

21.1

KEY CONCEPT

Earth's past is revealed in rocks and fossils.

BEFORE, you learned

- The slow, continuous movement of tectonic plates causes large changes over time
- Molten rock cools to form solid rock

NOW, you will learn

- How different kinds of fossils show traces of life from Earth's past
- How ice cores and tree rings reveal conditions and changes in the environment

VOCABULARY

fossil p. 715

original remains p. 716

ice core p. 721

EXPLORE Rocks

What can we learn from a rock?

PROCEDURE

- 1 Use a hand lens to examine the rock sample.
- 2 Make a sketch of any shapes you see in the rock.

MATERIALS

- rock sample
- hand lens
- paper and pencil

WHAT DO YOU THINK?

- What do you think those shapes are?
- How did they get there?



Rocks, fossils, and original remains give clues about the past.

OUTLINE

Remember to take notes on this section in outline form.

- I. Main idea
 - A. Supporting idea
 1. Detail
 2. Detail
 - B. Supporting idea

You have read about mountain formation, earthquakes, and other ways in which Earth changes over time. Scientists have learned about these changes—even changes that happened long ago—by studying rocks, fossils, and other natural evidence. Two hundred million years ago, for example, huge dinosaurs walked on Earth. These giant reptiles were a major form of animal life on the planet for millions of years. Then, about 65 million years ago, the dinosaurs became extinct, or died out. What happened?

To solve the mystery of why dinosaurs disappeared, scientists look for clues. Fossils, for example, are important clues about past events. **Fossils** are traces or remains of living things from long ago. Dinosaur bones and footprints preserved in stone are examples of fossils.

Using fossils and other natural evidence, scientists have formed a theory about why the dinosaurs disappeared. They now think that some major event, such as the crashing of one or more giant asteroids into Earth, led to rapid changes that caused the dinosaurs to become extinct.

Fossils also tell us about organisms, such as dinosaurs, that are now extinct. Even though no one has ever seen a dinosaur, people have some idea about what dinosaurs looked like and how they behaved because of fossils.

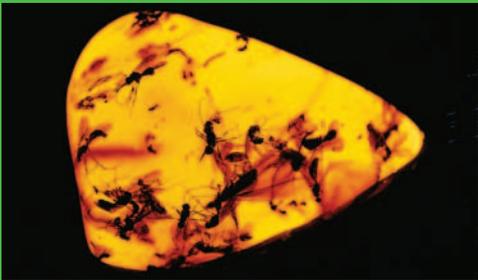
Original Remains

1 Ice



This frozen mammoth body was found in Siberia.

2 Amber



These insects, which are related to flies and mosquitoes, were trapped and preserved in amber 40 million years ago.

3 Tar



This skull of a saber-toothed cat, found in the La Brea Tar Pits in California, was preserved in the tar for 10,000 to 40,000 years.

Fossils exist in many different forms. Most fossils are hardened animal remains such as shells, bones, and teeth. Minerals replace the remains, forming a fossil of the hard skeletal body parts. Other fossils are impressions or other evidence of an organism preserved in rock. Sometimes, an actual organism—or part of an organism—can be preserved and become a fossil.

Original Remains

Fossils that are the actual bodies or body parts of organisms are called **original remains**. Usually, soft parts of dead animals and plants decay and disappear. But soft parts can become fossil evidence if they are sealed in a substance that keeps out air and tiny organisms. Original remains are found in places where conditions prevent the decomposition, or breakdown, that normally occurs. Original remains are important because they give direct evidence of forms of life that lived long ago.

- 1 Ice** Ice is one of the best preservers of the remains of prehistoric life. Huge ice fields in Siberia and Alaska contain the bodies of 10,000-year-old mammoths and prehistoric rhinos, with bones, muscle, skin, and even hair still in place. The ice preserved the animals after they died.
- 2 Amber** Another natural substance that preserves the remains of some living things is amber. Amber forms from resin, a sticky substance inside trees that flows like syrup and protects the tree by trapping insects. If the tree gets buried after it dies, the resin can harden into amber. Amber can contain the remains of insects and other small organisms.
- 3 Tar** The original remains of animals have also been found in places where there were pools of tar—a thick, oily liquid. Saber-toothed cats and other animals were trapped in the tar and preserved.

Fossil Formation

Conditions have to be just right for a fossil to form in rock. The organism or trace of the organism must be preserved before it decomposes or disappears. Usually, the soft parts of an organism decay too quickly to be preserved in rock. For that reason, many rock fossils reveal traces or shapes of only the hard parts of animals or plants. Hard parts, such as shells, bones, teeth, and stems or tree trunks, decompose slowly, so they are more likely to be preserved as fossil evidence. Most organisms that lived in the past died and decomposed without leaving any traces. An organism that has no hard parts, such as a mushroom or a slug, rarely leaves fossil evidence.

Rock fossils form in sedimentary rock. Sedimentary rock forms from layers of sediment, such as sand or mud. Sometimes, the sediment builds up around animal and plant remains, which can leave fossils in the rock. If sedimentary rocks are changed by heat or pressure, their fossils can be destroyed. Igneous rocks never contain fossils. The heat of the molten rock—from which igneous rock cools—destroys any traces of plants or animals.

CHECK YOUR READING Why do rock fossils form in sedimentary rock rather than in igneous rock?

Theropod Fossil



Artist's Drawing of Theropod



This 130-million-year-old skeleton of a small theropod dinosaur, found between two slabs of rock in China, contains well-preserved featherlike structures. The fossil is about a meter (3 ft) long.

Fossils in Rocks

If an organism is covered by or buried in sediment, it may become a fossil as the sediments become rock. Many rock fossils are actual body parts, such as bones or teeth, that were buried in sediment and then replaced by minerals and turned to stone.

Some fossils are not original remains or actual body parts that have turned to stone. Instead, these fossils are impressions or traces made of rock and provide indirect evidence that the organisms were there, just as a shoeprint can reveal much about the shoe that made it. Rocks can contain detailed shapes or prints of plants, animals, and even organisms too small to see without a microscope. Fossils in rock include molds and casts, petrified wood, carbon films, and trace fossils.

- 1 Molds and Casts** Some fossils that form in sedimentary rock are mold fossils. A mold is a visible shape that was left after an animal or plant was buried in sediment and then decayed away. In some cases, a hollow mold later becomes filled with minerals, producing a cast fossil. The cast fossil is a solid model in the shape of the organism. If you think of the mold as a shoeprint, the cast would be what would result if sand filled the print and hardened into stone.
- 2 Petrified Wood** The stone fossil of a tree is called petrified wood. In certain conditions, a fallen tree can become covered with sediments. Over time, water passes through the sediments and into the tree's cells. Minerals that are carried in the water take the place of the cells, producing a stone likeness of the tree.
- 3 Carbon Films** Carbon is an element that is found in every living thing. Sometimes when a dead plant or animal decays, its carbon is left behind as a visible layer. This image is called a carbon film. Carbon films can show details of soft parts of animals and plants that are rarely seen in other fossils.
- 4 Trace Fossils** Do you want to know how fast a dinosaur could run? Trace fossils might be able to tell you. These are not parts of an animal or impressions of it, but rather evidence of an animal's presence in a given location. Trace fossils include preserved footprints, trails, animal holes, and even feces. By comparing these clues with what is known about modern animals, scientists can learn how prehistoric animals may have lived, what they ate, and how they behaved. For instance, dinosaur tracks can be studied to learn how fast dinosaurs ran.



Learn more about fossils.

These ancient logs in the Painted Desert Wilderness in Arizona have been preserved as petrified wood for around 225 million years. Minerals replaced the wood to make the stone logs.

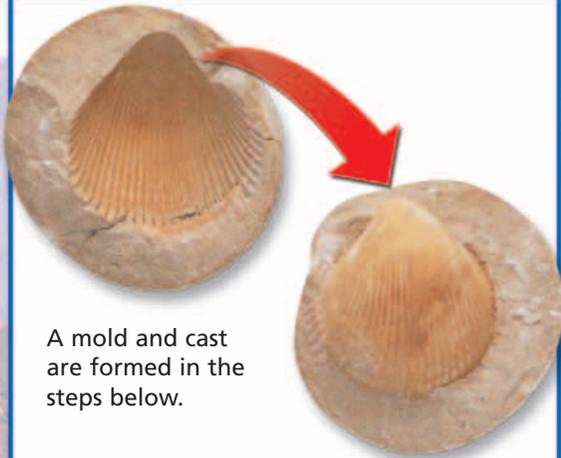


What do carbon film fossils show that trace fossils do not show?

Fossils in Rocks

Rock fossils show shapes and traces of past life.

1 Molds and Casts



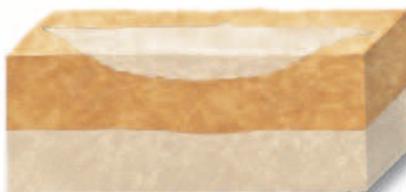
A mold and cast are formed in the steps below.



An organism dies and falls into soft sediment.



Over time, the sediment becomes rock and the organism decays, leaving a mold.



Minerals fill the mold and make a cast of the organism.

2 Petrified Wood



In this close-up, you can see the minerals that replaced the wood, forming petrified wood.

3 Carbon Films



This carbon film of a moth is about 10 million years old. Carbon films are especially useful because they can show details of the soft parts of organisms.

4 Trace Fossils



A trace fossil, such as this footprint of a dinosaur in rock, can provide important information about where an animal lived and how it walked and ran.

READING VISUALS

What is similar about mold-and-cast fossils and petrified wood?

Fossils and other natural evidence show changes in life and the environment.

Fossils reveal that Earth has undergone many changes over billions of years. Scientists study fossils to learn what organisms and animals once lived in places where the fossils were found. Today the land around the South Pole is mostly covered by ice, but fossils show that crocodiles, dinosaurs, and palm trees once lived on that land. The land was once much closer to the equator.

The earliest fossils are of tiny one-celled organisms that lived in an environment without oxygen. Three billion years ago, humans or the land animals we know today could not have breathed the air on Earth. Fossils also record the disappearance of many species.

Tree Rings

The rings in tree trunks are also a tool for studying the past. The width of tree rings varies, depending on how much the tree grows in various years. In dry years, a tree does not grow very much and the rings for those years are thin. A thick ring is a sign of a good year for growth, with enough rainfall. By analyzing the tree rings of many old trees, scientists can develop an accurate history of overall weather patterns over time.

INVESTIGATE Learning from Tree Rings

What do tree rings tell about the past?

- 1 Examine the photograph of a cross section of a tree trunk.
- 2 Count the dark and light rings in the cross section.
- 3 Compare the rings with one another. Record your observations.

WHAT DO YOU THINK?

- Rings in a tree trunk form as the tree grows each year. The number of rings tells the tree's age. A light ring forms in the early part of the growing season, and a dark ring in the later part. How old was the tree when it was cut down?
- In what year did the tree first grow?
- During dry years, trees don't grow as much. Which year was very dry where this tree grew?

CHALLENGE During what part of the growing season was this tree probably cut down? How do you know?

SKILL FOCUS
Observing

MATERIALS

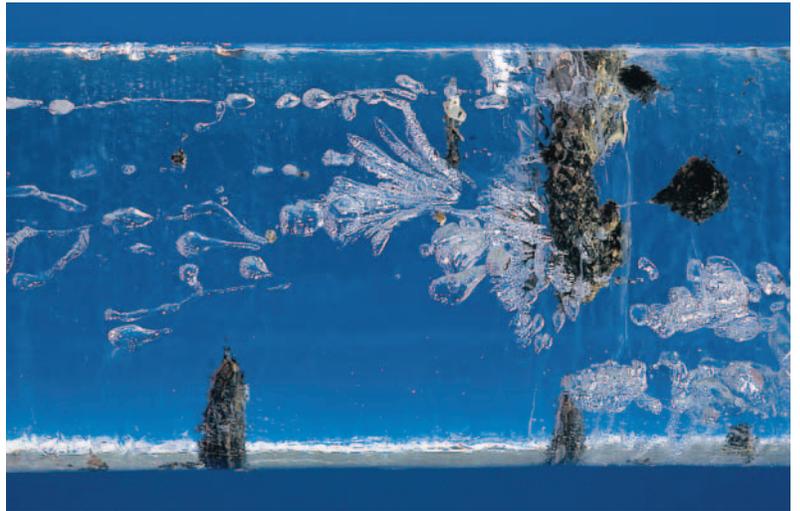
- Tree Cross Section
- Datasheet
- hand lens

TIME
20 minutes





These scientists are removing an ice core from a thick ice sheet in Antarctica. Ice at the bottom end is oldest.



Scientists study tiny specks of dirt in the ice, looking for signs of past microscopic organisms.

Ice Cores

In Greenland and Antarctica, snowfall has built up gigantic layers of ice that can be much deeper than the height of skyscrapers and as much as 530,000 years old at the bottom. Scientists drill into the ice and remove ice cores for study. An **ice core** is a tubular sample that shows the layers of snow and ice that have built up over thousands of years. The layers serve as a vertical timeline of part of Earth's past.

Scientists analyze air trapped in the ice to learn how the atmosphere has changed. Increases in dust or ash in the ice show when major volcanic eruptions occurred somewhere on Earth. Differences in the air content at different levels of the ice indicate how much temperatures went up and down, showing how long ice ages and warm periods lasted. This information can help scientists understand how Earth's climate might be changing now and how it might change in the future.



How does an ice core provide information about Earth's history?

21.1 Review

KEY CONCEPTS

1. What can rock fossils and original remains show about Earth's past?
2. Why do rock fossils form in sedimentary rock and not in igneous rock?
3. How do tree rings and ice cores help scientists understand how Earth has changed over time?

CRITICAL THINKING

4. **Infer** If you uncovered fossils of tropical fish and palm trees, what could you say about the environment at the time the fossils formed?
5. **Synthesize** Why might ancient lake and sea beds be rich sources of fossils?

CHALLENGE

6. **Rank** Which evidence—a fossil, a tree ring, or an ice core—would be most helpful to a historian studying how the Pilgrims grew food at Plymouth Colony in 1620? Explain your reasoning.