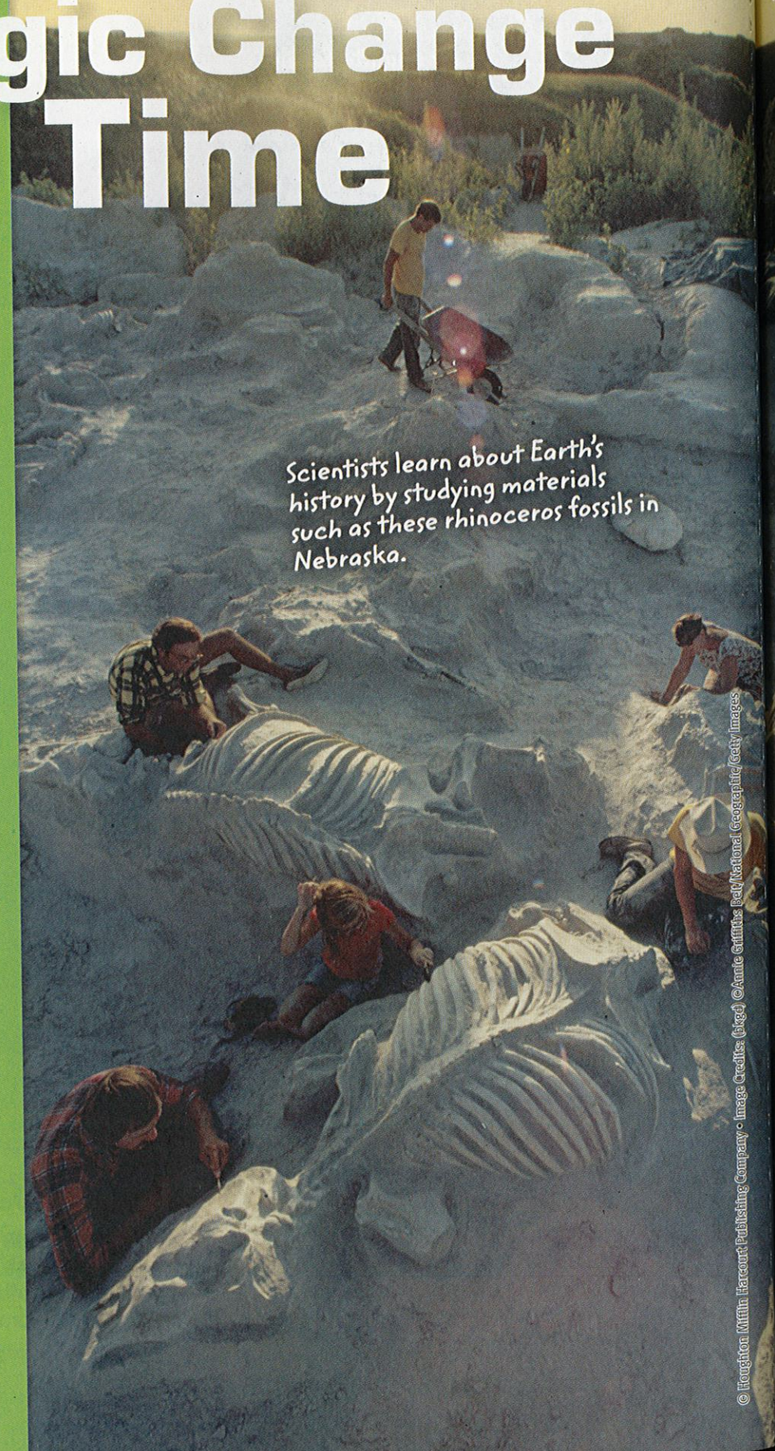
Lesson 1

Geologic Change over Time

ESSENTIAL QUESTION

How do we learn about Earth's history?

By the end of this lesson, you should be able to explain how Earth materials, such as rock, fossils, and ice, show that Earth has changed over time.



Scientists learn about Earth's history by studying materials such as these rhinoceros fossils in Nebraska.

Lesson Labs

Quick Labs
- Modeling the Fossil Record
- Fossil Flipbooks

S.T.E.M. Lab
- Exploring Landforms

Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false:

T	F	
☐	☐	Once rock forms, it never changes.
☐	☐	Fossils can tell us which animals lived at a certain time.
☐	☐	The climate is exactly the same all over the world.
☐	☐	A volcano erupting is an example of a geologic process.

2 Explain What can you infer about the environment in which this fossil probably formed?

_____

_____

_____

Active Reading

3 Synthesize You can often define an unknown word if you know the meaning of its word parts. Use the word parts and sentence below to make an educated guess about the meaning of the word *uniformitarianism*.

Word part	Meaning
uniform-	the same in all cases and at all times
-ism	a system of beliefs or actions

Example sentence
The idea that erosion has occurred the same way throughout Earth's history is an example of uniformitarianism.

uniformitarianism:

_____

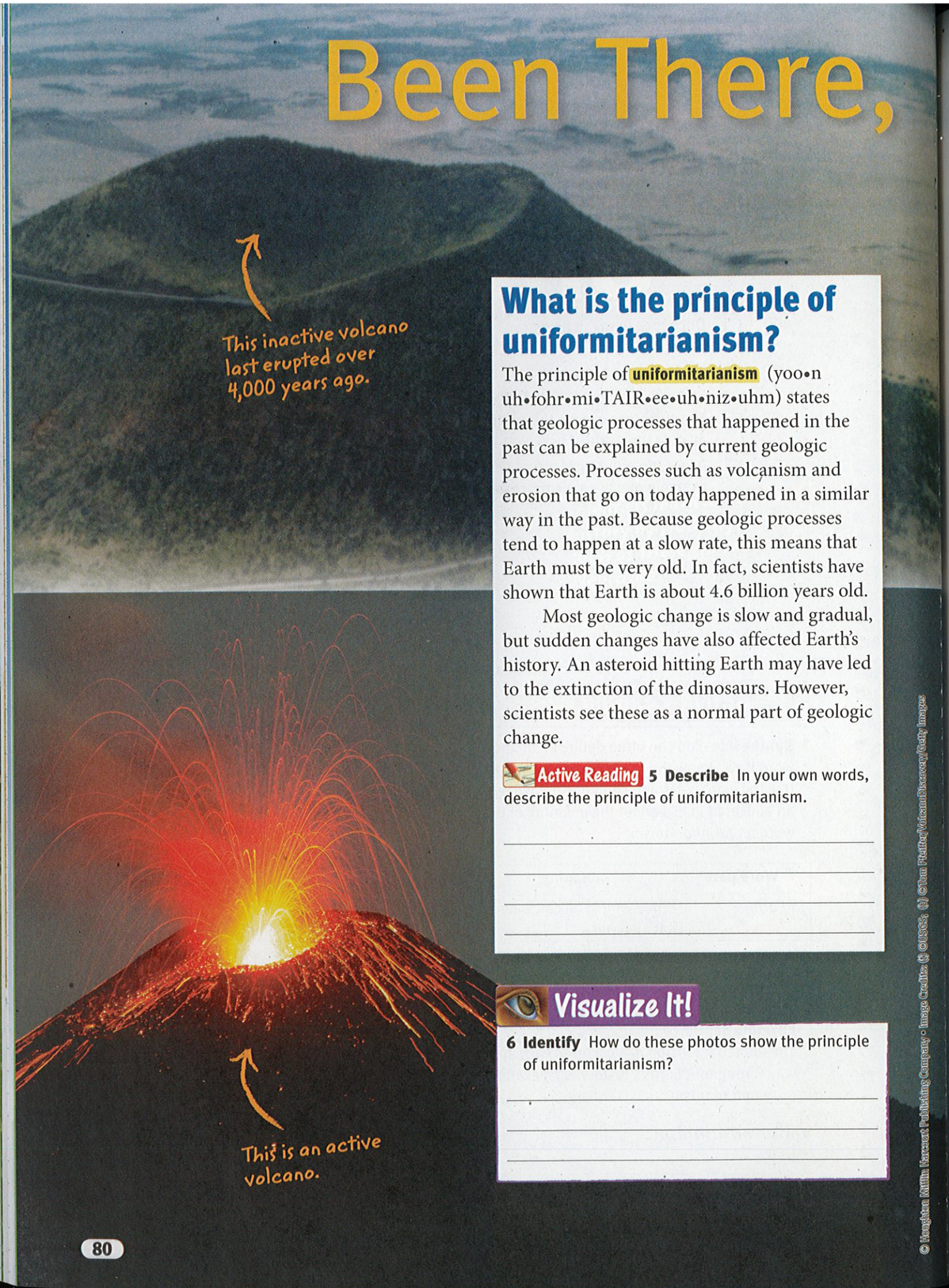
_____

Vocabulary Terms

- **uniformitarianism**
- **climate**
- **fossil**
- **ice core**
- **trace fossil**

4 Identify This list contains vocabulary terms you'll learn in this lesson. As you read, circle the definition of each term.

Been There,



What is the principle of uniformitarianism?

The principle of **uniformitarianism** (yoo•n uh•fohr•mi•TAIR•ee•uh•niz•uhm) states that geologic processes that happened in the past can be explained by current geologic processes. Processes such as volcanism and erosion that go on today happened in a similar way in the past. Because geologic processes tend to happen at a slow rate, this means that Earth must be very old. In fact, scientists have shown that Earth is about 4.6 billion years old.

Most geologic change is slow and gradual, but sudden changes have also affected Earth's history. An asteroid hitting Earth may have led to the extinction of the dinosaurs. However, scientists see these as a normal part of geologic change.

Active Reading **5 Describe** In your own words, describe the principle of uniformitarianism.

Visualize It!

6 Identify How do these photos show the principle of uniformitarianism?

Done That

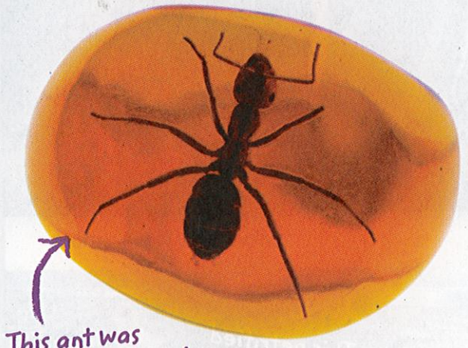
How do organisms become preserved as fossils?

Organisms can leave evidence of themselves in different ways. **Fossils** are the trace or remains of an organism that lived long ago, most commonly preserved in sedimentary rock. Fossils may be skeletons or body parts, shells, burrows, or ancient coral reefs. Fossils form in many different ways.

Visualize It!

Trapped in Amber

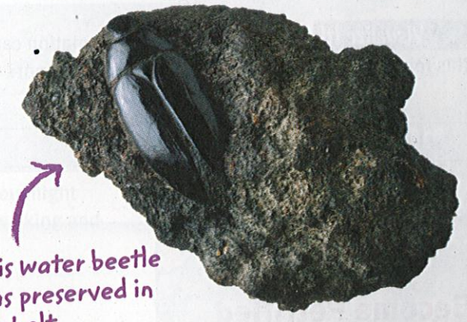
Imagine that an insect is caught in soft, sticky tree sap. Suppose that the insect is covered by more sap, which hardens with the body of the insect inside. Amber is formed when hardened tree sap is buried and preserved in sediment. Some of the best insect fossils, such as the one shown below, are found in amber. Fossil spiders, frogs, and lizards have also been found in amber.



7 Analyze What features of the ant can you still see in this fossil?

Trapped in Asphalt

There are places where asphalt wells up at Earth's surface in thick, sticky pools. One such place is La Brea Tar Pits in California. These asphalt pools have trapped and preserved many fossils over the past 40,000 years, such as the one shown below. Fossils such as these show a lot about what life was like in Southern California in the past.



8 Describe How did this organism become a fossil?

Buried in Rock

When an organism dies, it often starts to decay or is eaten by other organisms. Sometimes, however, organisms are quickly buried by sediment when they die. The sediment slows down decay and can protect parts of the body from damage. Hard parts of organisms, such as shells and bones, do not break down as easily as soft parts do. So, when sediments become rock, the hard parts of animals are preserved and become part of the rock as the sediments harden.

Visualize It! **9 Analyze** What part of the organism was preserved as a fossil in this rock?

Ammonites once lived in shells in ancient seas.

Become Frozen

In very cold places on Earth, the soil can be frozen all the time. An animal that dies there may also be frozen. It is frozen with skin and flesh, as well as bones. Because cold temperatures slow down decay, many types of frozen fossils are preserved from the last ice age.

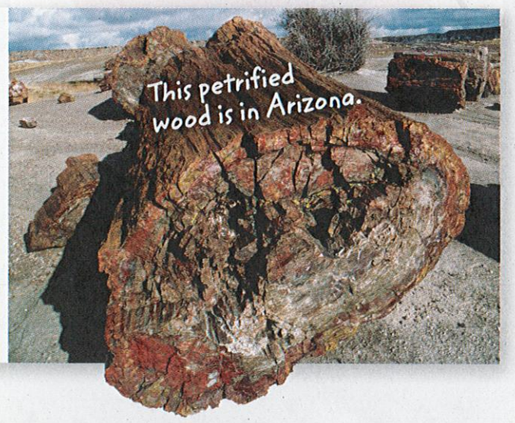
Visualize It! **10 Compare** What information can this fossil give that fossils preserved in rock cannot?

This frozen mammoth was discovered in Siberia.

Become Petrified

Petrification (pet•ruh•fi•KAY•shuhn) happens when an organism's tissues are replaced by minerals. In some petrified wood, minerals have replaced all of the wood. A sample of petrified wood is shown at the right. This wood is in the Petrified Forest National Park in Arizona.

A similar thing happens when the pore space in an organism's hard tissue, such as bone, is filled up with minerals.



This petrified wood is in Arizona.

What are trace fossils?

Active Reading **11 Identify** As you read, underline examples of trace fossils.

Fossils of organisms can tell us a lot about the bodies of life forms. Another type of fossil may also give evidence about how some animals behaved. A **trace fossil** is a fossilized structure that formed in sedimentary rock by animal activity on or in soft sediment.

Tracks, like the ones across this page, are one type of trace fossil. They are footprints made by animals in soft sediment that later became hard rock. Tracks show a lot about the animal that made them, such as how it lived, how big it was, and how fast it moved. For example, scientists have found paths of tracks showing that a group of dinosaurs moved in the same direction. This has led scientists to hypothesize that some dinosaurs moved in herds.

Burrows are another kind of trace fossil. Burrows are pathways or shelters made by animals, such as clams on the sea floor or rodents on land, that dig in sediment. Some scientists also classify animal dung, called coprolite (KAHP•ruh•lyt), as a trace fossil. Some coprolites are shown at the right.

These tracks were made by dinosaurs that once lived in Utah.

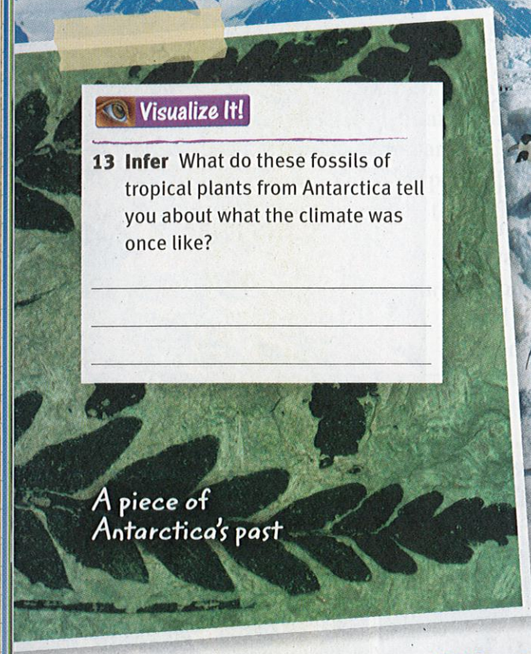
Visualize It! Inquiry

12 Illustrate Draw two sets of tracks that represent what you might leave for future scientists to study. Draw one set of you walking and another set of you running.

Walking

Running

Time Is on Our Side



What can fossils tell us?

Active Reading

14 **Identify** As you read, underline two types of changes on Earth that fossils can give information about.

All of the fossils that have been discovered on Earth are called the *fossil record*. The fossil record shows part of the history of life on Earth. It is only part of the history because some things are still unknown. Not all the organisms that ever lived have left behind fossils. Also, there are many fossils that have not been discovered yet. Even so, fossils that are available do provide important information about Earth's history.

Fossils can tell scientists about environmental changes over time. The types of fossils preserved in sedimentary rock show what the environment was like when the organisms were alive. For example, fish fossils indicate that an aquatic environment was present. Palm fronds mean a tropical environment was present. Scientists have found fossils of trees and dinosaurs in Antarctica, so the climate there must have been warm in the past.

Fossils can also tell scientists how life forms have changed over time. Major changes in Earth's environmental conditions and surface can influence an organism's survival and the types of adaptations that a species must have to survive. To learn about how life on Earth has changed, scientists study relationships between different fossils and between fossils and living organisms.

How does sedimentary rock show Earth's history?

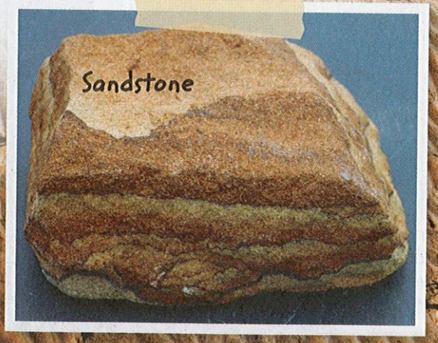
Rock and mineral fragments move from one place to another during erosion. Eventually, this sediment is deposited in layers. As new layers of sediment are deposited, they cover older layers. Older layers become compacted. Dissolved minerals, such as calcite and quartz, separate from water that passes through the sediment. This forms a natural cement that holds the rock and mineral fragments together in sedimentary rock.

Scientists use different characteristics to classify sedimentary rock. These provide evidence of the environment that the sedimentary rock formed in.

Composition

The composition of sedimentary rock shows the source of the sediment that makes up the rock. Some sedimentary rock forms when rock or mineral fragments are cemented together. Sandstone, shown below, forms when sand grains are deposited and buried, then cemented together. Other sedimentary rock forms from the remains of once-living plants and animals. Most limestone forms from the remains of animals that lived in the ocean. Another sedimentary rock, called coal, forms underground from partially decomposed plant material that is buried beneath sediment.

Active Reading 15 **Describe** What processes can cause rock to break apart into sediment?

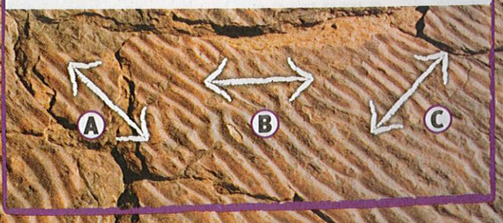


Texture and Features

The texture of sedimentary rock shows the environment in which the sediment was carried and deposited. Sedimentary rock is arranged in layers. Layers can differ from one another, depending on the kind, size, and color of their sediment. Features on sedimentary rock called *ripple marks* record the motion of wind or water waves over sediment. An example of sedimentary rock with ripple marks is shown below. Other features, called *mud cracks,* form when fine-grained sediments at the bottom of a shallow body of water are exposed to the air and dry out. Mud cracks show that an ancient lake, stream, or ocean shoreline was once a part of an area.

Visualize It!

16 **Identify** Which arrow shows the direction that water was moving to make these ripple marks?



These are ripple marks in sandstone.

What do Earth's surface features tell us?

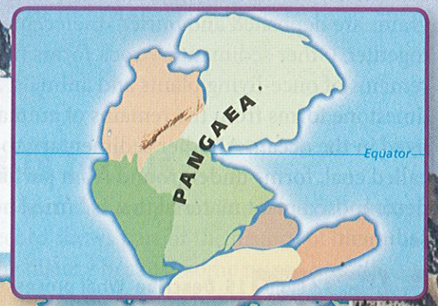
Earth's surface is always changing. Continents change position continuously as tectonic plates move across Earth's surface.

Continents Move

The continents have been moving throughout Earth's history. For example, at one time the continents formed a single landmass called *Pangaea* (pan•JEE•uh). Pangaea broke apart about 200 million years ago. Since then, the continents have been slowly moving to their present locations, and continue to move today.

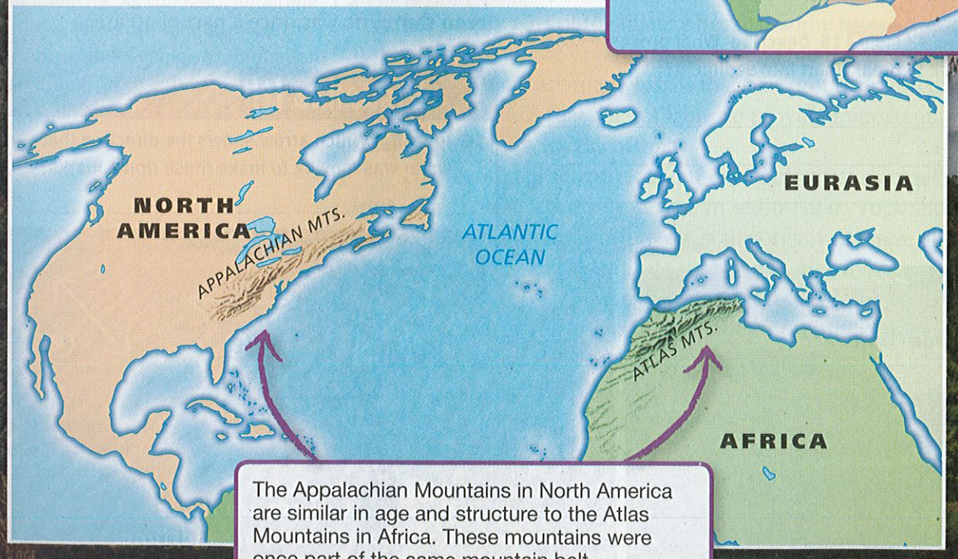
Evidence of Pangaea can be seen by the way rock types, mountains, and fossils are now distributed on Earth's surface. For example, mountain-building events from tectonic plate movements produced different mountain belts on Earth. As the map below shows, rock from one of these mountain belts is now on opposite sides of the Atlantic Ocean. Scientists think this mountain belt separated as continents have moved to their current locations.

Today's continents were once part of a landmass called Pangaea.



Visualize It!

17 Illustrate Draw the rest of the mountain belt on the Pangaea map, based on where the mountains are in the current map of the continents.



The Appalachian Mountains in North America are similar in age and structure to the Atlas Mountains in Africa. These mountains were once part of the same mountain belt.

Landforms Change over Time

The movement of tectonic plates across Earth has resulted in extraordinary events. When continental plates collide, mountain ranges such as the ones shown below can form. As they pull apart, magma can be released in volcanic eruptions. When they grind past one another, breaks in Earth's surface form, where earthquakes can occur. Collisions between oceanic and continental plates can also cause volcanoes and the formation of mountains.

In addition to forces that build up Earth's surface features, there are forces that break them down as well. Weathering and erosion always act on Earth's surface, changing it with time. For example, high, jagged mountains can become lower and more rounded over time. So, the height and shape of mountains can tell scientists about the geologic history of mountains.

Think Outside the Book

19 Support Find out about how the continents continue to move today. Draw a map that shows the relative motion along some of the tectonic plate boundaries.

Visualize It!

18 Analyze Label the older and younger mountains below. Explain how you decided which was older and which was younger.

_____

_____

_____

Rocky Mountains

_____

Appalachian Mountains

_____

Back to the Future

What other materials tell us about Earth's climate history?

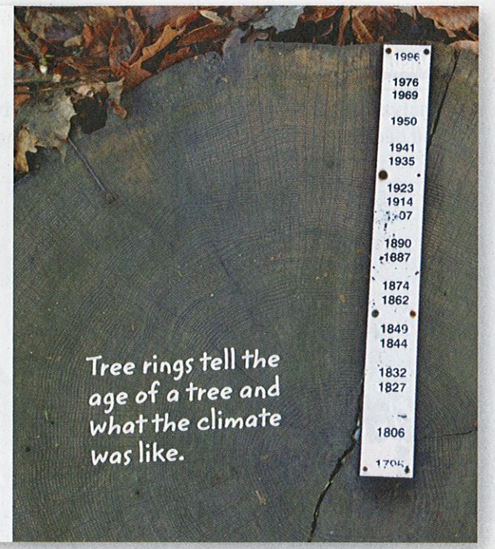
The **climate** of an area describes the weather conditions in the area over a long period of time. Climate is mostly determined by temperature and precipitation. In addition to using fossils, scientists also analyze other materials to study how Earth's climate and environmental conditions have changed over time.

Active Reading

20 Identify As you read the next two pages, underline the evidence that scientists use to learn about Earth's climate history.

Trees

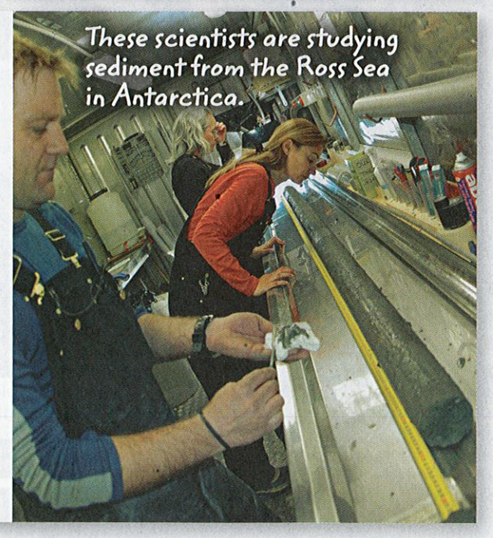
When most trees grow, a new layer of wood is added to the trunk every year. This forms rings around the circumference (suhr•KUHM•fuhr•uhns) of the tree, as shown at the right. These rings tell the age of the tree. Some trees are over 2,000 years old. Scientists can use tree rings to find out about the climate during the life of the tree. If a tree ring is thick, it means the tree grew well—there was plenty of rain and favorable temperatures existed at that time. Thin tree rings mean the growing conditions were poor.



Visualize It! **21 Analyze** What is the time frame for which this tree can give information about Earth's climate?

Sea-Floor Sediments

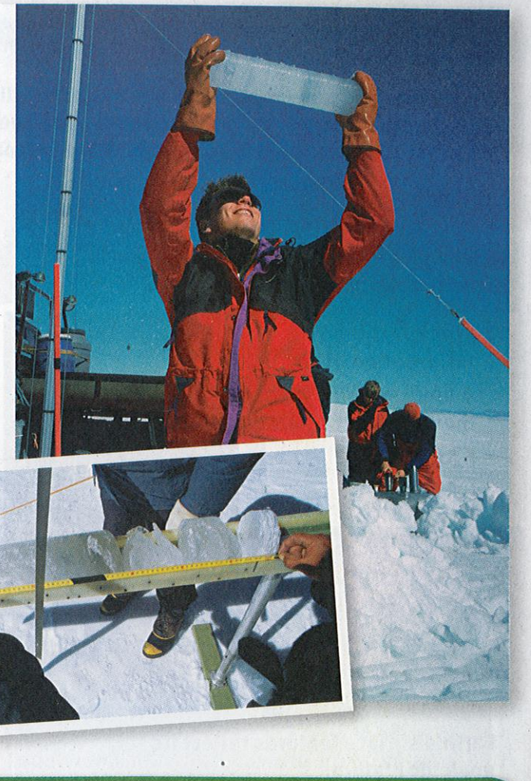
Evidence about past climates can also be found deep beneath the ocean floor. Scientists remove and study long cylinders of sediment from the ocean floor, such as the one shown at the right. Preserved in these sediments are fossil remains of microscopic organisms that have died and settled on the ocean floor. These remains build up in layers, over time. If certain organisms are present, it can mean that the climate was particularly cold or warm at a certain time. The chemical composition of sediments, especially of the shells of certain microorganisms, can also be important. It shows what the composition was of the ocean water and atmosphere when the organisms were alive.



Ice

Icecaps are found in places such as Iceland and islands in the Arctic. The icecaps formed as older snow was squeezed into ice by new snow falling on top of it. Scientists can drill down into icecaps to collect a long cylinder of ice, called an **ice core**.

Ice cores, such as the ones shown in these photographs, give a history of Earth's climate over time. Some ice cores have regular layers, called bands, which form each year. Band size shows how much precipitation fell during a given time. The composition of water and concentration of gases in the ice core show the conditions of the atmosphere at the time that the ice formed.



Scientists study ice cores to find out about amounts of precipitation in the past.

22 Evaluate Fill in the table by reading the evidence and suggesting what it could mean.

Evidence	What it could mean
A. A scientist finds a fossil of a shark tooth in a layer of rock that is high in the mountains.	
B. Rocks from mountains on two different continents were found to have formed at the same time and to have the same composition.	
C. Upon studying an ice core, scientists find that a particular band is very wide.	

Visual Summary

To complete this summary, check the box that indicates true or false. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

Fossils give information about changes in Earth's environments and life forms.

23 Trace fossils give information about animal activity and movement.

☐ True
☐ False

Sedimentary rocks provide information about Earth's geologic history.

24 These are ripple marks in sedimentary rock.

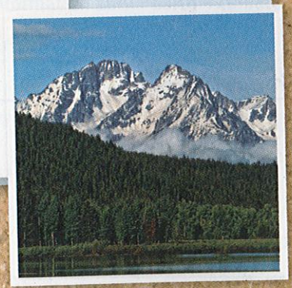
☐ True
☐ False

Studying Earth's History

Earth's surface features reflect its geologic history.

25 Tall, jagged mountains are older than rounded, smaller mountains.

☐ True
☐ False



Besides fossils, other materials give information about Earth's climate history.

26 Scientists study the width of tree rings to learn about past climate conditions.

☐ True
☐ False

Answers: 23 T; 24 T; 25 F; 26 T

27 **Explain** Describe three different materials that can be used to study Earth's history. What type of evidence does each give?

Lesson Review

Vocabulary

In your own words, define the following terms.

1 uniformitarianism _____

2 trace fossil _____

Key Concepts

3 **Identify** How old is Earth?

4 **Explain** How can sedimentary rock show Earth's history?

5 **List** Name three examples of trace fossils.

6 **Explain** Name five ways that organisms can be preserved as fossils, and explain what fossils can show about Earth's history.

7 **Describe** How do Earth's surface features indicate changes over time?

8 **Describe** What are two ways that scientists can study Earth's climate history?

Critical Thinking

9 **Justify** Is a piece of pottery an example of a fossil? Why or why not?

Use this photo to answer the following questions.

10 **Synthesize** How does the erosion of these mountains support the principle of uniformitarianism?

11 **Infer** The type and age of rocks found in this mountain range are also found on another continent. What might this mean?