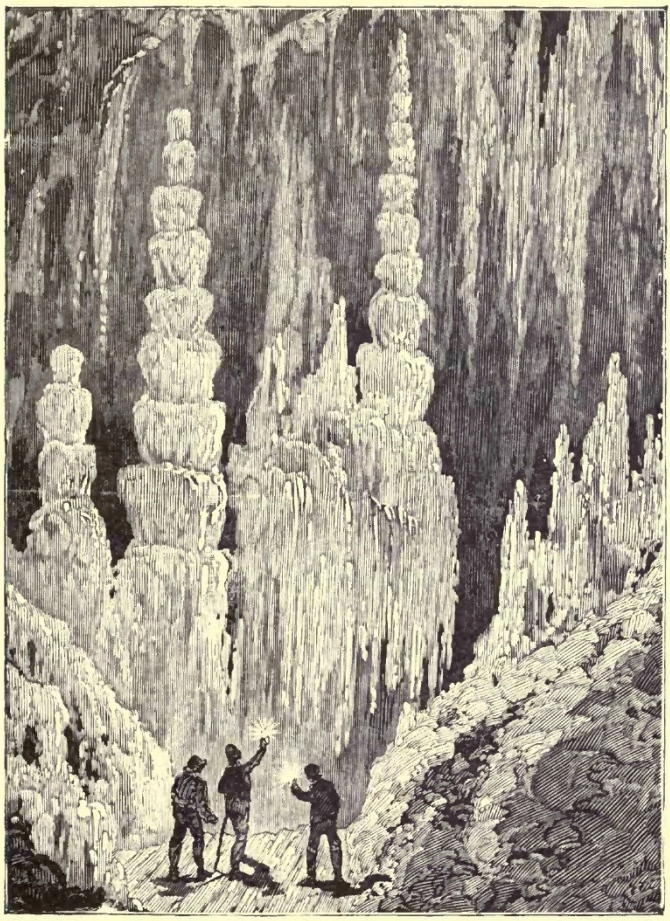


Fig. 9.—"The Cathedral," Luray Caves, Virginia.

thing happens. The water, instead of leaving a little of itself frozen behind, leaves a little of the limestone that

was dissolved in it behind, and great stone icicles are formed, which never melt. These are called stalactites, and below them the mounds of stone grow up, often far finer than the stalactites. The stalactite from above and the heap, or stalagmite, below often meet, and so form a pillar from floor to roof. Some of the best examples of these formations are found in the Luray Caves, Virginia (Fig. 9).

These limestone caves are sometimes so near the surface of the ground that the roof gives way, broken in by the roots of a tree, and down goes the living tree into a great hole in the earth. These are very common in the limestone section of Kentucky, and go by the name of sink-holes. In the "Western country some of the rivers rush into such openings, and run underground for miles through cavern after cavern; these are called lost rivers; but far away, perhaps, the same river comes to light again, though it is not always recognized as the same.

Chapter IV

The Reign of Fire

You remember that besides the water and the air that helped to fashion our beautiful earth out of the globe of rock covered by a heated ocean which existed in the past, another force has been mentioned fire. Fire is still working day and night in changing the world, but it is mostly underground.

Air and water are as much levelers as they are builders. If only these two forces had been at work, the mountains would gradually have been brought low, and the valleys exalted, till finally every rock and island would have been worn down and buried in the depths of the sea. The world would have returned to the condition it had been in thousands of years before, only it would have become cooler.

But the internal fires were there to upset all this gradual change. They were never at rest. Again and again the sea-bottom was lifted up and became dry land, and the waters gathered together in new hollows.

Miners who go down into the earth for coal and iron find, after a certain distance, that it grows steadily warmer and warmer as they descend. If the heat of the earth goes on increasing at this rate, at thirty miles below the surface of the earth the heat would be so intense as to melt even iron or stone. As a matter of fact, things melt a great deal more easily when they are open to the air than when they are under pressure. Down deep in the earth the pressure of the rocks above is tremendous, and this gets heavier the deeper it is. So there is a battle between the heat and the pressure down deep in the earth, and whether the rocks there are melted or solid depends on which is the stronger. Some people think that all but a thin shell over the outside of the world is red-hot liquid; others think it is hot enough to be liquid, but that the pressure keeps it solid. However this may be, whenever, from any cause, the pressure is sufficiently lightened, the melted stone and cinders and steam come rushing out. Volcanoes are the chimneys by which they escape.

The cool crust of the earth is a great deal thinner in proportion to the rest of the globe than an eggshell is to the egg. In old geologic times the shell was thinner even than it is now. The fires then worked wonderful changes, the same in kind as they are

working now, but much greater. The earth's crust—made of many layers of different kinds deposited by the water—was crumpled and torn and twisted in a most remarkable way.

The struggles of the internal fires often produce a sound and shaking—an earthquake. Suppose you were to lower a can of gunpowder (sealed up tight, and so arranged that it would go off in half an hour) into a pond. When the powder took fire it would explode, and as soon as the commotion reached the top of the water a wave would spread out from the point above the explosion. An earthquake is such an explosion, only it is underground; the earth is thrown into waves, but instead of rocking and moving off as the water does, the ground, being solid, is torn and broken, and if the shock is severe, houses are thrown down and people destroyed. Sometimes things are thrown straight up into the air by an earthquake shock; at other times they are shaken backward and forward till they fall in ruins. The movement of the earth during a shock is at times a curious, twisting motion, which has been known to turn pieces of furniture around so that their faces were to the wall. Rows of trees have been found all twisted out of line, though still growing, after such a shock. We are apt to think of earthquakes as being very rare, and so they are

with us; but in hot countries they are so common that it is probable that some part of the earth is quaking all the time.

Sometimes, when the shock is not very severe, the earth cracks underneath, but the cracks do not quite come through. The melted stone then pours up and fills the cracks (Fig. 10), and hardens there. The intense heat of the melted stone often changes the rock through which it flows. Limestone, which is a rather soft stone made up largely of shells, is turned into marble in this way. Marble, then, is merely "cooked" limestone.

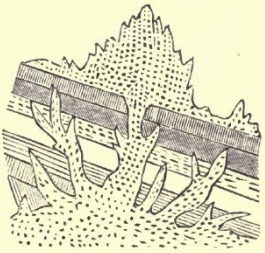


Fig. 10.—Rock Veins.
From Hooker's "Mineralogy and Geology."

In Fig. 11 you see a cut through a part of the earth's surface. At first, underneath all, was the melted stone; over this formed the layered rocks. Then the melted stone rose up, lifting the layers S S as it rose.

As time went on, the air and water washed the layers from the top of the mountain, leaving it bare (A). After a while an earthquake cracked the earth, and more melted rock poured up. At B the cracks only reached part of the way up, and the lava, after rising to

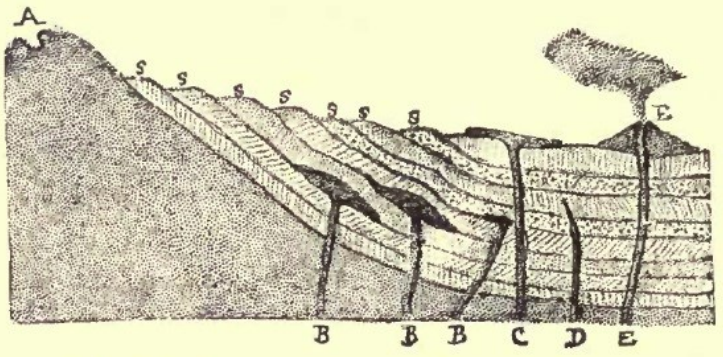


Fig. 11.—Section of the Earth's Crust.

the top of the crack, spread out between two layers. At C it reached the top and flowed over the ground, making a solid slab of volcanic rock on top of the layered rock. At E the lava came out with such a rush that it built up a little volcano there.

Very often, when one stone is melted in this way, the crystals of another kind of mineral are enclosed in it (Fig. 12). Here is another curious stone made by the



Fig. 12.—White Crystals of Feldspar.

From Lyell's "Geology."



Fig. 13.—Scoriaceous Lava.

From Lyell's "Geology."

fire. The lava cooled full of bubbles, and with these holes another mineral collected and hardened, as plaster of Paris fills a mould into which it is poured.

The molds were made by fire, though it was a dissolved and not a melted mineral which filled them (Fig. 13).

A volcano, you know, is a mountain that sends out burning gases and lava and cinders. It is usually a high peak with a cup-like depression in the top, called a crater. The volcanoes of the world are found almost always near the sea, and nearly three-quarters of them are situated upon islands.

If you have a globe—or if you have not, a map of the world—put your finger on Terra del Fuego (the land of fire), at the very southern part of South America, then run it along the western coast of the two continents—the Andes and the Rocky Mountains being your guide—till you get to Alaska, where Asia and America almost touch; pass over to the Aleutian Islands and down by way of islands across the Indian and Pacific oceans back to Terra del Fuego again.

Your finger will have passed over most of the large volcanoes in the world. It is as if the earth's crust were cracked all around in this irregular line, that the

mountain-chains were the raised edges of this crack, and that the crack gave way every now and then, and through the broken places melted stone and gas and flames rushed out.

Some of the grandest volcanoes in the world are in the Pacific islands. One of the Sandwich(Hawaiian) Islands is nothing but an immense volcano with three craters. The island has been built up by the outpouring of lava, which gradually lifted it, craters and all, out of the sea. One of these craters, Mount Kilauea, is an immense wide pit, large enough to hold a city. The rocky plain at the bottom of the pit, when there is an eruption, breaks up and fills with lava. It is a wonderful sight to see these great lakes of red-hot melted stone boiling and bubbling like a great pot of boiling water, and the red-hot waves beating against the rocky shore, and spurting fountains of fire rising up here and there. In one eruption the weight of the lava was so great that it broke through the side of the crater, and ran down a river of living fire to the sea. When it met the water, great clouds of hissing steam spouted up, carrying the cooled and shattered lava with it.

The lava in Kilauea is often like clear glass, and when the bubbles burst in the boiling lake it is drawn out into fine spun glass, which the wind collects in

sheltered spots. The Sandwich Islanders used to call it Pele's hair, because they believed their goddess Pele lived under the crater, and caused its eruptions. After I wrote these words a curious thing happened to Kilauea: the bottom tumbled out of the crater, and the boiling, fiery lakes and fountains suddenly sunk in, and left it a great dark abyss.

In the sea near the coast of Greece, more than two thousand years ago, the crater of a great volcano was lifted out of the water. It made a sort of horseshoe island, part of the rim having been broken away. This island is called Santorin. In the curve of the bay enclosed by the horseshoe several volcanoes have burst up since, and are still sending out steam and vapor. The water around them is hot, and is colored orange by the iron and other things thrown out by the volcanoes.

The volcanoes in Europe, such as Ætna and Vesuvius, are different from Kilauea. Before an eruption loud noises are heard, an earthquake shakes the ground, and then comes a sudden outpouring of lava and cinders and smoke. In one of these eruptions, soon after the time of Christ, two cities were buried by an overflow, one of mud and the other of cinders. A little more than a hundred years ago, in digging a well in a town that had grown up over the old one, the city



Fig. 16.—Santorin.
From Winchell's "Sketches of Creation."

was discovered. Imagine what a wonderful thing it must have been to walk those deserted streets, sealed up for nearly two thousand years, and find the houses, the baths, the libraries, almost uninjured! These buried cities, Herculaneum and Pompeii, were destroyed as was thought until their rediscovery,

about the middle of the eighteenth century—in the year 79. Someday you will read about them in Bulwer-Lytton's fascinating romance, "The Last Days of Pompeii."

In Mexico, in a peaceful district where there were fine cotton plantations, a hundred and thirty years ago lived a rich planter quietly cultivating his crops. Suddenly one day loud and terrible noises were heard underground; earthquake shocks were felt. This went on for two months, and then all quieted down. After a few weeks of quiet, the noises began again, the ground for about four miles swelled up in a great bladder five hundred feet high, which rose and fell, till finally a yawning gulf opened. Two rivers, which before had flowed peacefully through the country, plunged into this opening and were lost. Thousands of little mud volcanoes burst up all over the plain, an immense crater opened, and poured out such quantities of red-hot stones and ashes that it built up a range of six mountains. One of these is a volcano, called Jorullo, which has been active ever since.

Chapter V

Fire and Water

The sea along the western coast of Scotland is filled with numberless islands, which look on the map as if they might have been broken from the solid land. One of these is a tiny island lying close in the embrace of a larger one. Though it shows as a mere speck on the map, this little island of Staffa is known the world over for its wonderful natural formations. On the edge of the sea, rising direct from the water, is the well-

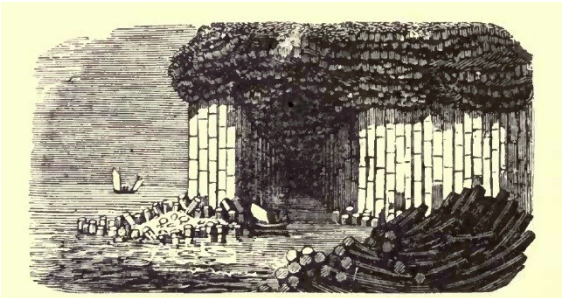


Fig. 17.—Fingal's Cave.

known Fingal's Cave (Fig. 17). The regularity of its formation is so remarkable that it is hard to believe it to be a work of nature. Lofty columns of regular shape stand up out of the sea, built up, it would seem, of block upon block of solid stone carefully chiseled and as carefully laid upon one another.

On the northern coast of Ireland, at the point which is nearest the Scottish coast, is another wonderful assemblage of these columns, roofless, and running out into the sea, called the Giant's Causeway.

An old story makes these two wonders the ruins of castles built and inhabited by two unfriendly giants. The cave has received the name of the Scotch giant, Fingal. There are many old poems, sung among the Highlanders in the far past, of which Fingal is the hero; but we now know that no man's or giant's hand helped to lift these great blocks of stone one upon the other. They were built up by the fires under the earth. The melted stone poured out of the volcanoes above and spread over the land, and there, as it hardened and cooled, split up into great crystals, or columns. The water dashing for thousands of years against them washed away the earth around and the broken fragments, but was dashed back again by a few of the hard, unbroken columns, and so were left Fingal's Cave, the Giant's Causeway, and other formations like these.

Too long ago for you even to imagine it, there was a great bridge of these columns reaching from Scotland to Ireland; the Giant's Causeway was one abutment, and Fingal's Cave another. In the thousands of years that have passed since, the rest of

the bridge has been swept away and destroyed, with only here and there an island of columns between to tell the tale.

These rocks—hardened volcanic rock—are called basalt. They are not the only things which in drying contract and split into crystals. Take some common starch, dissolve it in water, and let it gradually dry. When it is perfectly dry, you will see that the sheet is full of quantities of fine cracks; loosen it from the plate, and you will find it all in crystals. Sulphur or salt will crystallize in the same way. Few things, however, split up as regularly as basalt does.

Sometimes where there has been a wide crack in the older rocks the melted basalt has run into and filled the crack. In that case the stone as it hardened split up the other way, and instead of columns it looks like piles of logs. On the coast of Lake Superior there is a remarkable instance of this; the surrounding rock has worn away, leaving the hard basalt lying like a carefully arranged pile of cord-wood.

The great central fires of the earth are constantly at work, sometimes acting with shocks, and sometimes quietly and steadily changing the face of the earth. In India, seventy years ago, one of these sudden changes took place which was very

remarkable. There was an earthquake shock, and a great piece of land fifty miles long and sixteen broad was suddenly lifted up ten feet higher than the country around, and there it has stayed, with a straight wall around the edge called by the natives "Ullah Bund," or "God's Wall," from the mysterious way in which it arose.

Without any earthquake shock or sudden movement continents are in some places slowly sinking and in others as slowly rising. It might seem as if it were the waters which were rising or falling, but a moment's thinking will show you that this cannot be so. Water soon comes to a level; and as there is nearly the same quantity in the oceans all the while, it must be the land that is changing.

There was, a great many years ago, before Christ came into the world, a temple built on the Gulf of Baiae, near Naples (Fig. 18). Three pillars of this temple are still standing, though they have seen many ups and downs since their building. The original pavement was of beautiful mosaic, and so well built that it still remains, though the earth on which it stands slowly sank for many years. About two hundred years after Christ a new floor was laid six feet above the old one, showing at that time how much the earth had sunk. Down, down the pillars went into the

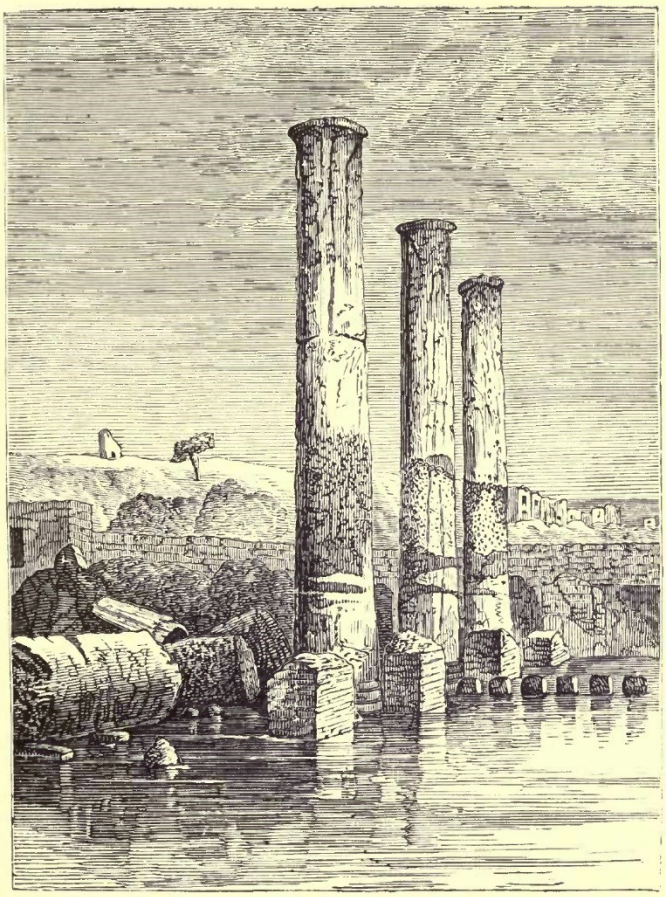


FIG. 18.—TEMPLE OF SERAPIS.

sea, till they had sunk twenty-six feet. Then came a terrible eruption of volcanic lava, and the temple was lifted bodily more than twenty feet, the pillars still standing upright. Twenty-six feet above the first pavement, and for twelve feet below that line, the pillars have been fairly pitted by some small sea-

animal which had burrowed into the marble when it was under the sea. The story of the temple's travels is written on the face of the pillars. Now the temple is again slowly sinking at the rate of an inch a year.

Our own continent is tilting up in some places and sinking down in others. The Florida coast is sinking, the North Carolina coast is rising. Near Boston the land is rising, and Greenland, for six hundred miles, is sinking so manifestly that the Greenlanders have learned not to build their huts close by the sea. An island in the Gulf of St. Lawrence is gradually tipping; its southern coast is dipping down and its northern rising into high bluffs.

The water and the fire in doing these mighty works, in gradually turning and tilting continents and islands, and wearing them down again, do not forget some smaller duties in the way of carving and ornamenting and beautifying the earth.

There is no country in the world which has more wonderful hot springs than our own. The hot water, filled with carbonic acid, which comes from the fires beneath the earth, has the power to dissolve certain minerals; these it brings up to the surface of the earth. The carbonic acid goes off in gas when it comes to the air, but the lime and other minerals are allowed to

settle; there they harden and form a cup, from which the water drips down, forming limestone icicles or stalactites. Finally, cup after cup is formed in this way (Fig. 19), most wonderfully ornamented. In one place in Italy such a spring, which is at the top of a hill, has encased the whole hill in a layer of stone formed from its settlings. In carbonated springs like those in Figure 19 most of the lime settles at the bottom, as earth will in water; but there is a still more wonderful kind of spring, which builds its own basin, and after a while makes itself into a fountain. Such a spring is called a geyser. These are very rare, because it takes so many different things acting together to form them. They are the children of fire and water. Geysers are found in Iceland, New Zealand, and our own Western country (Fig. 20). Those in the Yellowstone National Park, in Wyoming Territory, are perhaps the largest and most curious in the world. Indeed, that region abounds

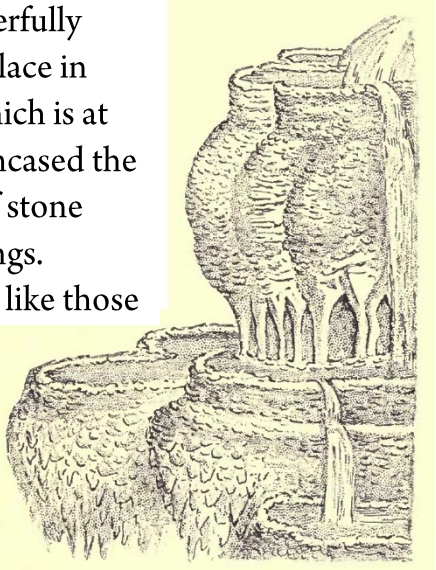


Fig. 19.—Carbonated Springs.

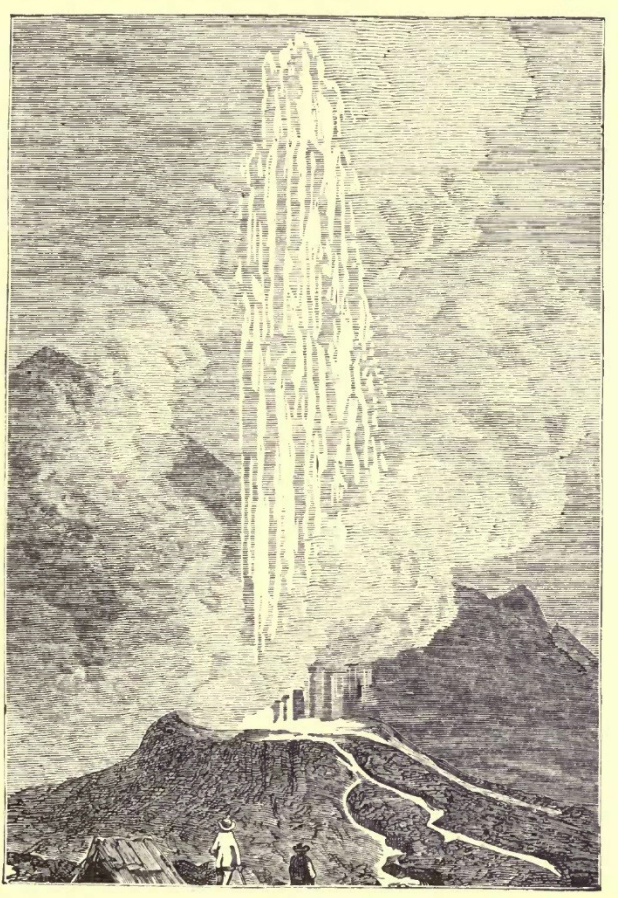


Fig. 20.—A Geyser.

with wonderful examples of Nature's handiwork, which must be interesting to all students of geology.

A geyser begins by being a little hot spring; it ends by being a natural fountain. Geyser water has been put into a basin, and allowed slowly to dry up. It is then found that the settlings from this water are not on the

bottom, but that, as the water dried, it left a solid rim around the basin, and as it sank the rim broadened downward.

In the geyser water there is a white and glassy substance that, as it settles, builds a cup for itself; when the water overflows the cup, it naturally runs out of the lowest place. Here the solid rim is built up by the glassy silica till that gets higher; the water then shifts and flows over the lowest place left, building slowly the lowest places in the rim, till, instead of a cup, it makes a high tube with a mound of silica all around it.

Sometimes the water will lie quiet in the tube for a good while; but the fires beneath are turning water into steam, and when enough steam forms it lifts the water in the tube, in its struggles to get out, until finally the water is thrown up into the air violently, like the jet of a mighty fountain. The steam escapes in a single burst or in several; the water sinks back and lies quiet for a while, till steam is again formed, and the fountain jets again.

A toy geyser can be made of an upright tube of iron filled with water, and two gas-jets burning against the tube, one above another. Every different way that a geyser plays can be imitated on this simple little

arrangement. It would take too long to explain why some geysers are too young to play and why some are too old; why some play at fixed times, and others only when a clod of earth or something of the kind is thrown into the tube; but if you could see the experiment tried on the toy geyser it would not be hard to understand.

Chapter VI

The Ice-King at Work

We have seen how water wears away the land in one place to build it up in another, how it carves channels for itself through the solid rock, and builds up new layers of rock out of the ground-up material, but we have not seen all that water can do. In its solid form, as ice, it has had a great part to perform in world-making.

I am sure you have often read of the wonderful glaciers of Switzerland, where, between the rocky sides of a mountain gorge, the ice seems like a great river flowing downward. Glaciers are found in many countries—everywhere, in fact, where the climate and the formation of the land are both favorable. We hear more of Swiss glaciers only because a larger number of people visit and write about Switzerland than about the other countries where they are to be found. Greenland and Alaska have many glaciers quite as wonderful as those of Switzerland.

A glacier is really what it looks like—a river of ice; and more than that, it is a moving river. It does not seem possible that anything as solid and as brittle as

ice could move in this way through an uneven rough channel, and fill it as a glacier does.

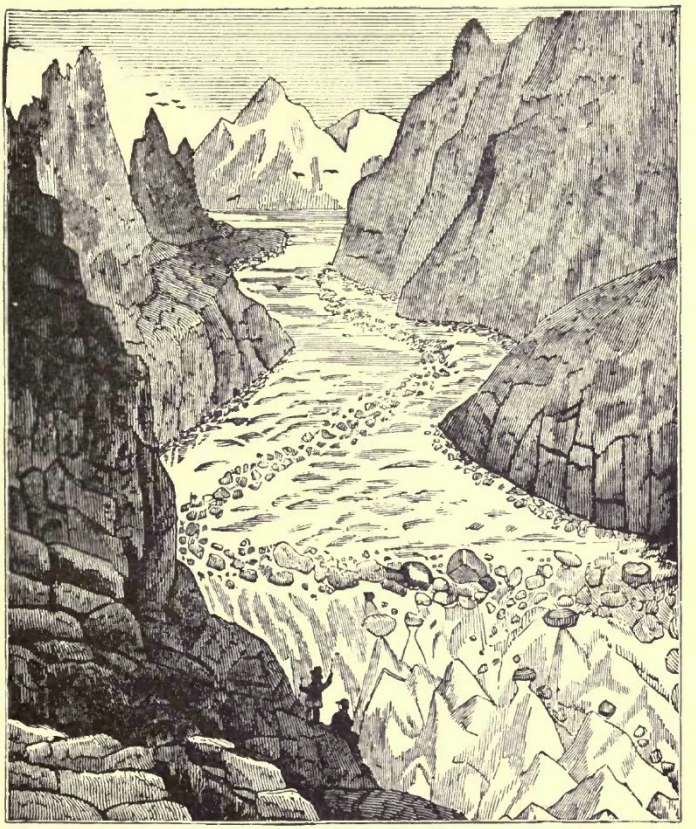


FIG. 21.—A GLACIER.

The beginning or source of the glacier is snow packed tightly in a high mountain valley. As we follow its course it gradually changes into a solid mass of whitish ice, scored all over with cracks and crevices, broken up into great masses and blocks of ice on the

surface, and covered often with dirt and stones. Finally we come to a place where the weather is warm enough to melt the ice, and then it flows off as a stream of water.

The glaciers had been for a long time under suspicion of moving, but it was not generally believed till a man named Hugi, in 1827, built a hut upon one of them. Each year it was found that the hut was farther down the gorge.

The fact was proved, and people became interested in finding out more about this movement. A row of stakes was set up in the ice, straight across from side to side of the glacier, and two on each bank to mark the starting-point. This row of poles, as it moved, did not remain straight; it bent like a bow in the middle, curving out towards the lower end of the glacier, showing that the middle part moved faster than the edge. This is known to be true of an ordinary river: the water rubbing against the banks and against the bottom of its bed is hindered, and moves more slowly than the water in the middle and on top does.

The glacier ice not only moves where the channel is even and smooth, but in some places where the channel narrows and is bordered by great masses of rock the wide sheet of ice squeezes itself through the

narrow gorge, piling itself high in mighty blocks in obedience to the tremendous pressure behind. Of course most of this movement is in summer; the advance of the rows of stakes showed this. There are two very wonderful things to be studied out about this the cause of the movement, and the way it is affected.

First for the cause: that has to be sought in the high and lonely mountain valleys. Each winter snow piles itself high on the mountain-top; each summer this snow is softened and made slushy, but not melted entirely. The soft snow sinks and packs, and is pushed down into the easiest channel. The next winter a new weight of snow is added, making a greater pushing force.

On a cold, clear winter's day you have often picked up a handful of snow and tried to make it into a snowball, and found that it would not pack; it would crumble up in your hands. By putting a little water on it you can pack it into a hard, partly clear ball.

If moist snow is put in a mould and squeezed, a block of ice the shape of the mould can be made. Your hands cannot press the snow hard enough to make it into ice, but the mould can. Snow is nothing but ice in fine, beautiful crystals with air caught in its meshes. When you squeeze it you press out the air, and bring

the ice particles near enough together for them to freeze solid. A tiny little bit of water added runs in between the particles of ice and pushes the air out before it, and so helps to make it solid; and when the water too is squeezed out, makes it freeze. Too much is worse than none at all. Each winter's weight of snow lies during the cold weather without doing much, but when the summer warmth begins to soften the snow it begins to pack, as the moist snowball does, and being a little softened, and pressed by the weight above, to push its way down through some valley. It is hindered in its travels, and being pushed behind and hindered in front, it packs tighter and tighter till we find it, farther down in its bed, a mass of ice. The weight is getting greater and greater behind it with each winter's load of snow, and so the ice is forced down, no matter what is in the way, and the valley is finally filled with the moving river of ice.

The ice is not soft like water, or even mud; how, then, can it fit itself to the channel? That has puzzled a great many wise heads before yours. Ice is one of the brittlest things in the world, but it has a quality that we do not often have occasion to notice. It melts easily, but it also freezes easily. Faraday, one of the greatest men of science in our century, and one of the noblest and simplest men of any time, discovered this quality

of ice in a very commonplace way. One hot summer's day, in a restaurant, he noticed some bits of ice floating in a dish of water. The ice was melting, and yet every time two pieces touched they froze together. Tyndall, another great scientist, has explained the movement of glaciers by this simple principle. It was he who found that ice could be crushed out of one shape into another, and that the broken bits froze at once together and made a solid lump, as the snow does. Now, glacier ice, underneath the surface, is squeezed in a mould made of its bed and banks and the heavy weight of ice above; the moving part of the ice, which fits itself to the channel mould, is broken and ground up into bits; but these bits, being pressed together again, freeze into the new mould that it is pushed into—that is, the new part of the channel—just as Tyndall's ice, which was first squeezed in a round mould, came out a ball, and, being squeezed again in a cup-shaped mould, came out a perfect cup of ice.

A glacier moves so slowly that it freezes to fragments of stone in its bed and on its banks, and carries them along with it (Fig. 21), scratching and scoring with them the stones it finds lower down in its channel. Where the end of the glacier melts, these bottom stones are left in a curved heap. "When from

change of climate the glacier ends farther up the slope than it once did, two lines of stones show where the banks were. In the picture you see a line of stones down through the middle of the glacier. These are where two glaciers have joined, and the stones mark the joined edges. These stones are always worn round by the grinding and rubbing they have received, and are called "muttoned" rocks by the French, because at a distance they look like the round backs of a flock of sheep; they are scratched, too, in straight lines (Fig. 22).

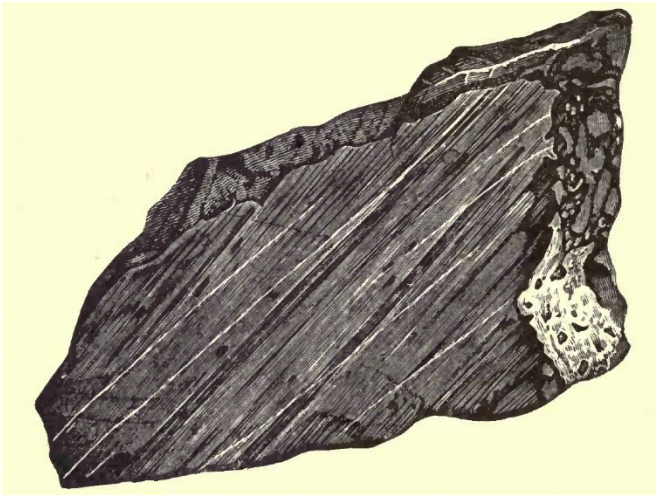


Fig. 22.—Rock Scratched by Glacier.
From Lyell's "Elements of Geology."

These glacier signs are very important in studying what the Ice-king has done in bringing the earth to its present state. Long before there were any people to

write about them, the glaciers were writing little scraps of their history and travels on the stones, as the savages did, and this history we can read today.

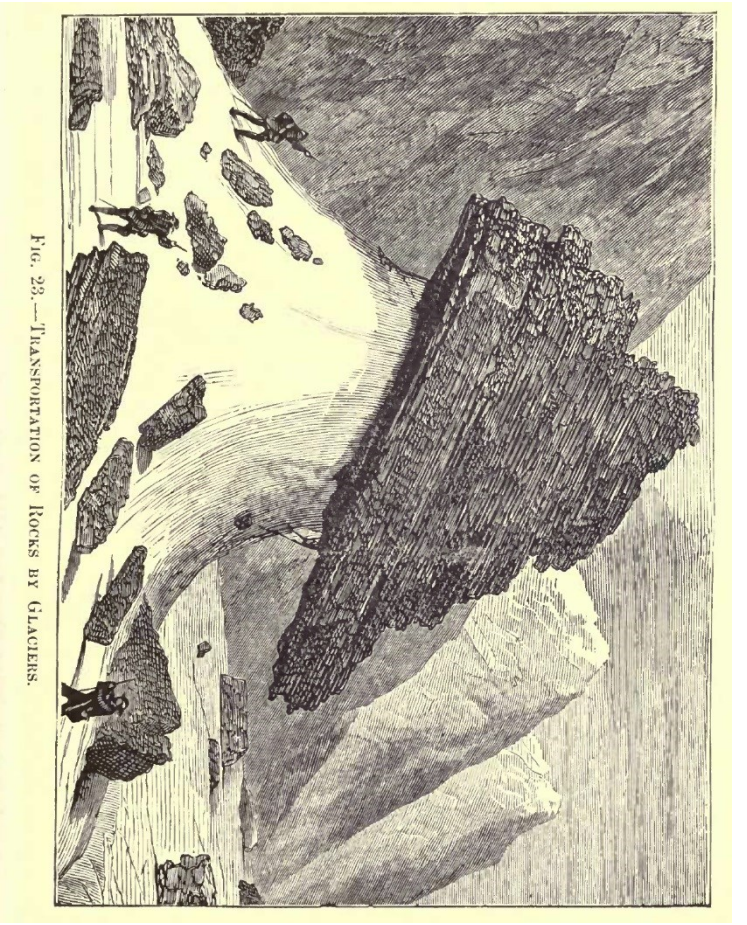


FIG. 23.—TRANSPORTATION OF ROCKS BY GLACIERS.

Sometimes may be seen a very curious effect that the stones have upon the ice, which they protect from the melting rays of the sun. Each block of stone rests

upon a pillar of ice of its own making. The stone is like the top, and the ice-pillar like the stem of a great toadstool (Fig. 23).

Icebergs, you know, are great floating mountains of ice: as not more than one-eighth of the iceberg is above water, you can guess how immense some of them are. They are really only the snouts of arctic glaciers which have pushed themselves into the sea without melting, and been broken off by the tides and the waves. When an iceberg gets afloat it sometimes comes as far south as Washington before it is broken up and melted. Usually they melt in the sea, and then rocks are deposited at the sea-bottom; but sometimes they run aground, and then on the soil of countries far to the southward arctic rocks are dropped. The icebergs and glaciers of the far past have mixed up things very much in this way.

In Greenland no rain falls only snow; there are no rivers but ice rivers. A large part of the country is covered by a great sheet of ice, nearly half a mile thick, slowly travelling to the sea, and there launching thousands of icebergs.

Strewed all over the northern part of our continent over mountains, hills, valleys, and plains is a layer of glacier stones, scratched and "muttoned," different

from the rocks below them, showing that once a sheet of ice covered this country as it now covers Greenland. This broke up into separate glaciers, as we shall find out more fully after a while, filling the valleys, as the Hudson and the Susquehanna, till it came to a climate warm enough to melt the ice.

As time went our part of the earth grew warmer. We do not know why; we only know it was so. The glaciers were driven back to the arctic regions. Our country was no longer a wide, barren ice-field, but was getting slowly ready for the day when God should command it to blossom as the rose, and be a home for His children.

Chapter VII
Plants As Builders

Besides the forces of moving water, fire, air, and ice, which have been continually shifting and rearranging the materials on the surface of the earth, we have other builders at work. There are the plants and animals—things that have lived and had organs, and so are called organic forces; the others, because they have never lived, are called inorganic, or not organic.

The plants and animals helped to build up the layers of the earth, but they did so without meaning; they just lived and grew and died, dropping upon the soil, and those parts that did not soon decay—like the limbs of trees, the bones or shells of animals—were sometimes covered over and preserved in great layers. This same process is going on now.

In Virginia, near where Chesapeake Bay meets the Atlantic Ocean, lies a wonderful forest, different probably from anything you have ever seen. Tall tree-trunks rise out of the dark water below, and stretch up and up till they are lost in the great matted bed of dark-green leaves and boughs, which seem as if they were

the roof of a cavern above-ground. It is always dim and dusky beneath this roof, even at noonday.

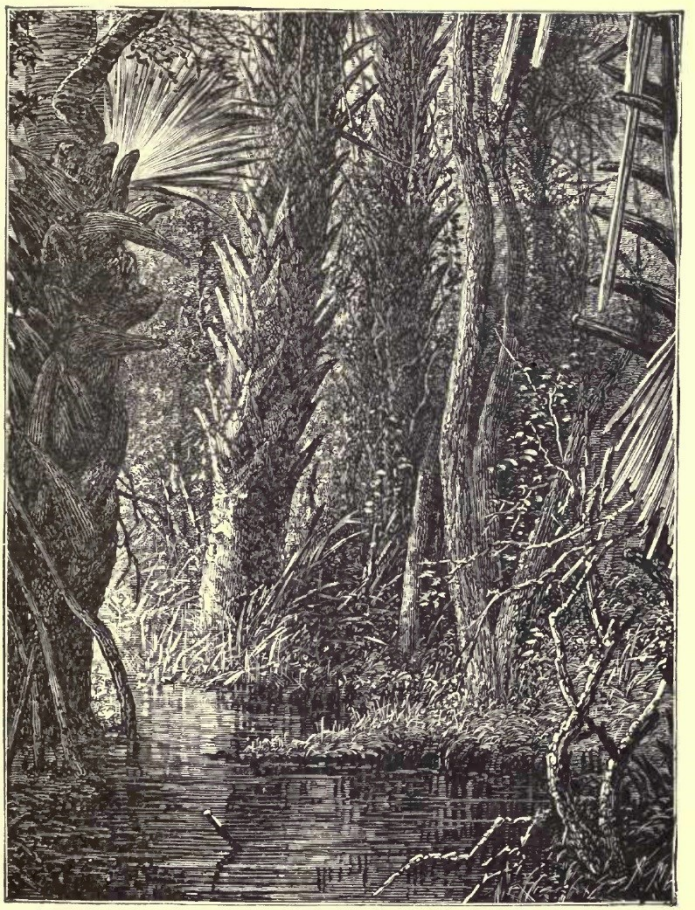


FIG. 24.—A TROPICAL MORASS.

Great coils of grape-vines bind together the tree-trunks, and out of the water rise the cypress knees—trunks that have grown up and then turned suddenly

back again into the water. These serve to steady the trees and keep them firm in the wet, insecure soil. Tall reeds and grasses grow up between the trunks of the trees, and hanging masses of solemn gray moss drape their boughs. Here and there the surface of the sullen water is broken by little tussocks of grass.

The water is a dark coffee-color, but clear and sparkling, and sweet to the taste. Over all this wilderness of solemn trees and dark water reigns a death-like stillness, broken only by the humming of millions of mosquitoes or the splash and rush through the water of some water-snake or venomous moccasin which has been sunning itself on a log, and drops into the water on your approach. Here in this Dismal Swamp the battle between land and water is going on. The land, aided by the plants, is continually gaining ground. Into the water the leaves are always falling, the dead boughs from the trees, the dripping gray moss and the juniper berries, making a solid mass and slowly filling up the pools.

The water has the power of keeping the leaves from decaying as they would on land. This water is a very wonderful thing. Many years ago, when I was a child, I went out from Norfolk, Virginia, to see the old war-ship Pennsylvania, that was lying near the city. One of the ship's officers handed me a glass of what I

took to be brown sherry wine. I tasted it, and found it was pure, sweet water. This was the coffee-colored water of the great Dismal Swamp, and it will keep sweet for twenty years on account of the juniper berries that have colored it. I think the glass I drank had been something like that time in the hold of the ship.

In some of the Louisiana swamps the surface of the water is covered for many thousands of acres with a growth of grass and plants, making what is called a floating prairie, where twenty years ago there was an expanse of clear water. The grass grows thicker and thicker every year. Sometimes, when this floating prairie gets heavy and water-soaked, it will all sink into the shallow water beneath. When this has happened often enough, the lake of the past will have been converted into a soggy swamp. Willow-trees seem to come up of themselves, and their roots bind more firmly together the slight soil and grass roots, and the land is born out of the water, gaining solidity and firmness year by year. These floating prairies, when the grass and roots and earth are only two feet thick, are strong enough to allow a man to walk about with ease, though they are floating on clear water several feet deep underneath.

In some countries,--Ireland, for instance, where there is a great deal of rain--moss and small plants growing on a soft, muddy place make a deep coating. Each year's growth is packed closely down on the growth of the year before. In this way a peat-bog is formed. In the open air, when plants perish, they dry up and blow away, or decay, and so are lost; but in the peat-bogs the water, like that of the Dismal Swamp, preserves things that drop into it. Bog oak, out of which ornaments are sometimes made, is oak that has been preserved in the water and turned black and hard with years, but is perfectly sound.

About a hundred years ago the body of a woman was found deep down in an Irish peat-bog almost perfectly preserved; even the hair and skin and nails were sound. She must have been there a long, long while, for on her feet were, not shoes, but ancient sandals, such as have not been worn for hundreds of years.

The solid packings of moss forming peat are cut into squares and dried, and then used to burn instead of wood or coal in many parts of Ireland. This peat is coal partly formed. When it is pressed very, very hard by machinery it is made into a kind of coal which burns quite well. Some of the peat-bogs in Europe were formed by the cutting down of the forests by the

Romans. The trees were left lying where they fell, and often dammed up springs, and so a bog was formed which in the eighteen hundred years since has grown into a peat-bog.

In most bogs formed in this way the peat is not pure; it is mixed with mud and sand; but in some places, as in the swamps along the Mississippi, the water has been strained of its mud before it reaches the swamp, so the peat is made just of layers and layers of leaves packed together by the water, and is perfectly pure.

Sometimes, when solid continents or islands have sunk beneath the water, whole forests have gone down with them, the fallen trunks of trees and stumps in place; the dirt has sifted over these, till new land has formed above the old; new forests have grown up and fallen and been buried. A cut through such a bed may be seen in Figure 26; the layers of sand and shells between the layers of tree-trunks show that it has been under water between-times.

In New Jersey there are great buried forests of cedar which have lain there for centuries uninjured. People actually mine for timber. Some of the tree-trunks lie fifteen feet underground. One of these trunks, which had lived for five hundred years, as

showed by the yearly rings, was underneath another which had a thousand yearly rings.

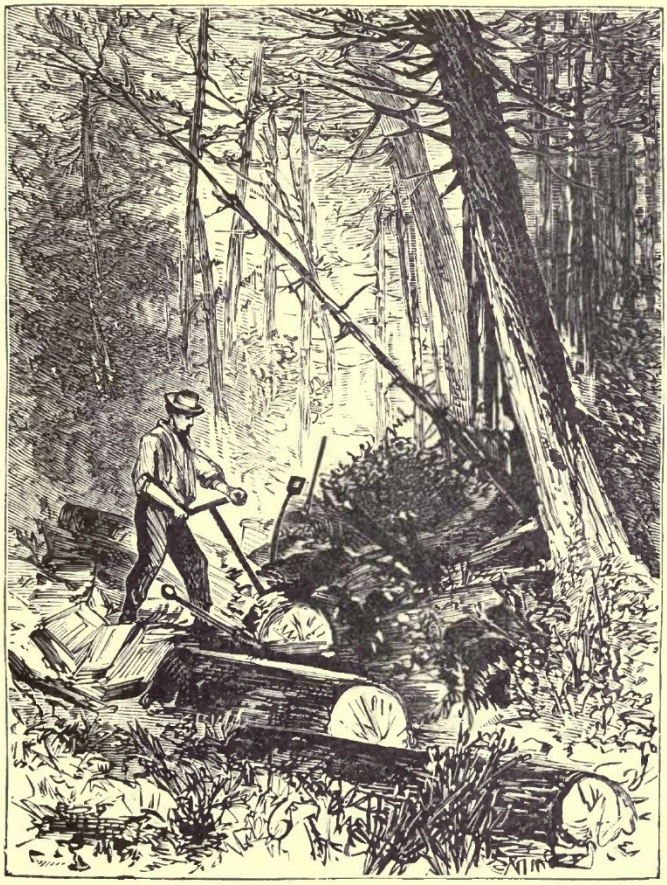


Fig. 25.—Mining for Cedar Logs in New Jersey

In Louisiana, where the timber grows heavily, great trees are often torn up and carried down-stream by sudden and heavy floods. These get wedged, and dam the stream, so that though the water can filter

through, everything which comes floating down the stream is stopped and packed together, and forms great natural rafts. About forty years ago the Government had one of these removed, which measured ten miles long, seven hundred feet thick, and eight feet high. It was covered with plants, and even a few great trees sixty feet high were growing on the top.

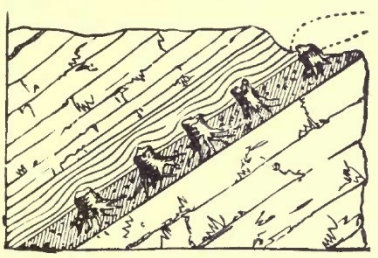


Fig. 26.—Section of Cliff.

From Lyell's "Elements of Geology."

The plants we have been talking about are good-sized—some of them large trees; but there are other earth-builders among plants too small for the eye to see. These are very wonderful little plants; in many ways they seem more like animals than plants. Each one is a little greenish dot of jelly, with a glassy coat like a shell. They may be found in almost any water, but it takes a good magnifying-glass to see them. I have found them in the water from a running stream, in a spoonful dipped up from the hollow made in a

country road by a horse's hoof, or in a way-side pool. In the seas and lakes and rivers of the Old World these little creatures lived and multiplied and died, dropping to the bottom, and making earth of their tiny glassy shells. A piece of this earth smaller than an ordinary bullet or green pea would have in it over two hundred million shells, and yet this earth covers thousands of acres several feet thick.

Out in the western part of Virginia, only about a hundred feet below the top of one of the highest mountains in the State, there is a lake nearly a mile long and a quarter of a mile broad. It is as clear as crystal, and if you take a boat and go out upon its still surface you will probably look at the sky or the green banks till someone says to you, "Look down." Then you see a wonderful thing. Down at the bottom of the water is a dead forest; the trees are standing up, with their naked branches spreading abroad in the water far below you. How such a lake can exist so high up it is difficult to guess. The water must come from the small portion of the mountain above it. Some years ago an old man said that he remembered, about seventy years before, when there was no lake, only a valley filled with trees. How or why the lake came no one seems to have found out, though many guesses have been made. It is thought that the water which

drained from the mountain used to escape, but that the way of escape was somehow closed, and so the water filled up the valley. The trees, of course, died, but the water kept them from decaying and being lost. I do not know of any other place in the world just like this; but the same thing may have happened long ages ago, and trees in this way have helped to be earth-builders.

Chapter VIII
The Builders Under the Sea

The Pacific and Atlantic oceans, where the water is not too cold, are dotted over with myriads of islands of a very peculiar kind. Many of these islands can be found upon the map, but a great multitude of them are too small to be put down.

These are coral islands, and they are formed, little by little, by tiny living beings, some of them so small that you can only see them plainly by using a magnifying-glass. The Florida Keys, the Bermudas, and other islands near our Southern coasts are the work of the coral animal, as well as the reefs along the Florida coasts. Many of the islands built up in this way are ring-shaped—round, or oval, or irregular—but enclosing a quiet lake. In some the ring is incomplete, and the water inside it is a landlocked bay; in others there is a row of islands which, if connected, would make a ring. The Bermuda Islands are such a row.

The land lies low, and the curved strip of land forming the island bears a grove of feathery palms and beautiful flowering trees, bordered by a beach of pure

white sand. Seen from above, an atoll would look like a gigantic green wreath floating on the bosom of the water (Fig. 27).

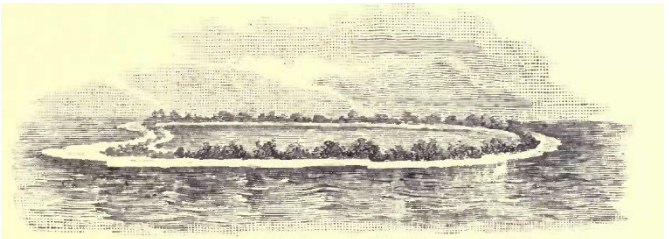


Fig. 27.—Atoll.

It must be a wonderful thing to be the first person who has visited one of the lovely, lonely atolls of the Pacific, whose only inhabitants are birds. Fifty years ago this was a more common occurrence than it is now, when the seas are so full of great ships and steamers, as well as smaller craft, that most of them have been at some time visited. Professor Dana, who went out on an exploring expedition some time ago, says that "on one atoll, where no natives ever dwell, the birds were so innocent of fear that we took them from trees as we would fruit, and many a songster lost a tail feather as it sat perched upon a branch apparently unconscious that the world contained an enemy. They had never found out the vow of eternal enmity sworn against the birds by the boys. Poor little heathen birds! How they did need a missionary!"

You may have heard of the coral insect, and of its wonderful industry in building up great islands in the sea, as if coral was built as honey-comb is. The coral animal is not an insect, nor anything like one, and it builds the coral precisely as you build up the bones in your body. It is a sort of flower-animal, shaped like an aster or an anemone or a daisy. It has nothing of the flower about it except a resemblance in shape, but is as much of an animal as an oyster or a fish. The coral polyp has a thick stem crowned by a row of petal-like arms arranged about a center, or sometimes several rows so arranged. The stem is the body, and in the upper part of this is a hollow sac—the stomach. The center of the flower is the mouth, and the petals are feeders to catch and draw in the floating food that comes within reach. Some of the sea-anemones do not make coral, and others do, but all are constructed on this simple flower plan (Fig. 28, a, b).

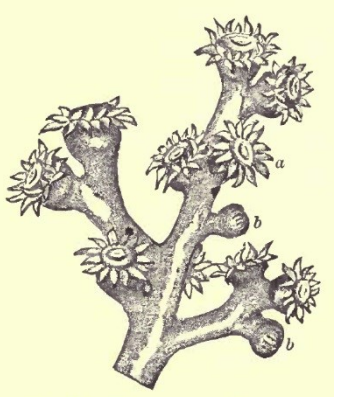


Fig. 28.—Coral with Polyps.

When you eat and digest your food, new particles of flesh are formed. These are pushed in between the

particles already there, and at the same time old particles which are dead and of no further use to you are cast off. While you are growing, more new particles are made than old ones are cast off. When you are grown, those that are taken on are equal to those that are cast off. This constant change goes on in the bones as well as in the flesh, though more slowly.

Such a change is all the while taking place in the coral polyps. The coral is the skeleton of the polyp. Instead of the skeleton being all inside the polyp's body, as yours is in you (except your teeth), or all outside, as it is in the oyster, it is partly in and partly out. In the lower part of the stem of the coral animal, below the stomach, is the skeleton; as the polyp grows it keeps adding particles to its skeleton, and as it casts off less than it adds, the skeleton grows too long for the polyp, and is left behind as a solid stem, on the tip of which is the flower-like animal (Fig. 28, a).

The polyp, though an animal, is of a very low order. It is really only a stomach, a mouth, and feeders. Although it has no eyes, it can somehow tell when its prey is near, for it is quick to reach out its beautiful petal-like arms and draw it in. It has no ears, but the softest footfall will cause it to draw in all its petals and shrink down into a little brown knob which can

scarcely be found among the seaweed at its foot (Fig. 28, b). It cannot move about, for it is fastened tight to its coral stem, but it is provided with a wonderful contrivance for the capture of the prey beyond the reach of its arms. All along the beautiful petals are thousands and thousands of tiny pockets, and in each one is coiled up a long, slender thread. Let an unwary little fish come within range, and in a second hundreds of these threads are shot out, each turning itself inside out as it comes. The threads are barbed and poisoned, and woe to the fish who is lassoed. He is stunned, and soon dies. Then the victim is drawn into the innocent-looking flower. After the meal is digested, the flower turns itself wrong side outward, and so gets rid of any fish bones it cannot digest. Out of food so caught and digested the solid coral is formed. A single polyp would form only a small stem, but the polyps increase by sprouting from buds, or by one of them stretching and splitting up into two or three or a dozen polyps, till great branches or sheets of them are formed with the coral underneath. The

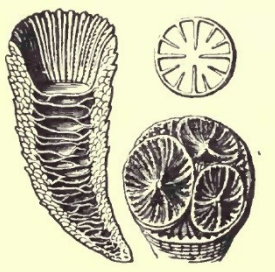


Fig. 29.—Corals.
From Lyell's "Elements of Geology."

shape of the clumps or branches is determined by the way they increase (Figs. 29 and 30).

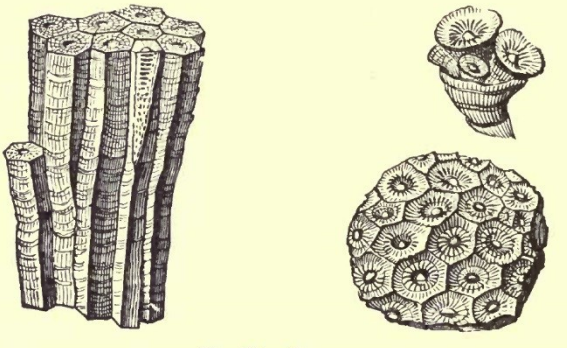


Fig. 30.—Corals.

From Lyell's "Elements of Geology."

Reef-making polyps cannot live in the depths of the sea, but when they lodge near enough to the surface, and in water which all the year round is never cold enough to kill them, they grow steadily, though slowly, and increase enormously in numbers.

All through the Pacific Ocean these curious islands are found. They are of three kinds; either an ordinary island, surrounded by a pure white beach made of coral sand, or an island with a ring around it, or one which is nothing but a ring. Sometimes the beach or ring is broken—up that is, some parts of it do not rise above the surface of the water, and the ring is only marked by dots of islands arranged around in a circle.

Wherever such islands occur they have been slowly built up by coral polyps. When the clumps of coral have grown up to the surface, the branches are broken off by the waves and ground into powder or coral sand, as it is called if coarse, and coral mud if finely ground. This powdered coral sinks over the spreading branches of the living coral and finally fills them up, and with shells and bones they heap up above the surface of the water and gradually harden into rock.

Below the water, on the sloping beach that runs out towards the sea for a little distance, you may see, if you look downward, a wonderful fairy garden. The polyps sometimes look like beautiful animal flowers, waving their fringe of feelers like leaves with every movement of the water; other fan-like corals, called gorgonias, send the pink lace-work of their leaves up through the water, while bright fish dart in and out amid the curious animal forest, showing their vivid colors against the white background of the coral sand.

Many of the polyps are too small to be seen without a magnifying-glass, so you would only see the clumps and trees of growing coral covered over with a coating of a soft, fleshy substance if you looked at them through the water.

The peninsula of Florida, on the south-eastern end of the United States, is a land made by the coral polyps. Several reefs have been built, one beyond the other, and the space between became gradually filled up with drifting sand and floating wood, till the solid land was formed. There are still reefs beyond the main-land called the Florida Keys.

Just why reefs should form as they do in lines and rings off the shore of the land, or make ring-shaped islands in mid-ocean, is not absolutely certain. Years ago, when Mr. Darwin was a young and unknown man, he gave the first explanation that seemed really to satisfy men of science. For forty-five years these ideas of Darwin were believed in by all the world, but of late years there has been much talk and much study about the question, and geologists are divided. All hold the same *facts*—it is the reasons for them that they cannot agree upon. So it seems to me wiser to give you the facts only, and not attempt to give an explanation that may not prove true.

In great storms near the coral islands, the water often looks milky, whitened by the fine coral mud.

In shallow seas corals often grow up in a sort of umbrella or mushroom shape, with a central stalk and a wide, flat top. A great many of these will unite and

make an island, held up by great columns below. Sometimes in the Pacific a ship has run aground on one of these umbrella-shaped reefs, the column has broken, and, to the surprise of the crew, the vessel has gone safety ahead.



Fig. 31.—Magnesian Limestone.
From Lyell's "Elements of Geology."

There are many other kinds of sea creatures which are helping to build up land in the bed of the ocean. Fish, large and small, when they die, drop their beautiful shells, or their skeletons, and these collect in the sea depths, and after a while become packed into a solid stone. In this piece of limestone (Fig. 31), see how closely the shells lie together; in other pieces there will be dozens of different kinds packed in the broken bits and dust made by thousands of other shells (Fig. 32).

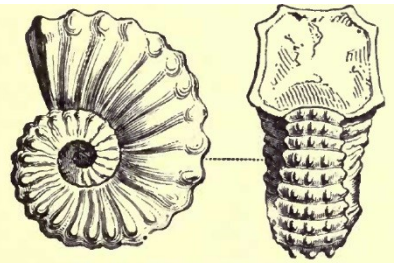


Fig. 32.—Fossils of Chalk.
From Lyell's "Elements of Geology."

The chalk cliffs of Dover, which gave to England her poetic name of Albion (from albus, white), are solid masses of tiny shells.

At the bottom of the Atlantic there are today forming just such beds of chalk, not yet made into a solid mass, but on their way to be (Fig. 33), and if the chalk which was made ages ago and that which is making today are compared, they will be found to be very much the same.

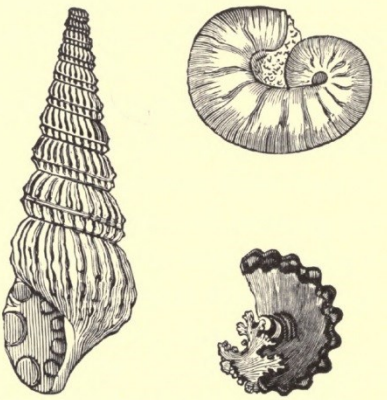


Fig. 33.—Fossils of Chalk.
From Lyell's "Elements of Geology."

Chapter IX
The Crust of the Earth

The earth, as you know, is a great globe, eight thousand miles through from side to side. Geology would not be a possible study if we were obliged to learn about the earth, down to its center, four thousand miles below the surface. All this mighty mass, except a sort of skin which encloses it, as the rind encloses an orange, is made up of metals and minerals, just as the fire has molded them. At first the "rind" was only the outer part of the globe of melted rock, which had hardened as the earth cooled down.

You remember what it was that changed the hardened surface of the globe into the wonderful layered crust that now covers it: how the air and water and fire went to work, the air and water powdering the rock and letting it settle into the water's depths; and then, when this had again become solid, how the imprisoned fire burst through, turning and tearing and wrinkling the layers.

The crust of the earth, so far as we know, is not more than ten miles deep anywhere, and in many places is not more than three. This seems a wonderful

depth when we think how long it would take to walk so far, but it is very little when compared with the size of the earth.

Of course we could never have reached to the bottom layers if they had all settled quietly down, one on top of the other, and stayed just where they first settled, for the deepest mines cut down through only about one mile; but fire has come to our help, and broken and tilted them up so that the edges of the layers are exposed, and can be studied better than if men had dug down to them.

The crust of the earth is like a wonderful book, with its leaf upon leaf, close shut, yet each bearing upon it the record of a life long passed away. For hundreds, even for thousands, of years the pages of this book lay unread. Men had seen them; they had perhaps guessed and wondered at the curious forms impressed upon them; but no one had looked at them with a seeing eye, no one had worked out the problem, no one had guessed the riddle of the rocks. Underneath these written pages, where the history of the past may be read, lies the fire-made rock, like so many blank pages. No life had ever existed there, and so the pages are empty.

The crust of the earth is very irregular; great mountains and plains rise above the level of the oceans, and mighty valleys sink beneath their depths. The highest mountains stand only about five miles above the sea-level, and the deepest ocean valley sinks only about the same distance beneath its waters. Great as this unevenness of the surface seems, it is less, in proportion to the size of the globe, than the roughness of its rind is to an orange.

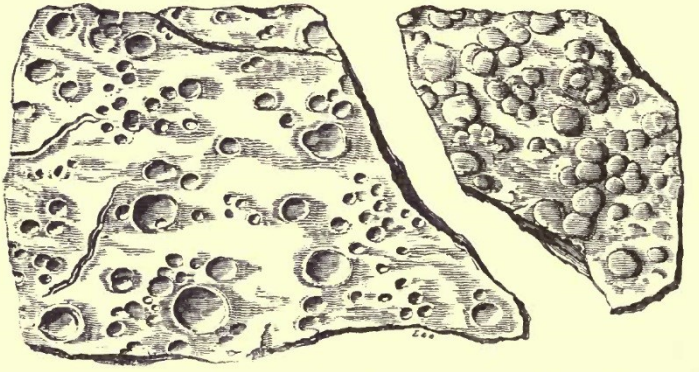
When you look on the map of the world, the continents appear to be very irregular in shape. There seems to be no sort of rule in their formation; but there is: some things are alike in them all. Each continent—Europe and Asia—being one is surrounded, or nearly surrounded, by water; the mountains run somewhere not far from the rim, making of each a great shallow, irregular basin, and the highest range of mountains is nearest the largest ocean. In North America, for example, the Pacific Ocean is larger than the Atlantic; the Rocky Mountains, which face the Pacific, are higher than the Eastern ranges that face the Atlantic. The same thing is true of the other continents.

During the struggle of the imprisoned giant, Fire, to make his escape, many changes have taken place in the shape of the land, but the changes have been a sort

of growth or development; the continents have gradually become larger, the land has slowly been lifted up out of the water.

Layered rocks are of as many kinds as there are of sea-shores and lake-bottoms. Some of them are fine mud, some sand, some pebbles, and some broken bits of stone or coral cemented together and hardened into rock. A layer has often been traced from its condition as mud or sand to the place where it is a layer of solid rock, with all the different stages of change between.

In the layered rock sea-shells lie just as they lie in the water's bottom. You remember how Hugh Miller saw, on the slab of sandstone his hammer laid open, ripple marks such as he had often seen in the sands of



Figs. 34, 35.—Rain-drops and Worm-tracks on Green Shale.
From Lyell's "Elements of Geology."

Cromarty Frith, and he knew he had come upon an ancient sea-beach.

Think how strange it must seem to lift one layer of rock from another and find there the impression of rain-drops the record of a rain-storm that had swept over some lonely sea-shore millions of years ago, which yet is as clearly to be read as if the drops had fallen yesterday (Figs. 34, 35).

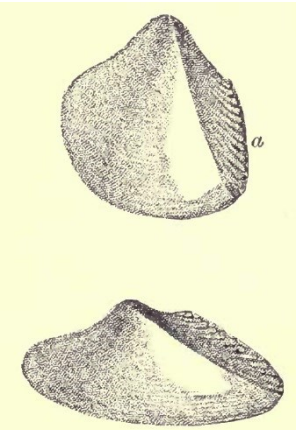


Fig. 36.—A Distorted Shell.

Earth, or sand, has been changed into solid rock in several ways; sometimes it has been slowly baked by the inner fires, somewhat as clay is baked into brick in a kiln. At other times it has been pressed into stone by the enormous weight of the layers on top of it. Shells are found in rock which has been made in this way pressed into curious shapes (see Fig. 36). The upper one of these shells (a) has its natural shape; the lower is the form into which it was pressed by the weight above.

In Figure 37 you see a shell on the inside of which some curious worm-like cases are glued. The dead

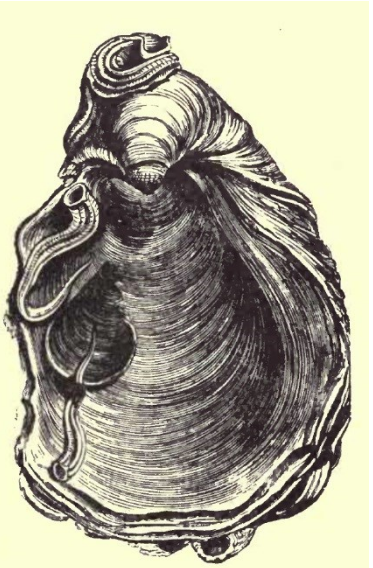


Fig. 37.—Sea-worm on Oyster-shell.
From Lyell's "Elements of Geology."

oyster-shell must have lain long enough on the bottom of the sea for the sea-worm to have built its case, which it takes some time to do, before the earth settled over and enclosed them both.

It is very easy to see that when one layer of earth settles over another the rock would easily split in that direction; but rocks split in other directions too (Fig. 38). You see there are three different sets of lines in these rocks, and the rock will split along either of these. A and B are the layers formed by settling; C is one of the cracks made by the

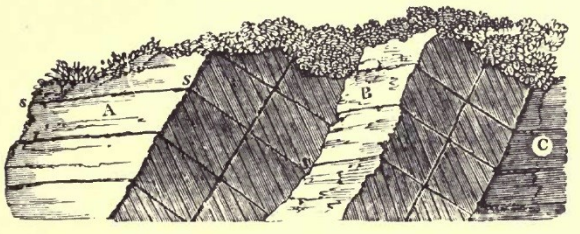


Fig. 38.—Stratification, Joints, and Cleavage.
From Lyell's "Elements of Geology."

shrinking of the rock as it cooled; but the other lines, diagonal to these, are formed by heavy pressure. If you take such a thing as beeswax or white-lead and put it under heavy pressure, it will come out in such a condition that you can easily separate it into sheets.

Slate that is used for the roofs of houses is stone which has been put under such heavy pressure, while it was hardening, that it came out as beeswax or white-lead would, and will split into thin sheets. The pressed and distorted shells in Figure 36 are frequently found in rock like this, and the shells are always pressed out of shape in the same direction as the cleavage of the slate, no matter in what position they had fallen, showing that there was no accidental distortion in the form of the shell.

Chapter X
Mountain-Building

The most beautiful scenery on the face of our earth owes its beauty in great part to the presence of mountains. Whatever may be said for the beauty of ocean scenery by its lovers, it is still true that the mountains divide the honors with the sea.

Mountains have been formed in different ways, and are different in their appearance, but each possesses a beauty of its own. The soft-swelling, forest-crowned domes of the Blue Ridge and Alleghanies, in the East, are scarcely less beautiful than the majestic snow-crowned peaks of the Rockies, in the West.

The real mountain-builders of the world are the earth-builders, fire and water; and the different ways in which the work was done came from the various combinations of these forces. After the water had done its work in depositing the layers, one on top of the other, under the sea, a change would come—the hardened crust would be slowly wrinkled up by the shrinkage of the globe beneath. This shrinking was in part due to the cooling of the melted portion in the

interior, and part probably to the escape of gases and water in the form of vapor. The skin, or crust, that would fit smoothly over the larger globe would naturally wrinkle over the globe that had become smaller.

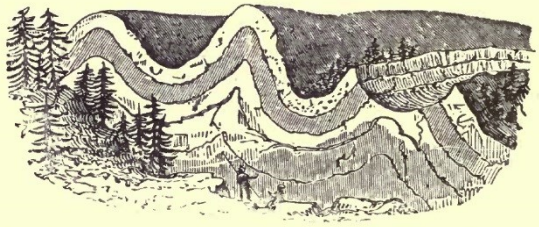


Fig. 39.—Section illustrating the Structure of the Swiss Jura. From Lyell's "Elements of Geology."

Such wrinkles are our mountain chains as they first appeared. Some mountains are still little more than such wrinkles, with the layers unchanged (Fig. 39). In the picture we see just how the layers follow the curves of the mountain. A great cleft has been made through the three wrinkles, or mountain ranges, and this enables one to see just how the layers run in the two left-hand peaks. In the right-hand range water has come in and cut through, and lowered the mountain-top. Fire is the cause of mountain-building, either directly or indirectly; while water carves and sculptures and wears away in various ways the simple folds or wrinkles as first made.

First we will try to understand just how the crust of the earth is thrown into wrinkles. Take a dozen pieces of cloth or flannel, cut them the same shape and size, and lay them on the table in an even pile, put two books at the ends, as you see in the picture (Fig. 40), and one on top to hold them in place; now press the

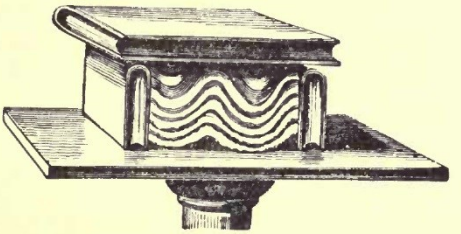


Fig. 40.—Wrinkled Layers.

two standing books gently towards each other, and the cloth will wrinkle up, the layers still lying on top of each other, or *conformably*, as it is called. An experiment has been made with layers of moist clay, put one above the other in a pile, a weight placed on top, and then pressed as the flannel is, gently together. When the open sides are watched the layers of clay are seen to wrinkle up, just as they did ages ago in the formation of mountain chains; where the pressure is great, many wrinkles are formed side by side, with valleys between, as in the case of the Rockies and Cordilleras and our Eastern mountains.

The Alleghanies and Blue Ridge, as well as the White and Green mountains of our Eastern States, have been made by such a crumpling of the earth's crust, followed by the action of water and ice. The rains have washed and worn away the crumbled rock; the air and the ice have helped to do the work, till the original forms of these mountains have all been changed.

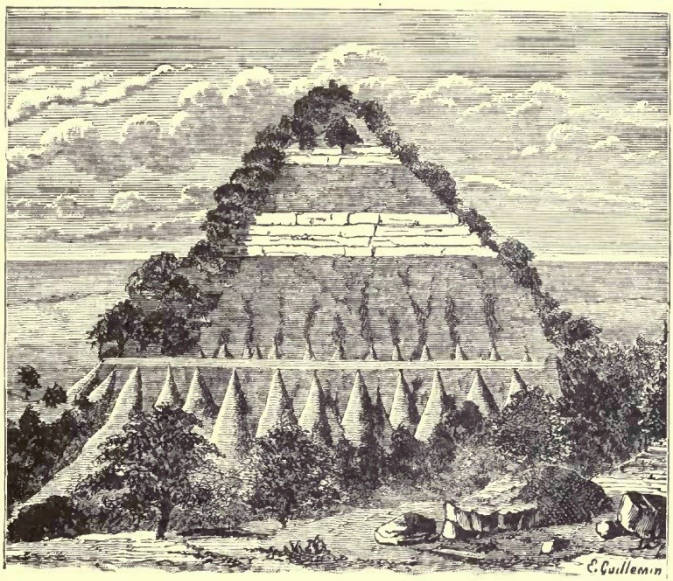


Fig. 41.—Pyramid Mountain.
From Reclus's "Earth."

One of the most singular mountains in the world has been made entirely by the action of water (Fig. 41). The layers of rock running across the mountain

look as if they had been built by a stone-mason, and the little cones of washed earth as though they had been sculptured out of the rock by tools. These have been built and sculptured too, but they have been done by water, and not by the hand of man.

From the kind of layers forming mountain ranges and the shells and bones found in them, it is known that the part of the earth's crust which was forced up into wrinkles, as the inner portions of the globe contracted, lay along the sea-bottoms, but near the coasts. There were reasons why the earth's crust here was softer than elsewhere, and it gave way along its weakest lines.

Of course this solid crust has cracked and broken under the strain. In some places these cracks have been widened by water flowing through them, and as a result we have the deep clefts in the rocks, with streams running through the bottom of them that are called canyons (pronounced canyons) (Fig. 42). No picture can give an idea of these wonderful walls of rock rising up on each side of the stream running along at the bottom, sometimes thousands of feet high.

Where the crust of the earth is cracked through by the action of fire, one half will sometimes settle lower

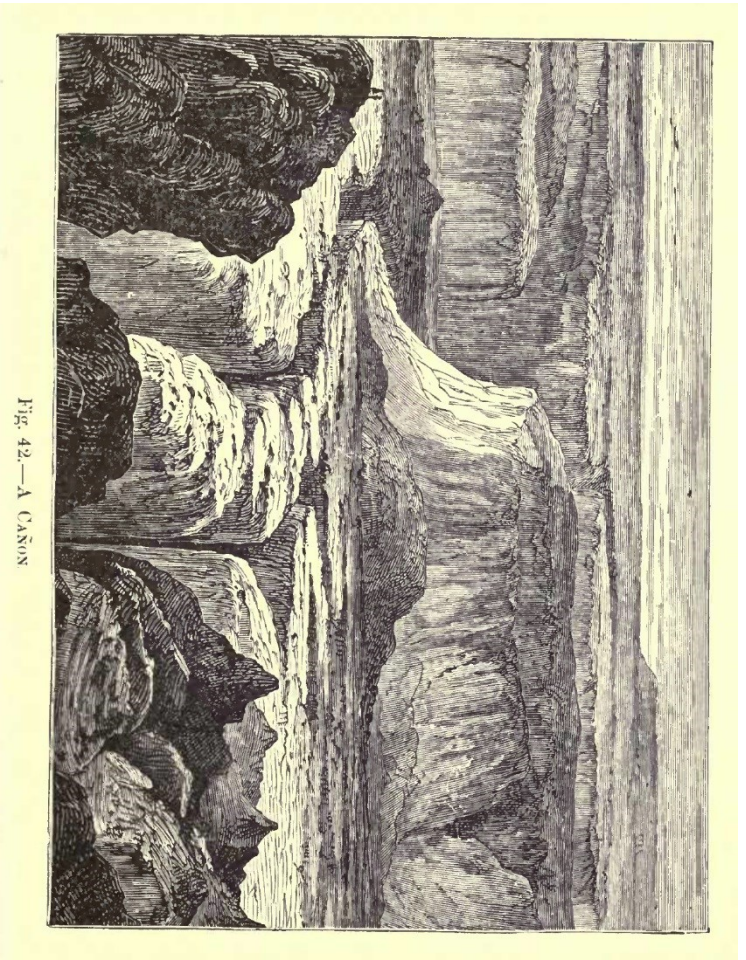


Fig. 42.—A Cañon

than the other, and then the crack will close up. Of course, where this is the case the layers will no longer match. This is called a fault by miners, who are very much troubled when they are engaged in digging out a layer of coal or iron, and suddenly find it end in a blank wall of rock. They know that this is a fault, and

that the layer they want to follow is either above or below them. A knowledge of geology is a great help in determining which way they shall work in trying to find the layer, or vein, they have lost by the fault.

The causes that are changing the earth's surface today, as you know, are the very same that were at work changing it in the past; but we must remember that there is a difference between the past and the present. The earth's crust was thinner then, and the forces struggling under it were stronger; so we should expect some difference in the results.

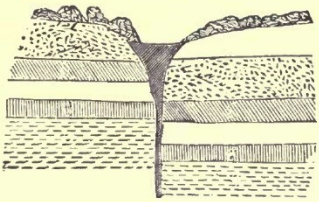


Fig. 43.—FAULTS.
From Hooker's "Mineralogy and Geology."

There are places on the face of the earth where the rocks gave way, and the melted stone has broken through the weakest spots, and flows out as lava. These are volcanoes. In the past it seems probable that the fire and lava, gases and steam, poured out not only in spots, but along lines; that there were long cracks and fissures through which the interior fires escaped. In the far West there are vast tracts of land covered with sheets of lava nearly half a mile thick, which it seems impossible the few extinct volcanoes there could have poured out. The Cascade and Sierra

ranges seem, to be built up by the outpouring of lava along their lines.

This country was the scene of a terrible eruption; but now there is not a single active volcano left. The hot springs and geysers are all that is left to bear witness to the almost exhausted force of the fire that once did such a mighty work there in mountain-building.

Chapter XI
Metals at Home

The crust of the earth is made up of many other things besides layered stone, and very valuable things they are, too. Gold and silver, iron and copper, lead and tin, as well as many other metals, are found among the rocks.

Iron is really the most valuable of the metals. We are accustomed to think that gold is more valuable because it will bring a higher price. But think for yourself, and you will see what thousands of useful things are made of iron and steel, and how very few real uses, apart from money, gold has. Nothing else is so good for filling teeth, a mixture of gold is used in some kinds of photography, and gold is valuable for coins because it does not rust or corrupt; but its real uses are not many.

If you were cast away on a desert island, which would you choose to find, a bag of gold or a case of tools? One single knife would outweigh in value all the gold you could carry. Comparing the two metals in such a way as this makes us see how much more really valuable iron is than gold. Savages of all countries

have made their first metal tools of copper, or a mixture of copper and other metals, called bronze. This is because copper is found in a purer state than iron, and is softer, so that it is more easily obtained, and more readily worked with the simple tools that savages use. So you, in your desert island, if not a savage, at least living the life of a savage, might prefer the softer metal, because you probably would not have the means of separating from its ore the harder metal, or of working it. In reading about savage people you often hear of gold and silver and copper, but never of iron, and this is the reason.

Gold and platinum are always pure, copper and silver sometimes so, but are also sometimes found in the condition of ore. Ore, correctly speaking, is a mixture of one or more metals with earth or other mineral matter. This is not a common mixture, such as you could make by stirring salt and sugar together, but is a union of another kind, a chemical union, by which two things may be so united as to form a new substance unlike either of the two out of which it has been made. Air is a mixture of several gases; water is several gases in chemical union. Air remains a gas, but water is utterly unlike a gas it is a liquid.

You often hear of gold ore, but it is not truly an ore; the pure gold is mixed with other minerals or metals.

Iron ore is a chemical union of iron and other things one of the gases of the air and water, for example. Iron ore of a common kind is iron rust; the solid, heavy, black metal has been turned into red, powdery dust.

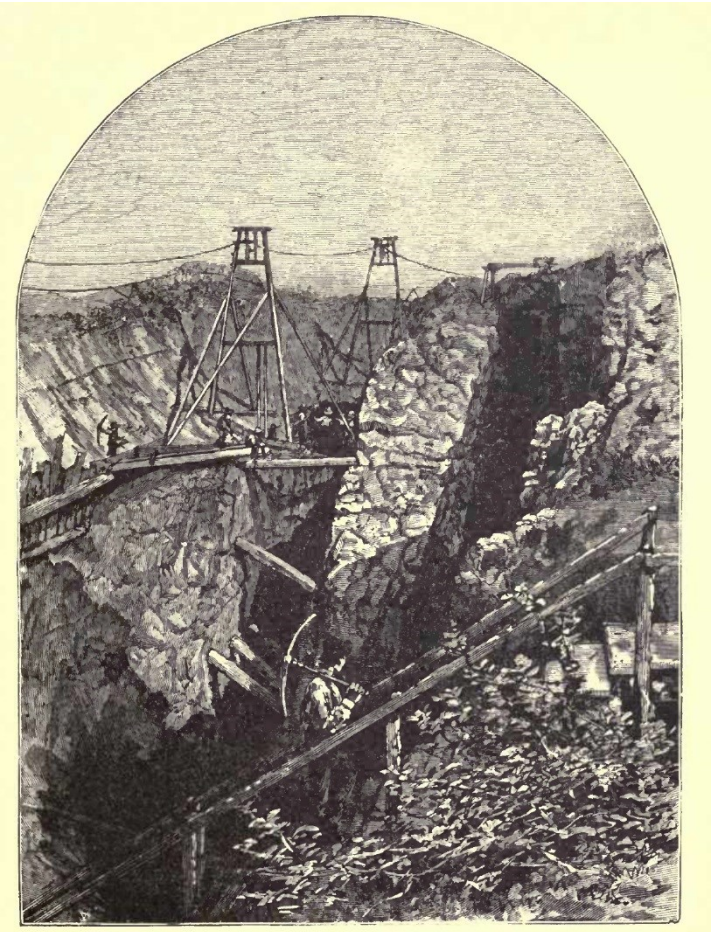


Fig. 44.—Scene at an Iron Mine.

If you have travelled much you have probably noticed how very red in some places the earth is; the mountain land in Virginia and many parts of New Jersey, for instance, is like this. I have seen the ground in Virginia look fairly crimson in the sunlight. This red look of the earth means iron, and iron well rusted at that.

Underneath bogs and swamps great flat cakes of iron ore are found, sometimes as large as the swamp, and one or two feet thick. This collects in a very curious way. The rusted iron, which is scattered all through the earth, will not dissolve in pure water; but when matter that has once been living, either vegetable or animal, decays, it changes the water that flows through it on its way down through the crust of the earth, so that the iron rust dissolves in it. This is carried down till it reaches some layer of earth or rock which the water cannot get through. There it settles, and in the course of years a great flat bed of iron ore is formed.

Iron is often to be found somewhere near these great beds of decaying vegetable matter; it is generally found very near the coal-fields, and these were once great forests. Time and heat and pressure have changed them from wood into coal.

A great deal of labor is required to dig the iron ore; mighty derricks lift it, vast furnaces, white hot, are waiting to smelt it, and so separate the iron from the useless matter in the ores. Life near an iron-mine is very curious and interesting.

In Cornwall, at the south-western point of England, are today the same mines that were worked before the birth of Christ. The Phoenicians, who were the seafaring men of those days, used to come to England—Albion they called it, because of the white chalk cliffs along the southern coast—to get the copper and tin from these mines. Some of them have been dug down and out so that they run under the bed of the sea, and when there is a storm the miners can hear the great waves hurling themselves on the rocks and breaking in thunder above their heads.

In these Cornwall mines are found tin and copper in some places, and iron and lead in others. A very curious thing has been discovered about them: all the tin and copper mines run east and west, while all the lead and iron run north and south.

The layered crust of the earth, as we know, has been many times upheaved and heated and cracked by the fires beneath. Sometimes the melted stone ran up and filled these cracks, and hardened there, as the

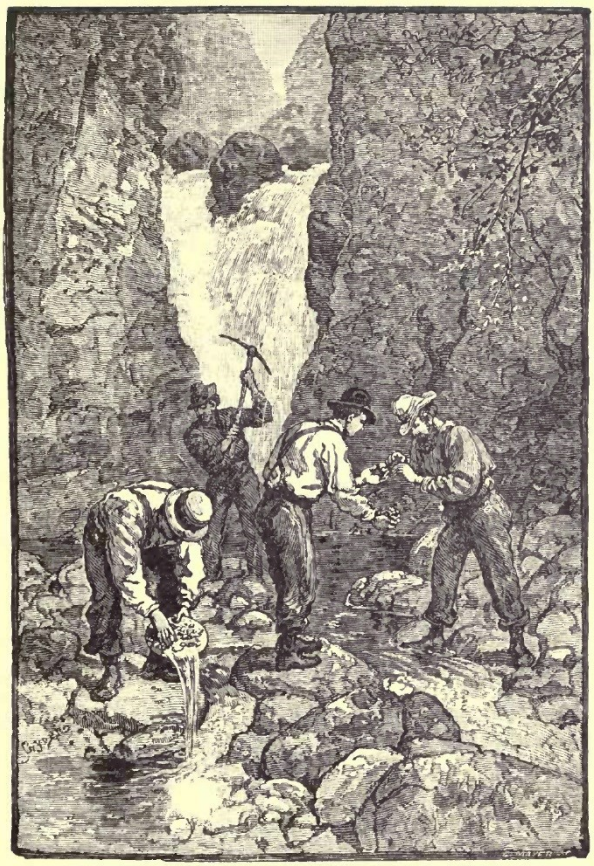


Fig. 45.—Placer Mining.

basalt did making Fingal's Cave and other wonderful formations; sometimes, as we have seen, the cracks closed after one side had slipped and sunk down, so that the layers on one side did not match those on the other. The rocks have been broken and healed again till they are all seamed and scarred. Many of the cracks

were not filled at once with melted stone, and did not close. These were gradually filled later. The hot waters of that ancient world, full of dissolved metals and minerals, dripped and oozed through the cracks, leaving behind part of the material which they had dissolved, till each crack was filled. These are called veins, and are filled sometimes with gold, sometimes with silver or other metals, and sometimes with minerals. The beautiful striping of agate, for instance, comes from such a cause. All metal veins are supposed to have been formed in this way.

The quantity of gold in circulation was not very great till about forty years ago, when gold was found in many places nearly at the same time. Our Western country and Australia were both settled in a wonderfully short time, because of the rush to the gold and silver fields after the precious metals had been discovered there.

Mining for gold is in some respects very peculiar and interesting. The metal being pure, it lies embedded in a clear whitish stone called quartz. You have probably seen Indian arrow-heads which have been chipped out of this stone, and know its look. Gold is found with other metals and minerals, but it oftenest occurs in quartz. The falling of rocks, the rattling about in the mountain torrents of broken bits

of gold-bearing quartz, have turned the stone fragments into pebbles, and set the gold grains free.

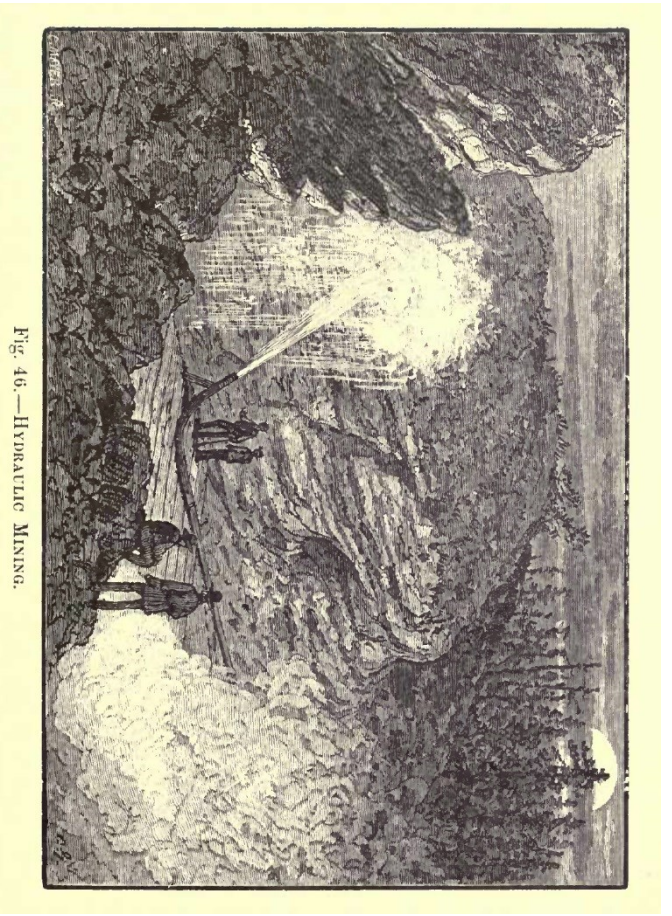


Fig. 46.—Hydraulic Mining.

The first of the Western miners used to shake this gravel in pans, and the gold grains, being heavier, would sink and be afterwards collected. The common slang expression, to "pan out well," came from this

method of collecting gold. This was called placer mining. Then the cradle, with water running through it, was used as an improvement upon the earlier method. This also soon proved too slow for our American haste to get rich.

Change after change was introduced, each as an improvement upon the last, till a new method, called hydraulic mining, was adopted in the end. It is called hydraulic from hydra, water, because water does the greatest part of the work.

To understand just how it is done we must get a clearer idea of the state in which gold is usually found. There are some gold-mines where the gold is shut up in the solid quartz, and has to be dug for and taken out of the solid rock as the kernel is taken out of the nutshell. But most of the gold in the world is in among the broken fragments of rock and pebble banks which fill the beds of old rivers now dry. By the old mining methods these were painfully dug out, washed, and the gold collected.

Now the water digs the ore, washes it, and separates it. A great engine, looking like a cannon more than anything else, shoots an immense stream of water against the gravel-bank, wearing it away, bringing down great quantities of stone and pebbles,

with the gold in grains and threads among it. The stream is so strong that enormous rocks weighing thousands of pounds are tossed in the air as though they were pieces of wood, and an avalanche of stones is carried in the water as it rushes down the slope. The heavier gold grains drop as the mass moves on.

In one way this kind of mining has proved a great curse to the country. In more than one place whole river-beds have been so choked with the rocks and earth that when the water rises in spring terrible floods come, and the whole country is covered with the powdered stone, the crops are killed, and the soil very much injured; towns are almost ruined, and farm buildings totally destroyed. The greatest efforts have been made to put a stop to hydraulic mining by law, and there is no telling where the fight will end, and who will be the victors in the contest.

Chapter XII
A Study of Bones

I have been trying to take you with me, while we looked into all the forces and agencies that have been building up the earth and bringing it to the condition which we now know. This is one kind of geology—it is called structural, because we are by it learning about the structure, the building, of the earth. Now, I want you to begin in another way, and we will follow the different forms of life in the vegetable and animal world as they followed one another, beginning with the simplest creatures such mere lumps of jelly that it is hard to tell whether they belong to the animal or vegetable kingdom. Such a study as this of the life of the past is called historical geology.

Long before the science of the earth was thought of, a careful study had been made of living animals and plants. To do this properly, and make it easy to remember, they were arranged in different classes. Everything in the world is in this way divided into three kingdoms—animal, vegetable, and mineral. Take one of these kingdoms—the animal, for instance, to make the divisions clear—and we find it

divided into four grand divisions. The lowest of these is the Radiates; that is, creatures that have no backbone, but which are formed by rays going out from a center, like star-fish and coral polyps. (2) The Mollusks, or shell-fish, like oysters and clams. (3) Articulates, insects; and (4) Vertebrates, things with backbones. Under these divisions come what are called classes. Under the backboned animals are four classes: fishes, reptiles, birds, and mammals. Under the classes are orders; under the orders, families; under the families, genera; under the genera, species; under the species, varieties. To make it simpler, and to have something to look back to if you are in doubt, I will write these in a list just in the order in which they come. By the side of these divisions I classify you to give you a notion what it means. I do not know your name nor where you live, but I shall just imagine that your name is John Smith, that you live in New York, and belong to the white race.

John Smith belongs to:

1. Kingdoms Animal kingdom.
2. Divisions Mammal division.
3. Classes Human class.
4. Orders Caucasian, or white, order.
5. Families American family.

6. Genera New York genera.

7. Species Smith species.

8. Varieties John variety.

Of course this is not correct, but it is near enough the truth to make it easy to understand what is meant by classifying an animal or plant.

This arrangement into these divisions is not merely made for use—though it is very useful—it is rather a finding out of a truth than the invention of a system.

When geology began to be studied, it was gradually found out that beings had come into existence—that they were found in the rocks in—almost the same order in which scientific men had already arranged them. Science is not the making up of a system, it is the discovery of something that already existed.

George Cuvier, a Frenchman who lived and labored about one hundred years ago, made a general study of bones. He found that between the different bones in animals' bodies there is a curious relation; so that when one bone, say a tooth, is different from the usual form, you may expect to find the foot different too. We do not understand the reason why this should be so; we only find that it is so as a matter of fact.

When such facts as these are found to exist always, they are written out in a short and general form and are called natural laws.

By studying the great number of skeletons of animals which still exist, Cuvier was able to find out what parts changed together; that is, he found out the rule which God had made for himself in creating life. After long years of such study, Cuvier could tell just what animal a bone belonged to when he saw it. This knowledge was a wonderful help to him when he began to study the bones of unfamiliar animals—the bones dug out of the rocks. He did not have all the bones of any one kind of animal to fit together like the pieces of a dissected map. He did not even have all the bones of a large number of animals to arrange. If he had, the puzzle would have been only like a great many hard dissected maps, all jumbled up together, which he had to sort out and put together correctly. This would have been hard enough, but his puzzle was harder still. He would have one bone from one animal, and another from another animal of a somewhat different kind, and from these he had to make out what both kinds of creatures from which they came were like.

In his own words, translated: "Mine was the case of a man to whom had been given the imperfect

remains of some hundreds of skeletons belonging to twenty sorts of animals. It was necessary that each bone should find itself alongside that to which it had been connected. It was almost like a small resurrection, and I had not at my disposal the all-powerful trumpet; but I did have the unchangeable laws by which living beings were created as my guide, and at the voice of the anatomist each bone and each part of a bone took its place."

If you take notice, you know something of this yourself—that animals which chew the cud, like cows, and have a peculiar kind of teeth, also have cloven hoofs. Darwin has carried this study further even than Cuvier did. He studied all the different parts of animals and their relations to one another. He has made some very curious discoveries in regard to such relations, for example: White cats with blue eyes are sure to be deaf; and young kittens, so long as their eyes are blue, are also deaf. Some South American horses, instead of straight hair, have curly wool; and these horses have mules' hoofs. Angora goats, when they have long, curly hair, have long horns; while the hornless ones are found with short hair. A great many curious things of this kind have been observed. You can see that in finding out about animals from their bones, certain of these relations must often be of great

assistance where all of the bones of any of the animals he was trying to understand, or "restore," as it is called, had not been discovered.

Chapter XIII
The Dawn of Life

After the terrible storms and earthquakes and volcanic fires had done their earliest work in building up the world, a quiet settled down upon the earth. The hot rains that had for so long been pouring down into the hot seas became gentler. The heavy clouds which had hung like a pall over the face of the earth sometimes lifted. A watery daylight shone faintly over the waste and desolate seas, and showed the bare and jagged rocks of the new-born continents and islands.

Under the surface of the still water of the seas and the lakes faint stirrings of life began. The first living things were very simple beings—little more, indeed, than formless masses of jelly, such as may be found on sea-bottoms nowadays. Such beings might have lived by millions, and died and left no sign, as they are doing at the bottom of the Atlantic Ocean today, as they would naturally be easily crushed out of shape, destroyed, and washed away.

Some of them, however, vegetable as well as animal, have horny or chalky or glassy shells. Though the living parts quickly disappear, the shells last for a

long, long time. We might expect to find traces of such shells in the rocks that formed the ancient sea-bottom; and so we do find them here and there, but very few and very far between.

"No history is able to write its own beginning." All the earliest histories of different peoples are confused and dim; this is true even of America. When we go back to its real beginning—long before the people of Europe came over and settled it, and before even the Indians they found here were living—mighty nations occupied the land. We have no written histories of these people, but we know they lived here, because we find on the Western plains curious mounds which they raised, and on the cliffs in the mountain countries still farther west wonderful dwellings built upon and cut into the rocks. We do not need written words to tell us that life once existed there; the cliff dwellings tell us that plainly enough.

Just so in the rocks that were once at the bottom of these old seas we find the dwellings—the shells—in which the earliest life was housed. What sort of life it was we can only judge by studying the life like it which exists now, and by guessing out the secret slowly as our knowledge grows.

A great deal of this scientific guessing has to be done in searching out the truths of nature. I want you to see just what sort of guessing it is. The first trace of a living creature found in the lowest rocks is certainly an animal, or colony of animals, whose shell has been enclosed in the mud, which has hardened over it, and preserved it for millions of years (Fig. 47). And yet, in spite of our knowledge of this fact, we guess that plants were created before animals. Why?

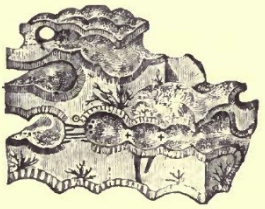


Fig. 47.—Eozoon Canadense. From Lyell's "Elements of Geology."

Because from a careful study of plant life we find that plants have a power possessed by nothing else, the power of feeding on minerals, of living and growing with no other thing to feed upon but earth and air and water. Those were just the things to be found on our earth at first. Animals have life too, but they cannot feed upon minerals alone. Besides the air and the water, and salt and some other minerals, they must have as food something that has been alive—vegetable or animal food.

You see, then, why we guess that plants came first: because, as the earth then was, the food for plants was there, while, till the plants had come, no food for

animals existed. This is no wild and foolish guessing, but a sober conclusion reached through knowledge. I have been so very particular about this because many people who are ignorant of geology—that is, the science of earth-making—are fond of speaking of it with contempt, calling it mere guesswork; and I want you to see just what sort of guesswork it is. Without this kind of guessing the world would still be in darkness on most subjects worth knowing. The only danger in the matter is when the guesses are insisted upon as facts proved to be true.

The vegetable life in the sea-bottom is very different from anything we usually see. The plants there are often mere lumps of greenish jelly, but they have the power that belongs only to vegetable life, of transforming the minerals, earth, and air, and water, into some material like that they are composed of; that is, they live and grow, feeding on minerals alone. Things that are alive, high or low, animal or vegetable, show that they are alive by doing something, and show which they are by what they do. Minerals and metals never do anything; they are acted upon and changed, but they have no power to work changes in other things. That power is something wonderful and mysterious, and we call it life. All things into which God has breathed this power are called organic,

because they have organs by which they live and grow. The rest of the things in the world are inorganic, not organic.

The vegetable life that came first was all in the water, but it was just the sort of food necessary for the first animals, which also lived in the water. The two lived side by side; you could not tell one from the other, they looked so much and seemed so much alike. The only way you could tell was to wait and see what each would do.

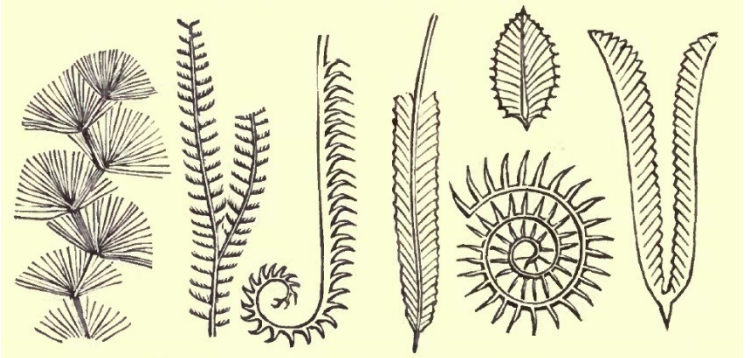


Fig. 48.—Sea-weeds and Sea Animals.
From Hooker's "Mineralogy and Geology."

After a while these simple jelly-like forms were followed by a higher kind of vegetable life. Delicate sea-plants floated through the waters (Fig. 48), and were imprisoned in the rocks, where they are found today. Masses of sea-weed growing in favorable spots

have been enclosed in solid blocks of stone (Fig. 49), besides many other soft and delicate water-plants.

The way being paved for them, many curious

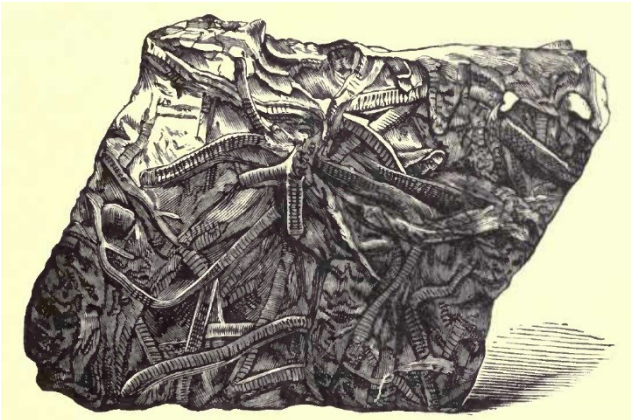


Fig. 49.—Silurian Sea-weed.

From Winchell's "Sketches of Creation."

animals also had begun to fill the waters. All very simple, though some were much larger than anything of their kind living today. Each age since life came upon our globe seemed to belong to a certain class of being, beginning with the lowest, and growing higher and higher. This time might almost have been called the reign of jelly. As higher kinds of beings came in they did not push out the lower, the jelly-like animals and plants existing in great numbers still, so that the whole sea-bottoms are covered with them; but the lower and simpler life seemed to sink into less importance when a new reign began.

The most singular creature in the old seas, which might almost be called the king of the jelly kingdom, was a queer three-lobed shell -fish. It is known to have had legs, because its nearest of kin living now is formed in somewhat the same way (Fig. 51).

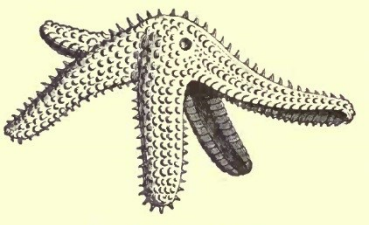


Fig. 50.—Star-fish.
From Lyell's "Elements of Geology."

Beautiful star-fish (Fig. 50) swam through the waters of these seas; lovely corals (Fig. 52) crowded the bottoms, and slowly grew towards the light; tall and graceful stone-lilies shot upward through the water; gigantic sponges and queer plant-like creatures called grapholites grew in great numbers (Fig. 48).

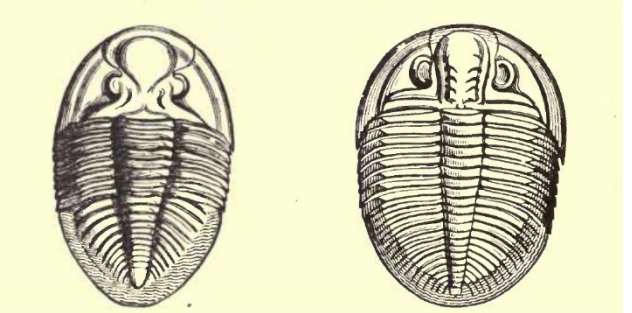


Fig. 51.—Trilobites.
From Lyell's "Elements of Geology."

These, though in many respects seeming to be plants, are really animal forms. Shell-fish too, in great variety, lived and died in those old days.

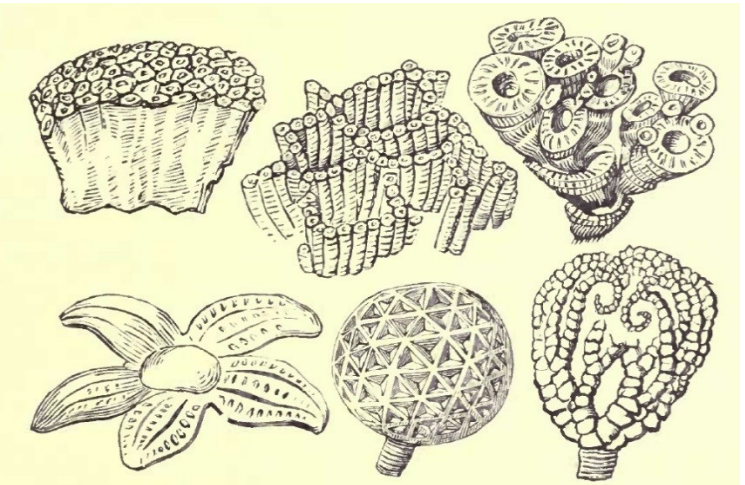


Fig. 52.—Corals.

From Hooker's "Mineralogy and Geology."

The climate, judging from the creatures that lived then, must have been rather warm all over the world; the heat from the earth would help to keep the waters warm, and the clouds of mist wrapped the earth around like a blanket, and would not let the heat all escape.

Though the waters were teeming with life, the land remained desolate. Bare rocks and barren sands stood out of the dark waters and under the lowering sky. Not a spear of grass, not a bush, nor tree, nor flower

relieved the barren, lifeless stretches, but the time was drawing near when the earth should be clothed with beauty as with a garment.

The soft and formless beings that filled the waters were not living for themselves alone; they were also preparing the world for the higher and nobler life that was to come.

We have only been watching the dawning of life which had been gently stealing upon the world, but it was as important to the full life that was coming as is the dawn of every new day which ushers in the sun with all the attendant beauty and stir of a full-pulsed life.

Chapter XIV

The Reign of Fishes

About this time the world was very wonderful, and filled with strange inhabitants. The sun's rays, still struggling through clouds of mist and banks of fog, shone upon wide, shallow seas. Here and there the roll of the waves was broken by bare, jutting rocks, or by low, flat mud-banks. The sun baked the mud, and it dried and cracked and warped up in the heat, till someday a loud rumbling would be heard, the mud-bank crumble up and sink beneath the water, and the waves roll on unchecked over the spot. Somewhere else, before long, another mud-bank would arise, bake in the heated air, crumble away, and disappear.

The inhabitants of this world all lived in the water. They were the flower-like coral animals which slowly, year by year, built up circular islands from the beds of the shallow seas, or lowly, palpitating jelly-fish, dragging their long ribbon-like arms after them, or star-fish, or creatures living protected, as our clams and oysters do, between two hard shells. One thing, and it is the commonest kind of thing in our world, was not to be found then, and that is a backbone.

This period followed the dawn of life upon the earth; the creatures that now appeared were not only larger, but a higher kind of being.

You know very well, if you ever noticed at all, when you were carefully taking the bones out of a piece of shad or other fish before putting it in your mouth, that a backbone is really made up of a number of separate bones neatly fitted together, to which the other bones are attached. These separate bones, making up the backbone, are called vertebrae. The lower forms of life —those which have no backbone—are classed together, and called invertebrates; the higher are called vertebrates.

The old world we have been trying to picture was only our world before it was "grown up." Fire and water and ice had not yet finished their part in the work of world-building; but all the while it was making ready for higher kinds of beings, and slowly, one by one, these beings came into existence. There are places here and there in our world nowadays that look very much as every part of the earth must have looked then. Hugh Miller the poor Scotch boy you read about in Chapter II has studied this part of the world's history very patiently and carefully. He says that, looking off from the rocky, barren coast of the western part of Scotland, you see only bare rocks

covered with dismal seaweed, clumps of it growing on the rocks that are washed over by the waves, long floating streamers rising and falling with the tide; shallow sheets of water, whose beds are covered with other kinds of green water-weeds and shells. All this, he says, is very much what any part of the earth would have shown in the days before the fishes began their reign.

But the dawn of life which first glimmered in these ancient seas did not go out in darkness, it did not even stand still, but grew more and more into the perfect day. It became stronger and spread wider, filling the seas with hundreds of new forms of life, and thousands upon thousands more of the old forms — corals and star-fish and shell-fish; and then came the creatures with the backbones, and the reign of the vertebrates had begun. Fish are the lowest of the vertebrates, so they came first. The geologic fish were like, and yet unlike, the fish we now find. Curious creatures, some of them, wearing, like the knights of old, heavy helmets, or even a complete suit of armor, to protect them against other monstrous armed fish, with which they lived in perpetual warfare.

The wing-fish (Fig. 53) wore on its head a heavy helmet, with two holes for the eyes; the body was covered with a coat of mail made of strong plates, and

the tail was protected with a flexible armor of bony scales. The tail, which could scull the animal along if necessary, also served as a rudder if he decided to use his paddles to carry him through the water. These were two long arms that projected from each side of his head.

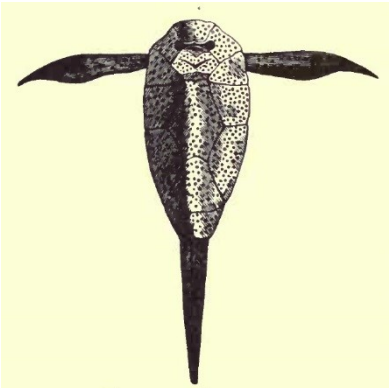


Fig. 53.—Wing-fish.
From Lyell's "Elements of Geology."

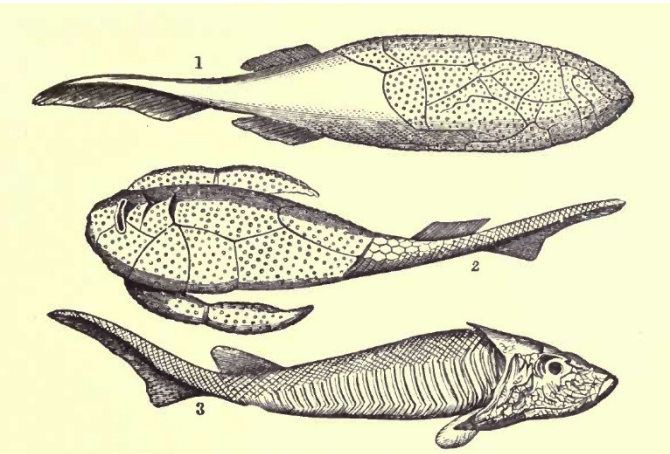


Fig. 54.—Mailed Fishes.
From Hooker's "Mineralogy and Geology."

Three kinds of mailed fish are given in Figure 54. No. 1 has the upper part of its body incased in armor; No. 2 has plates of bone protecting its whole body;

and No. 3 wears a queer helmet, made of a single bone. Some of the singular scales out of which the

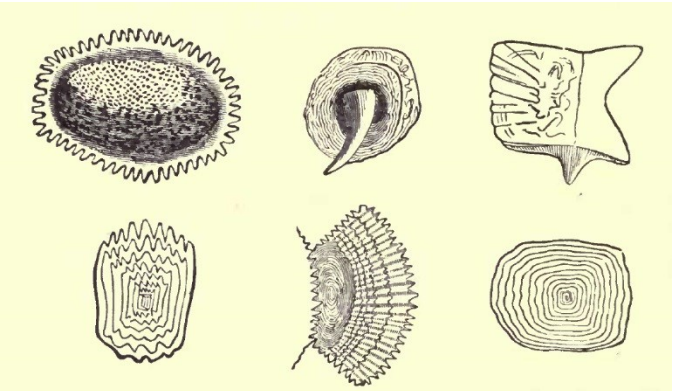


Fig. 55.—Scales.
From Hooker's "Mineralogy and Geology."

armor is made are given in Figure 55. One of the great mailed fish of that time was as large as an alligator; the helmet it wore would cover the front part of an elephant's skull, and was thick enough to turn aside a musket-ball. Though this was truly a fish, it had the jaws and teeth of an alligator.

The rocks belonging to this time are called the old red sandstone. Perhaps it will interest you to know (as I remember it interested me when I first found it out) that the brown stone of which so many houses and churches are built in this country, particularly in New York City, is old red sandstone. It is wonderful to think that many of the blocks of stone which form,

perhaps, our own homes hold within them curious fish and shells that lived in these old seas. Hugh Miller

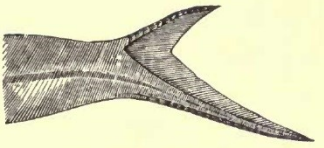


Fig. 56.—Unilobed Tail.

From Hooker's "Mineralogy and Geology."

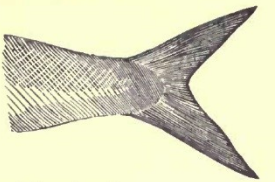


Fig. 57.—Bilobed Tail.

From Hooker's "Mineralogy and Geology."

tells us of what he found among the rocks of that day, which showed how full the sea was of fish, and how suddenly sometimes whole armies of them were overwhelmed and killed by the sudden upheavings of the earth's thin crust. He says that he found what he calls "one of those platforms of violent death for which the old red sandstone is so remarkable:" the layer of rock laid open by his hammer was covered with the remains of a whole fleet of mailed fish, some of them still twisted and contorted as in their dying agony.

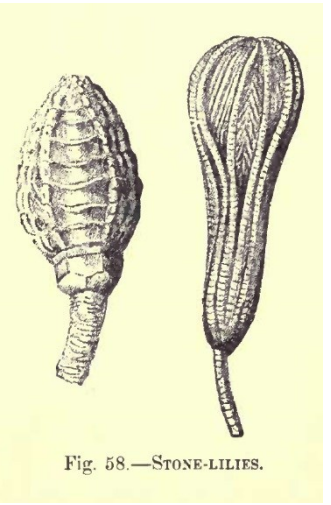


Fig. 58.—Stone-lilies.

Though fish were the reigning kind of life in this age, there were other creatures still more beautiful and curious. Along the shallows near the shores of the sea grew great gardens of stone lilies. These are wonderful creatures, animal, not vegetable; they are cousins of the star-fishes, but they are shaped something like a flower, and grow upon stems (Fig. 58).

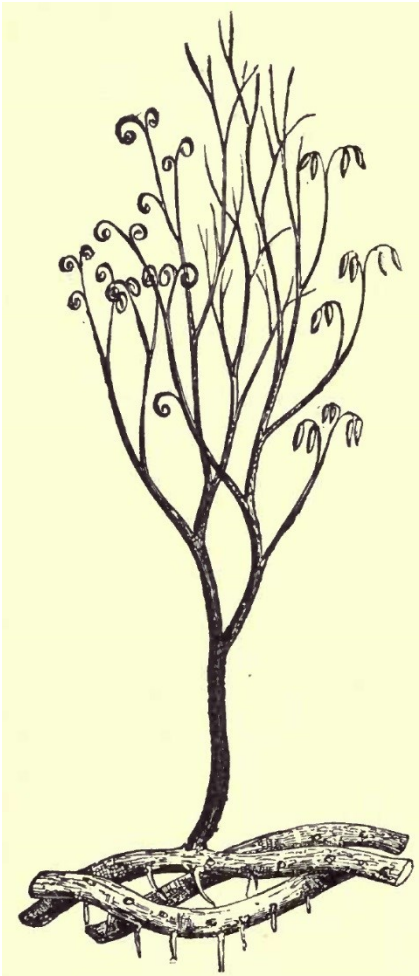


Fig. 59.—Psilophyton.

The land, too, began to show signs of life; the sea-weeds and a few mosses which had been all the earth brought forth gave place to singular plants, which grew to the size of trees. Figure 59 shows a sort of club-moss, which looks more as if it had been drawn upon a slate

by a very young artist than something that had ever grown and borne fruit as curious as itself. Enormous reeds shot up through the marshy soil, sending out feathery shoots that made them look like giant trees. Forests of slender stems bearing star-shaped drooping leaves covered the mud-banks, and mighty ferns lifted their fronds to the height of many feet.

There were a few trees too, whose rings, which can still be counted, tell that they were a hundred or more years old, and give us a hint that in those old days there were summer and winter, seed-time and harvest, as well as now. You know that the rings which show in a stump of wood show the age of the tree. Each ring is made up of a layer of loose, soft wood, and one of hard wood next it. The loose, soft wood grows in spring and summer, and the close, hard wood in fall and winter. From this we can tell that each year had a season of growth—summer—and a season of rest—winter—and just how many years the tree lived.

The age that is to follow is one full of marvels, and here and there in the time we are speaking of we catch a hint of the coming beauty and glory breaking through the desolation that had so long held sway.

Chapter XV

The Reign of Plants

Down deep in the earth, hundreds of feet below the surface, may be found strange cities, roofed over, walled in, and pillared with what looks like jet-black stone. No light reaches the narrow streets, except here and there where a flaring lamp stuck into a socket in the wall makes a circle of brightness around it, or a tiny flame, imprisoned in a wire cage, and worn in the front of his cap by each of the dwellers in this underground world, sends out a slender flame to light him on his way.

This curious place is a coal-mine, which has been slowly dug out by men who toiled there day after day and year after year, away from the light of the sun and God's beautiful green earth.

I want you to go back with me, in imagination, to the times when the coal was making. We must go back more years than we can even think of to do this. It was after the reign of the fishes; the land then existing was only low mud-banks and barren rocks, where a few plants and trees were growing. Most of the globe was

covered with water, ceaselessly beating upon the desolate shores.

A death-like silence hung over the dreary land and sullen waters. No insect's hum or bird's song broke the stillness of the air. The sounds that might have been heard, if there had been an ear that could listen, were sounds of destruction and death rather than sounds of life. The heavy muttering of the storm, the sudden claps of thunder echoing through the hollow air, the crash of earthquake and volcano, and then silence again, marked by the monotonous roll of the waves, as the silence of night is marked by the regular tick of a clock.

It almost seemed as if the earth, in spite of the heat, had not yet been released from the death-like spell of winter. But at last a new life was beginning to wake. Almost as spring comes to us each year this awakening came to the bare and desert land. Cannot you look back upon last winter and remember how long it seemed?—how you waited and watched for the spring so eagerly and impatiently that it seemed as though it would never come? At last, when you had almost begun to despair, there came a few soft, warm days, and the miracle of nature was wrought. The whole air was full of the whispers of the coming leaves, murmuring their gladness as they burst from their

dark prison-houses in the rough boughs, and pushed their way out into the air and sunshine.

Now that the spring had come to the world, after millions of years of waiting, it brought a wonderful and brilliant life. The excessive heat and moisture together made of the whole land one great green-house. The plants grew to a gigantic size. The swampy ground brought forth huge reeds that reared themselves forty or fifty feet high, and were clothed with masses of feathery leaves. Ferns shot up tall trunks crowned with foliage like palms. Singular trees, unlike any living now upon the earth, whose trunks looked like carved columns of wood, filled the forest, and must have given it a most peculiar look.

In this ideal landscape the trees and plants that are known to have made up the coal forests are shown. In the water on the left of the scene are two things peeping up that look like asparagus tips. These are the growing ends of the reeds that are going to make great trees. In the middle and to the right are some singular round balls with long fringed arms lying out on the water. These for a long time were a great puzzle to geologists, till in some of the coal-beds they were found to be the roots of the carven stems near them. The marking on the stems was also found to be scars left by leaves which had fallen off; but the plants that

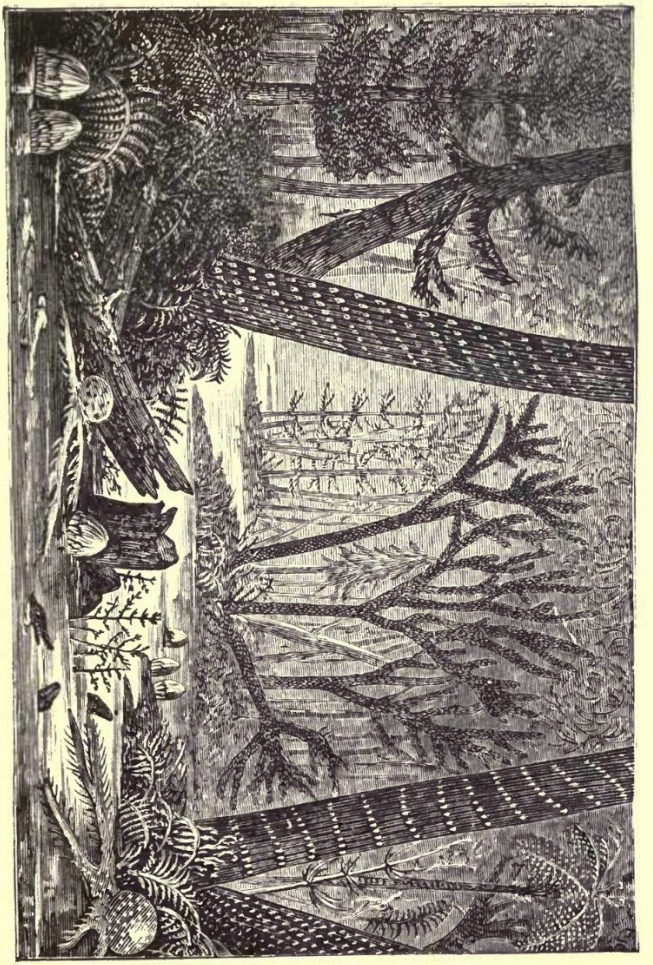


Fig. 60.—Ideal Landscape of the Coal Period.
From Winchell's "Sketches of Creation."

were most common and grew most freely were ferns, both tree and creeping ferns. These plants were all found in the swamps; at the same time on the rocky lands a few evergreens had sprung up, which were

sometimes carried down in the freshets and packed among the living plants of the swamps.

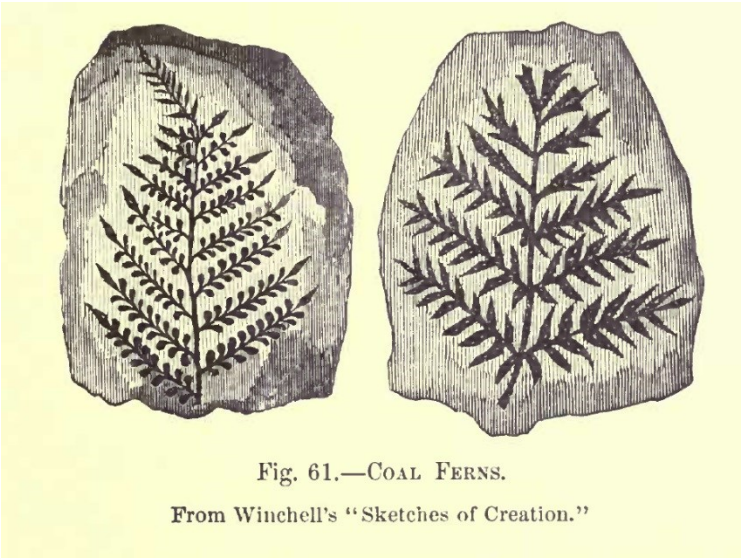


Fig. 61.—Coal Ferns.

From Winchell's "Sketches of Creation."

It seems a wonderful leap to make from such a dense living forest as this to a seam of solid coal, lying between layers of stone, hundreds of feet underground, and so it would be if we tried to take it in one jump. But we are able to trace the change step by step from wood to coal almost as perfectly as we can the wood that is stacked, and covered in from the air, and slowly heated till it turns into charcoal, in the charcoal-burner's pits.

Do you remember anything about the peat-bogs we were examining in Chapter VII—how the leaves

and stems of plants, and even stumps and logs of wood, sunk in the swampy waters, instead of turning to dust and blowing away, as they would have done in the air, were packed down and gradually changed into a black, pasty mass, and that this mass when dried



Fig. 62.—Tree-trunks found in a Mine.
From Winchell's "Sketches of Creation."

would burn? Well, peat is the first step that wood takes in its change into coal.

Coal is nothing but wood—leaves, stems, roots, and trunks—which under water, and by means of heat and pressure, has slowly changed its form. A coal fire is, after all, made from wood, but wood that grew millions of years ago, and was packed away and kept all that time underground, while a wood fire comes from last year's forest that was cut and for a few months perhaps stored away to dry.

We can find in different parts of the world fuel in all its various stages of change from wood, through peat and brown coal and soft coal of various kinds, up to hard coal. Two other things that we do not think of as coal form links in this chain of change. Jet, out of which jewelry is made, is one form of soft coal, and graphite, that makes the best lead for lead-pencils, is the hardest of the hard coals.

A piece of common coal ground down into a thin slice shows under the magnifying-glass just the sort of cells that a piece of wood cut thin and even will show. Perfect leaves are often found in coal, with every vein distinct; and in some coal-mines great tree-trunks of solid coal, embedded in coal as solid, have been found (Fig. 63).

You remember the sudden changes in this old world were something like what happen now, only more violent and more swift. The coal swamps lay usually near river mouths. Besides the leaves and fallen trunks from the forest where they grew, the river in its uprising would carry down masses of logs and up-rooted trees, and pack them in among the living-plants, and over all would settle loads of river mud and sand brought down by the freshet. Something like this is going on at the mouth of the Mississippi and other rivers now, and peat-bogs are forming there as the coal-beds began to form so long ago.

Coal seams are large, flat layers of coal pressed between layers of various kinds of rock. Usually there are many layers of coal with layers of rock between, like a natural jelly-cake, the jelly being the coal, and the cake the thick rock between. Each layer of coal represents a buried forest, and the layer of stone just under it is crowded with the roots and stumps standing just as they grew millions of years ago. In Wales, in one place, there are one hundred layers of coal, with rocks between, one on top of the other, for over two miles deep.

Though plants reigned in the coal-measures, the waters were not empty of animal life: great fish swam about in the waters, beautiful corals clustered on the

rocks near the sea surface, star-fish and stone-lilies, shell-fish and lobster-like creatures, dwelt in the sea. A

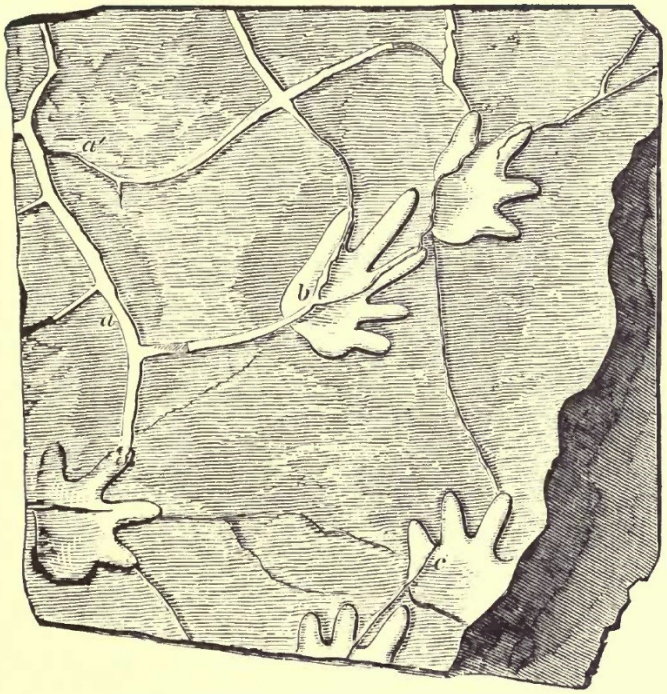


Fig. 63.—Slab of Sandstone showing Footprints of Saurians.
From Lyell's "Elements of Geology."

few insects had begun to flit about over the surface of the water, and enormous lizards made their appearance. Clumsy footprints on the sandstones (Fig. 63) show where they have lived and swarmed, and singular skeletons leave in the rocks a record of their deaths. A new and higher life had begun in the

animal world while the coal forests were growing and perishing and being packed away for future use.

After the end of this period the earth, with its great beds of forest and forming coal, suffered terrible convulsion. Again the crust was thrown into wrinkles. The mountains of our Eastern States were thrown up at that time, and then the water began wearing them down. The animals and plants of the coal period began slowly dying out. It was like the twilight of the day that had dawned so long ago; but it came before a time of comparative rest, and the dawn of a new day.

Chapter XVI
"Striking Oil"

The expression "striking oil" is such a common, every-day phrase that we hardly stop to remember what it really means, and yet thirty years ago such a term was never used, for the very fact that gave rise to it did not exist.

A hundred years or so ago a curious sight might have been seen in the Indians' country of western Pennsylvania. Early in the morning one of the squaws would carry a dirty blanket down to the borders of the stream. A natural conclusion would be that she was about to give her blanket a much-needed washing. But no; instead of dipping the blanket in the water and rubbing and squeezing and wringing it, she merely flings it out on the surface of the stream, and when it becomes soaked draws it towards her and begins carefully squeezing out the liquid that it has caught in its meshes into a gourd. The observer begins to catch the idea. It is not a clean blanket that she wants, but the disagreeable, ill-smelling, greasy scum that floats upon the surface of the water.

In this simple manner and by these queer means the Indians of that time collected oil, not to give them light, but to be used as a liniment to rub their poor joints when swollen with rheumatism. This was the old savage way of "striking oil;" for this oil gathered was petroleum, which is now so commonly known as kerosene, but was then called "Seneca oil," and used only as a medicine.

A certain Colonel Drake, who had a farm in that part of the country, came to the conclusion that somewhere in the earth was to be found a reservoir of oil, which he could reach by digging for it. He believed that the oil which oozed out of the rock and made a greasy scum on the Oil Creek waters came from somewhere, and that somewhere he meant to discover. His neighbors amused themselves by laughing at him and joking him, much as Noah's neighbors did when he was building the ark. Their tune was changed, however, when in the summer of 1859 Colonel Drake "struck oil." In the course of four months Drake's well had poured forth two thousand barrels of oil. Then the nation took the oil fever. Speculators rushed in, new wells were dug, and the once desolate fields bristled with derricks.

Before Drake's well was dug, manufactories were in existence in which oil was distilled out of coal, and

called coal-oil. Petroleum was found to be so like this substance that it too is often called coal-oil, and supposed to be distilled in the great workshop of nature out of coal. But that idea is incorrect. It is not made out of coal, but it is closely connected with coal in this way, that both coal and petroleum are made from the plant life of the past, which in the course of ages has been changed into these two substances. If coal-oil were made out of coal, it would be found near the great coal-beds. This, however, is not always, not even usually, the case.

We have seen how the coal-beds were formed by the great swamp forests, which, under fresh-water and by means of great heat and pressure, were turned into coal. Oil, it is thought, is formed by the softer plants, sea-weed and water-plants, which have been, under salt-water and at a lesser heat, distilled beneath the surface of the earth. The oil being formed in the water, of course floated on the top. Sometimes it soaked into porous sandstone, sometimes it ran into holes and fissures of the rocks. Usually it is found associated with the salt-water under which it was gradually formed.

I have said that oil is distilled out of plants; it is also distilled in much the same way from the animal life of the past; but we probably owe most of what is sold to

a distillation of plants. The rocks of many periods, besides that when plants grew in such enormous quantities, are full of oil. In the coal-beds, you remember, we found every kind of coal showing the gradual change of vegetable matter into coalfrom peat through soft coal to hard coal. In the same way petroleum is found in all the different forms it takes on in its change—light oil, heavy oil, bitumen, and last, it is thought by some, diamond. If a great mass of vegetable matter is heaped up and left, and after a while examined, in the middle of it is found an oily, tarry substance, like one of the forms of petroleum—bitumen.

With the oil and the salt-water in the underground pools there is found a quantity of gas formed from the petroleum. And it is this gas, which is very much squeezed up, that makes the oil spout up when a boring reaches the reservoir. When water and oil and gas exist

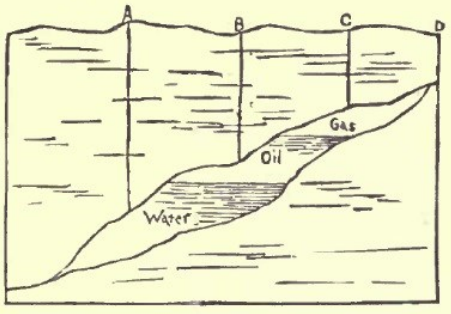


Fig. 64.—Oil Pool under the Earth.

A, water well; B, oil well; C, gas well; D, surface of the earth.

together in the same crevice of the rock, the water, being heaviest, will lie at the bottom; on top of that will be the oil, and above both of them the squeezed-up gas (Fig. 64).

Now you can see that if a well is dug at A, the crowded-up gas will force up water in trying to get room for itself. After the water has all come up, if the gas is still very much compressed, the oil, which has run down to B to take the place of the water, will follow the flow of water. If the power of the expanding gas has gone, the oil must then be pumped up. If, however, the well has been dug at C, gas comes up, and oil must be pumped up when the gas has all escaped.

Natural gas is used to a great extent to light and in part to heat great cities in the coal and oil districts. It seems as though the supply must soon give out, but as a matter of fact it seems to be nearly undiminished in places where the wells have been blowing off gas for nine years. And if it should give out, the pipes being all laid, it is possible to make a kind of cheap gas at the mines which can be carried and used as the natural gas has been.

The oil is certainly failing in the old fields. New fields may of course be found, and probably will; for

the oil that has been burned all over the world until a short time ago came mainly from a strip of land only one hundred and fifty miles long, and from two to twenty miles wide. But of late years there has been a wonderful discovery of oil in Russia, where wells have spouted the incredible amount of fifty thousand barrels a day.

The great works that used to distil coal-oil have been turned into refineries of petroleum (Fig. 65). After the kerosene has been made, a thick, tarry, disagreeable stuff is left. This looks like the most hopeless sort of material for any use, but out of it are made our modern "wax" candles, "wax" matches, and even some sorts of candy and chewing-gum. Another of the materials left when the kerosene is taken out is made into beautiful dyes colors that were never seen in old times. Unfortunately these colors do not hold like the simpler old-fashioned dyes, but often fade out, or, what is worse, fade into very ugly tints.

Much of the oil is brought from the region where it is found in curious tank cars, but some of it is pumped through pipes three hundred miles long,

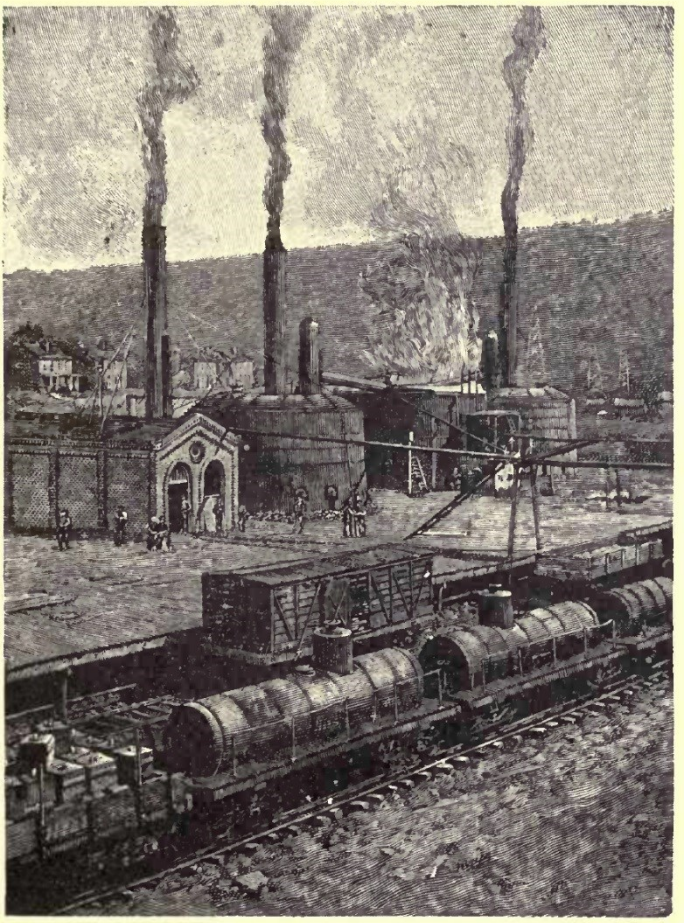


Fig. 65.—Oil Refinery, showing Tank Cars.

from the mines to the refineries. Beside the track of the Central Railroad of New Jersey such a pipe runs.

If you ever chance to go over that road to Long Branch or Philadelphia, or to some Jersey town near

New York, notice this pipe, and you may hear the oil from three hundred miles away give a thud, thud, as it is pumped into the reservoirs at Bayonne. If you look to the eastward, about six miles below Jersey City on this road, you will see a branch track curving off to New York Bay, where it ends in a forest of masts and factories and great oil tanks. Many a time you may see from New York the whole heavens ablaze with the fire from a tank that has been struck by lightning or has caught on fire some other way.

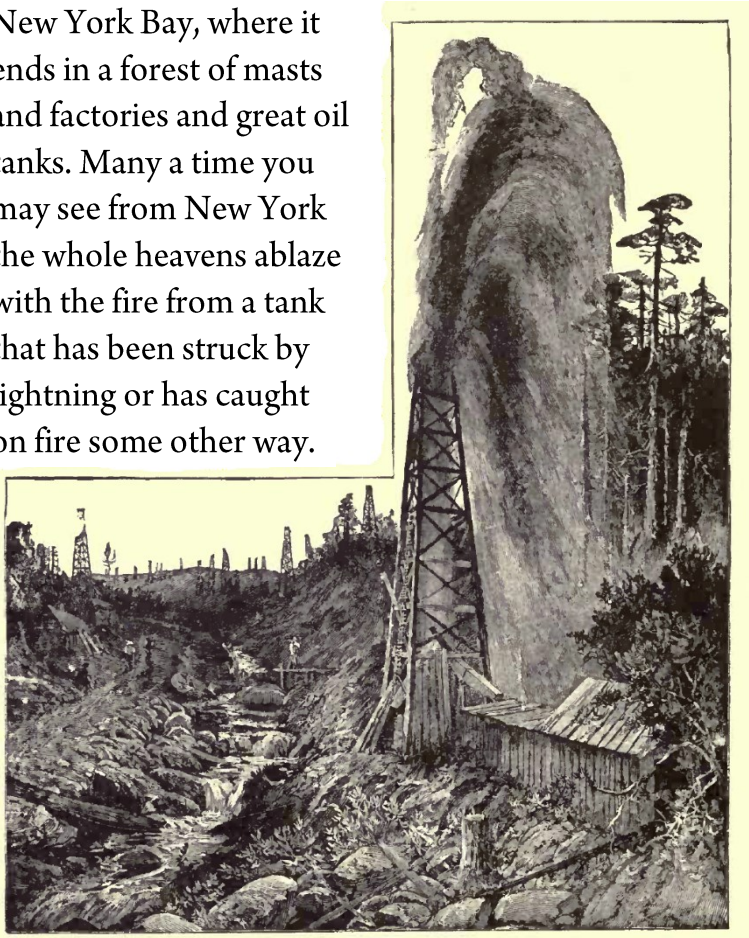


Fig. 66.—A Field of Derricks.—Effect of a Torpedo.

A still more wonderful sight, however, is to see a natural oil well ablaze. One of these wells at Cherry Grove, Pennsylvania, in the summer of 1882, was sending out oil at the rate of a thousand barrels a day. By some accident it took fire, and for four days and nights it shot up into the air a blazing fountain, breaking into millions of fiery drops, the great column of fire swept here and there by the passing winds. The fire at last was quenched by shooting off with a cannon-ball the top of the tube out of which the oil was spouting, and plugging the pipe below the blaze; but some of these wells have gone on burning till all the oil which they contained has been consumed.

Chapter XVII
Salt

In the Holy Land there is a great cleft which runs north and south, and ends near the southern part of the country. Just before the end it dips deep into the earth, more than a mile lower than the level of the Mediterranean Sea, not far away. Through this cleft flows the river Jordan, and the deep gouge into the crust of the earth is the bottom of the Dead Sea. This sea, called in the Bible the Salt Sea, is one of the most curious bodies of water on the face of our earth. If you came upon it in your travels it would not seem so wonderful. Under the bright sun of Syria you would see a beautiful sheet of blue water rippling under the breath of the breeze, bounded on either side by bare, rugged mountains, with scarcely a blade of grass or tree to break the solitary, barren grandeur. It is not horrible and greasy to the look, nor disgusting to the smell, as many old writers used to say—though the shores are covered with a brown, pitchy substance called asphaltum, and great masses of salt and sulphur and gypsum, or plaster of Paris.

The water is so heavy with these substances that a man can scarcely sink in it, but when he tries to swim will find himself almost out of the water, and his feet kicking in the air. A curious old writer, who visited the Dead Sea before Columbus discovered America—in fact, more than four hundred years ago—says, "It is called the Dead Sea because it does not run, but is ever motionless. . . . And you shall understand that the river Jordan runs into the Dead Sea, and there it dies, for it runs no farther."

In this sentence he tells us the secret of the sea. The river Jordan does run into the salty lake, hemmed in by high mountains on both sides, but there is no way for the water to get out.

You know when water is put in a shallow vessel it will dry up; that is, it will pass into the air in an invisible steam, or vapor, and the vessel will be left dry. If you take some water in which a great deal of salt has been melted and let it dry in the pan, the water will dry away, leaving the salt behind. Suppose every day from your pan of salt-water ten spoonfuls of water dried away, and you each day put nine spoonfuls of fresh-water into it, there would be at the end of each day a little less water in the pan, and it would be a little saltier to the taste. Now, this is just what happened to the Dead Sea. In the first place, the sea was probably

an arm of the Mediterranean, which was cut off from it by the lifting up of the land between. This salt lake would soon have dried up, leaving a flat cake of salt where its bottom had been; but the river Jordan pours into it "and dies," as old Sir John says; but in dying it leaves in the water of the sea all the dissolved earth and salt and other things it had brought down in its current. More water dries out of the sea each day than the Jordan and other rivers bring to it; so the sea for long ages has been slowly shrinking and growing saltier. Along the old sea margins there are cakes and blocks of salt, as well as asphalt and sulphur, left by the retiring water; and at the bottom of the sea crystals are forming and settling down from the intensely bitter salty water.

It has been long believed that the Dead Sea covers the cities of Sodom and Gomorrah, but that is a mere guess. That the cities were to the north of the sea is believed by people who have studied it very carefully, and the "slime-pits "mentioned in the Bible were pits of asphaltum or bitumen. You remember that I told you in the chapter on oil that it was distilled from vegetable matter under salt-water. This asphalt is only one of the harder forms of oil, and here we find it close to the beds of salt.

There are other salt lakes in the world something like the Dead Sea, but none that are so curious or interesting. The Caspian Sea is a sea without an outlet; but from what we can find about it by studying its shores, it may never have been a part of the great ocean, but formed and made salty by the drying up of river-water age after age, leaving the settlings to accumulate till the water of the Caspian is salty. It is plain to be seen that the Caspian has shrunk a great deal owing to the same fact that has caused the shrinkage of the Dead Sea, that more water is lost by drying than is gained by the river's tribute. Still, with all this loss of water, it is not so salty as the Mediterranean. This is one of the reasons it is not thought to have been an arm of the sea cut off, though it is not quite certain.

Great Salt Lake, where the Mormons live, is a sea like the Caspian, mainly made by the rivers that empty into it and pass away in vapor. Ages ago Lake Champlain was part of the sea, and the waters were salt; but the fresh-water rivers running into it and out again at the lower end have rinsed out the salt and left it sweet.

Salt lakes almost always have other settlings forming layers at the bottom besides salt. One of these is plaster of Paris, or gypsum. This is dissolved in the

water of the lake, but as the water becomes more and more salty it finally settles; then, as the water gets all the salt in it that it can dissolve, salt begins to settle above the gypsum, and we generally find a layer of gypsum and then one of salt, and dirt washed down by the summer floods over them both.

Just as under coal-beds iron is found, so under salt-beds gypsum is found. The salt accumulates in great masses and cakes. Sometimes it is lifted by fire up into mountains; and at the lower end of the Dead Sea there are great masses of salt reaching several miles in length, and in some places four hundred feet in height. The rain-storms have worn and melted it till it stands in buttresses and pillars. At the foot of the hills these monuments stand, strewn around with great lumps of pinkish salt, soft and slushy in winter, but sparkling with brilliant crystals under the hot summer's sun.

In Louisiana, among the low prairies, where Evangeline, in Longfellow's beautiful poem, sought her lover, there rise five humps of land partly surrounded by water, called islands. One of these contains one of the most wonderful salt-mines in America. During the war the terrible want of salt made the owner of this island dig for it. After digging for days, some hard substance was struck, black and solid. It was at first thought to be a stump, but a few blows

of the pick and out flew a pure white piece of salt. It had been covered with a coat of black asphalt. It is not known how deep this salt-bed is, but no bottom had been touched after digging through sixty-five feet of pure salt. At one place in Europe a mine has been sunk for one thousand feet and no bottom found.

Near where famous old Troy stood are some marvelous salt springs. The place is a valley enclosed in mountains, colored by the minerals in the water—gorgeous reds and blues and yellows. The floor of the valley is a variegated crust, through which jets of hot, intensely salt water come up. In one place from the rocks at the side jets of boiling water spout out like fountains at play, and flow away as a rivulet of salty, steaming water.

Chapter XVIII
The Reign of Reptiles

One summer, about a dozen years ago, I was visiting Hartford, Connecticut. A number of people meet together every summer in some part of the United States, to discuss questions of science. After the science is over the members of the association often go upon excursions.

One day during the Hartford meeting the geologists and others paid a visit to a very wonderful place on the Connecticut River, near Middletown, called the Portland Quarries. Quantities of brown stone for house-building had been taken out and shipped to various places. This quarrying had been going on for about one hundred years.

In one place a broad, uneven floor had been left littered over with slabs of stone of various sizes. On the broken bits and on the floor were great numbers of the most wonderful footprints, as clear and distinct as if they had been made an hour before in wet earth.

Some of the tracks were eight or ten inches in length, others were not more than four or five. The tracks looked like those of gigantic birds, and were

called for many years "the bird-tracks of the Connecticut Valley."

The sandstone quarry had once been the beach of a shallow sea. Over the sand which had been left wet by the receding water myriads of strange creatures roamed in search of food. More than fifty different kinds of creatures have left a record of their presence on this shore, and there were probably hundreds upon hundreds of each kind. On this single slab of stone, six feet by eight, and dug from one of the quarries of the valley, are the tracks of six different creatures, inhabitants of that ancient world (Fig. 67).

Before the footprints had lost their distinctness, the next tide, rising and sweeping inland, carried a new supply of sand and spread it over the beach, covering the footprints and making a fresh, smooth surface for new ones. So layer after layer was formed, each holding the record left of their presence by the visitors of the day. Slowly the whole mass hardened into stone, keeping through thousands of years the marks impressed upon it when it was yielding sand.

The sandstone readily splits between any two layers. When an upper slab is turned over, the same footprint is found upon it as was upon the one below it, only the print is raised instead of being hollowed

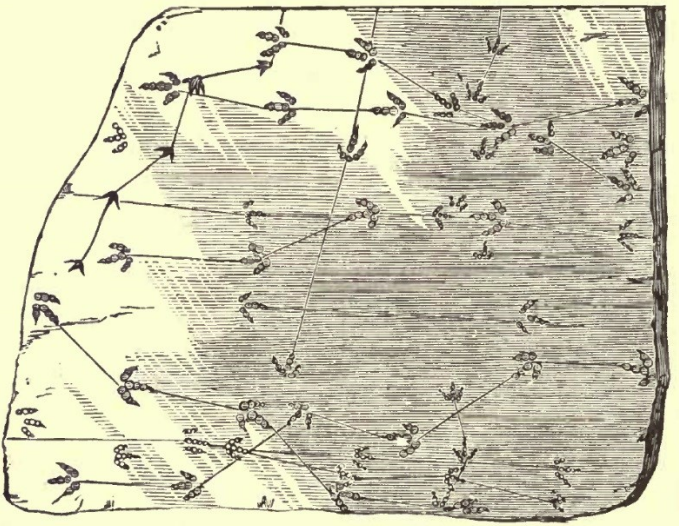


Fig. 67.—Slab of Sandstone, with Tracks of Bipeds.

From Winchell's "Sketches of Creation."

out, just as the sealing-wax on a letter shows the same figure raised upon it which was hollowed out on the seal that pressed it.

The markings so long considered to be bird-tracks are now thought to have been made by a strange winged reptile with bird-like claws, whose bones have been found in the rocks of that time. It is not so singular as it may seem at first glance that such doubt exists. Reptiles and birds are nearer cousins than one would be apt to guess. They are really only two branches of one great division of the animal world. Now, it is true, we find them very widely separated,

but if we could see some of these old-time monsters it would puzzle us to tell whether they were birds or reptiles.

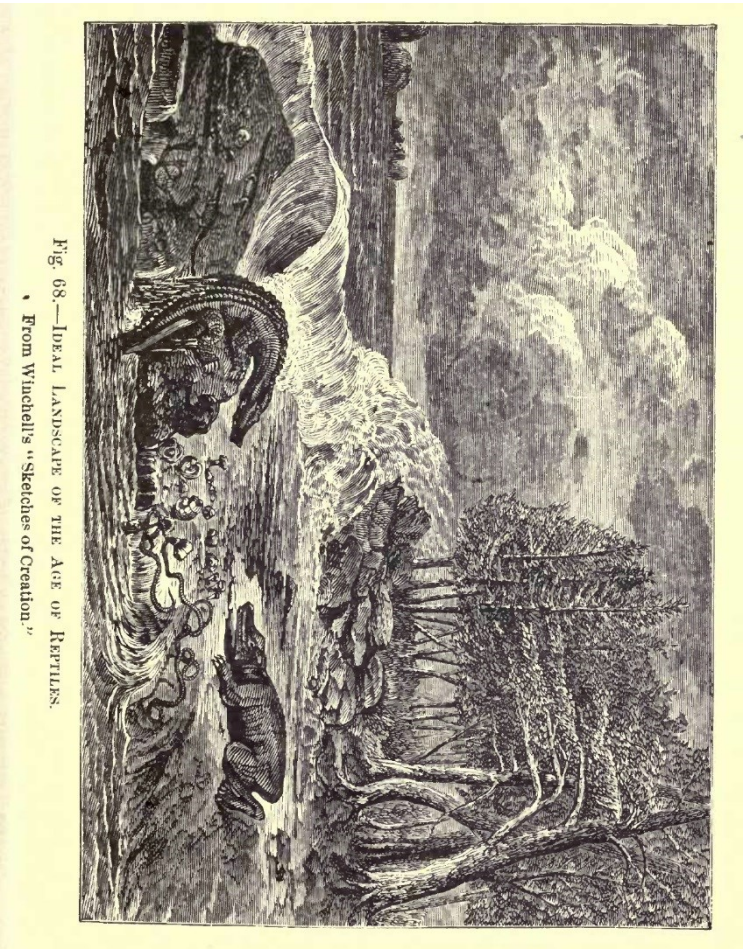


Fig. 68.—Ideal Landscape of the Age of Reptiles.

From Winchell's "Sketches of Creation."

These tracks in the sandstone may have been made by a reptile-like bird, but more probably they were those of a bird-like reptile.

"When a reptile is spoken of, the idea it suggests is a snake, as snakes are the commonest of the reptile class in our time and our country. There are, however, many creatures living on the earth now which are just as truly reptiles as snakes are; we may not see many of these creatures, but we often hear or read of them crocodiles, and their American cousins alligators, turtles or tortoises, and lizards. These do not form a very important class in the animal kingdom now, but there was a time in the world's history when they were the rulers everywhere, in the air and the sea and the land. There were probably more in number and more in kind than the world has seen before and since, and besides this, they were enormously larger, more powerful, and more dangerous. Many of these creatures were forty feet long, and some were as much as sixty or seventy feet.

The reptiles that ruled in the air were utterly unlike anything we now see. Some of them were twenty feet from tip to tip of their out-spread wings. One of them, you see (Fig. 69), has just thrown himself from a rock in pursuit of a dragon-fly, while his companion sits perched above him on the top of the bank.

Another of these singular creatures may be seen in Figure 70, leaving behind it, as it walks, the prints of



Fig. 69.—The Pterodactyl.
From Winchell's "Sketches of Creation."

its bird-like claws and sharp tail and queer wings. The wings, you see, are nothing like a bird's wings; they are more like those of a bat, the skin being stretched to a bone of the fore-foot from the side of the body.

Terrible frog -like animals roamed over the land, leaving footprints curiously like the impression from a flat human hand (Fig. 72).

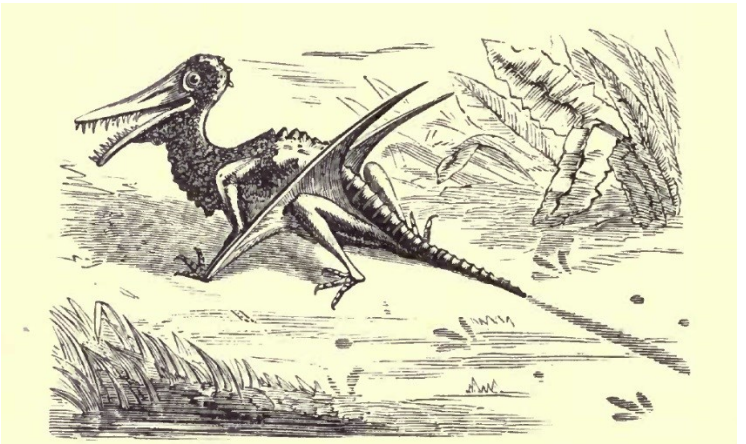


Fig. 70.—Ramphorhyncus—One-quarter Natural Size.
From Winchell's "Sketches of Creation."

The shores of the ancient seas were infested with other huge beings something like our alligators. In the landscape (Fig. 68) one of these may be seen, in the middle of the picture, crawling up on a rock, while the huge frog-like reptile is making his lumbering way down to the water, where he spent most of his time.

It was the ocean, however, in which most of the monsters of that time lived. The waters of its seas were lashed into fury by their sports and spoutings and battles to the death. Such a battle is shown in the picture (Fig. 71). The larger, to the left, must have been a terror to the watery world around him. Not content with devouring all the fish and lizards that came in his way, he also lived upon the young of his

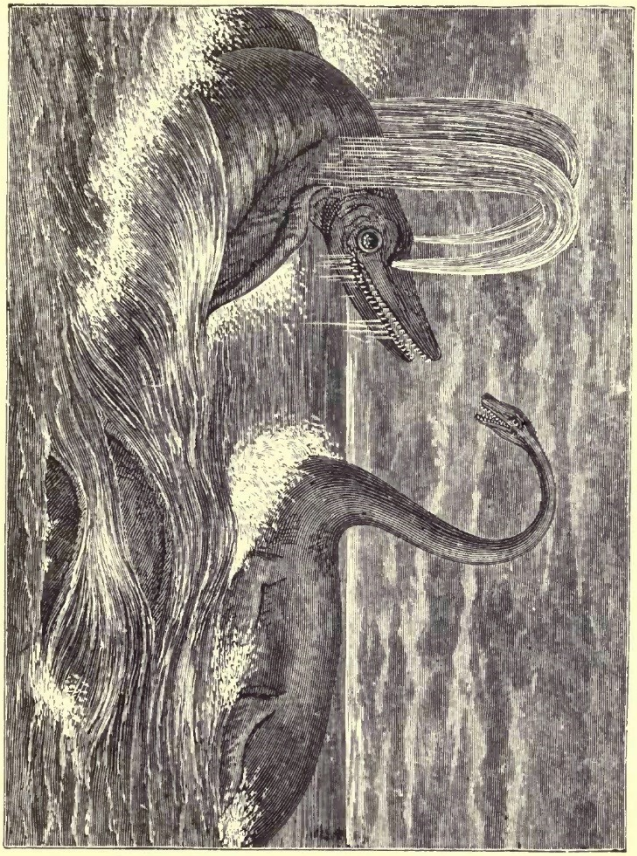


Fig. 71—Ichthyosaurus and Plesiosaurus.
From Winchell's "Sketches of Creation."

own kind, as the bones found in the stomach of a skeleton show.

The huge sea-lizard to the right in the same picture was a much less dangerous creature. At this time there

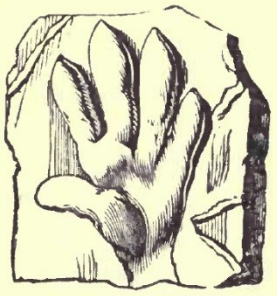


Fig. 72.—TRACKS OF LABYRINTHODON.

From Lyell's "Elements of Geology."

existed creatures more nearly approaching serpents; these have sometimes reached a length of eighty feet. It is possible that some of his cousins still exist in the ocean, and that they occasionally show themselves. There have been a great many stories of sea-serpents seen by many people and at various times. Most of these are undoubtedly sailors' yarns, and deserve no attention; but leaving these out of the question, there still remain some that we cannot refuse to credit one of these, for instance, where five hundred people saw the creature again and again, and near enough to distinguish its eyes; and some of these witnesses were men whose evidence would have been taken in any court of justice in the land. Not very long ago a strange carcass was caught in the anchor of a sailing-vessel and beached on the Florida coast. A storm washed it away before such drawings and measurements could be made as would have settled the question as to what it was. Now that people are seriously beginning to listen to stories of the sea-serpent, we may hope that someday one will be captured, and then all doubts as to its existence and

what manner of reptile it really is will be finally set at rest.

During the age of reptiles many new shells and stone-lilies, etc., first appeared in the waters; but they were not sufficiently unlike those that had already come and those that, followed after to require description here.

The character of the forests, too, was changing all the while from what it had been in the coal-making period. The great club mosses with their carven stems, and the huge, feathery-leaved reeds, were passing away. The ferns still grew in great profusion; both the low and creeping kinds and the tree-ferns filled the woods, but other trees and plants, like our evergreens and palms, took the place of vanishing kinds. These, too, made coal-beds, though not such vast ones as were stored away during the reign of plants.

It must be understood that the whole world, Europe and America and Australia, had each its history, when the reign of water and fire and ice, of plants and animals, followed each other very much in the same way, but not at the same time. Europe is an older country than America, and America is older than Australia, in other things besides those about which our written histories tell us. The animals and

plants of America when it was first discovered were like those of Europe in a time much earlier. Australia had animals and plants that corresponded with an age still earlier than those of America. Some of the curious birds and animals of Australia help us to understand the meaning of the singular skeletons dug out of the rocks in European countries.

In the history of each country, after man came upon the earth, we see something like this. When Rome was in its later days, England was full of barbarians; and England was an old country, in her turn, when America was still barbarous. Just as man's work in the world his diggings and minings and quarryings changes the order of nature in the layers of the earth, so his moving in and taking possession of the new countries changes the order of things there too, and interferes with the regular succession of creatures which would have followed, one kind succeeding another till all was complete.

Chapter XIX
The Bottom of the Sea

About three-quarters of our world is under water. This we all know very well, if we have not grown so old or so wise as to have forgotten our geography. We are apt to think of this vast expanse of ocean as having very few inhabitants; in fact, as being a sort of watery great desert, with fish passing through it, something as the caravans pass over Sahara. It is chiefly important to us as the pathway over which steamships and sailing-vessels go, carrying passengers and exchanging the products of one country for those of others.

But the ocean is even more than the land teeming with life. Not only are its waters full of darting fish, but there is a silent life filling the sea-bottom, and doing more towards building it up than all the larger creatures above. And so it was in the past ages, only more truly so. Large as the ocean is now, it was far larger then. The Atlantic waves as they swept westward did not break upon the coast of the British Islands, for England, Ireland, and Scotland were deep down under water. The inhabitants of the British Isles in that day were principally little shell-fish, so tiny that

you could not have seen what they were with your unaided eye. As each generation of these little creatures died, these shells, some of glass and others of a limy or chalky substance, beautifully formed and delicately carved, dropped to the bottom, and so built up the earth. There was nobody around then with his magnifying-glass to look at the curious earth as it was forming, but it has been saved for us in one of the great layers of earth called "the chalk." Much of England

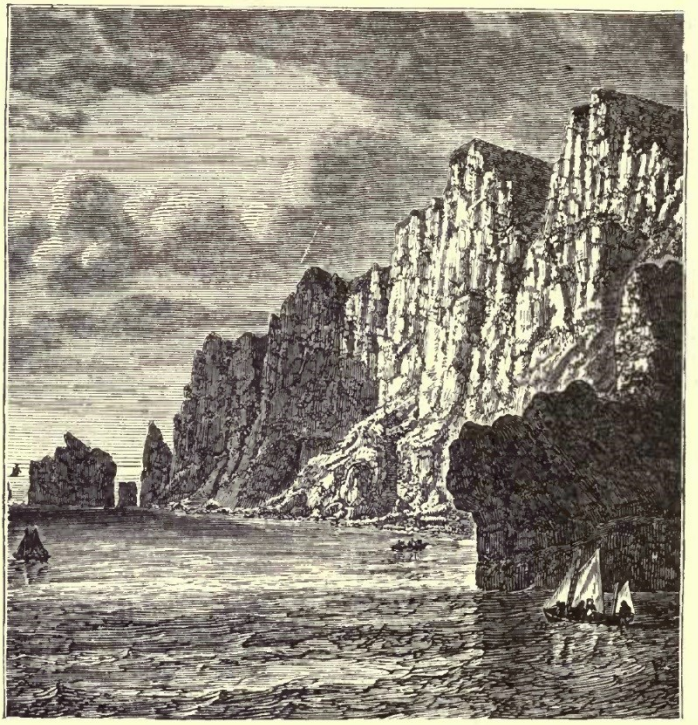


Fig. 73.—Chalk Cliffs of Dover.

was built up in this way by the dropping of myriads of shells when the little life that had animated it went out. At the end of the English chalk period Great Britain and more besides were lifted bodily above the waters, and then the waves went to work to carve England, with all her bays and inlets, out of the great stretch of uplifted land. The Strait of Dover was cut through, leaving the edges of the chalk layer standing up, white and tall, facing the water.

These chalk cliffs gave the poetical name of Albion, or the white, to England; and these were the shores to which the men of Tyre and Sidon came in their ships to gather the tin found in the southern counties of England, and carry it away to their own land, long before our Lord was born in Bethlehem.

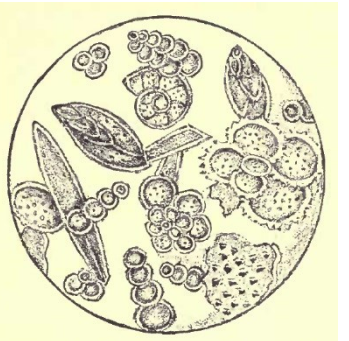


Fig. 74.—English Chalk.

Though England was no longer receiving new layers of shells, the same thing went on and is going on today in portions of the Atlantic Ocean. The difference between the chalk formed so many millions of years ago and that forming now you can see by looking at from the English chalk-beds, and

then comparing it with Figure 75, from the bottom of the Atlantic today.

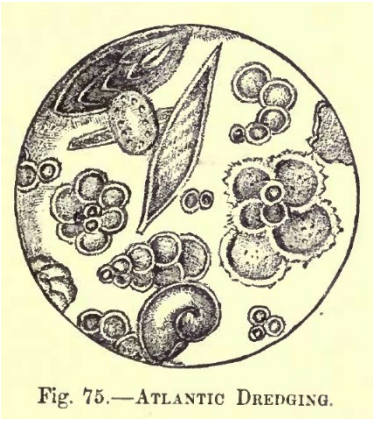


Fig. 75.—Atlantic Dredging.

Very little was known of the great oceans before the days of Columbus and the other voyagers of his time. All the sailing done before that was in inland seas like the Mediterranean, or along the shores. And people imagined that down in the depths the cold and darkness and tremendous weight of the water would prevent anything from living there. A few examinations were made, it is true, in a part of the Mediterranean near Greece, and no life being found there, that settled the question for a while.

But just thirty years ago men of science found occasion to change their minds upon this point. A telegraphic cable which had been lying in deep water (the exact depth was known) was broken. In order to mend it the cable had to be drawn up out of the water. When this was done, thousands of tiny living creatures were found on the wire. Not loose, as though they had been caught on the cable as it was dragged up through the waters, but closely cemented

to it, showing that they had lived where the wire was lying in the depths of the sea.

As soon as the fact was known that there was life in the sea-depths a great interest was aroused. Ships were fitted up with all sorts of dredges and scoops and nets to catch the delicate creatures living down deep in the water, and to bring up the soil from the bottom so gently that its inhabitants would not be killed.

Day by day the formation of chalk, as it is going on now at the sea-bottom, was watched and recorded.

Nowhere else do we find a link that binds our world of today so closely with the far distant past as just here. The higher the form of life, the more easily does it change and develop. We find in the mud from the Atlantic bottom living creatures whose shells are very much the same as those which millions of years ago built up the English chalk. These are almost unchanged, while above them all the wonderful panorama of life has passed unnoticed. The strange fish and monstrous reptiles and curious reptilian birds have all passed and vanished utterly from the earth, the water and the air knowing them no more.

The reason of this is clear. All life depends much on its surroundings: if they remain the same, the forms of life usually do not change much. On land and

on the surface of the water the surroundings constantly vary. Heat and cold, moisture and drought and plant life, have changed, and the animal life has changed with them, but in the depths of the sea there has been only one marked change—the waters have been slowly cooling off, and so the changes have been slight and gradual. Everything else remaining the same, we ought not to expect, and we do not find, any violent change in the forms of deep-sea life. The geologic period of the Atlantic depths is therefore not far from that of the British Isles some millions of years ago.

It perhaps seems like going backward instead of forward when we take up the study of these tiny, simple forms of life, after the mighty reptiles that have ruled with a rod of iron the world of waters. But we are going upward through the layers of rock, and after the coal-fields and the rocks that contain the foot-prints and bones of the reptiles, come these beds made of tiny glass and chalky shells. The reason of this is that great tracts of land sank under the sea, and over it settled myriads of the chalk shells, forming a thick layer. These little creatures had been living from the earliest

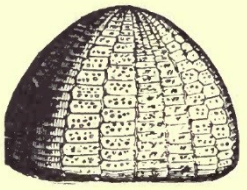


Fig. 76.—ECHINUS (Fossil Sea-urchin).

From Lyell's "Elements of Geology."

ages. Indeed, the *Eozoon*—the dawn-animal—the earliest form we know—was cousin to these sea-shells, which you may see in the illustration called English Chalk.

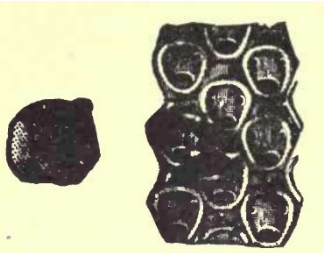


Fig. 77.—Corals of Chalk.

a, Natural size; *b*, Part of the same magnified.

From Lyell's "Elements of Geology."

Though these tiny shell-fish made so much of the land at that time as to give a name to the period, the chalk, there were existing at the same time a great many other forms of life. Sea-urchins abounded (Fig. 76), and corals (Fig. 77), and other shell-fish (Fig. 78), also other forms, called glass sponges, living with shell-fish as they do now.

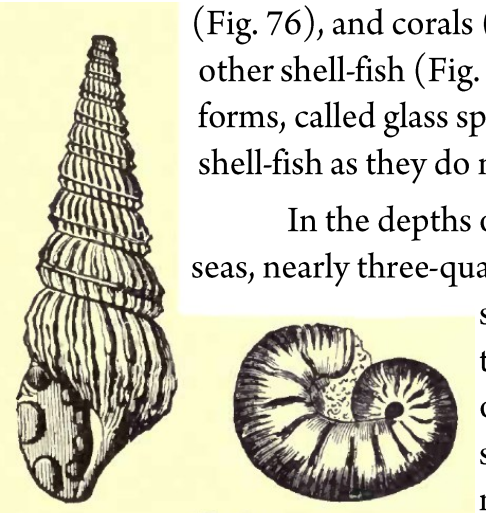


Fig. 78.

Turrilite. Scaphite.

From Lyell's "Elements of Geology."

In the depths of the Philippine seas, nearly three-quarters of a mile straight down, live the most beautiful of the glass sponges nowadays.

They are almost the most beautiful of all nature's works long curved cornucopias made of the finest spun glass woven into a square-meshed lace.

Around the horn run short frills of delicate lace, while the small end of the horn is enclosed in a tuft of the silvery hair. This beautiful thing is second-cousin to our common drudge of a sponge, and nearer still to the glass sponges among the chalk (Fig. 79). Whenever you are in a museum, ask to see the Venus's Flower-pot, for that is the name of this particular kind of a glass sponge.

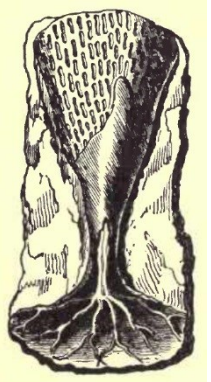


Fig. 79.—Sponge of Chalk.
From Lyell's "Elements of Geology."

While the earth was being slowly built up by these beautiful beings under the sea, you may be sure the land was not empty. Enormous lizard-like creatures wandered over the shores or slipped heavily into the water. Great flying lizards beat the air as they rushed downward from some high tree or lofty rock. There were fifty different kinds of immense snake-like creatures, some of them eighty feet long. The reign of reptiles was drawing to a close, but it was not over. There are on the earth now only six large kinds of reptiles, and these not over twenty-five feet in length.

There were still very few beings above the reptile class, but the highest forms were beginning to be shadowed forth by a class, the lowest of the quadrupeds, to which the kangaroo and opossum of our time belong. These creatures have a pouch in which the unformed young are kept till they are fully developed.

The climate must have been warm all over the earth. The plants and animals that existed in all parts of the world in those days live only in the hottest countries now. The forests through which the reptile monsters roamed were made up of tree-ferns and palms, in the island of Spitzbergen, where there is now perpetual ice and snow.

At the end of this period a great change took place in the New World. North and South America had been up to this time two islands, widely separated. By an uplifting of the western part of the two islands the land that connected them under the sea was raised above water, and the continent of America was born out of the sea. This was the age of continent and mountain making. A map of America before this upheaval, and one afterwards, do not look as though they were made to represent the same world, they are so very different.

Chapter XX
Birds of the Past

One period in the building up of the earth we have called the Reign of the Fishes, for two reasons: first, because the greatest and most terrible of living creatures were of the fish tribe; second, because the fish were at that time the highest kind of animal living. Another and a later period was for the same reason called the Reign of Reptiles. Other and lower creatures lived in great multitudes, but the reptiles were the mightiest.

Birds lived in geologic times, too, quite as wonderful and monstrous as either fish or reptile, but there was no one time that could be correctly called the age of birds. They never had a distinct reign of their own.

This seems a little strange, for there is no class of living creatures that seems so entirely distinct and separate from the rest of the animal world as birds. They have so many peculiarities all to themselves; their horny bills and feathers and wings, their power of flight and of song, seem to set them apart from

other living beings. And so we might very naturally expect to find in the past a reign of birds.

You remember that the arrangement that was given to the different kinds of living creatures by naturalists, beginning at the simplest kind of life and going gradually up, was found, when geology began to be studied, to correspond very nearly with the order of animal life found in the rocks, beginning at the lowest; that is, men studying the works of God, and arranging them in classes, followed almost the same order that God had followed in creating them.

But there was one point where the order of science was found to be different from the order of nature. Men put birds next after reptiles, while in the rocks they were found to be side by side. This looks as if there must be a mistake somewhere. But there is no mistake; in this seeming difference is hidden a wonderful natural truth. Birds, as we know them now, seem quite as far removed from reptiles as they are from fish or from quadrupeds; but this is only seeming. Birds are, as a matter of fact, only one great branch of the reptile family; but they have been separated so many millions of years that the family likeness is not very strong. That they once belonged to the same family, geology, more than anything else, tells us.

Don't you remember, in Chapter XVIL, the Reign of Reptiles, the curious footprints that were sometimes taken for bird-tracks and sometimes for the tracks of reptiles? Well, they were made by creatures that had a good deal of both bird and reptile in them. Their footprints told the tale. In Figure 80 you see the outline of one of these queer birdlike reptiles, and there were many others, as well as reptile-like birds.



Fig. 80.—Bird like Reptile.

The manner in which such tracks were preserved in the sand, and retained when it was baked and pressed into stone, is very easy to understand. Where the tracks are found was a shallow inland sea, connected with the ocean by a narrow strip of water. The tides flowed in, deposited the sand that they had swept up with them, and then flowed out, leaving a coating of wet, smooth sand behind. This is shown in several ways. Slabs of sandstone are often found, as we have seen, with ripple marks as perfectly distinct as if

it were moist sand that the water had washed an hour before.

On the wet sand of the shore many strange creatures, reptiles and birds especially, came in search of food cast up by the tide. They left distinct tracks in the sand, which caked in drying. The next tide would bring in more sand and spread it over these tracks, and this would happen again and again. When it all hardened and became stone, the footprints and ripples and rain-drops would remain unchanged; and when the sandstone was, ages and ages afterwards, broken with the pick, it would naturally split between the layers, and show the marks.

The first bird found in the rocks is a most wonderful creature. Near Munich, in Bavaria, there is a quarry of stone which is quite celebrated because the chalky slate taken out of it is used for lithographic engravings and chromos, and is perhaps the best in the world for that purpose. Slate, you know, splits in thin layers; this is partly because it was laid down by the water, layer on layer, and partly also because it has been subjected to enormous pressure, and it splits in one direction, just as pie-crust does from the pressure of the rolling-pin.

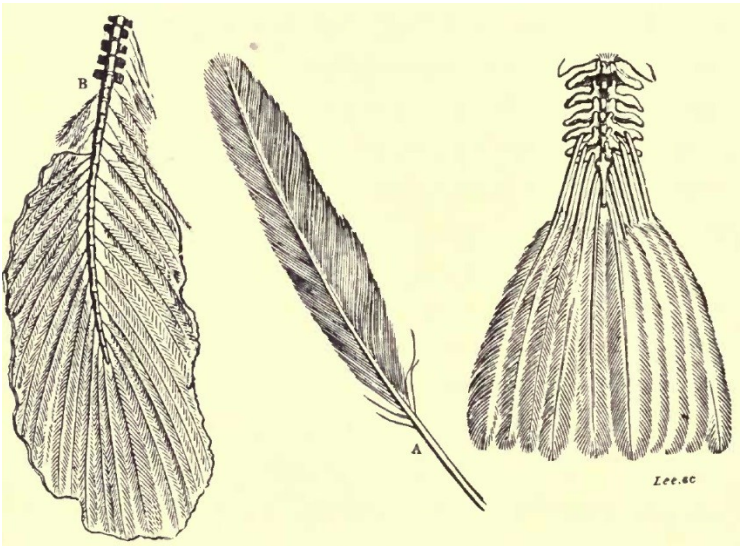


Fig. 81.—Tail and Feather of Reptile-like Bird, with Tail of Modern Bird for Comparison.

From Lyell's "Elements of Geology."

In between two layers of this slate, about thirty years ago, a single but perfect feather was found (Fig. 81, A); this is the first trace of the earliest bird known. Soon another specimen was found; this was the hinder parts of a very strange creature, with tail feathers growing out of each side of a reptile-like tail.

Figure 81, B, is the tail of the bird of the slate; C shows the tail of the birds we have now. You see how differently the feathers are attached. Some years later a slab of this same stone was found. A blow of the hammer and it fell open, showing, after careful

working, bones, wings, tail, and head, which you see in Figure 82 just in the position in which they lay.



Fig. 82.—Skeleton in Stone of Reptile-like Bird.

Several attempts have been made to draw the animal or bird to which this skeleton belonged. Figure 83 is one of these, and if you compare part by part you will see how closely the skeleton is followed. There is nothing to indicate that this curious creature had any feathers on its body. This is about as far from our idea



Fig. 83.—The Earliest Bird (*Archæopteryx*).
Restored by R. W. Shufeldt.

of a bird as anything could well be, apart from its feathers and its legs. Notice the claws on the ends of the wings, its lizard-like head, arms, and teeth.

America has added of late years a large number of reptile-like birds. They come mainly from New Jersey and Kansas. Among them are waders, swimmers, and divers. Some of them were evidently flying birds, for they have the keel down the breastbone, which sustains the muscles of the wings. This keel you have often seen when the white meat is cut from a chicken or turkey. Others, like the ostrich, which do not fly, but assist themselves with their small wings in running, have no keel. Six kinds of the American reptile-birds have teeth, a thing no living bird has nowadays. The two great branches of the reptile family were not then disentangled and separated from each other; so that the birds still had some things left from their reptile forefathers, and the reptiles had not lost certain other things which afterwards disappeared in their branch, but were kept and developed by the birds.

There are very few bird skeletons in the rocks—few even when compared with the bones of fish and reptiles. The reason of this is not far to seek. In our own times, when the woods are full of birds, many thousands must of course die every year, and yet who

ever sees a bird skeleton after the feathers and flesh are gone? A large part of the bones of animals are gnawed by other creatures, broken up, or decayed, and so blow away and are lost. What is true of all wild creatures is especially true of birds. If they fall on land, they fare like everything else; but if they fall in the water, instead of sinking and being covered over, their feathers buoy them up, and keep them afloat till they are beaten about and destroyed. It was only one bird, probably, in many hundreds of thousands that fell in the right place on the sand or mud at the water's edge, near enough to be covered by the next tide, but not near enough to be washed away; so we are rather fortunate in finding traces of so many of these delicate creatures in the rocks. As time went on, the birds lost more and more of their reptile features, and became gradually like the birds we now know, while the reptiles lost their bird-like qualities all but the laying of eggs, which both do now.

Although there is no time that could properly be called the reign of birds, there is one place that, when it was discovered by Europeans, might have received justly the title of the Bird Kingdom: this is the island of New Zealand, near Australia. When it was first visited by white men not a single four-footed beast was found upon it, large or small. The highest form of

life was the bird; and there were multitudes of these, closely allied to the birds of geology, with neither wings nor tails; and great quantities of bird skeletons of gigantic size, some of them twelve or fourteen feet high. There are numbers of these skeletons at the Museum of Natural History, Eighty-second Street and Ninth Avenue, New York; also an egg which would contain as much as one hundred and fifty hen's eggs.

Chapter XXI
The Reign of Land Monsters

You remember, I hope, that the four-footed creatures had begun to come some time ago, when the chalk and limestone were forming at the bottom of the sea; but they were of a peculiar kind, like the kangaroo and opossum. These creatures are called marsupials, from a Latin word meaning bag or pouch, because the mother has on her body a sort of pocket or pouch, in which her tiny babies are put, and there they live till they open their eyes, and are strong enough to walk about alone.

One of the very largest land animals the world has ever known, it is believed from a bone lately found, belonged to the pouched animals. It was much larger than any living elephant, though looking like one, with great trunk and tusks (Fig. 85). It was related to other creatures that you have probably seen in a menagerie, the rhinoceros and tapir as well as the elephant. One curious thing about the animals of these long-past days is that they are not like any of the living forms, but are connecting links between different kinds.

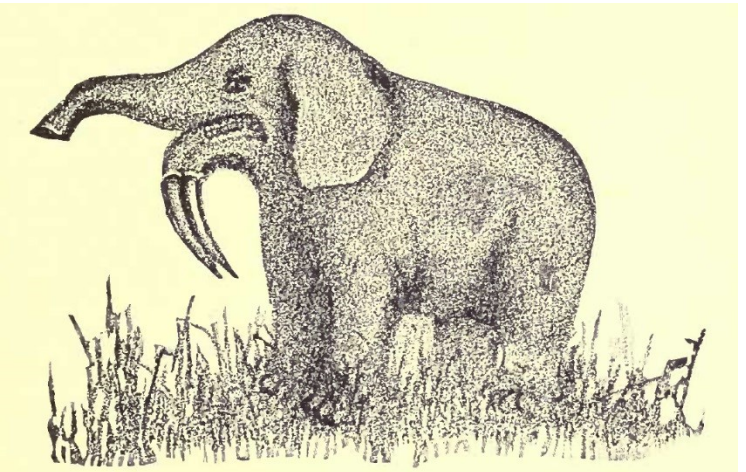


Fig. 85.—Dinotherium.

The great four-footed beasts and the small ones are called mammals, because their young live upon mother's milk. Besides the land animals there are other mammals—whales and dolphins, seals and bats. The lowest order of the mammals are the marsupials, so they naturally were the first in the order of creation.

About a century ago Australia was scarcely known. When it began to be settled by white men they found living in it very singular plants and animals, unlike those known in Europe. Very nearly at the same time that travelers were describing the curious life in Australia, geologists were studying the bones of very queer animals which had been dug up out of the earth; and it was discovered that Australian life was very

much more like that which had been in Europe, thousands upon thousands of years before man came upon earth, than it was like anything then existing in the known world. In Australia there was not a single mammal higher than a marsupial, not a rat, nor a mouse, nor a rabbit; nothing but kangaroos and opossums and such creatures. It was, in fact, a young earth, not yet grown up; it had only reached the marsupial stage. America is young in the same sense, but not so young as Australia, while New Zealand is the youngest of the three. It has only grown up to the bird age. Of course, when these countries came to be settled by white people, plants and animals from Europe were introduced, and the changes which would have taken perhaps millions of years if left to natural causes were in this way greatly hurried.

The knowledge which went deeper into the earth, geology, and the knowledge which spread wider over its surface, natural history, thus were found to confirm and explain each other.

I remember reading a long time ago, but I have never been able to find it since, that a singular bone found in the earth was taken to Richard Owen, the man who perhaps knew more about bones than any man of his day. After studying it carefully he said it belonged to a bird without wings or tail. In spite of his

friends' advice to keep this quiet, as being probably incorrect, he published his views. These were soon after confirmed by the finding of a wingless, tailless bird in New Zealand. This is a good example of scientific guessing.

As we approach the coming of man upon the earth, we find all nature beginning to put on the look so familiar to us. The forests were made up of trees very like those we now know oaks and elms, walnuts and birches, interspersed with pines and firs, yews and cypresses. The fields were covered with grass and flowers. On the surfaces of quiet ponds the water-lilies spread their broad leaves and opened their fragrant flower-cups, while underneath could be seen the delicate fronds and thread-like leaves of water-plants, swaying back and forth with every gentle movement of the water. Mosses and liverworts clothed the damp rocks with a garment of living green. The trees and flowers of that day did not, in many cases, differ from ours; more than one kind of maple, for instance, differs from another (Fig. 86).



Fig. 86.—Maple Leaf.
From Lyell's "Elements of Geology."

The most interesting thing in the plant life of that day is the proof it gives of difference of climate from that which exists in the same parts of the world now. Mingled with the oaks and birches of our zone are great palms and tree-ferns, which now grow only in very hot countries. The cypresses and magnolias that today grow in the swamps, of Carolina and Louisiana then grew in Greenland. There is strong reason to believe that America was joined with Europe on the east by way of Greenland, Iceland, and Norway, and that at the same time it was joined with Asia on the west across Behring Strait.

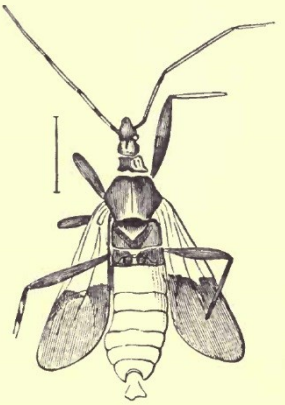


Fig. 87. — INSECT FOUND IN ROCK.

From Lyell's "Elements of Geology."

Among the shell-fish, oysters grew in great abundance and to great size, and the rivers were filled with eatable fish, shad and perch.

One very wonderful thing in that time was the myriads of insects that filled the earth and air. It would seem impossible that so delicate a thing as an insect could be kept in the rocks all these thousands of years in such a state that it could be recognized (Figs. 87 and 88), and yet this is true, not

of one, but of hundreds of varieties. Uncounted millions of insects of various kinds perished, and are found packed in solid layers in the rocks. How this happened we may guess from something that Professor Le Conte tells us. He says that he has seen, after a storm, on the sands that border Lake Superior, millions of insects that had been drowned and washed ashore, till the banks were black with them. A layer of sand, washed up by the beating waves, and deposited on top of these, would preserve them, as the insects of old were preserved.

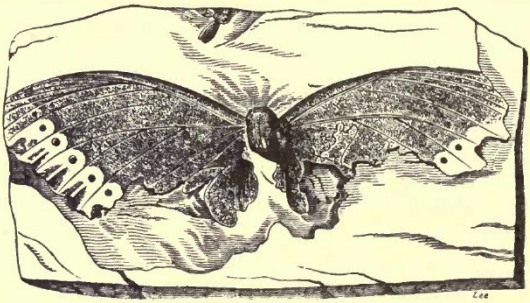


Fig. 88.—Butterfly found in Rock.

From Lyell's "Elements of Geology."

In the whole of Europe there are now only fifty species of ants known, but in a layer of rock in Switzerland one hundred species have been found, and these were all winged ants. In a colony of ants of our day there are at least three kinds of ants—males, females, and workers. The males and females have

wings at first and the workers do not. When they settle down into nest life the males are left out; the females, or queens, unhook their wings, and become good mothers and home-keepers. The workers attend to the young, keep the nest clean, and do all the work. But with the geologic ants all the members of the colony had wings. They probably lived a savage life of freedom, and were as improvident as the grasshoppers and butterflies of today.

The most perfect specimens we have are those flies and moths which were enclosed in amber. Amber is only fossil-tree gum. You have often seen a clear, sticky gum oozing out of cherry and peach trees. If you notice next summer you will very likely see some unfortunate insects that have alighted on the sticky stuff and are caught fast. The next gum that oozes out may roll over the poor little victim and enclose it. As long as the amber lasts, the insect enclosed will remain unchanged. Most of the fossil insects in amber are perfect, except their legs, which have been broken in the struggle to free themselves.

Enormous monsters roamed through the woods. Their habits, however, were generally less alarming than their looks, for most of them were herb-eating animals. Great sloths as large as an elephant, with terrible paws (Figs. 89 and 90) and gigantic tails, tore

down the branches of trees or dug up eatable roots. The brains of these animals were small compared to those of the same families nowadays, though the animals themselves were so much larger. There were, to be sure, some lions, tigers, and wolves roaming about in search of prey, but most of the animals were herb-eating, as are the largest of the beasts of the present day.

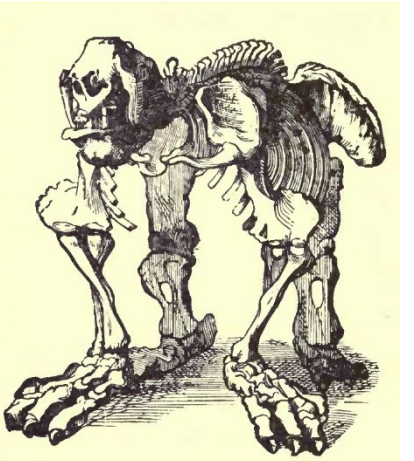


Fig. 89.—Skeleton of Megatherium.
From Hooker's "Mineralogy and Geology."

Among the quadrupeds we see the same approach to living forms. The forefathers of the horse, deer, antelope, elephant, rhinoceros, and tapir appear. The strange reptilian birds are gone, and in their places swallows are building in the crevices of the rocks; song-birds fill the forests with their happy voices; parrots call from one tree to be answered from another; cranes and flamingoes wade in the shallow water, seeking their food; sand-grouse and the ancestors of our domestic fowls scratch around with their broods. All nature is making ready for man, who



Fig. 90.—Skeleton of Mylodon.
From Hooker's "Mineralogy and Geology."

will appear in the next period of the world as the crown of the Creator's work.

Chapter XXII
The Coming of Man

The last period that belongs to geology was the most remarkable in the history of the earth for the great changes in the earth's crust, and in consequence of this, for its changes in climate.

During the early part of this period, for some unknown reason, certain parts of the continents lifted themselves up till they stood one or two thousand feet higher than they now stand. Later on, a sinking took place, which carried some parts of the continents as much as one thousand feet below where they are today, and after that they began again to rise till they reached very much their present level.

These movements caused, of course, an enormous alteration of climate, and the changes in vegetable and animal life which accompany variation in climate. There is still some movement going on; some parts of America are rising, while other parts are slowly sinking.

The parts of America and Europe that rose were all towards the north. The mountain chains there and the high plains all became covered with a thick sheet

of ice, which moved, like the glaciers of Switzerland, to the lower land, grinding and wearing down the rocks over which they passed.

You may very naturally ask, how can we know that this all really happened? I want you to look back at the chapter on the work of the Ice-king. You will find there that all glaciers move, and as they move they take up pieces of broken rock in their way; these freeze into the under side of the moving ice, and scratch and score the bed-rock over which it passes, and polish off their own corners at the same time.

Strewed all over the northern part of our continent, on the tops of the hills as well as in the bottoms of the valleys, is a surface soil from thirty to three hundred feet deep. This soil is made up of stones, gravel, sand, and earth, which, you remember, is pulverized rock. The stones are irregular, but rounded on the corners, scratched, and worn exactly like the stones that are found beyond the end of a glacier. If you dig you will find the stones becoming more worn and scratched as you go down, and when you get to the solid rock underneath it all, that too is scored and polished, all in one direction, as only a heavy body passing over it and grinding it down could do. The very top stones are neither scratched nor rounded, only those that have rubbed against one

another in the movement of the glacier, or scratched against the bottom rock.

This is called the northern drift; and the writing upon the wall that terrified Belshazzar so, but which Daniel so easily read, was no clearer than the history of its progress which the long-vanished glacier has left written upon the rocks. If more proof were needed, it is here. These rocks lying loose mixed with the soil are not at all like the rock beneath. Sometimes, for instance, they will be blocks of granite, when the nearest granite bed-rock is a hundred miles away.

In the Southern States there is no such drift. The soil there is often mixed with stones, but they are neither scratched, nor scored, nor worn down, and they are usually exactly the same material as the rock underneath them.

By carefully examining the drift boulders we find that in New England they have come from the rocks of the far north-west; in Ohio, from due north; and in Iowa, from north-east; that is, the glaciers, on the testimony of the rocks, started from the high lands of British America, and spreading out both east and west, moved downward and outward in a fan shape towards the south. The distance travelled over by this

sheet of ice was in some places only a few miles; in other places, some hundreds of miles.

These glaciers were not exactly like the Swiss glaciers, for they are formed and move in a warm climate, but they were like the glaciers of Greenland. This country, you know from your geographies, is a great peninsula in the north-eastern part of America. It is twelve hundred miles long by about five hundred miles wide; the whole country is covered with a great ice sheet more than a mile thick. This sheet moves southward and towards the sea, forced onward by the weight of snow and ice on the northern and high land part, which each winter's freeze makes heavier. The solid sheet only separates into distinct glaciers when it reaches the ocean. As these move off the coast, the waves wear them, and they finally break off, and with a thundering noise go splashing into the sea and float away as icebergs.

Just so New England, Ohio, Illinois, Indiana, and Iowa were covered with a great ice sheet that moved southward, scouring and polishing the bed-rock, and gouging out lake-beds. From its southern margin the ice sheet "stretched out icy fingers" down the valleys of the Hudson, the Susquehanna, and other rivers, and passed away as icebergs when they reached the sea.

After this came the time when the continents began to sink. Down, down they went, so slowly that we cannot conceive of it as motion, till the land lay in places two or three thousand feet below where it had been in the ice period, and one thousand feet below the present level. The water, of course, rushed in, filling the low lands, and turning them into lakes and inland seas. Above the drift there are plainly to be seen old lake-margins and signs of flood proving this point. Europe had very much the same experience as America in the rising and falling of certain parts of the continent.

During this age there were immense numbers of mammals. Their skeletons are to be found in old sea-beaches and lake-margins, where they were stranded and covered over with mud and sand; in marshes and bogs, where they had been mired when seeking for food, and preserved by the bog-water (Fig. 91); and in frozen ground and ice-banks, where some of them have been preserved to the present century.

Do you remember about the limestone caverns great holes worn out in the midst of the rocks by the dripping water? Look back to Chapter III, at the picture of Luray, if you have forgotten. These caves seem to have been the homes of myriads of animals at this time; hundreds of skeletons and bones are found

in them elephants and bears, elks, horses, and oxen, hyenas, lions, and tigers in a jumble, covered over with

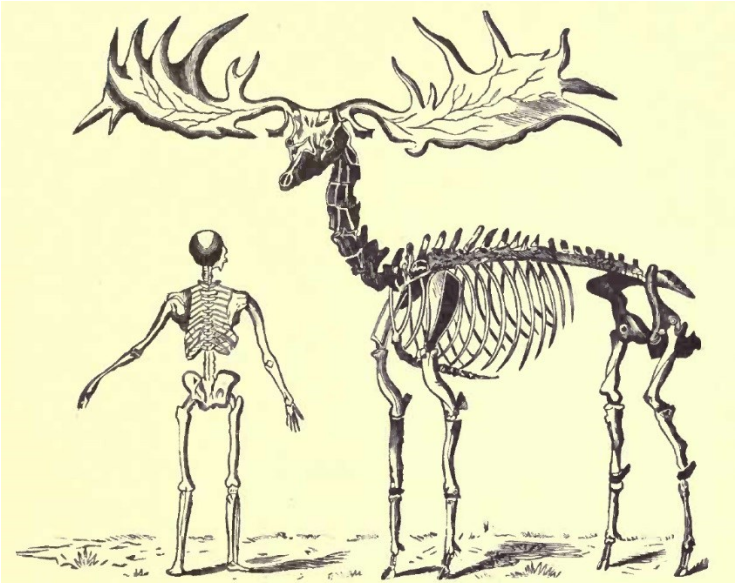


Fig. 91.—The Irish Elk compared with Man.
From Winchell's "Sketches of Creation."

the stalagmites from the drippings of the cave. It is generally supposed, from the gnawed state of some of the bones, that these caves were the homes of the lions, bears, and hyenas, and that they dragged their prey in here to devour them. It may have been that others were washed in by the water which overlaid them in many cases with mud and sand.

The animals found in bogs were almost always herb-eating creatures, who evidently went there for food, and sank in and were drowned.

The most wonderful specimens which have been found belonging to this era were those that had been in some way enclosed in ice and frozen up, and have come down to modern times entire, not mere skeletons, but with flesh and skin, tusks and wool, all preserved. The creature so frozen up is called the hairy mammoth (Fig. 92), and this is the way he was found:

In 1799 an Asiatic chief, who used to collect the tusks found in the northern part of Siberia for sale observed a queer dark mass in a block of ice. Each year

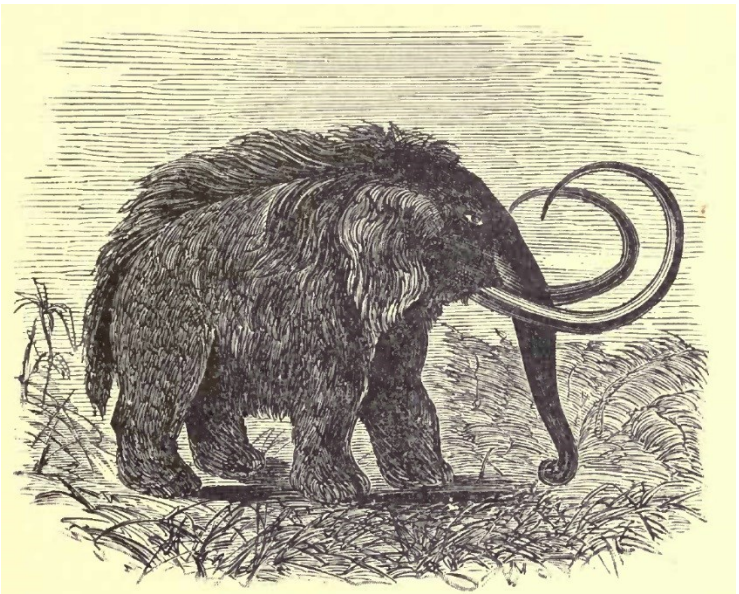


Fig. 92.—The Hairy Mammoth.
From Winchell's "Sketches of Creation."

on his hunts, as the ice broke away, he saw more and more of the body of a mammoth exposed; finally, at the end of five years, the ice melted so much that the body rolled out upon a sand-bank below. The hunter cut off the tusks, which he sold for about forty dollars. The animal was a mammoth, covered with reddish wool and long coarse hair, and with a heavy mane. The flesh, after its burial in the ice for uncounted thousands of years, was fresh enough for the dogs to devour it eagerly. When it was found by Mr. Adams, who knew the value of the creature as a specimen, he says that the ground around it was trampled by the wild beasts white bears, wolves, and foxes which had come to feed upon the flesh. Mr. Adams got the bones out of the ice, bought back the tusks, and brought the whole thing over seven thousand miles to St. Petersburg, where its skeleton now is. He says he collected more than thirty-six pounds of hair and wool, which had been trampled into the ground by the animals that came to feed on the flesh. The skin still remains on its head, and some of the mane on its neck. Other specimens have been found in the ice, but this one is the best preserved.

The mastodon, another member of the elephant family, occurs in America. The mastodon was one of the two largest land animals; it was fourteen feet high,



Fig. 93.—Prehistoric Man.
From Winchell's "Sketches of Creation."

and twenty-five feet long, including its tusks. Along with these mighty elephants and the cave animals man appeared upon the earth (Fig. 93). He may have come earlier, but that is not perfectly certain. In the caves human bones are mixed with those of the cave lion

and bear; together they have been covered over and preserved. Stone implements, and piles of what are called kitchen-middens, also occur: these are refuse of food, piles of oyster-shells that have been opened, and other things that prove conclusively that they are the work of men.

But the strongest proof of all that human beings lived at the same time as the cave animals and mammoths is that in a cave in France several smooth pieces of bone, with rough pictures of the animals scratched upon them with some sharp-pointed instrument, have been found. In Figure 92 you see such a picture of the mammoth drawn by primeval or early man.

This age I have called the Coming of Man, and not the Reign of Man. He has only appeared upon the scene, but he has not yet gained the mastery over the brutes; he is still a savage, with only the rudest and simplest arts, but he is a man--as truly a member of the human race as any who have come after him. But it is as the promise of the reign to come that he means anything, rather than that he is, for some time to come, to be fully established as the lord of creation.

THE END.