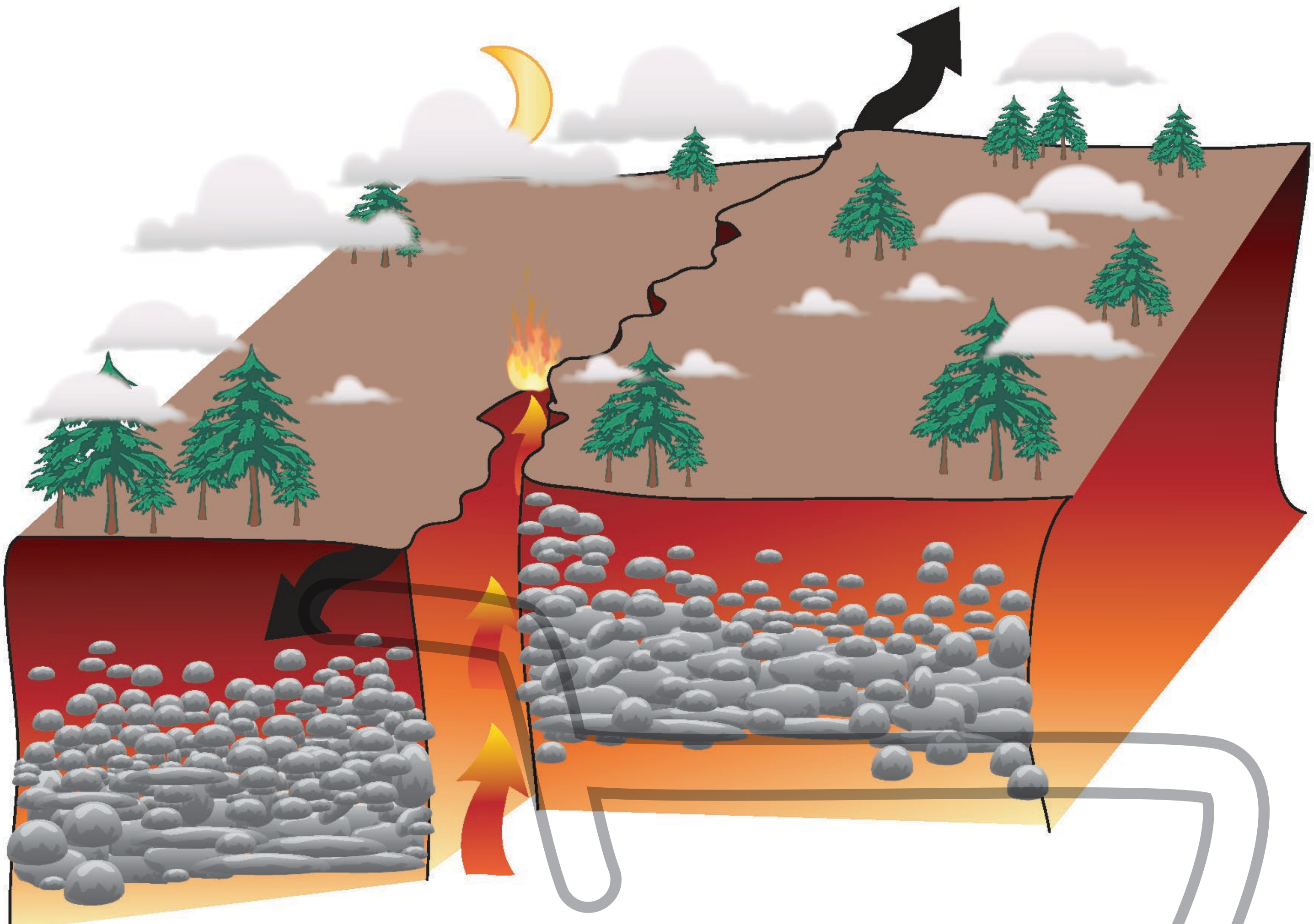
DYNAMIC EARTH



Supermarket Science

LEARN

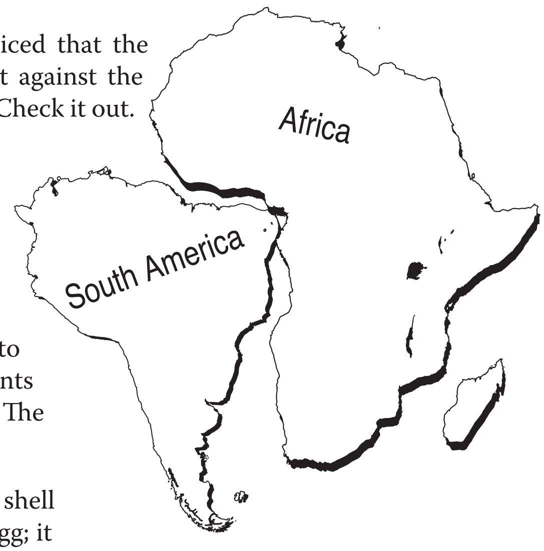
A Crusty Story: Jigsaw Puzzle Evidence

If we dig a really, really, deep hole into the Earth what would we find? What's inside? That's an interesting question to which we still don't have a very good answer. Even now, we know surprisingly little about our planet's interior. For example, we don't really know how hot it is at the center. Scientists estimate an internal temperature anywhere between 7,000°F and 13,000°F. That's a 6,000°F swing! If a student was that far off on a test…well, you get the idea. In comparison, the surface temperature of the sun is 13,000°F. How come our feet are not hot from just standing on the ground?

It's hard to figure out how hidden things, like the interior of the planet, work. And scientists, being people too, sometimes have prejudices and fixed ideas which blind them to the truth. Most people think that scientific discovery is an orderly and rational process. So the reality of how scientific advances are made is sometimes surprising.

Geographic Evidence—Pieces of the Puzzle

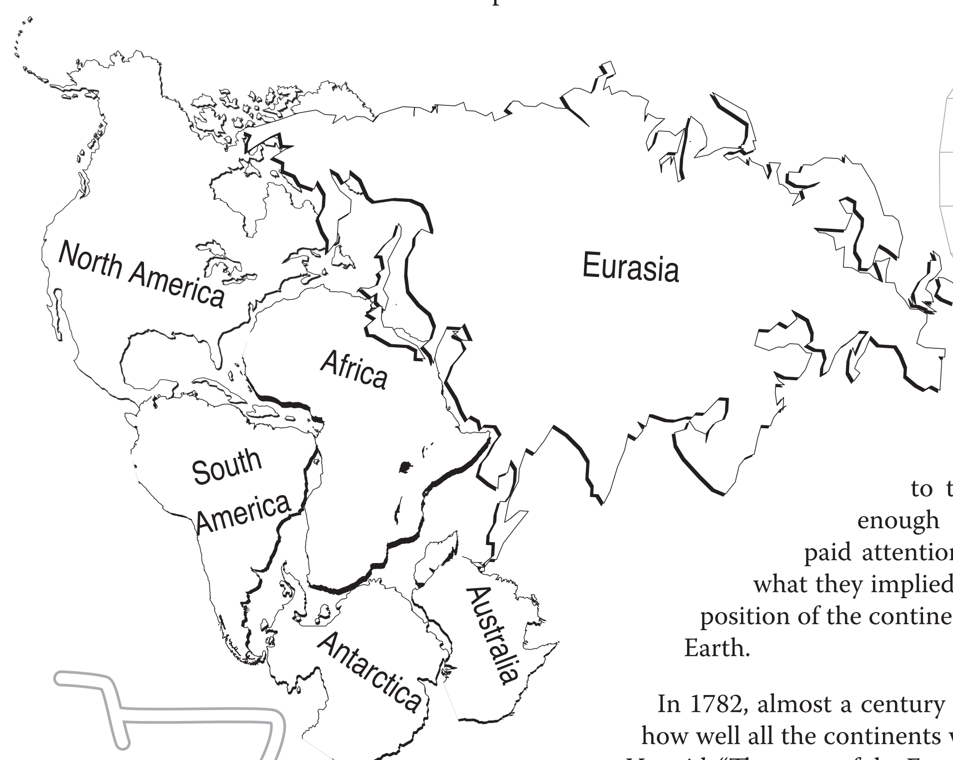
Scientists, map makers, and travelers have long noticed that the Western coast line of Africa seems like it would fit against the Eastern coast of South America if you rotate them a bit. Check it out.



Coincidence? Perhaps. But it got people asking whether these two separate continents could have been a single continent in the distant past. Do other continents fit so well together? Look at th little map of the world on the below.

What if we move all of the land masses on the map to form one big continent? Do the shape of the continents fit together like pieces of a jigsaw puzzle? Let's try. The illustration below shows what this would look like.

The land "pieces" seem to fit together like pieces of shell peeled from a hard-boiled egg. But the Earth is not an egg; it doesn't have a shell…or does it? And how would it get broken and how would the pieces move around?



Sir Francis Bacon was one of the first to notice the surprising fit of the African and South American coasts in 1620. Prior to that, the maps of the world weren't good enough to make such observations. Few people paid attention to Bacon's continental jigsaw ideas or to what they implied. At the time, most people thought that the position of the continents hadn't changed since the creation of the Earth.

In 1782, almost a century and a half later, Benjamin Franklin noticed how well all the continents would fit together if they were repositioned. He said: "The crust of the Earth must be a shell floating on a fluid interior." Even though Franklin was a famous and respected scientist (as well as one of the Founding Fathers of the United States of America), it seemed to be such an outlandish idea that few paid attention to him.

Supermarket Science

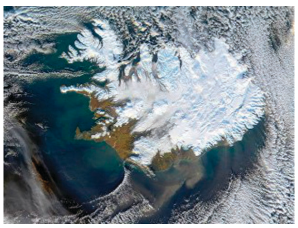
LEARN

A Crusty Story: Rocks and Fossil Evidence

Geologic Evidence—Are These the Same Rocks?

If the continents were indeed once part of the same large land mass, and if the rocks formed before they broke apart, wouldn't the rocks on one side match the rocks on the other? Imagine a dinner plate with a baked-in design. If you broke the plate and then reassembled the pieces, not only would the pieces match but so would the design. Now imagine that you have one giant land mass consisting of a "design" of many different types of minerals. When you break up that land mass and scatter the pieces, on places where these pieces used to fit, the rock formations should match as well and be made out of the same rocks.

In 1799, German scientist Alexander von Humboldt set out on a five year expedition to South America to collect information about plants, animals, and local geology. He discovered that in the places where the coast of South America and Africa seemed to fit, the rock formations also matched. Not only did the rocks from both coasts looked similar, they were the same rocks.



Iceland is an island in Northern Atlantic Ocean. It is the only land mass to cross the mid-Atlantic ridge. There are no fossils in found in Iceland. Why?

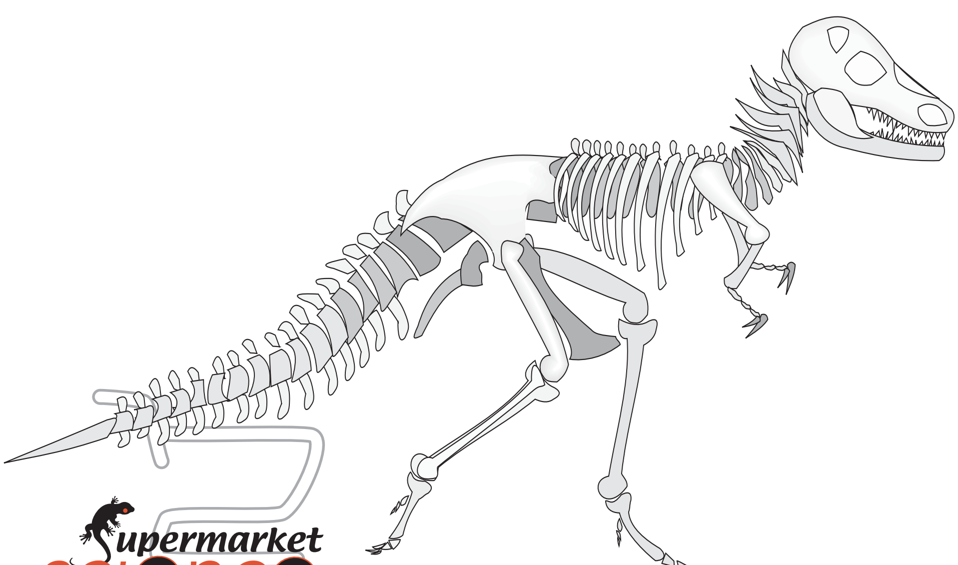
Paleontological Evidence—The Stories of Ancient Life

People have been finding bones, shells, and imprints of leaves in rocks for a very long time. Usually organic matter decays. But sometimes, if the conditions are just right, organic matter is replaced by minerals leaving either an impression or a casting in stone. This is a fossil. Fossils are found in most environments on Earth except within freshly created lava.

Fossils of the same animal found on continents separated by vast oceans can serve as clues to Earth's past.

Alfred Wegner, a German meteorologist, liked to collect and study fossils, but he was puzzled by some fossils collected in locations that were hard to explain. For example, there were identical fossils of land snails found on opposite sides of the Atlantic Ocean. How could a little snail cross an ocean? Some scientists imagined long, narrow land passages spanning the continents that animals could have used to cross oceans in the distant past. But as more and more of these matching fossilized animal pairs were discovered, more and more of these bridges need to have existed. The Earth, it seemed, was crisscrossed with bridges for animals to travel between continents.

Alfred Wegner didn't think this made any sense. In 1912, he proposed instead that the continents used to form one single land mass many millions of years ago. This super continent broke up into smaller ones, which drifted apart to their current positions, taking the fossils buried in them along for the ride.



By Wegner's time, there were three strong groups of evidence supporting his theory. First, there was the *geographic evidence*—the rough shape of the continents fitting together like a jigsaw puzzle. Second, there was the *geological evidence*—seams of rock matching on land masses now separated by an ocean. Third, there was the *paleontological evidence*—matching pairs of fossils found across oceans.

But most geologists hated Wegner's ideas. *Who did he think he was? He was just a weatherman. What did he know about geology and fossils? How could he come up with a theory of continental movement?* And the idea itself was pretty hard to swallow. How can huge continents move around the Earth? And so the idea of the Earth's crust breaking and spreading was abandoned once again.

Supermarket science

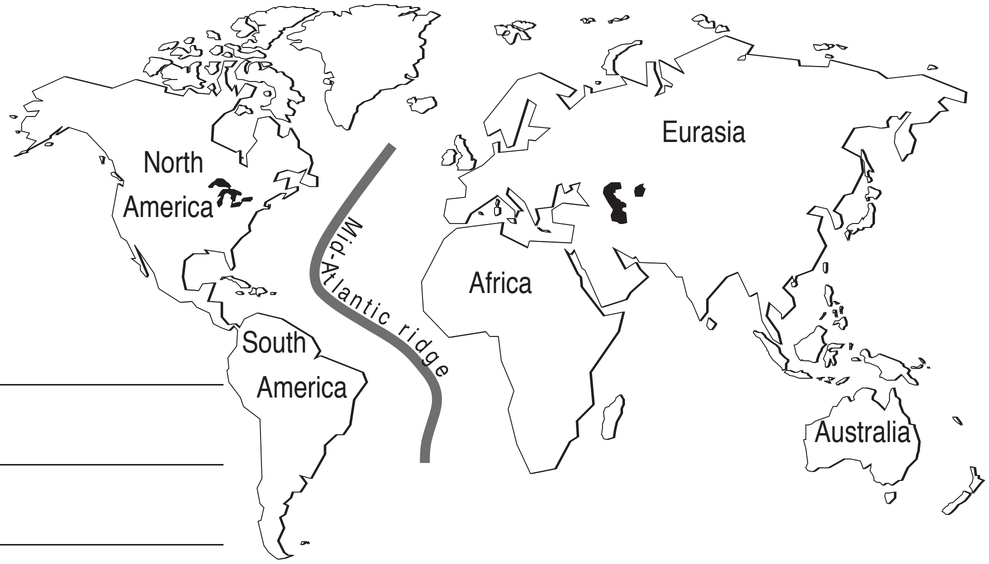
LEARN

A Crusty Story: New Land

Mysteries of the Deep

It's hard to tell what the bottom of an ocean is like. The first attempts used weighted ropes lowered to the bottom of oceans from ships. Each ship could determine the depth of the ocean along its path, but only as long it wasn't deeper then the length of their rope. It wasn't until more sophisticated technology in the middle of the 20th Century that scientists begone to really visualize the shape of the oceans' floors. Then they discovered huge mountains, miles and miles of canyons, and underwater volcanoes. Some of the Earth's biggest mountains and deepest canyons are hidden from sight, under the surface of the water.

One underwater mountain chain was particularly surprising in its size, location, and shape. In the middle of the Atlantic, between the Americas on one side and Eurasia and Africa on the other, runs a long chain of mountains that follows the shape of these continents' coastlines.



What do you think is going on? ______________________________

____

____

____

____

____

____

____

____

____

____

And even more curious was the age of the rocks found on the bottom of the ocean. None of the rocks the scientists examined were older than 175 millions years. But rocks found on land were often much older and sometimes as old as four billion years. What was going on? Why was the ocean floor so young compared to continental rocks?

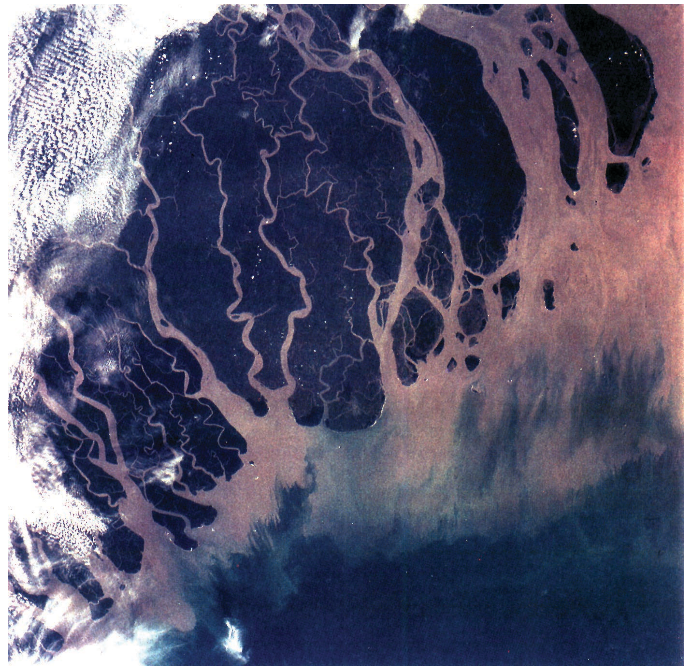
The survey of the Atlantic Ocean also revealed a deep trench that splits the whole mid-Atlantic underwater mountain chain in half along its entire length. Scientists noticed that the closer they were to this trench, the younger the age of the rock samples they collected. The rocks collected away from the trench and closer to the coasts were the oldest. Here was another mystery.

LEARN

Cruddy Mystery Points to Drifting Theory

The River Crud Mystery

Rivers usually begin in mountains where clouds release their water as rain. As rivers flow from the mountains down toward the oceans, they carry lots of mud, sand, rocks, and other debris along with them. Some rivers move so much stuff that their clear waters become opaque and colored with the minerals that they're carrying along.



In this photo taken from space, it is easy to see the muddy river waters of Ganges spilling into Indian Ocean (from top to bottom in the satellite image above).

For millions of years, all of the Earth rivers transported all that crud into the world's oceans. When scientists calculated just how much crud the rivers would have moved in all that time, they got an astonishing number—the world's oceans should be filled, buried under river crud twelve miles thick! Since no ocean is twelve miles deep, this calculation states that the ocean should have been replaced with mountains of crud.

Since that's clearly not true, there is something wrong either with our reasoning or our understanding. The calculations were checked over and over again but seemed to be right. So where did all that crud go? For years, scientists dealt with this paradox by simply not thinking about it.

Where do you think all that river crud goes? ____________________________________

Get My Drift

The continents look like they can be reassembled with a near perfect fit. The rocks on different sides of the ocean turn out to be identical. Fossils of the same animals are found across the ocean from each other. River crud mysteriously disappears. There is a giant ridge with a trench in the middle that runs along the center of the Atlantic Ocean, matching the shape of the coast on both sides. What theory can explain all this?

Almost 200 years after Benjamin Franklin first proposed it, the theory of continental drift slowly gained acceptance in the scientific community, although textbooks from 1970s still treated the ideas as a preposterous side note. As continents drifted apart, the ocean floor spread. This spread created a deep rift—the trench in the mid-Atlantic ridge. The lava that spread from this hole formed the ridge itself, pushing the edges farther and farther apart. This explains the newness of rocks at the center of the Atlantic Ocean. As the ocean floor spread, the portions closest to the coast submerged back down under the continents, taking the river crud back into the depths of the planet. Animals whose fossils are found on opposites sides of the oceans used to live side by side before the continents split apart from one great land mass. One theory explained so many mysteries. Geologists call the moving pieces of the Earth's crust "plates" and the whole theory is called "plate tectonics." As with most ideas in science, plate tectonics is continually evolving and being refined. Sometimes the evolution of scientific ideas is a messy process.

Supermarket Science

DO

Evidence

The Earth's surface is broken into several segments called plates. There are plates that make up the land masses and those that contain the oceans. The science of how these plates move over the molten interior of the Earth is called plate tectonics.

There are three primary lines of evidence that support the theory of plate tectonics: Geologic, Geographic, and Paleontological. Read The Crusty Story LEARN pages to find out more information about these different types of evidence.

The Three Types of Evidence Experiment

Take a blank sheet of paper. Take three different colored pencils or crayons. Make huge scribbles over the entire page in all three colors. You can make spiky scribbles in one color and curly ones with another. Or you can mix it all up and cover the page with colorful decorations.

Now write your name in super large black letters across the whole paper. Make sure you can see it well among all the colors. Beautiful, isn't it?

Rip it! Tear the paper into four or five pieces just like in the picture. Glue it back together onto another sheet of paper.

What You Need:

Clues

What are the different types of evidence that the paper you've ripped up used to be one single sheet? Consider the evidence for the plate tectonics. How did scientists figure out that in the distant past, there used to be just one large land mass on the Earth?

1. ____

____

____

2. ____

____

____

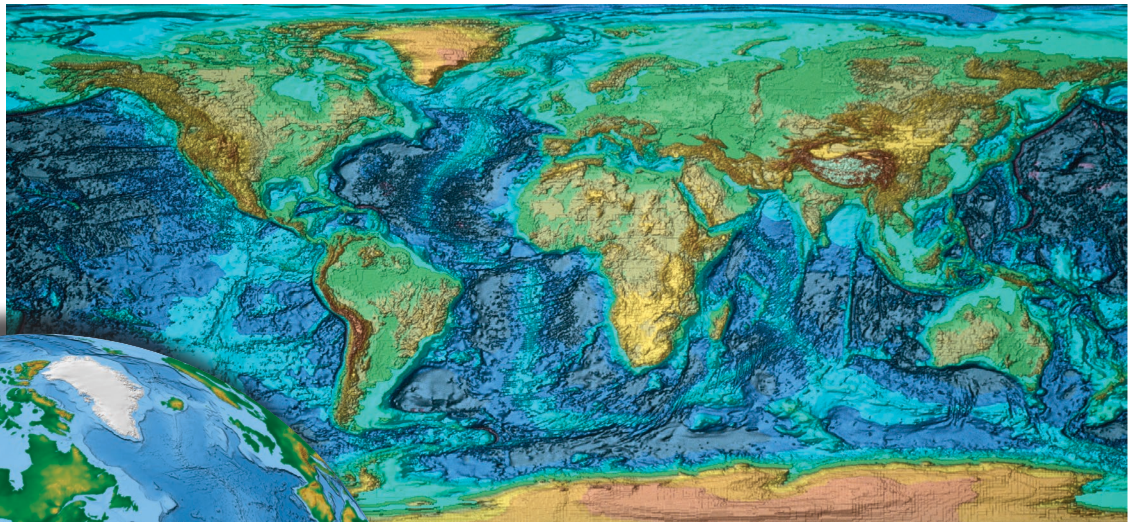
3. ____

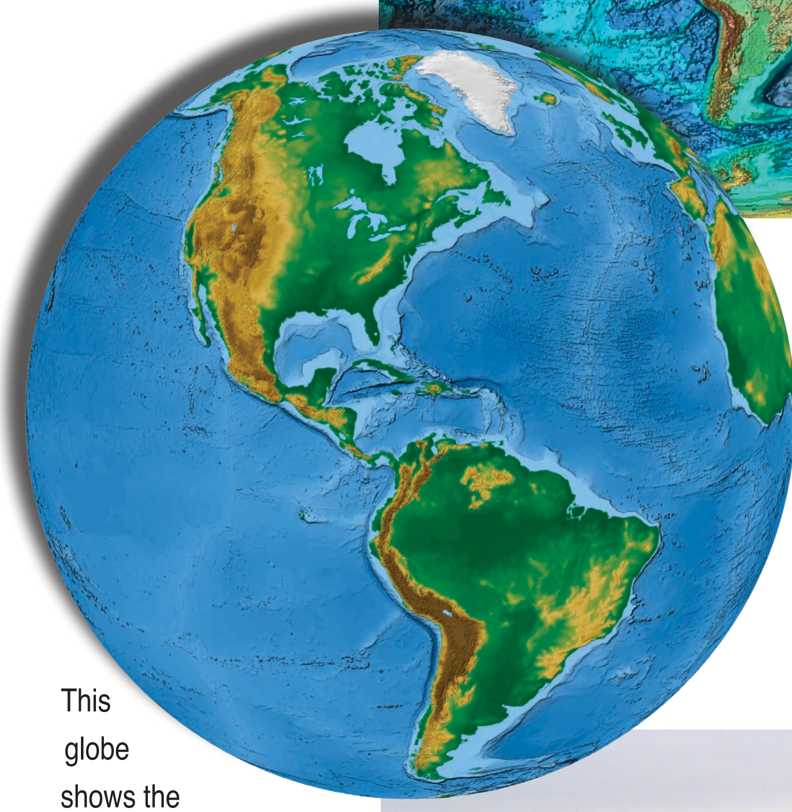
____

____

SHOW

Mid-Atlantic Ridge





Mapping instruments placed in orbit around the Earth allow us to make detailed elevation maps of the surface.

Iceland is the only place where mid-Atlantic ridge crosses land. This small island is composed of two continental plates: European and American. In the photograph below, the European plate is seen across a glacial lake. The rocks in front belong to the American plate.

This globe shows the Western Hemisphere. Can you see the mid-Atlantic ridge? Greenland is clearly visible—it's the big white island at the top. Just to the right of Greenland is a small island named Iceland.

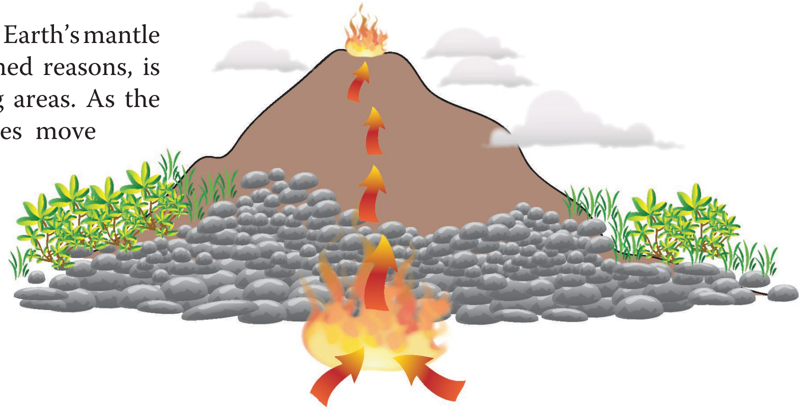
Supermarket Science

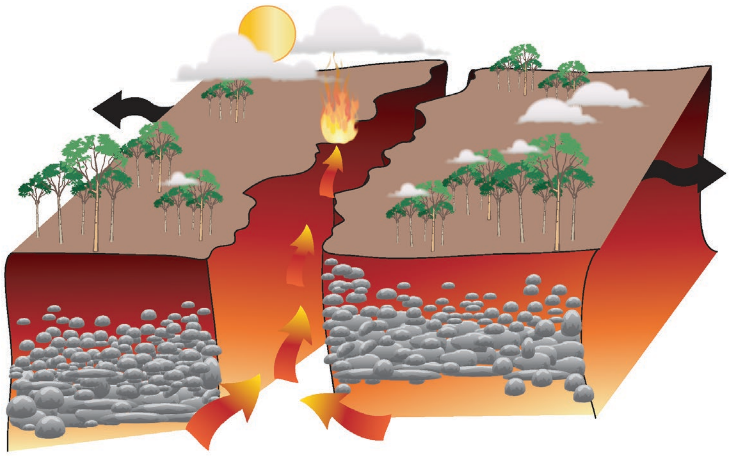
LEARN

Different Volcano Types

Hot Spot

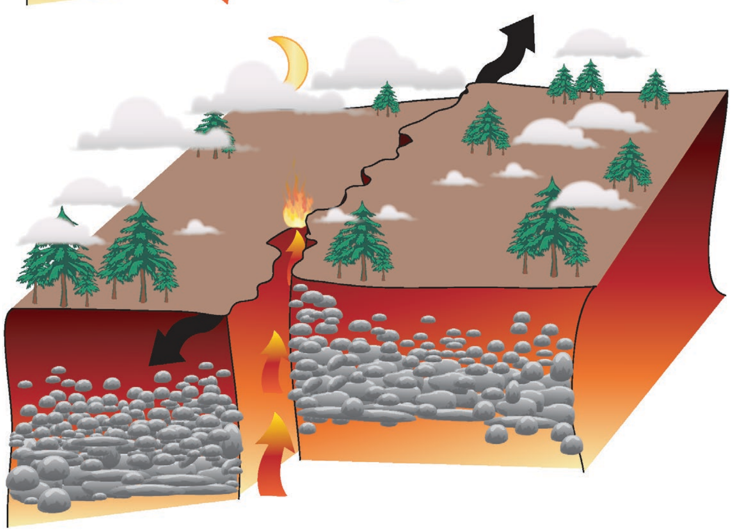
A hot spot is a fixed spot in the Earth's mantle that, for currently unexplained reasons, is hotter than the surrounding areas. As the continental or oceanic plates move over such spots, a volcano develops. Hawaii islands are examples of volcanic islands formed over a hot spot.





Rift Zone

A rift zone is a place on the Earth's surface where two plates are moving away from each other. The Mid Atlantic Ridge is one such place: the ocean floor is splitting apart, and magma comes up from beneath and pushes the oceanic plates even farther away from each other. Iceland is an example of a volcanic island which formed over a rift zone.

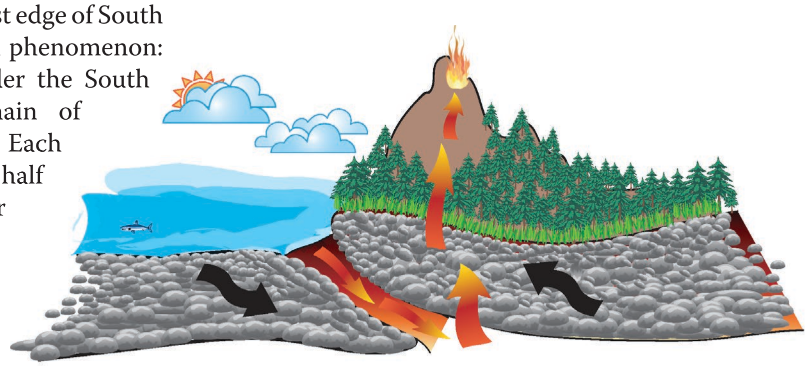


Slide Zone

A slide zone is a place on the Earth's surface where two plates are moving past from each other. San Andreas Fault is an example of this phenomena: the Pacific and North American plates move is the opposite directions, rubbing each other as they do. Earthquakes and volcanoes form in such places of great tension.

Subduction Zone

A subduction zone is a place on the Earth's surface where two plates collide, and one plate moves under the other. The west edge of South America is an example of such phenomenon: as the Pacific plate slides under the South American plate, a great chain of mountains forms—the Andes. Each year, the Andes are growing half an inch taller as the result! Over millions of years, the inches add up, and today Andes mountains stand 20,000 feet tall!

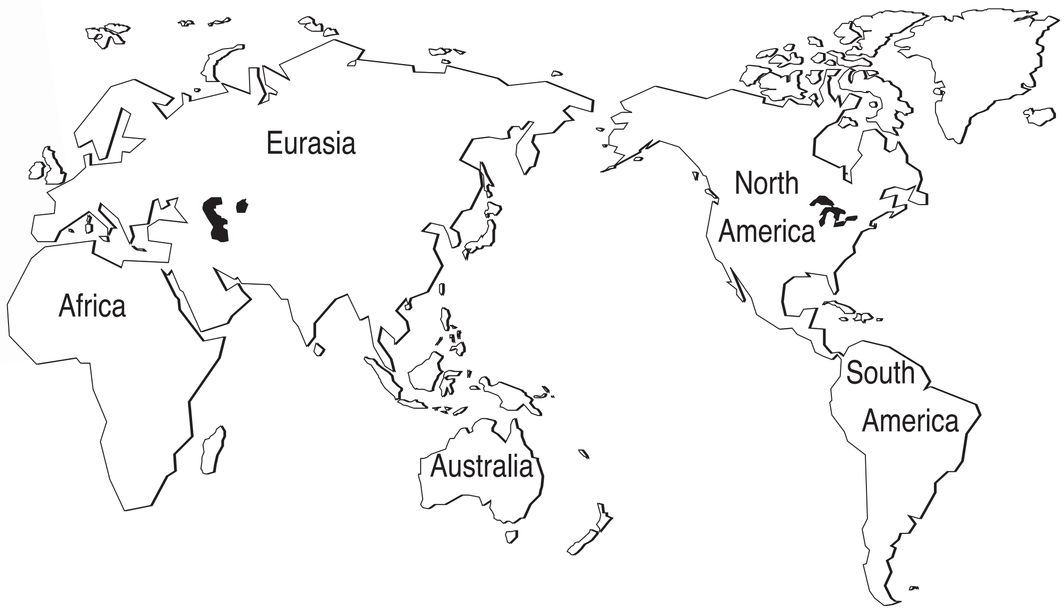


Supermarket science

LEARN

Ring of Fire is an imaginary line on the surface of the Earth which encircles the Pacific Ocean, connecting 75% of all active and dormant volcanoes. This line travels through the West Coast of North and South Americas, Japan, Eastern edge of Eurasia, and North and East Coasts of Australia, including New Zealand. Hawaiian Islands form the center of the Ring.

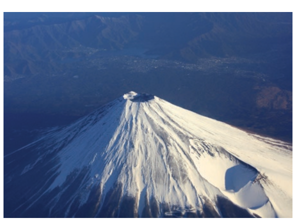
Find and mark the position of the Hawaiian Islands on the map below and using a bright red pencil draw the Ring of Fire (hint: it's more of an oval than a ring).



What You Need:

The Ring of Fire gets its name from the violent eruptions and red lava which flows from the active volcanoes on its rim. People who reside on the Ring of Fire have to accept earthquakes and volcanism as part of their life.

But what makes these places marked by the Ring so dangerous? Why does the ground move and rip in those locations? The crust of the Earth is broken into several large sections called "plates." These plates move apart and smash into each, creating rifts and mountains and releasing enormous amounts of energy in a form of earthquakes and volcanic eruptions.



Mt. Fuji, the beautiful but deadly volcano in Japan, is the product of the Pacific plate sliding under the Eurasian plate.

On the West side of South America, the Nazca plate (a little plate just of the coast of South America) is smashing with South American plate. This collision resulted in the rise of the Andes mountains and the birth of Azul and Cotopaxi volcanoes.

Paricutun is an instant-made volcano—it rose up out of the Mexican cornfield in a matter of weeks in 1943. It is the result of pressure from two crushing plates: the Cocos and the North American.

Mount Saint Helens, which erupted in 1980, was created by the friction of the Pacific and the North American plates sliding past each other. And farther North, where these two plates collide, Alaska is puckered by a chain of volcanoes that keep that region rocking and rolling.

The chain of islands North and East of Australia are home to numerous active volcanoes. They mark the place where the Indo-Australian plate bumps and submerges under the Pacific plate.

The center of the Ring of Fire is marked by the volcanoes of Hawaii. These volcanoes are far from the edges of the Pacific plate. The current theory for their active status is called the *Hot Spot Theory*. This theory stipulates a place under the Earth's crust that is particularly hot and melts the rocks above, forming volcanoes.

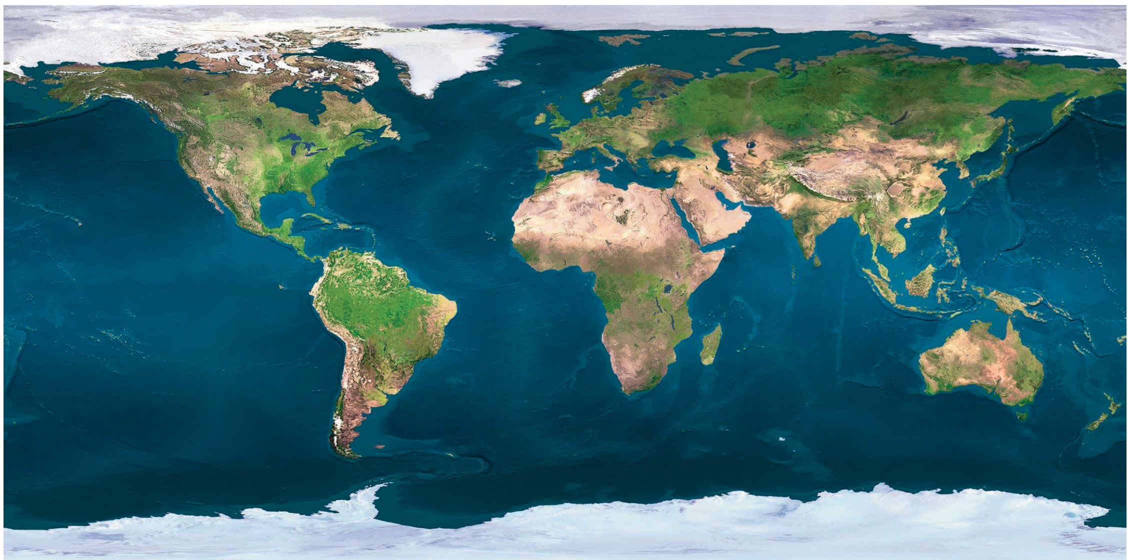
Supermarket science

DO

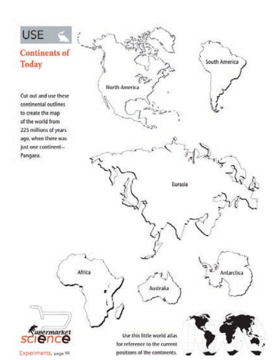
225 Million Years Ago

Our planet didn't always look the way it does today. Time travelers to Earth distant past, 225 million years ago or there about, with a current world map would find themselves quite lost: Where is Africa? What happened to the Americas? Did anyone one see Australia? The problem is that continents keep moving several inches a year or so. If you travel to a far future, today's map would also be no good.

If you look at the Earth map below, you can see something that looks like cracks—lines encircling the continents and breaking apart the world's oceans. These are the edges of the continental and oceanic plates. Use a red crayon to outline the biggest cracks.



What You Need:



If we cut along the cracks and move all of the land masses on the map to form one big continent, we can imagine what the Earth looked like 225 million years ago. Cut up the Continents of Today USE page to try this out. The illustration below shows what this would look like.

Do you think the weather would be the same in California 225 million years ago?

USE

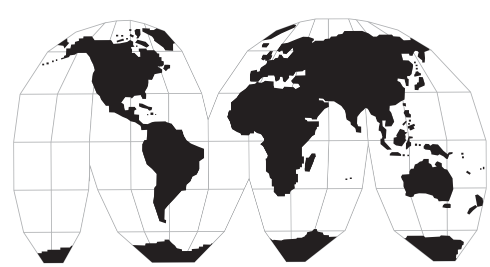
Continent of Today

Cut out and use these continental outlines to create the map of the world from 225 millions of years ago, when there was just one continent—Pangaea.

Pangaea literally means *one land*. And the one world ocean that surrounded the shores of Pangaea was called Panthalassa.

Supermarket science

Use this little world atlas for reference to the current positions of the continents.



SHOW

New Land

The top 3 photographs show images of Hawaii. The bottom 3, Iceland.

The islands of Hawaii are new, in geologic terms. The Big Island of Hawaii still has active volcanoes, and new land is made continuously, adding to this island's area and height. Sometimes, fresh lava flows over houses and roads, burning everything in its pass.

Iceland and the islands of Hawaii have some of the youngest rocks around. If you are a fossil hunter, these would be bad places to search for evidence of life in distant past. But there is definitely lots of life on both Iceland and Hawaii. As soon as lava cools, plants start to grow. In the bottom photograph, small plants are colonizing a wrinkly lava field in Iceland.

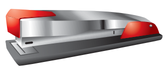
Some lava fields have huge underground tunnels, lava tubes, where molten rock used to flow like a river. Years later, water uses these tunnels as highways. In the photo of an Icelandic waterfall above, the water seems to seep directly from the lava cliff. And it does! Hundreds of tons of water fall into a raging river below.

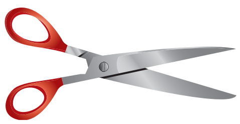
DO

Continental Drift Flip Book I

Cut out these pages to make a flip book which shows the movement of continental plates through time. Line up and staple the pages where indicated. Use both Continental Drift Flip Book I and II.

What You Need:





Present Time

10 Million Years Ago

40 Million Years Ago

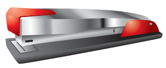
70 Million Years Ago

DO

Continental Drift Flip Book II

Cut out these pages to make a flip book which shows the movement of continental plates through time. Line up and staple the pages where indicated. Use both Continental Drift Flip Book I and II.

What You Need:



100 Million Years Ago

130 Million Years Ago

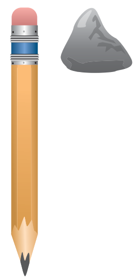
160 Million Years Ago

190 Million Years Ago

DO

Rock Analysis: Taking Measurements

What You Need:



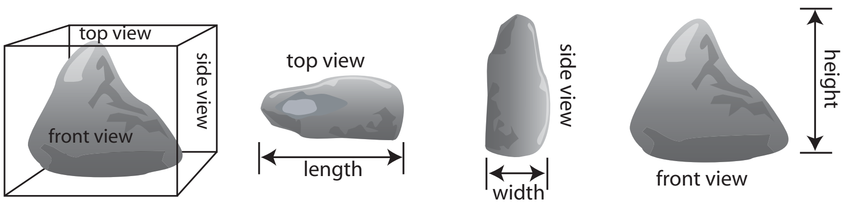
An important part of doing science is making careful observations and recording data. Get a small rock—this is your rock sample. Follow directions below to collect and record observations on your rock sample through visual inspection.

1. In the space on the left, draw your rock sample. You can put the rock sample directly on the paper and trace its outline using a pencil. Make a decision about which view of the rock is the top view, which is the side view, and which is the front view.

   Look at the illustration for an example.

2. Use a ruler and measure your rock sample. Record the width, height, and length of your rock in inches and in centimeters. You can use the ruler on the right edge of this page.

   Look at the illustration for an example.



Careful examination can reveal a lot about rock's history. Even without scientific instruments, sight, smell, and touch can provide accurate geological clues.

Width in inches = ____________________

Length in inches = ____________________

Height in inches = ____________________

Width in centimeters = _______________

Length in centimeters = _______________

Height in centimeters = _______________

Width in centimeters = _______________

Length in centimeters = _______________

Height in centimeters = _______________

front view

side view

top view

Supermarket science

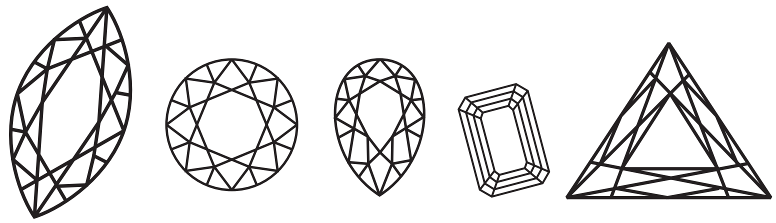
DO

Rock Analysis: Taking Observations

An important part of doing science is making careful observations and recording data. You have a rock sample. Follow directions below to collect and record observations about your sample through visual inspection.

What You Need:

What is the color of your rock sample?____________________



What are the most distinguishing characteristics of your rock sample? ____________________

What makes it unique? ____

Lava rocks come in a variety of colors and shapes, depending on the mixture of chemicals, its temperature, and amount of gas trapped inside the liquid rock when it reached the surface.

For example, does your rock have a hole in it? Is it smooth? How does it feel in your hand? Is it heavy? Is it unusually light? Does it float? Does it have crystalline inclusions?

My rock sample: ____

____

____

____

Geologists classify rocks in three groups according to how they were formed. The three rock groups are ***igneous***, ***sedimentary***, and ***metamorphic*** rocks. ***Igneous*** rocks are formed from melted rock that has cooled and solidified. ***Sedimentary*** rocks are formed through accumulations of sediments of rocks, minerals, or animal or plant matter. When igneous or sedimentary rocks are transformed by pressure into a new kind of rock, they are called ***metamorphic*** rocks.

Which type do you have? How do you know?____

____

____

____

____

Supermarket science

SHOW

Lava Tree Molds

Sometimes during a volcanic eruption, lava flows over a forest of trees. Some trees burn even before the molten rock touches them—the air temperature is hot enough to spontaneously combust wood! But sometimes, lava flows so fast, that it surrounds a tree before it burns down. When that tree finally turns to dust, it will leave behind a perfect mold of its trunk. In the top photograph, you can see tree molds left behind a recent eruption on the Big Island of Hawaii. The bottom photo shows the hole at the center of one of these mushroom-like structures. It looks a bit like a chimney or a vertical pipe. If you look closely on the sides of the hole, you will see impressions of bark pattern!

Take a small twig and wrap it in playdough or some other modeling clay. Unwrap carefully—do you see the impression of bark in the clay?

Supermarket science