SCIENCE FOR THE YOUNG

# WATER & LAND

BY JACOB ABBOTT

# SCIENCE FOR THE YOUNG;

OR,

THE FUNDAMENTAL PRINCIPLES OF MODERN PHILOSOPHY EXPLAINED AND ILLUSTRATED

IN

CONVERSATIONS AND EXPERIMENTS,

AND IN

NARRATIVES OF TRAVEL AND ADVENTURE BY YOUNG PERSONS IN PURSUIT OF KNOWLEDGE.

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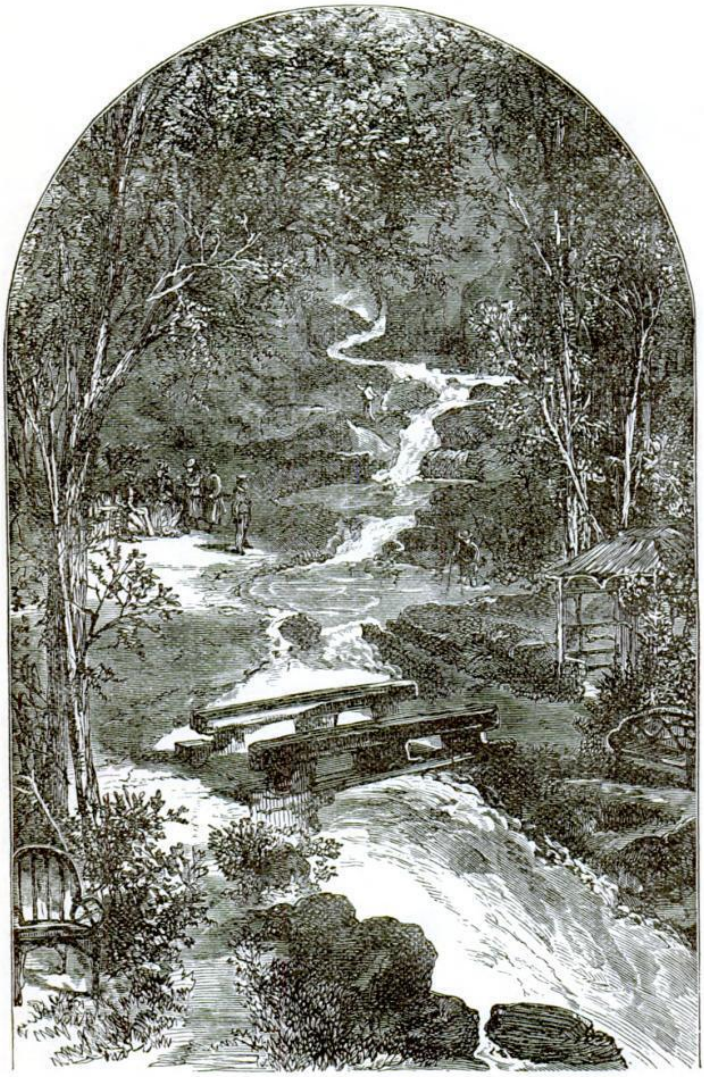
## VOL. III.—WATER AND LAND.



THE FRESHET.

*Science for the Young.*

v. 3.

# WATER AND LAND.

By JACOB ABBOTT,

AUTHOR OF

"THE FRANCONIA STORIES," "MARCO PAUL SERIES," "YOUNG CHRISTIAN SERIES," "HARPER'S STORY BOOKS," "ABBOTT'S ILLUSTRATED HISTORIES," &c.

*WITH NUMEROUS ENGRAVINGS.*



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## OBJECT OF THE WORK.

The object of this series, though it has been prepared with special reference to the young, and is written to a considerable extent in a narrative form, is not mainly to amuse the readers with the interest of incident and adventure, nor even to entertain them with accounts of curious or wonderful phenomena, but to give to those who, though perhaps still young, have attained, in respect to their powers of observation and reflection, to a certain degree of development, some substantial and thorough instruction in respect to the fundamental principles of the sciences treated of in the several volumes. The pleasure, therefore, which the readers of these pages will derive from the perusal of them, so far as the object which the author has in view is attained, will be that of understanding principles which will be in some respects new to them, and which it will often require careful attention on their part fully to comprehend, and of perceiving subsequently by means of these principles the import and significance of phenomena occurring around them which had before been mysterious or unmeaning.

In the preparation of the volumes the author has been greatly indebted to the works of recent European, and especially French writers, both for the clear and succinct expositions they have given of the results of modern investigations and discoveries, and also for the designs and engravings with which they have illustrated them.

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## CHAPTER I.

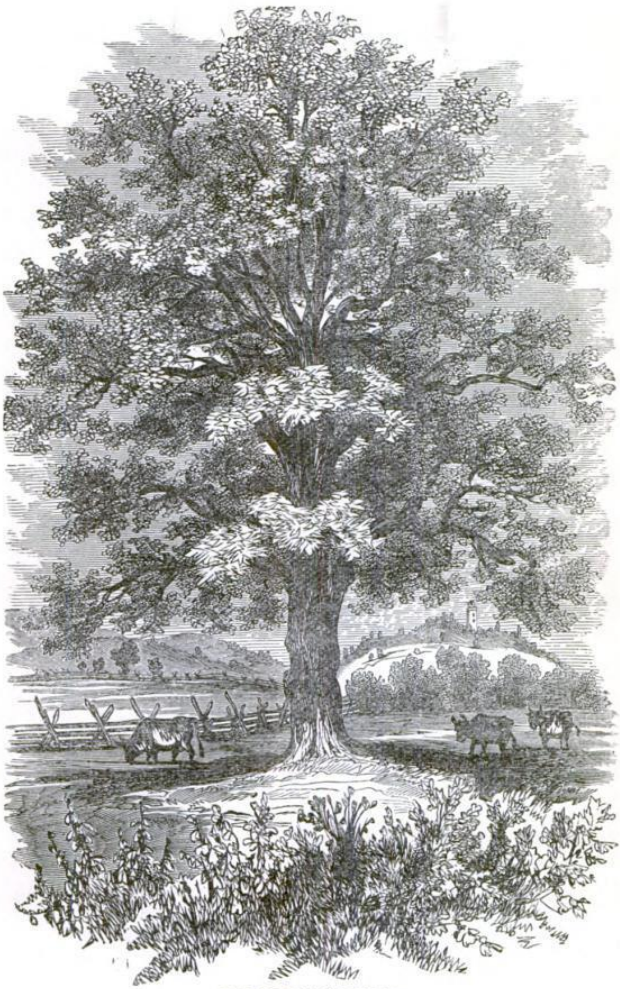
### PROGRESSIVE CONDITION OF THE PLANET.

THE true scientific way to study the natural history of the earth would seem to be to examine attentively the state in which we find it at the present time, with a view to observing the processes and movements which are now going on, and from these to work backward as far as we can go, in order to ascertain what such observations can teach us in respect to the extent of the changes through which it has passed in former ages, and the manner in which they have been effected.

A bird, when she builds a nest, does not begin to occupy it until it is finished. It is true that it is subject to certain gradual changes after its completion. The materials become darkened by the action of the air upon them. A straw falls out here and there, and the rain may soften and wear away some of the clay with which it is cemented. But these changes are slight, and do not affect the structure itself in any radical manner. The dwelling remains, during all the time it is occupied by the bird, in substantially the same condition that it had attained when the bird finished the building of it.

The case is very different with the habitation of the squirrel when he chooses, as he often does, for his habitation *a living tree*—an ancient oak, for example, which has stood for centuries. A gale of wind tears off a branch from this tree. The water of the rains insinuates itself into the pores of the exposed wood, and a process of decay is commenced. The woodpeckers, in search of the insects which constitute their food, peck out the decayed wood as fast as it forms, and in process of time a cavity is produced. A squirrel finds it, and at once resolves to make that tree his home, with the view of using the cavity as the bed-chamber for his mate, the nursery for his children, and the magazine for his stores. Here the mother squirrel rears her young; and as the nuts ripen on the branches in the fall, the parents gather and bring them in, and carefully store them.

Now if the squirrels were of a reflective and philosophical turn of mind, and had as much intelligence as one would think squirrels ought to have, as the foundation of the forethought and thrift they display in laying up so prudently their winter stores, they might imagine that while they observe a gradual change in the leaves, and in the growth and ripening of the nuts, that the tree itself, in respect to the size and condition of its trunk, and the forms and positions of its branches, was fixed and unchangeable. If their parents lived in that tree, and if any thing like history or tradition had come from them or from any of the previous generations, it would contain unquestionably no reference to any change in the size or form of the trunk, or of any of the principal branches of the tree. The squirrel population might very probably have observed the change in the form and appearance of the leaves, and the gradual development and ripening of the fruit, but they would look upon the tree itself as permanent and unchangeable.



THE SQUIRREL'S WORLD.

And yet the tree, with its monstrous trunk, and its gnarled and gigantic roots, and its wide-spreading top, was once an acorn lying unseen in the ground, and every one of its massive branches was developed from a bud at first almost invisible in its minuteness. The whole of the immense growth and expansion to which the tree had attained had been the effect of a series of changes precisely similar in character, and no more rapid or violent in their rate of progress than those which were still going on.

Such a tree, when we see it standing in the forest, and occupied by the family of squirrels as we have described it, notwithstanding its seeming state of quiescence and repose, is really, while we stand viewing it, growing and changing as fast as ever. A new layer of wood is in process of formation over every part of it under the squirrel's feet. The branches are gradually extending themselves in every direction. New roots are in process of formation under ground. Small branches are dying from time to time, and are carried away by the wind. New cavities are beginning to be formed by the infiltration of water and consequent decay, which in process of time will become the homes of squirrels of future generations. The bark of the tree is gradually abraded and washed away; and, in a word, the tree which constitutes the squirrel's little world is going through, during their lifetime, as rapid a progress of change as it has been ever subjected to, while they themselves are wholly unconscious of it, but look upon their tree, in connection with the other trees in the forest around them, as constituting a universe finished and unchangeable.

Now our situation as inhabitants of this earth is in many respects substantially the same with that of the squirrels upon their tree. We see certain obvious changes going on in the condition of things around us, such as forests growing or being cut down, coasts in certain places

wearing away, and now and then a land-slide on a small scale, or a piece of ground rising or subsiding under the shock of an earthquake. We are apt to think that such local and limited changes as these, which appear to us somewhat in the form of sudden and extraordinary catastrophes, are all to which the earth is subject; while all the time these are really only the symptoms, and the occasional special results of a vast process—sufficient, if we take the immense duration of it into account, to produce results of inconceivable magnitude and grandeur.

For a long period, that is, during many centuries of the earth's history, mankind were wholly unconscious of the magnitude of the changes which were taking place around them. In recent times, however, scientific men have turned their attention very specially to the observation of these changes, and the world is surprised at the extent of the action which is every where going on, irresistibly though slowly, and at the vastness of the effects which the same causes, operating precisely as they are operating now, must have produced in times past, as well as of those which they must produce if they continue their operation in time to come.

It is as if the squirrels had in some way suddenly found out that their tree was all the time growing — growing, too, in such a way and at such a rate as would be sufficient, with time enough, to have produced the whole immense mass of it from even so small a thing as an acorn, without at any time changing its form any more rapidly than it was actually changing it then, at the time when they first began to observe it, nor in any essentially different way.

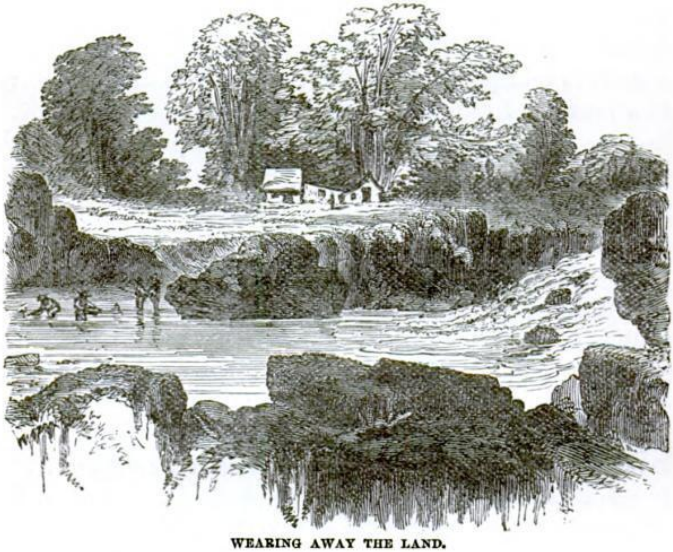
Not that the kind of change which is taking place now all the time in the structure and condition of the earth is a *process of growing* analogous to that of a tree. The only

analogy between the case of the earth and the tree here referred to is, that a great and constant, though very slow change is taking place in both. In the case of the tree it is a process of vegetable growth. In that of the earth it is something entirely different, as we shall presently see.

Lawrence and his cousin John, at the time of the commencement of this story, were returning from an absence of some time in Europe. They were going to their home in a town which I shall call Carleton, which was situated among the mountains of New England. Lawrence had completed his course of study at the scientific school at New Haven, and was going to spend the winter at his home in Carleton, for the purpose of continuing his studies during the winter by a course of reading which he had marked out for himself. John, who was still comparatively young, was going to continue his studies too, as a pupil of a family school not far from his father's house. It was a boarding-school for most of the pupils, though John, by special privilege, was going as a day-scholar, by which arrangement he would be allowed the privilege of spending the evenings and nights at home.

On their way into the country from New York after their arrival from abroad, Lawrence had given John some information in respect to the work done by rivers. Rivers are, in fact, to be classed among the busiest, and, in some respects, perhaps, the most powerful agencies in nature in producing the vast changes which are all the time taking place in the structure and conformation of the globe. There are four grand operations which they are all the time carrying on.

First, they are incessantly engaged in disintegrating and leveling the mountains, and wearing away the rocks, and conveying the materials which form them ultimately into the sea.



WEARING AWAY THE LAND.

Secondly, in employing these materials by the way in filling up all the hollows and depressions in the land which they meet with on their course, and forming them into fertile plains. These plains are called alluvial, because they are formed by the action of rivers.

Thirdly, in spreading over these plains, and over all other lands that they can reach by their inundations, a very fertilizing deposit, which vastly increases the products of fruits and grain for the use of man.

Fourthly, in furnishing power, by means of waterfalls and cascades on their way, to aid man in grinding his corn, and in manufacturing his clothing and the implements that he uses in the cultivation of the ground.

Thus the river is one of the greatest friends of the successive generations of farmers that live upon its banks. Water gradually wears down and carries away the sub-

VIEW FROM MOUNT HOLYOKE.

stance of the mountains so as to form, ultimately, in the region which they occupied, a gently undulating country, fitted for the occupation of man in future years; and, in the mean time, by the use of the materials thus procured, it fertilizes the grounds, and by its force does the work of generations now existing; and, finally, by spreading out these materials over the bottom of the sea in smooth and extended layers, it lays the foundation of vast tracts of new country for ages yet to come.

Sometimes the river does a little too much. In his zeal, as it would seem, to fertilize as widely as possible the lands through which he flows, he raises his waters too high, and damages, or bears away, property which the owner had left too much exposed; but, on the whole, his action is wonderfully beneficial to man.

There is one very remarkable phenomenon connected with the flow of rivers which produces effects that often attract the attention, and even excite the wonder of people who observe it, and that is the extremely tortuous course of the channel by which it flows through the alluvial lands which it has itself formed. In the course of the journey which Lawrence and John made in going from New York to their home in New England, they stopped at Northampton for the purpose of going half way up Mount Holyoke, in order to obtain a view of the remarkable windings of the Connecticut among the broad and beautiful meadows which it has formed there, and which are now comprised between the towns of Northampton and Hadley. One would suppose that a river, in filling up a lake or pond formed by a depression of the land in its course, would keep open for itself a straight, or nearly straight channel through the centre of it; and that, even if the channel should by any accident become curved, the flow of the waters would tend to cut off the projecting parts, and

to fill up the hollows, so as soon to make it straight again.

In actual fact, the tendency is just the contrary of this. The flow of the river tends always to excavate and undermine the banks in all those places where they are concave toward the water, and to build them out by fresh deposits at all the projecting portions, so that the river, instead of straightening itself if it had been originally crooked, would be sure to crook itself if it had been originally made straight.

The consequence is, that every river in that part of its course where it flows through smooth and level lands, which it has itself formed by filling ancient lakes, or in the broad expanse of the valley through which it flows, makes for itself an extremely tortuous course, which it is continually changing, but which it never makes straight. You see this in looking at the map of the Mississippi, or of any other river flowing through alluvial lands, and in the course of brooks flowing through such lands, and of creeks in salt marshes near the sea.

HALF A MILE OF THE PHARPAR, a river near Damascus.*

The reason for this extraordinary sinuosity in the course of such streams is this mainly, that the water, in coming down through one curve in the channel, gets a set which throws the strength of the current away over into the hollow of the next curve, and cuts deeper and deeper into it, while it leaves the projecting curve or point on the other side undisturbed, and even builds it out farther and farther by depositing sand and gravel upon it, and in the eddy just below it. Even if the river had a straight channel to begin with, so that there was no curve above to

* As given by the author of the Rob Roy on the Jordan.

set the current over into the curve below, the water would soon begin to make one. A stone, a root, the smallest indentation or irregularity in the bank on one side would suffice for a beginning. No matter how slight the cause for a deflection on one side, it would soon begin to produce a greater one on the other side, a little lower down, and this a still greater one still lower; and thus the stream, even if artificially made straight, would soon become as crooked as ever.

And now comes a still more curious part of the process by which the condition of things in such cases is sustained, and that is, that as the water, in sweeping around under the banks in each curve, undermines them most, of course, in the part that is farthest down, the whole curve itself is, as it were, gradually carried down the stream, and the set of the current to the opposite bank is carried farther down too. Thus the whole system of curves, and the points or convex portions alternating with them, is carried gradually down. This process is very slow. It takes sometimes many years to make any very decided change in the form of the farmer's fields bordering upon the river. He notices that a few feet are carried away every year, and, if he lives long upon the same farm, he remembers that, since the days of his childhood, the change has been very great. In some cases, however, especially in large rivers, the process is so slow that it requires more than a generation to produce any very decidedly perceptible effects. Still the change is going on, and it will go on, unless something takes place to arrest it, forever.

Thus the whole material of sand and soil of which the meadows of such rivers are composed is worked over continually by the current of the stream, each portion of it, at every move, being borne a little farther down, and is destined, in the end, to be all carried out to sea; but then

the river is all the time bringing down from the muontains and hills above fresh supplies of sand and soil to repair the wastes. These the waters in freshets and inundations spread over the whole surface of the meadows. These fresh deposits are left in the low places first, and in ancient and deserted portions of the channel. The meadows that are already high are not reached except by the highest inundations, which are comparatively rare. The low places are of course filled fastest, and thus the tendency is to bring all up to the same level.

Thus, although the whole region is in course of being undermined and washed away, and finally carried off to sea, the process is so slow, and the waste is so constantly, though gradually and gently repaired by fresh materials brought down from above, that trees grow, and fields are cultivated, and land is bought and sold, and generations live and pass away, while none but careful observers have any adequate ideas of the extent of the change which is taking place, and which is really carrying, all the time, the ground away from under them.

## CHAPTER II.

### DOLPHIN'S GRAVE.

WITHIN a very few days after Lawrence and John arrived at their respective homes, they took a walk together down to the river to see whether they could perceive any indications of such changes in the flow of the water and in the conformation of the banks as Lawrence had described. In making this excursion, Lawrence, who lived in the village with his mother, called for John, as there was a kind of cart-road leading from near the house where John lived down to the river. This road, after descending from the upland, passed across some green meadows, and then, after traversing a sandy place overgrown with bushes, went down to the water's edge. It was worn partly by the cattle that went down there sometimes for water, and partly by the wheels of carts which were sent there from time to time to procure sand for various purposes.

This road came down to the river on the western side of it, so that, in standing upon the bank and looking across the river, the spectator was looking toward the east.

"No," said John, as soon as he and Lawrence drew near to the edge of the water, "there has not been any change at all. Every thing here is just as it always was."

"Exactly?" asked Lawrence.

"Yes," replied John. "Here is the same sandy beach, with pebbles on the bottom near the shore, and the same caving bank on the other side. Even the bushes here are of just the same size that they always were, and the edge of the water is just as far from the edge of the bushes."

"And how long is it since you were here?" asked Lawrence.

"Why, it must be as much as two years," replied John. "You see I was away at school. It is *more* than two years," he added, after a moment's thought, "and that is time enough for the place to have made change enough for us to see it, if it is going to change at all."

"That is not certain," replied Lawrence. "A very great change may be going on, and yet it may make progress so slowly that *two hundred years* would be required to produce any visible effect. We have to expand our ideas a good deal in respect to time when we commence studying the changes taking place in the structure of the earth."

Now John was right in his decision that the river was just as it was when he last saw it—about two years before—so far as the most obvious appearances were concerned. The sandy beach had the same slope, and presented the same aspect as before. There were bushes of the same apparent size growing at about the same distance from it, increasing gradually in size as they receded from the shore. On the opposite side of the river there was apparently the same bank, and at a little distance from it a very large tree. But then the beach had extended out toward the eastward, that is, in the direction of the channel of the river, about eight feet; the bushes which John saw growing near it were new ones that had sprung up that summer; while those which John had seen before had grown up to be trees of considerable size.

In respect to the great elm on the other side of the river, although it appeared, from the point where John stood in viewing it, to be in the same place as where he saw it before, it was really about eight feet nearer the bank; or, rather, the bank had been undermined and worn away until the edge of it had been brought about eight feet nearer

the tree. Thus the whole river had been at that point removed bodily, as it were, eight feet farther to the eastward; the banks having been changed in position by being gradually built out on one side and abraded on the other, while yet their general aspect had not been at all changed.

"Even the very bushes have not changed," said John. "They are just as large, and grow just as near the water as they did when I saw them two years ago."

"And I know," said Lawrence, "from that very fact, that the river itself has changed its bed."

"How so?" asked John.

"The bushes that you saw two years ago, of just the size of these, must have grown since then. These must be younger ones that have sprung up since. Your bushes must be somewhere farther back."

So saying, Lawrence looked back a little way. The bushes increased in size as their distance from the shore increased. There were none within fifteen or twenty feet of the water, though here and there a few small shrubs were seen springing up out of the sand.

Lawrence, after pausing to take a brief survey of the ground, walked back a little way among the bushes till he came to where they were about sixteen feet high.

"There!" said he; "I should think that somewhere about here must be the bushes that were just growing up two years ago. When *I* was here last it was *ten* years ago, and the edge of the water must have been then back thirty or forty feet at least. I remember coming down here with Dorrie to bury Dolphin."

"Dolphin?" said John. "Who was Dolphin?"

"He was a goldfish that Dorrie and I had in our aquarium," said Lawrence. "You see I made a kind of an aquarium out of a box. I put a pane of glass in on one side, so that we could look in and see the 'polliwogs' and

little fishes that we used to catch in the ponds and brooks, and put in.

"At last my aunt made us a present of a goldfish to put into our aquarium, and we were greatly pleased, of course. We named him Dolphin, and for a few days we were greatly delighted to see him swimming about. But, whether our little tank was too small for him, or what was the matter, I don't know. At any rate he died, and we brought him down here to the river to bury him."

"It was a funny idea to bring him here to be buried," said John.

"Yes," replied Lawrence; "but, being a fish, we thought that perhaps he would like better to be buried near the water, so we tried to dig a grave for him at the very edge of it. The nearer the better, we thought. But we could not succeed. The sand and the water came in faster than we could get it out with our little shovels. So we thought we would go back a little farther from the shore, and, as we found it rather hard digging there, I went up to the house to get a crowbar. I remember what a hard tug I had in bringing it down. I, however, succeeded at last, and then we tried to dig a hole with it a little way back from the water. I set the point of the bar in the sand, and soon found, on working it back and forth, this way and the other, that it was gradually settling down into the sand. I was very much pleased to see it going down so easily, and so kept on, till it was down nearly one half its length, and then I found that I could not get it out again. I tried very hard, but it would not come up; and so we concluded that we would leave it, and tell some of the men where it was when we went home, and let them go down and pull it out."

"And what became of Dolphin?" asked John.

"I have forgotten what became of Dolphin," said Law-

BURYING DOLPHIN.

rence. "We played about there some time. I think we must have buried him somehow or other, but I don't exactly remember. It must have been ten or twelve years ago. I don't even remember, either, what we did in regard to the crowbar. I should not wonder if we forgot all about it."

Lawrence's surmise was correct. They had forgotten all about it. There had been a great search made for the missing crowbar by the men on the farm, and finally it was given up for lost, and a new one was procured in its place. The one which had been left half imbedded in the sand

was soon rusted by the weather, which made it look like a half-decayed wooden stake. So it was left there in the place where the children had placed it, and there now Lawrence and John, in rambling around among the bushes a while, at a considerable distance back from the shore, finally found it.

The successive layers of sand that the river had left in its several risings during the ten or twelve years which had elapsed since it had been placed there, had raised the ground around it so high that there was now only a length of about eight inches of the bar above the ground. Trees had grown up around it, and had attained to considerable size. Lawrence, as soon as he discovered the end of the bar, took hold of it, and attempted to pull it up, but it was perfectly immovable.

"I must contrive some way to get a purchase upon it," said Lawrence.

So Lawrence and John went together to the house, and there Lawrence procured a shovel, a trace-chain, and a bar of wood like a handspike to serve as a pry. When they had returned to the place, Lawrence dug away the sand and gravel about the bar down for about two feet of its length. He wound the chain several times around the portion thus laid bare, and passed the end of the handspike through a bight in it which he made for the purpose above, by hooking the end in a link a little way below. He then brought up a pretty big stone for a fulcrum, and placed it at the edge of the hole which he had made around the bar, placing it as near as he could to the hole, so as to bring the bearing of the bar upon the stone as near as possible to its hold upon the chain. The outer end of the handspike extended upward at a considerable angle into the air.

"There, now, John," said Lawrence, "bear down upon

the outer end of the lever, and see if you can start the crowbar."

John took hold of the outer end of the handspike, and, by bearing down with all his force, he found that he could raise the bar. He raised it about two inches, though to do this he had to press down the outer end of the bar about two feet.

"Yes," said John, in quite an exultant tone, "he's coming."

Lawrence changed the hook of the chain so as to get a new hold for the inner end of the lever, and thus, by successive steps of the process, the bar was at length brought entirely out. It came up covered through its whole length with a rough and irregular incrustation of sand and gravel, cemented together by the iron rust which had resulted from the corrosion of the bar.

"I did not think I could pull it up," said John. "I could not have done it by my strength alone."

"But you did raise it by your strength alone," said Lawrence.

"I had the pry," said John.

"Yes, but there is no strength in the pry," said Lawrence. "The pry made no addition to your strength. It only concentrated it. All the strength of your arms, in a downward motion of two feet, was concentrated in an upward motion of the bar of not more than two inches."

"Is that it?" asked John.

"Yes," said Lawrence, "that is it exactly. There's no such thing as increasing force in any way, by any kind of contrivance or machinery. We can only direct it, or distribute it, or concentrate it, according to what we wish to do with it."

## CHAPTER III.

### THE ACTION OF RIVERS.

THE phenomena of river action in changing the conformation of the land through which it flows, which Lawrence and John were about to observe in one of its features, on a small scale, near where they lived, is constantly taking place on the grandest scale along the courses of all the great rivers of the globe; and not only on this grand scale with the great rivers, but also on a small scale along the course of every mill-stream and brook, and even of every little rivulet that is set in motion down the hills by the melting of the snows in the spring, or by the summer showers.

They all begin by abrading and carrying away the constituents of the higher ground, whether rock, or gravel, or loam. With these they first fill every hollow, or depression, or widening of passage-way open to their flow, leaving only a narrow and tortuous channel for themselves. The ground which they thus make, which, of course, is comparatively level and smooth upon its surface, they *work over*, as it were, continually, taking away here and reconstructing there, so that all the material which is brought down from above finds only a temporary and constantly shifting resting-place. The river, by its ever-changing windings, takes away in one age what it deposited in the preceding, and bears it farther onward, carrying it finally to its ultimate destination, which is to form an expanded layer, covering for hundreds, and sometimes thousands of miles, the bottom of the sea.

ANCIENT CHANNEL OF THE RIVER.

Sometimes these changes, taking place in the windings of a river through the alluvial district which they have themselves previously formed, are very slow, partly from natural causes, and partly from embankments, and jetties, and other artificial means adopted in densely peopled countries to confine the waters to one unchanging bed. In other cases they proceed with comparatively great rapidity, and produce the most remarkable effects. We shall have occasion, in a future chapter, to consider somewhat in detail the action of two particular rivers, which may be taken as striking examples respectively of these two classes—the Mississippi and the Nile. We have here first to consider the general character of the effects in respect to changes in their course, witnessed in the case of all rivers flowing through alluvial lands which they themselves seem to have formed.

The River Amazon affords a very striking exemplification of the general character of these effects. It flows through a region of low and level alluvial lands about three hundred miles wide and twelve hundred miles long, and through this whole region the river twists and turns in a most astonishing manner. Sometimes it takes a circuit of twenty or thirty miles, and comes back nearly to the same place as before, thus forming an immense bow, with a very narrow neck, which it would seem that the river could very easily cut through.

In the end it generally does cut through such a division, sometimes by gradually undermining and wearing away the banks on each side till the two channels come together, and sometimes by breaking through the barrier all at once, at the time of some great inundation. In such a case the course of the river is shortened; the main current flows through the gap newly formed, widening and deepening it continually, while the old channel, forming the

great sweep of many miles circuit, becomes a long winding lake of quiet water. This lake is gradually narrowed by the encroachments of vegetation along its banks, though this process is so slow that sometimes for many years it remains navigable for the people who live upon its shores.

In process of time, however, the river, by deposits of sand and loam, closes up the entrance and egress that connect the ancient channel with the river, and every inundation brings down trunks of trees and vast quantities of sediment, which gradually fill it up; so that in the end, after having been a stagnant lake filled with amphibious and aquatic animals, and overhung with tangled and impenetrable masses of vegetation for many years, it becomes a marsh or swamp, and finally dry land. And all the time that this change has been going on, the river is at work undermining and wearing away the banks in another great sweep in the vicinity, preparing the way for another such lake in centuries to come. Thus the work goes on forever.

By forever I mean as far forward into futurity as we can see; for it would seem that unless some change takes place in the level of the land, there is nothing that can stop the process until all the land around the sources of the river is disintegrated and abraded by the frost and the rains, and carried by the current of the river down to the sea.

Sometimes the river, in cutting across a neck and making for itself a new channel, preserves the old one for a century or two for a part of its flow, thus forming an island. Sometimes such an island is gradually enlarged by the accretion of logs and bushes brought down the stream, and by the sand and gravel which they intercept and hold. Sometimes it gradually diminishes by the wearing away of its banks, until at last it entirely disappears, leaving for

the coming generation only a sand-bank to mark its site. By these and similar changes, in process of time the whole country through which flow such rivers as the Mississippi and the Amazon, for a breadth of many miles becomes a perfect maze of deserted channels and crescent-shaped lakes, and long and narrow stagnant pools, and bogs and swamps, each portion, which was once a reach of the river, passing regularly and surely, though very slowly in reference to the life of man, through all these successive changes, till it becomes firm and solid land at last, covered with dense forests, and fertilized each year by the deposits of every fresh overflow. It remains in this condition until the river, in its never-ending windings, comes to the place again, undermines the forest at the rate of ten or twenty feet a year, and bears away sand, gravel, soil, and trees, to be used in new constructions far below.

Thus, if it were possible for us to raise ourselves into the air by a balloon, and take a view of one of the great rivers, and could compress into the half hour of our survey of it the duration of a few thousand years, we should see it writhing and wriggling through its valley like a serpent, or rather like a brood of serpents—a mother and her young—twisting and turning continually this way and that, now dividing, now uniting, now sending out a great coil to the very extreme border of the valley, and then drawing in again, leaving only a trace upon the ground formed by an opening through the forest of vegetation, which opening, however, would soon close up again and disappear. We should see forests continually undermined by the caving of the banks, and the tangled masses of trees borne down by the current to lodge on the shoals or on the shores below, and islands rising, and clothing themselves with verdure and beauty; and then, after a brief interval, we should see them sink again into the water and disappear.

We can see the curves and windings of the great rivers on the globe which flow through alluvial districts on their way from the mountains to the sea represented more or less distinctly on our maps, provided the map is on a sufficiently large scale. When it is on but a small scale it shows only the general direction of the stream, with imaginary curves drawn at random. Thus, in the case of the Mississippi, only the general curve of the river is shown in the map of the world. In the map of the United States the curves are more distinctly drawn; but if we look at the map of any of the particular states through which it flows, especially those in the lower portion of its course, we see the windings much more fully delineated, and many of the crescent-shaped lakes which have been left here and there in the deserted channels are shown. We should see the same in the case of all rivers and streams flowing through alluvial regions if we could have maps of them on a sufficiently large scale.

It is plain that the amount of material brought down by the rivers from the regions where they arise, to enable them to maintain incessantly this constant action, must be enormously large. It is wonderful how they can continue to procure such abundant and apparently inexhaustible supplies, especially when we consider that the supplies must come ultimately from the disintegration of rocks on which we should at first suppose that the action of water alone could have very little effect. The fact is that they are aided in this work by several agencies, which operate in a very remarkable manner. What these agencies are, and how they aid the river to obtain its regular supplies of the enormous quantity of material required to enable it to carry on its works, we shall hereafter see.

## CHAPTER IV.

### DORRIE.

The person whom Lawrence called Dorrie, and who had been as a child his playmate and companion in the time of Dolphin, was now a young lady. Her name in full was Theodora Random.

Lawrence had not seen her now for several years. She had been away at school, and, as their respective vacations had come at different times, it so happened they had not been at home at the same time since they were children. Lawrence, however, heard soon after his return that she was in town, and he resolved at once to call and see her.

He went with some little uncertainty in respect to the manner in which she would receive him—whether coldly as a stranger, or in a familiar and friendly manner, in recognition of the common feelings and sympathies which had bound them together in their early years. Theodora had been at a large and fashionable school, and had acquired, as Lawrence had heard, a great many accomplishments. He heard, moreover, that she was considered a very fine girl, and was every where much admired.

She received him when he called with great cordiality. She expressed surprise to see how much he had grown, and how entirely he had changed in becoming a man.

In the course of conversation Lawrence asked her if she remembered the burial of Dolphin, and informed her that he and John had a day or two before discovered the crowbar which they had left there, and which had remained where they had left it for so many years; and finally it

was arranged that he was to take Miss Random down there some day to see the place, and to observe the changes which time had made in the spot. This plan was accordingly carried into effect. Lawrence called for Miss Random, and they went together down to the river. John accompanied them, but he was so much engaged in running this way and that, collecting curiosities, or watching the movements of squirrels and birds, that he did not take much part in the conversation.

"So you have been to Europe since I saw you!" said Miss Random. "I should like to *be* in Europe, but I should not dare to go—at least not so long as we have to go by water."

"Why not?" asked Lawrence.

"Afraid of the boiler's bursting, or something," replied Miss Random. "They say they have thirty or forty furnaces down in the hold, all burning furiously day and night, and half-naked men all the time shoveling in more coal. I think it must be dreadfully dangerous!"

"Yes," said Lawrence, "it is—to the imagination."

"In imagination and in reality too," said Miss Random. "And then, besides, think of the storms and the waves. The waves, I hear, run as high as mountains."

"They must be very small mountains, then," said Lawrence, "for the highest waves do not rise more than fifteen feet above the level."

"Oh, Mr. Wollaston!" she exclaimed.

"It is fifteen feet above the level, understand," said Lawrence. "As the depression of the surface between two waves is the same, it makes thirty feet in all, as the whole distance from the lowest to the highest point."

"I thought they were a great deal higher," said Miss Random. "I have certainly read in books of waves running mountains high."

Just at this point John came back and began walking along by Miss Random's side, and listened to the conversation. She looked down upon him with a kind of smile, which showed that she was pleased to have him come, and which put John at once entirely at his ease.

"And besides," said she, "think of being cast away at sea, and all huddling into an open boat, and being out among the waves, and in the wind and rain, till you are almost starved. Isn't it awful to think of?"

"It certainly is—awful to think of," replied Lawrence; "but we don't think of such things. We don't allow ourselves to do it. And that is the difference in the mode of judging between young ladies and men. Young ladies often judge in such cases by pictures of the imagination which they form. But we go by the statistics."

"What do you mean by that?" asked Miss Random.

"Why, here is this Cunard line," replied Lawrence—"the one by which John and I crossed the Atlantic. The steamers of this line have been going to and fro among all the icebergs, and through all the waves, and fogs, and storms for a quarter of a century, at the rate of probably four voyages every month, and I don't know that of all the thousands upon thousands of passengers that have sailed in them, a single life has been lost in them by the dangers of the sea. There may possibly have been some cases, but, if any, they must have been very few. Thus the statistics show that the actual danger is exceedingly small, no matter what dreadful pictures we may conjure up by our imaginations."

"They contrive such dangerous ways of traveling nowadays," said Miss Random, without being apparently much impressed by Lawrence's argument from the statistics. "Think of going back and forth between London and Paris in a balloon!"

This conversation took place at the time that Paris was besieged by the German armies, when there was no way by which the inhabitants of the city could escape, or could communicate at all with their fellow-countrymen except by balloons.

"They say, too," continued Miss Random, "that you are not even *in* the balloon, but are only hung to it by cords in a basket. I read in the papers that they are getting up an *air line* between New York and Washington! I never should dare go by it."

"Why, Miss Random!" exclaimed John. "It is to go on the ground, just like any other railroad."

"Is it?" rejoined Miss Random. "I thought it was to go somehow through the air. Besides, my name is not Miss Random. It is Dorrie—for you. Mr. Wollaston may call me Miss Random, if he pleases. I suppose that is more proper. But Dorrie is my name for my friends in general, though I am going to change it to Lorrie, and so make my real name Laura instead of Theodora, which I never liked at all."

"How are you going to get it changed?" asked John. "You will have to go to the Legislature."

"No," replied Miss Random, "I shall just change it myself. It's nobody's business but mine."

"It will be against the law," said John.

"I don't see why," rejoined Miss Random. "And, besides, how can the law help itself. People can't be punished for calling me any thing they like, unless they call me something that's bad, and I'm sure *I* can't be punished for *being called any thing* by other people."

"Well, John," said Lawrence, after a moment's pause, "what have you to say to that argument?" John did not know what to say, except that he always thought there was a law against people's changing their names.

By this time the party had arrived at the place where Lawrence and John had drawn out the crowbar, and they showed Miss Dorrie the hole from which it had been taken, and also the pieces of conglomerated sand and pebbles which they had knocked off from the bar before they had carried it away.

"What silly things we were in those days!" said Miss Random. "The idea of burying a fish close to the water because we thought he would like it better! How absurd! But this was not the place where we buried him. We made the grave as close to the margin of the water as we could get it—down somewhere here."

So saying, Dorrie walked off out of the bushes toward the beach and the water. "It was somewhere about here," she said, when she found what she thought was the right place. "It was not more than three steps from the edge of the water."

"It was very near the water *then*," said Lawrence, "but the river has moved since then as much as two or three rods to the eastward."

"The river has moved!" exclaimed Dorrie, in a tone of incredulity. "That reminds me of my cousin Tommy. His father, my uncle, had a well behind his house, that was just outside of the shed. The roof of the shed came near it, but not over it. At last my uncle had the top extended over the well, and the first time that Tommy saw the change he ran into the house and told his mother that his father had had the well moved in under the shed!"

They all laughed together at this story, and then Miss Random added,

"If Tommy was here, I suppose you could convince *him* that the river had been moved, but not me."

Miss Dorrie laughed as she said this with an expression of satisfaction at the thought that she was not easily to be deceived against the evidence of her senses.

"It was just about here," she added, pointing with her parasol to a place very near the water.

"But we actually found the iron bar in there among the bushes," said John, "where you and Lawrence left it."

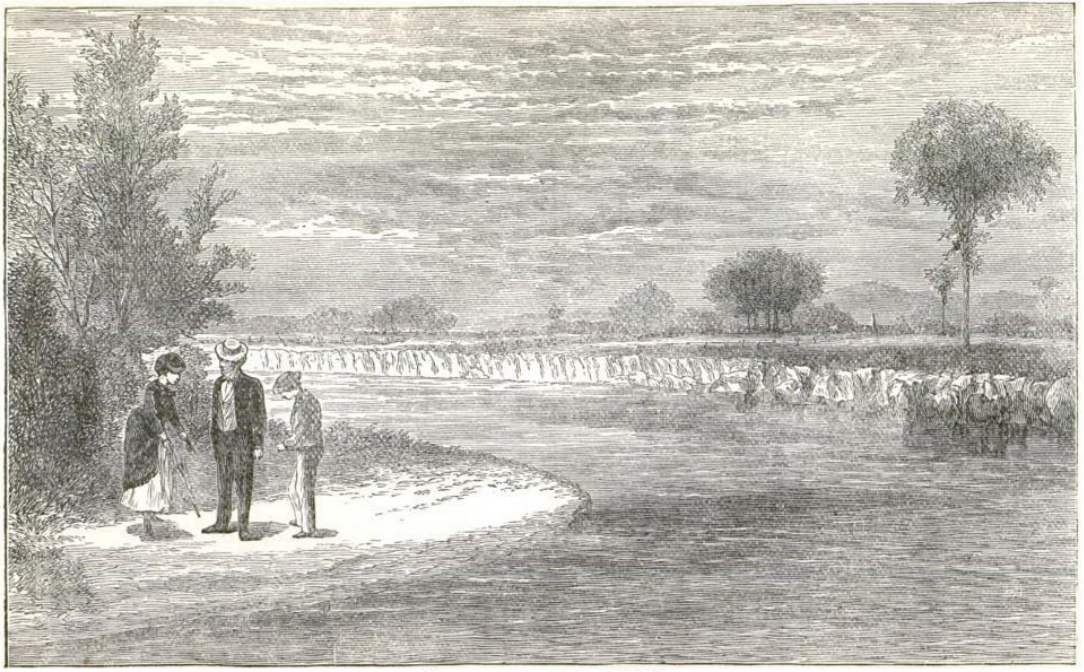
"But that could not be where we left it, child, I tell you," replied Miss Dorrie. "Somebody must have pulled it out of the hole we made for it, and have put it down in another place. That is entirely away from the shore, in the woods; but we put it down in the open sand, close to the shore. Besides," she added, "there's that big tree on the other side of the river just as far from the bank as it used to be."

"Exactly?" asked Lawrence.

"Yes," replied Miss Random, "exactly. I remember exactly how it looked. Besides, we used to go over there sometimes, and it was just as far from the shore as it is now. The river is not any nearer to it than it always was. The bank caves in a little now and then, in the freshets, I suppose, but as to the whole river moving, that's impossible."

Just then Miss Dorrie's attention was attracted by a pretty flower that her eye fell upon, and she at once gathered it, and then, with that and others, began forming a bouquet. Lawrence and John helped her by gathering flowers and bringing them to her. In arranging them, she herself sat upon a smooth trunk of a tree which had been floated down from the country above and lodged in the bushes. Some of the flowers which Lawrence and John brought her she added to her bouquet, and some she rejected, giving them the reasons in each case. She knew all about flowers, she said. She had studied them a great deal.

She did indeed know a great deal about them, but her knowledge was chiefly confined to their sensible qualities,



"IT WAS JUST ABOUT HERE."

and to the common names by which they were called. She knew all the names, she said—all except the botanical names, which, she added, she did not know, or care any thing about. She knew the peculiar fragrance of each flower, and the time that each would remain fresh, and she combined the colors in her bouquet in a charming manner. After she had finished one bouquet she began another, which, she said, was for John to carry home and put into one of his mother's vases.

"I don't suppose there is any harm in my making a bouquet for *you*, even if you have not asked me to do it," she said, addressing John.

"If asking makes any difference," said Lawrence, "I will ask you to make one for me."

"Well," she replied, "I will, if you wish it. Only I shall have to be very particular about the flowers in making one for you, on account of the language."

"The language!" replied Lawrence.

"Yes," said she. "You understand the language of flowers, don't you?"

"Not I," said Lawrence. "I know nothing at all about it."

"Not even that the blue violet means faithfulness?"

"No," replied Lawrence.

"Nor that"—here she looked up at Lawrence archly, but a little timidly—"nor what a moss-rose bud means?"

"No," replied Lawrence.

"Why, what have you been studying all this time at your famous scientific college? I thought you were very learned, and I was inclined to be rather afraid of you, and here you don't know the language of the commonest flowers. Don't they study botany at all at your college?"

"Not that branch of it," said Lawrence.

"Why not?" asked Miss Random.

"The professor, I think, does not take much interest in that branch—perhaps because he is a bachelor."

"Is he an *old* bachelor?" asked Miss Random.

"I don't think that he would be called old among botanists," said Lawrence. "He may be about thirty-five."

"I call that very old," said Miss Dorrie. "But he ought to know all the branches of botany if he pretends to teach it."

"He may possibly understand the language of flowers himself," said Lawrence, "but perhaps he thinks it not best to fill the heads of the scholars with such nonsense."

"Nonsense!" exclaimed Miss Dorrie, looking up from her work with an expression of good-natured surprise in her face. "Do you call the language of flowers nonsense?"

"I only thought that *he* might perhaps consider it so," said Lawrence.

They talked on in this strain for some time, and then, when the bouquets were finished, they set off on their return home. Miss Random found a great many pretty points of view where she stopped to admire the landscape on the way, and many picturesque objects which she said would make pretty subjects for sketches. She said that she meant to bring down her sketch-book some day and draw some of them. She evinced a great deal of good taste and judgment in respect to such subjects as these. She seemed to take quite a fancy to John, and talked with him a great deal about the various objects that attracted their attention as they walked along.

At length the party arrived at the door of the house where Miss Random lived, and there Lawrence and John, after they had thanked her for the pleasure of her company on the walk, and she had thanked them for their politeness in inviting her to go with them, bade her good-by.

"Well," said John, after they had gone a little way from the door, "and how do you like her?"

stream, where the materials of which it is composed can be borne away, the protection necessary is chiefly required along the margin of the water at its ordinary level. This protection is sometimes afforded by a low wall, or by a line of piles, the bank above being rounded down, and strengthened by plantations of willows, or other trees or shrubs that can not be drowned out by an occasional inundation, provided that during the remainder of the year they have a reasonable enjoyment of the sun and air.

A much more effectual mode of protecting the banks is by building out jetties of stone—very rude ones will answer the purpose—to keep the current off from the line of the land. These jetties are sometimes built out at right angles to the stream, at regular intervals along the exposed shore, like a line of piers, though at considerable distance from each other, and extending only a little way into the stream—just far enough to check the action of the current upon the shore.

Another mode is to build a larger jetty at the upper end of the portion of the bank to be protected, the jetty being built in such a manner as to shoot the current off toward the middle of the stream again. For this purpose the construction must not be at right angles to the stream, but must point obliquely downward, and the direction must be carefully adjusted so as not to throw the force of the current across to the opposite bank, and thus simply transfer the mischief from one side of the river to the other, but only to direct it toward the line of the middle of the channel.

By these and other methods, the tendency of the occupation by man of any of these alluvial valleys is to arrest the changes which the river is naturally inclined to make —to tame and inclose it, in fact, as we might say, so as to bring its forces more into subordination to the will and to the promotion of the purposes of man.

The country in which these limitations and regulations of river action has been longest going on is Egypt; and the Nile has now, for many centuries, presented itself in the view of mankind, as compared with many of the other great rivers on the globe, in a contrast similar to that between civilization and barbarism. It is a contrast somewhat analogous to that exhibited by a horse standing quietly, all saddled and bridled, and glossy and trim, at the door, waiting for his master, in comparison with a wild quagga or zebra galloping wildly over his native plains, his movements controlled entirely by his own wayward and ungovernable will. The horse is manageable, submissive, and useful; so is the Nile. The action of the zebra and the quagga, in the vast herds in which they congregate, on the other hand, though wild, is picturesque, and even grand; so is that of such rivers as the Mississippi and the Amazon.