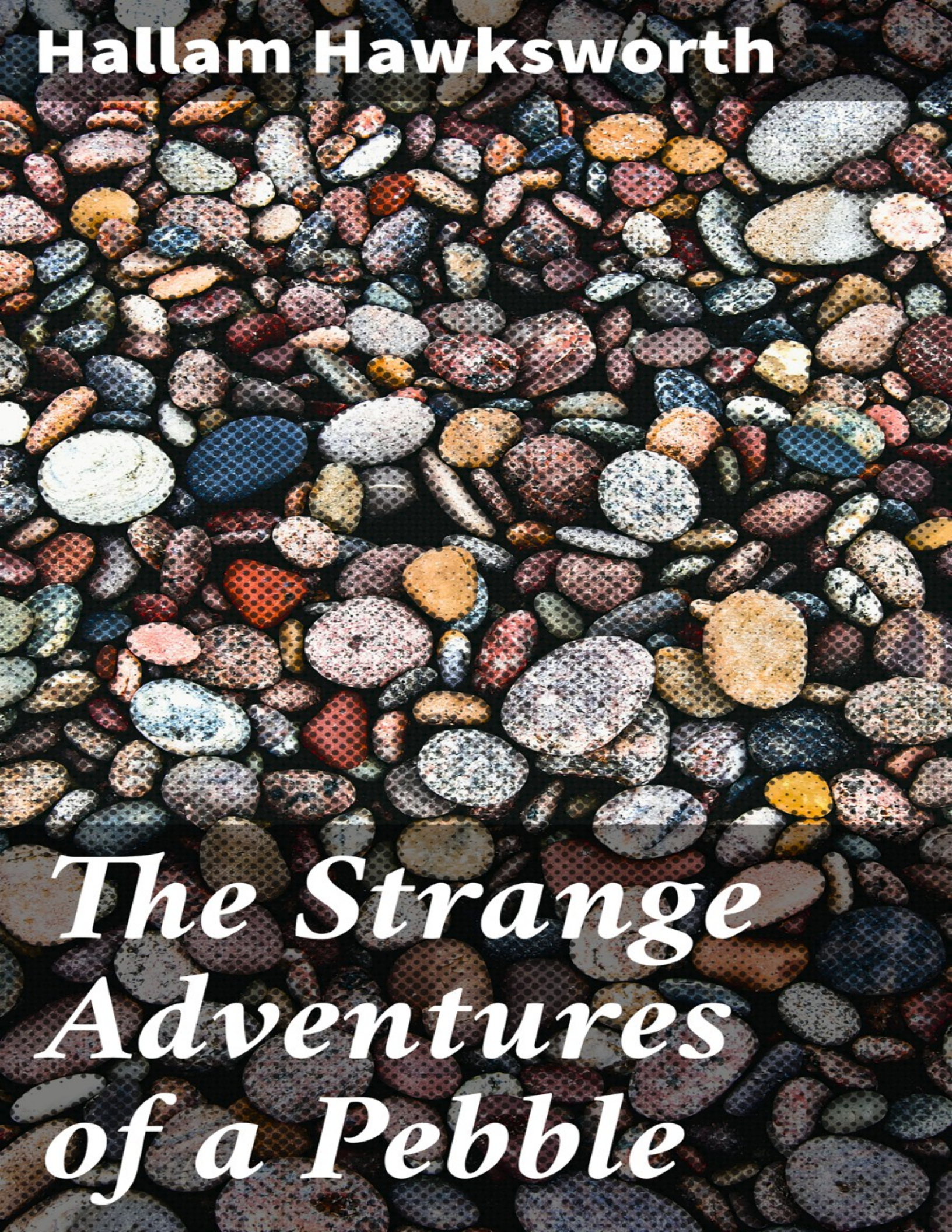
Hallam Hawksworth
The Strange Adventures of a Pebble

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PREFACE

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The purpose of this little book is to present the chief features in the strange story of the pebbles; and so of the larger pebble we call the earth. It is hoped that readers of various ages will be entertained, without suspecting that they are being taught.

Several things led the author to believe that such a book might be wanted.

(*a*) The circumstances under which it was written.

(*b*) The fact that there seemed to be an opportunity for improvement not only in the popular presentation of scientific topics but in the character and method of review questions and suggestions following such topics in school texts.

(*c*) Experience has shown that pictures may be made to perform a much more vital function in teaching than is usually assigned to them in the text-books.[1]

[1] On this subject I cannot do better, perhaps, than quote from an article on "The Picture Book in Education," contributed to the New York *Evening Post*:

"We learn more easily by looking at things than by memorizing words about them. The principle, of course, holds whether the image which the eye receives comes from the object itself or only from the picture of the object. Therefore we should learn to read pictures as well as books.

"New York has long recognized the added efficiency in the teaching process to be obtained from the use of pictures. The Division of Visual Instruction, established thirty years ago, has an international reputation for the extent of its equipment, the simplicity of its methods, and the excellence of its results."

(*d*) In the particular field to which this story relates comparatively little has been written either for reading in the family circle or for use in the school; although the

relation of physiography, not only to human history and political and commercial geography but to the whole immense realm of natural science, is so basic and its great principles and processes so striking in their appeal to curiosity and our sense of the grand and the dramatic.[2]

[2] Commenting on the need of popular literature dealing with earth science, Doctor Shaler says:

"In no other fields are large and important truths so distinctly related to human interests so readily traced; yet the treatises dealing with these truths are few in number and generally recondite."

What here appear as chapters were originally little talks for the evening entertainment of the juvenile members of a certain family and the neighboring children, who were attracted by what came to be known as the "pebble parties," during the season at Mount Desert Island. They are here given in substantially the form in which they first saw the light. While they proved entirely intelligible to boys and girls of eight and ten they seemed equally interesting to the older members of the audience, including a youth of eighteen in his last year of high school, whose comments, in the language of his caste, deserve to share the credit for whatever of whimsical humor and colloquial style the author may have succeeded in incorporating into the narrative.

The familiar tone, the number and variety of the chapters, the sub-heads and marginal captions and the character and treatment of the illustrations have a similar origin. They represent the variety of aspects under which it was found necessary to present the facts in order to hold a capricious audience whose attendance and attention were wholly voluntary.

The use of unfamiliar words and scientific terms has been avoided as much as possible, consistent with the educational purpose of the book. It is to be remembered that educators do not consider it good practice to omit all words which children cannot understand at sight; the theory being that it is by the judicious introduction of words not current on the playground that the intellectual interests and capacities of children are enlarged. With regard to scientific topics (it is further argued) a large proportion of the classics of science written for the general reader and which boys and girls of fourteen and upward should be able to read easily and with pleasure—Shaler, Darwin, and Wallace, for example—contain quite a few scientific terms; and these it would be well that young people learn from context or definition in their previous reading in works of a more elementary nature.

Moreover, while younger children will read a book the general character of which interests them, even though they do not understand every word or get all the thoughts in it, sophisticated youths of the high-school age will have none of it, if they suspect that they are being talked down to. In the story of the pebble the aim, accordingly, has been not only to make a book that young people will not outgrow but one that will be of some interest to adults, particularly to travellers.

Not only in the text is special emphasis laid on the interpretation of landscape, but the character, treatment, and arrangement of the illustrations is intended to train the eye to read the story of the earth drama as recorded in the forms of valley, mountain, field, and shore. And—since the

earth is not, after all, a mere geological specimen—these illustrations include reproductions of paintings, scenery as interpreted by the poet and the artist.

To create an appropriate atmosphere and so add to the vividness of conception, the twelve chapters each deal with a seasonable subject.

Relation to the Text-Book

The relation of this book to the formal study of physiography or geology in the schools will be apparent. The classified and exhaustive treatment of the text-book, while so admirably adapted to organize knowledge already acquired, or reward an appetite already aroused, is not at all adapted for creating this appetite in the first place; a thing so essential to true progress in education. For example, in a text-book, the many aspects of glaciers and their work, which are here distributed in a number of sections (as the discovery of these aspects was distributed in time), are usually dealt with in a single chapter or series of chapters, whose nature the reader at once gathers from the title, "The Work of the Glaciers."

The young reader or school pupil is thus deprived of the element of surprise, of the pleasure of following an unfolding mystery, which was at once the inspiration and reward of men of science to whom we owe these discoveries.

If left to the text-book alone, the student acquires his facts too rapidly and too easily. The result is a loss of both pleasure and profit. The movements of the glaciers and the nature of the movement, which gave Agassiz seven years of keen delight to ascertain, the pupil acquires through his

text-book in something like seven minutes, and without either the pleasure or the profit of Agassiz' gradual and inductive acquirement of this knowledge.

In other words, to begin the study of a given science by means of a text-book, without previously arousing interest in the subject, is to assume a greater zeal on the part of school pupils and college students than, it is reasonable to assume, was possessed by the scientists themselves. It was the attraction of the unknown rather than the rapid acquirement of the known that drew them on to their grand discoveries, their illuminating generalizations.

In recording the pebble's story the endeavor has been to cause the reader to come upon the data on which these generalizations were based, piece by piece, here a little and there a little—as did the scientists themselves.

Interesting as the mere facts of physiographic science finally become to the trained scientist they make little appeal either to the average boy or the average adult, if he must first come in contact with them as they are presented in the text-book; classified, catalogued, labelled in scientific terms and laid away (as it seems to him) in chapter, section, and paragraph, like specimens in a museum.

Since this book is concerned mainly with landscapes and the story of the forces that helped to shape them it does not undertake to deal with mineralogy. Within the fields thus defined it is believed that the larger facts, the great moving causes of things, have been covered as thoroughly as they are in the average elementary text-book. In addition, subjects in great variety are touched upon which do not come within the province of the text-book, but are such as

naturally suggest themselves in the broader and richer discussion of such topics in the conversation of cultivated people.

Hide and Seek in the Library

Since the whole purpose of the school is to prepare for the larger world of life and books outside the school, special attention is invited to the department of questions and suggestions following each chapter. As indicated in the introduction to the first of the series, an effort has been made to capitalize the fact that young people enjoy conundrums and curious quests in the field of books quite as well as mere passive reading.

The treatment is somewhat discursive, and in this and other respects is intended to be more like the conversation of cultivated parents with their children than like the review questions of a text-book; the review element being incidental, in recalling the topics out of which these questions and suggestions grow. The correlations in the most modern texts lead into equally wide and varied fields.

If he has succeeded in the aim thus indicated, the author believes this department may easily prove one of the most interesting as well as educatively useful features of the work.

H. H.

THE ILLUSTRATIONS

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In furtherance of the idea referred to in the preface, that a far more effective use may be made of pictures in teaching than is usual, a very extended use has been made of them in "The Strange Adventures of a Pebble," and, moreover, these pictures have been made to talk, as it were, by means of extended analysis and comment upon their significant features; this for the double purpose of teaching important facts, as only pictures can teach, and of stimulating the invaluable habit of observation and of logical reasoning about things observed.

One of the main purposes of the book, as stated in the preface, is to stimulate interest in further reading and study on the many subjects to which it relates.

The author wishes to make special acknowledgment of the co-operation of the editor of *St. Nicholas* and the following publishers in supplying the illustrations on the pages indicated:

The Macmillan Co.: 11, 29, 36, 41, 52, 83, 108, 121, 132, 145, 152, 168, 173, 195, 221, 225, 226, 235, 240, 249, 254, 257. The Century Co.: For the following from the *St. Nicholas* magazine: 38, 47, 70, 184, 199.

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THE STRANGE ADVENTURES OF A PEBBLE

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CHAPTER I

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(JANUARY)

In the beginning the earth was without form and void.

—*Genesis* 1:1-2.

IN THE BEGINNING

I. How the Worlds and Myself Were Born

I've been through fire and water, *I* tell you! From my earliest pebblehood the wildest things you could imagine have been happening to this world of ours, and I have been right in the midst of them.

HOW MR. APOLLO TURNED ON THE LIGHT

The first scenes of all in my strange, eventful history remind me of the old Greek story about Apollo and that boy of his—Phaeton. Apollo's business, you remember, was to take the sun through the skies every day in his golden chariot, so that people could see to get about. It was a ticklish job, as the horses were fiery. As a rule, however, things went fairly well. To be sure, there were overdone days occasionally, just as there are now. Then the crops would wither and the birds and brooks stop singing. This, as the little Greek boys and girls believed, was because Apollo's horses ran too near the earth.

HOW MR. APOLLO TURNED ON THE LIGHT

Behold the sun-god starting on his daily round! Aurora, Goddess of the Dawn, precedes him scattering flowers, the lovely colors of the morning sky. The other figures are the early hours.

The Greek poets used to play with these myth stories a good deal, changing them to suit their poetic fancy. Theocritus, for example, in a beautiful fragment that has come down to us, paints this picture of the breaking day:

"Dawn, up from the sea to the sky,
By her fleet-footed steeds was drawn."

You see, according to this poet's conception, Miss Dawn had a chariot of her own.

But nothing serious happened until one time Phaeton persuaded father to let him drive the sun chariot for a day. The horses, feeling at once a new and weak hand on the reins, tore out of the regular road and went dashing right and left. They even got so near the North Pole that the ice began to melt. They fairly flew down toward the earth, set

the mountains smoking, and dried up all the springs and most of the rivers.

THEN THINGS BEGAN TO HAPPEN

They dried up a certain great lake, so that there is to this day the Libyan Desert in Africa, where this lake used to be. They made the very sea shrink so that there were "wide naked plains where once its billows rose."

Finally Mother Earth called on Jupiter Pluvius, as god of thunder, rain, and storms, to stop Phaeton and the runaways and put out the fire.

Struck by a bolt of lightning poor Phaeton fell headlong from the skies, and a world-wide rain put out the world-wide fire.

From a cameo by Da Vinci

THE FALL OF PHAETON

(Museum, Florence)

Now, would you believe it, this queer old Old World story may really be true in its way. Of course there never was a sun god and no spoiled boy who did just that thing; although

many spoiled boys have *tried* to set the world on fire and failed because they thought it would be so easy.

But the earth really has been on fire in a sense; that is, has melted from the heat. And in parts where you would least suspect—the rocks. There's where I got into it. And some of these rocks, not more than ten miles[3] from where you live, are either still molten, or continue to melt from time to time; as you can see when lava comes pouring from volcanoes, such as those of Hawaii.

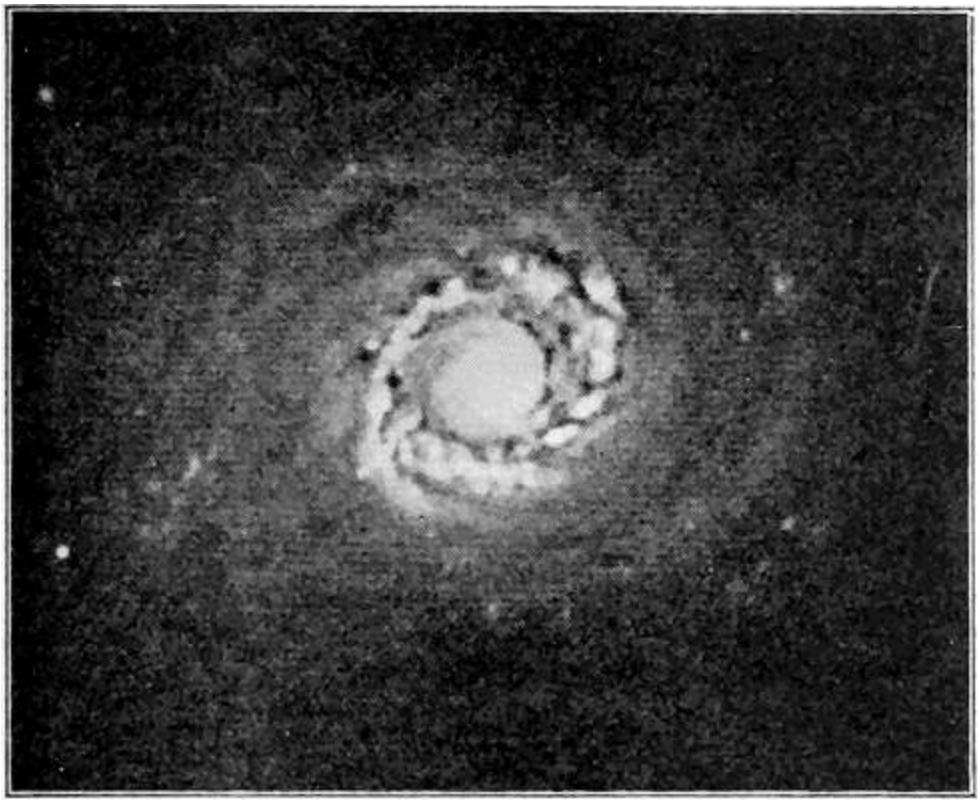
[3] Straight down, of course.

In the days of the Apollo story most men still thought the earth was the centre of the universe; that the sun, moon, and stars moved around it. But Pythagoras, one of the Greek philosophers, had formed a general notion of the truth that the earth is only one planet in a great system. Then, along in the Sixteenth Century, came Copernicus, and by mathematical calculation—he was a fine hand at figures—began to find out things that showed the wise old Greek had made a happy guess. Then Galileo, Kepler, Newton, and others, each working on different parts of the problem, finally settled the question. They found that there are just worlds of worlds, and that ours is only one of them.

About the time of the American Revolution a great French mathematician, Laplace, worked out a story of the origin of the earth which is, briefly, this:

What we know now as the solar system—the sun with its attendant worlds—was once a single big ball of fiery gas, a nebula. As this nebula cooled it shrank, and as it shrank it whirled faster because it had a smaller track in which to

turn, and with an equal amount of force would, of course, get around oftener. The faster it whirled the more the outside of it tended to fly off, as water flies off a whirling grindstone or as a stone flies from a sling. This centrifugal or "fly-away" force was greatest at the sun's equator, and it threw off big rings. Afterward, around some centre of greater density in these rings, the gaseous particles in the rest of the ring gathered, so forming spheres. Then some of the spheres themselves threw off rings in the same way which became what are called satellites. The moon, which is our satellite, Laplace supposed to have originated in this way. The ring which Saturn still wears he thought would some day become a satellite.

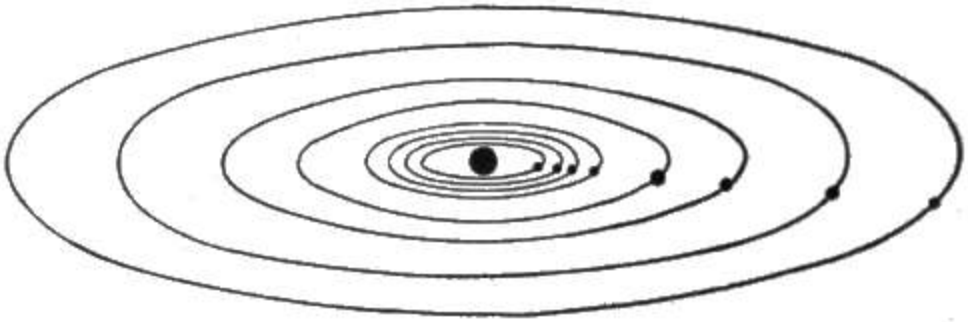


By permission of the Mount Wilson Observatory
WATCHING THE MAKING OF WORLDS

At first you won't see anything very striking about this picture, perhaps; but doesn't it give you something of a thrill to be told that you are here looking not only at the making of a *world*, but of worlds of worlds? A whole solar system! In the course of unthinkable time that big, round ball in the center will be the sun, and what appear to be little knots wrapped close around it—they are really far from each other and from the sun—will become rounded worlds like ours. They will be forced into roundness by their own gravity, pulling toward their centers. They don't look any farther apart than the strands in a little sister's braided hair, do they? But remember how small this picture is compared with what it represents. What here show as little dark lines, separating the embryo worlds, are in reality vast spaces, like those you see between the stars at night—millions and millions and millions of miles!

So, you see, the myth story of Phaeton foreshadowed, in a way, the science story of Laplace. For, according to the Laplace theory, the world *was* on fire; and a big rain storm, lasting for ages, with plenty of thunder and lightning, did help put it out.

This theory of Laplace was long accepted as the true one. Indeed, it was only yesterday, comparatively, that other explanations were offered as to how we came to have a world to stand on. The broadest of these new theories—the one that undertakes to explain the most—is that of Professor Chamberlin, of the University of Chicago.



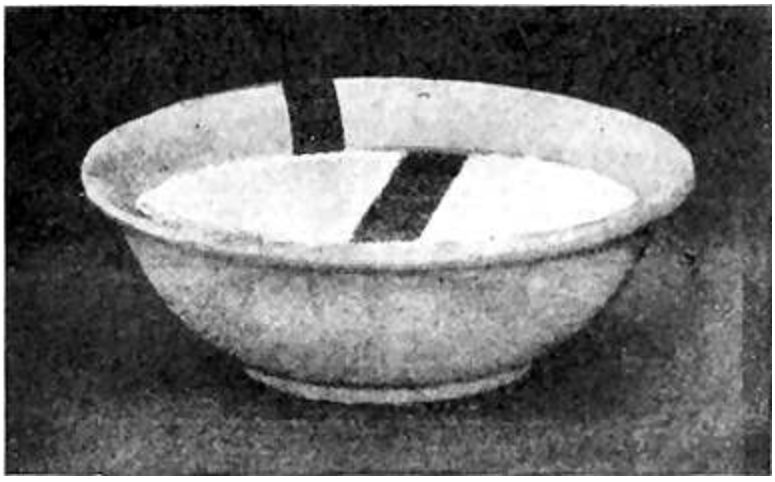
THE SUN AND HIS PEBBLE WORLDS

However the worlds of our solar system may have been made, when they were done there was the sun in the centre and his worlds travelling around him in their ordered orbits. Nearest the sun is Mercury. Then Venus, Earth, Mars, Jupiter, Saturn, Uranus; then, finally, Neptune nearly 3,000,000,000 miles away and with an orbit so big that Christmas comes only once in 60,000 years!

YOU CAN SEE THESE WORLDS IN THE MAKING

Owing to the more powerful telescopes of to-day, and the amount of exploring among the worlds that has been going on since the time of Laplace, several things have been discovered that have brought his theory into question. For one thing, many more nebulæ have been found in space than were known when Laplace worked out his great conception, and among them all not one has been found with a central mass surrounded by a ring. Moreover, our sharp-eyed telescopes show that Saturn's ring, which Laplace thought was a solid mass, is really made up of a great number of small satellites: baby worlds. The greater number of these nebulæ are like the ones you see in the illustration on page 5. They consist of very bright centres

with spirals streaming out from opposite sides. Just take a look at the picture. Doesn't the shape of those spirals suggest that the central mass is whirling? And notice the little white lumps here and there. The thinner, veil-like portions of the mass, as well as the "lumps," are supposed to be made of particles of matter, but the lumps to be more condensed. All the particles, big and little, are known to be revolving about the central mass, much as the earth revolves about the sun. The little white lumps, or knots, in the filmy skein are supposed to be worlds in the making. Being larger than the other particles, they draw the smaller to them, according to the same law of gravitation which makes every unsupported thing on earth fall to the ground, because the earth is so much bigger than anything there is on it. Since these bright little lumps behave so much like the worlds we know as planets, and yet are relatively so small, they are called planetessimals, or "little planets." So Professor Chamberlin's idea of the origin of worlds is known as the "planetessimal theory."



HOW YOU CAN WATCH THE WORLD TURN ROUND

Timepieces, you know, are really machines for keeping track of the apparent movement of the sun. Here is a device, as simple as a sun-dial and much simpler than a clock, by which you can record the actual motion of the earth. Sprinkle the surface of the water in a bowl with chalk dust. On this, sift from a piece of paper powdered charcoal or pencil dust, so as to make a clean-cut band extending across the centre and over the edge of the bowl. In the course of several hours you will find that the black band has swept round from east to west, because the water has stood still while the bowl has been carried from west to east by the whirling world.

According to this theory the earth was once a mere baby world like those white lumps, and grew by gathering in its smaller neighbors from time to time by the power of gravitation. The larger it grew the more particles of solid matter it could draw to itself. Then it drew larger masses, for with increased mass came an increased pull of gravity. In the same way the earth is still growing, for it is thought that the shooting stars or meteors we see at night are little planets being gathered in.

II. How the Continents Came Up Out of the Sea

And before I got to be myself at all, while I was still only a part of the big pebble called the Earth, your geography and I lay at the bottom of the sea.

For ages and ages!

This is one of the stories you will find in the literature of science, of how, along with North America, South America,

Europe, Asia, Africa, and Australia—have I left out any?—I came to land and brought your geography with me.

I remember hearing a pretty young lady say, once upon a time:

"There," said she, "I'm through with geography forever!"

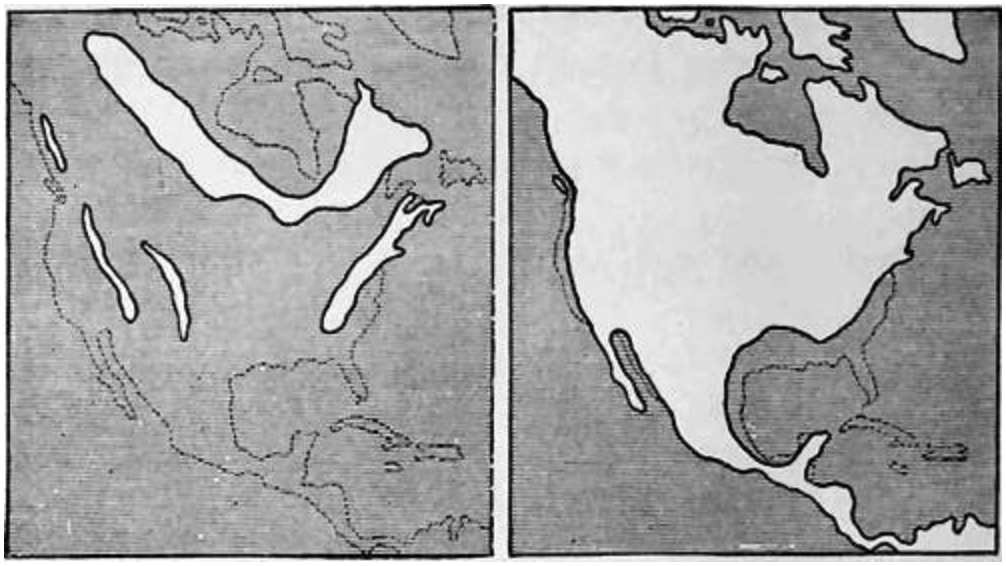
You see, although she had passed with marks around 90, she still had the idea that geography is a book. You and I know, of course, that the real geography isn't a book at all. It's the world itself.

PUTTING THE CONTINENTS ON THE GLOBE

But there was a time when there was no land. It was all water, and the continents were lifted into their places, much as you model a continent in making a relief map; they were sketched out and then filled in. North America, for example. First of all up came that mass in the northeast in what is now Canada; the Laurentian Highlands, as they are called in your geography. They rose very, very slowly, you understand, only a few feet in a thousand years; for Nature has all the time there is and never hurries. These highlands (they are really granite mountains worn down), along with the other rock formations of our continent, are supposed to be the oldest land on the earth. The continents of Europe and the rest were born later. So you see Columbus didn't discover the New World at all; he really came from the New World and discovered the Old!

Next after the highlands north of the St. Lawrence up came the tops of the mountains you see running along the eastern coast, what we now call the Appalachians. Then the Rocky Mountains began to raise their heads and looked eastward toward their brother mountains across a great

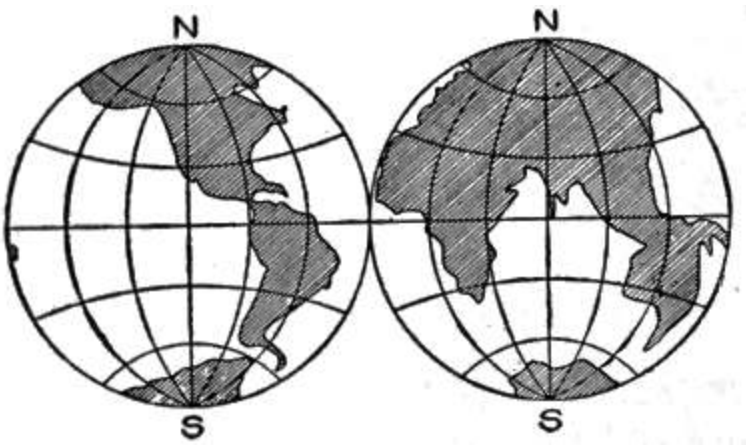
mediterranean sea, the bottom of which is now the Mississippi Valley. Mediterranean means "middle of the land."



HOW YOUR GEOGRAPHY ROSE OUT OF THE SEA

ADMITTING NEW STATES TO THE MAP

Wisconsin, into which I moved from the Laurentian Highlands in later years, was on the lower end of a long, thin tongue of rock reaching out from these highlands to the southwest. While Wisconsin went on growing, the Alleghanies came up and brought some Middle Atlantic geography with them. Up with all these early settler mountains came, in the course of time, the beginnings of neighbor States. All these big, barren rocks (as they were then), rising and ever rising, age after age, spread more surface to the sun. And the sun, and the wind, and the frost, followed by the lowest forms of plant life—the Adams of the vegetable world—gradually worked the surface of the rock into soil; and so, as we may say, got ready for the spring plowing.

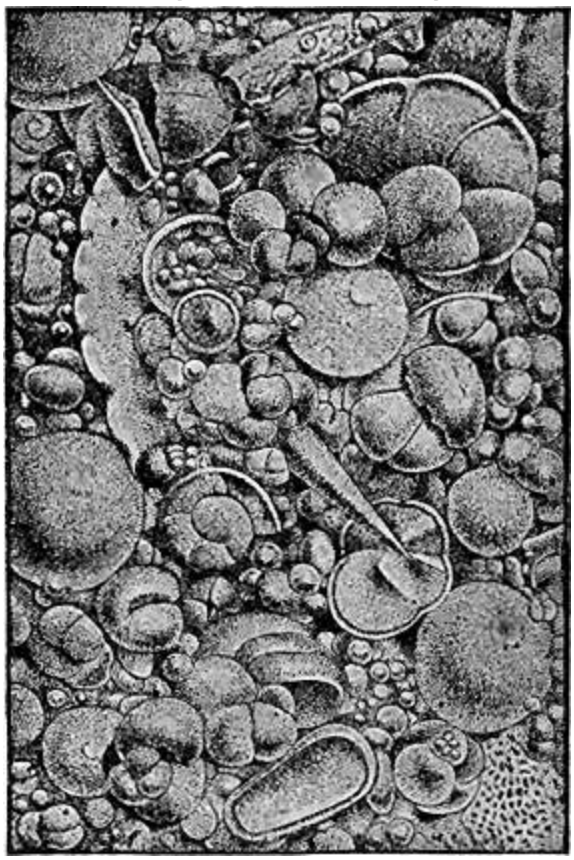


LANDS THE SEA HAS SWALLOWED

Parts of the continents as they used to be but which are now beneath the waters are here shown. Compare this with the globe map in your geography. It is estimated that there are 10,000,000 square miles of this land. You'll hear more about this swallowing habit of the sea in Chagter X; but, as you will learn, there's nothing to be frightened about.

By this constant rising and building on of the soil the foundations of our States grew out toward one another in order, according to the constitution of things, "to form a more perfect union." The United States, at a time which, we may say, corresponds to "The Expansion Period" in your school history, grew southward from Wisconsin and westward from the Appalachians until they made continuous land; and there was your Ohio and Indiana and the rest of the North Central group. Below, toward the south, were more big stone islands here and there, the first sketches or blockings out of the Southern States. Florida seems to have been added later, as a final touch; an afterthought, as one of my Wisconsin neighbors puts it. And it was much

enlarged by those remarkable little world builders, the corals. Mexico and Central America, of course, are a part of the Rocky Mountain system.



From Gilbert and Brigham's "An Introduction to Physical Geography." By permission of D. Appleton and Company

BUT WON'T WE GO UNDER AGAIN?

These little people of the sea-floor furnish one of the most assuring evidences we have that although the continents rose out of the sea, they will never go under the sea again. These are shell creatures found in the slime dredged from the bottom of the deepest parts of the sea. The shells of creatures that live near shore are found in abundance in our rocks, but these types are found only in the deepest seas. So, since

> the deep down-wrinklings of the earth that make the sea-basins have never risen, it is probable they never will; and consequently that the up-wrinkles—the continents—will continue to stay above the waters.

It's a wonderful old story, isn't it? But more wonderful still, it always seemed to me, is the story of how they found all this out.

Who do you suppose first told about it? The last people you would ever think of, I'm sure—the oysters!

WHAT THE OYSTERS TOLD XENOPHANES

It sounds like a passage from "Alice in Wonderland," or "Through the Looking-Glass," doesn't it? But it's a fact. Away back, more than 2,000 years ago, a wise Greek called Xenophanes, who lived in a place called Colophon, and so was called Xenophanes of Colophon, said that he thought the rocks of the mountain sides must once have been under the sea because of the oyster shells that were found embedded in many of them.

HOW THE OYSTERS TOLD THE GREAT SECRET

Here is a good example of the thing that led wise old Xenophanes of Colophon to make the startling assertion that the mountains were once at the bottom of the sea. These are the shells of oysters embedded in limestone—which, by the way, the shells of the oysters themselves helped make—and this piece of stone is from the top of a high mountain.

"For," said Xenophanes of Colophon, "how else could the oyster shells have got there? Who ever heard of oysters climbing a mountain?"

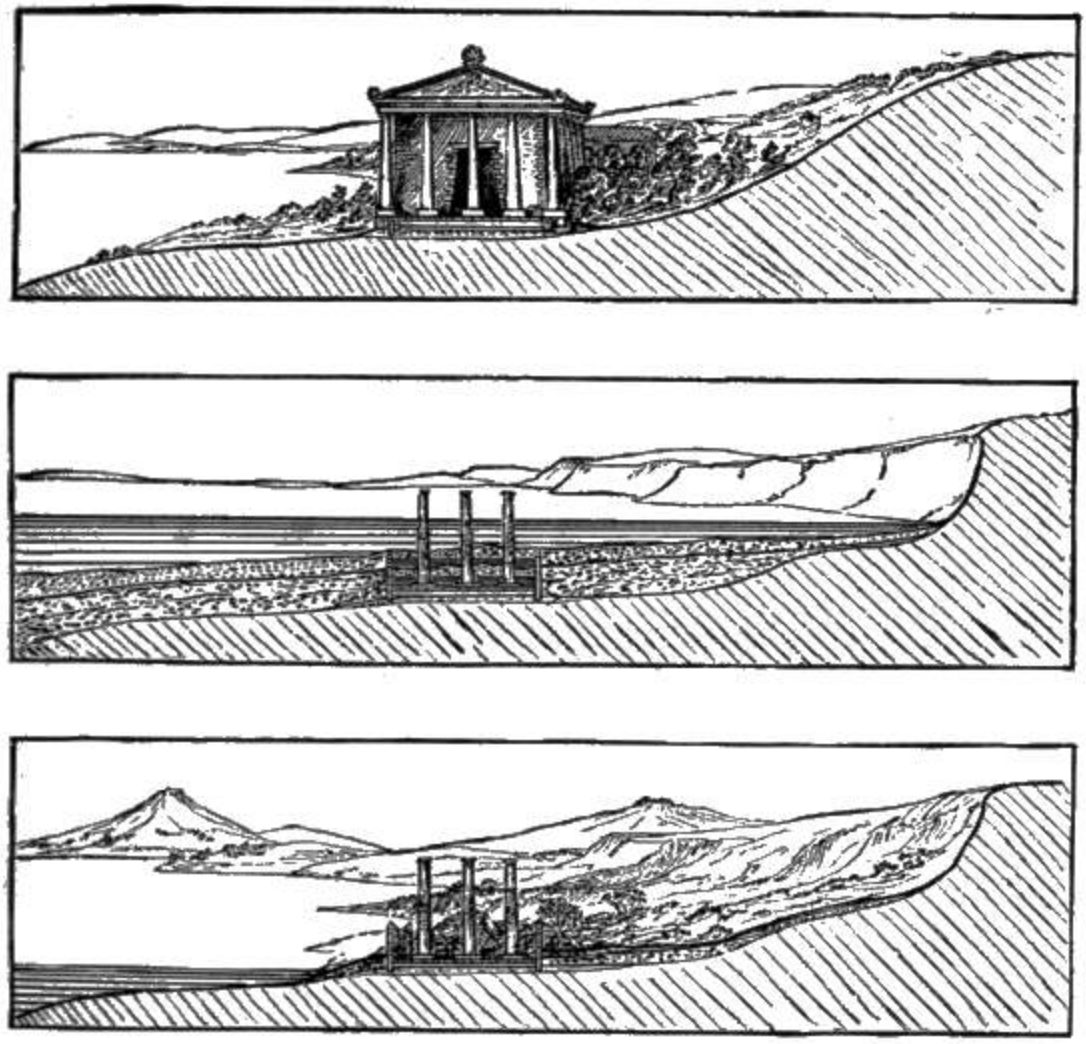
Another evidence that lands come up out of the sea is this: Even before the days of Scott and Maryatt and Fenimore Cooper, men—and, of course, boys—were interested in caves that face upon the sea. They are such jolly places for pirates, and for boys playing pirate, and for

mermaids drying their hair. It was plain that down where the waves in storms could reach them the sea itself bored out these caves. But how about those caves in the cliffs high above the waves? The sea must have made them, too, once upon a time when the land was lower in the water. Then the land was raised.

Still more striking was the fact that not only caves but old sea beaches were found on hill and mountain slopes far from the sea, sometimes hundreds of miles inland. You can tell the old beaches by their shape and the way in which the pebbles are sorted by size, just as you find them on beaches to-day.

THE BAKED APPLE AND THE BULGING WORLD

The causes of the rise and fall of the sea coasts are many, and there are things about these movements not yet understood. By what wonderful machinery, then (we might naturally ask), were the continents themselves lifted out of the sea? To this, which would seem much the harder question of the two, the answer is simple; as simple as a baked apple. You know an apple that goes into the oven with a smooth, neat skin comes out covered with wrinkles. Now suppose, instead of a little, hot apple, covered with a thin skin, you have a big, hot earth covered with a thick crust of stone, and the inside of the earth shrinking all the time as the inside of the apple shrank away from its skin. The rock skin would wrinkle, and the wrinkles, rising out of the seas that then covered it everywhere, would make continents.



THE RISE AND FALL OF JUPITER SERAPIS

In this account of the ups and downs of land and sea I must tell you the story of Jupiter Serapis. In the days of the Romans this temple, for his honor, stood on the seashore near Naples. Of that temple only three pillars remain, but they answer a very important question. On these pillars, over twenty feet above sea-level, is a belt of holes bored in the stone by a certain shelled sea-creature, one of the barnacle family; so evidently these pillars must, at some time, have sunk, as shown in the second picture, and then

risen again, as shown in the third, which represents them as they stand to-day.

Another interesting thing is that the third picture—observe—shows a volcano that isn't in the other two. Following a series of earthquake shocks in 1538 the earth opened and out popped hot stones and ashes and built themselves into a small volcano right before everybody; for it was all done in a short time, and you may be sure the frightened people kept their eyes on it, and they named it Monte Nuovo, which is Italian for "New Mountain."

"And God said, Let the waters under the heaven be gathered together into one place, and let the dry land appear: and it was so."

According to the planetessimal theory the way in which the seas were made was this:

Owing to the collision—the "bang"—of the planetessimals against the earth, and against each other as they met at the "terminal station," heat was generated. The compression, the squeezing together, of the earth from its own weight—the gravity pull of the whole mass toward the centre—generated still more heat, and the heat and pressure drove the gases out of the rock. These gases included hydrogen and oxygen. These two gases cooling and combining themselves, in a way they have, became water, and there were other gases, such as nitrogen and carbon gas, that helped to make the air.

WHEN THE SEAS WERE ALL IN THE SKY

At first the water was in the form of dense clouds of overhanging vapor which, growing bigger and bigger, finally