The Environment and Change Over Time

Fossil Evidence of Evolution

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	Original tissues can be preserved as fossils.	
	Organisms become extinct only in mass extinction events.	

Read to Learn

The Fossil Record

It might seem as if oak trees and robins have been on Earth forever. If you were to go back a few million years in time, you would not see oak trees or robins. You would see different species of trees and birds. That is because species change over time.

You might already know that fossils are the remains or evidence of once-living organisms. *The* **fossil record** *is made up of all the fossils ever discovered on Earth.* It has millions of fossils that come from many thousands of species. Most of these species are no longer alive on Earth.

The fossil record provides evidence that species have changed over time. Fossils help scientists picture what species looked like. Based on fossil evidence, scientists can re-create the physical appearance of species that are no longer alive.

The fossil record is huge, but it still has many missing parts. Scientists are still looking for more fossils to fill these missing parts. Scientists hypothesize that the fossil record represents only a small fraction of all the organisms that ever lived on Earth.

Essential Questions

- How do fossils form?
- How do scientists date fossils?
- How are fossils evidence of biological evolution?

Think it Over

1. Explain Why don't scientists know the exact number of species that have lived on Earth?

SCIENCE USE V. COMMON USE

tissue

Science Use similar cells that work together and perform a function

Common Use a piece of soft, absorbent paper

Fossil Formation

When animals eat a dead animal, they usually leave little behind. Any soft tissues that are not eaten are broken down by bacteria. Only the hard parts—bones, shells, and teeth—remain. Usually, these parts also break down over time. Sometimes they become fossils. Very rarely, the soft tissues of animals or plants—skin, muscles, or leaves—can also become fossils.

Mineralization

After an organism dies, its body might be buried under mud or sand in a river. Minerals in the water can take the place of the organism's original material and harden into rock. When this happens, a fossil forms. This process is called mineralization. Minerals in water also can fill the small spaces of a dead organism's tissues and become rock. Shells and bones are the most common mineralized fossils. Wood can also become a fossil in this way.

Carbonization

In carbonization, a fossil forms when a dead plant or animal is subjected to pressure over time. Pressure drives off the organism's liquids and gases. Only the carbon outline, or film, of the organism is left behind.

Identify

2. What types of organisms or tissues are often preserved as carbon films?

Mold and Casts

Sometimes the shell or bone of a dead animal makes an impression, the outline of its shape, in mud or sand. When the mud or sand hardens, so does the impression. *The impression of an organism in a rock is called a* **mold.** Sand or mud can later fill in the mold and harden to form a cast. *A* **cast** *is a fossil copy of an organism in a rock.* Molds and casts show only the outside parts of living organisms.

Trace Fossils

Fossils can give clues about the movement or behavior of once-living organisms. *A* **trace fossil** *is the preserved evidence of the activity of an organism.* For example, an organism might walk across mud and leave tracks. The tracks can become trace fossils if they fill with mud or sand that later hardens.

Explain

3. Why are trace fossils used as evidence of an organism's movement or behavior?

Original Material

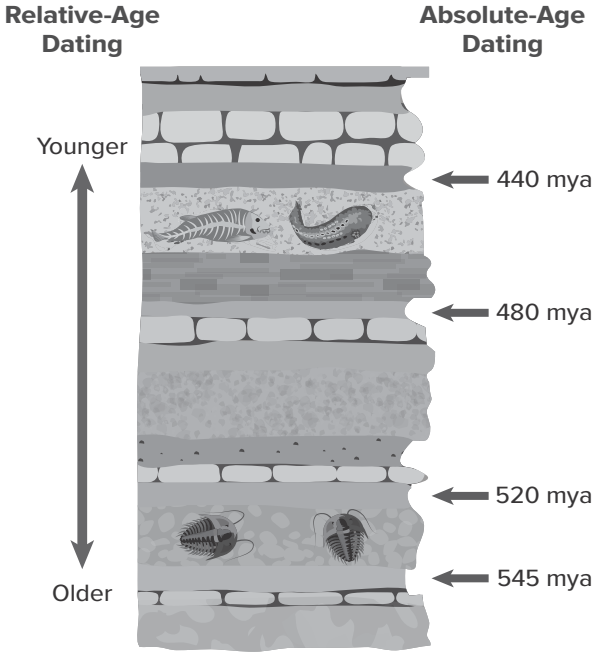
In rare cases, the actual parts of an organism can be preserved. Some original-material fossils include mammoths frozen in ice and saber-toothed cats preserved in tar pits. Even the bodies of ancient humans have been found in bogs. Some insects were preserved when they got stuck in sap that hardened into amber.

Determining a Fossil's Age

Scientists cannot date most fossils directly. Instead, they find the age of the rocks in which the fossils are found. Rocks erode or are recycled over time. However, scientists can determine ages for most of Earth's rocks.

Relative-Age Dating

You might be younger than a brother but older than a sister. This is your relative age. In the same way, a rock is either older or younger than rocks near it. In relative-age dating, scientists find the order in which rock layers formed. Some layers of rock have not moved since they formed. In these layers, scientists know that the bottom layers are older than the top layers, as shown in the figure below. Knowing the order in which the rocks formed helps scientists date the fossils in them. In this way, they can find the relative order in which species have appeared on Earth over time.



Absolute-Age Dating

Absolute-age dating is more exact than relative-age dating. A rock's absolute age is its age in years. To find absolute age, scientists use radioactive decay, which is a natural process that happens at a known rate. In radioactive decay, unstable isotopes in rocks change into stable isotopes over time. Scientists measure the ratio of unstable isotopes to stable isotopes to find the age of a rock. This ratio is best measured in igneous rocks, as shown above.

Connect

4. How does relative-age dating help scientists learn about fossils?

Estimate

5. What is the estimated age of the trilobite fossils (bottom layer of fossils) shown in the figure?

REVIEW VOCABULARY

isotopes atoms of the same element that have different numbers of neutrons

Dating Igneous Rock Absolute age is easiest to determine in igneous rocks. Igneous rocks form from volcanic magma. Magma is so hot that it is rare for parts of organisms in it to remain and form fossils.

Dating Sedimentary Rock Most fossils form in mud and sand, which become sedimentary rock. To measure the age of a sedimentary rock layer, scientists find the ages of igneous layers above and below it. They can estimate an age in between these ages for the fossils found in the sedimentary layer. Absolute-age dating is illustrated in the figure on the previous page.

Fossils Over Time

How old do you think Earth's oldest fossils are? Evidence of microscopic, unicellular organisms has been found in rocks 3.4 billion years old. The oldest fossils of larger living things are about 565 million years old.

The Geologic Time Scale

Scientists organize Earth's history into a time line called the geologic time scale. *The* **geologic time scale** *is a chart that divides Earth's history into different time units.* The longest time units in the geological time scale are eons. Earth's history is divided into four eons.

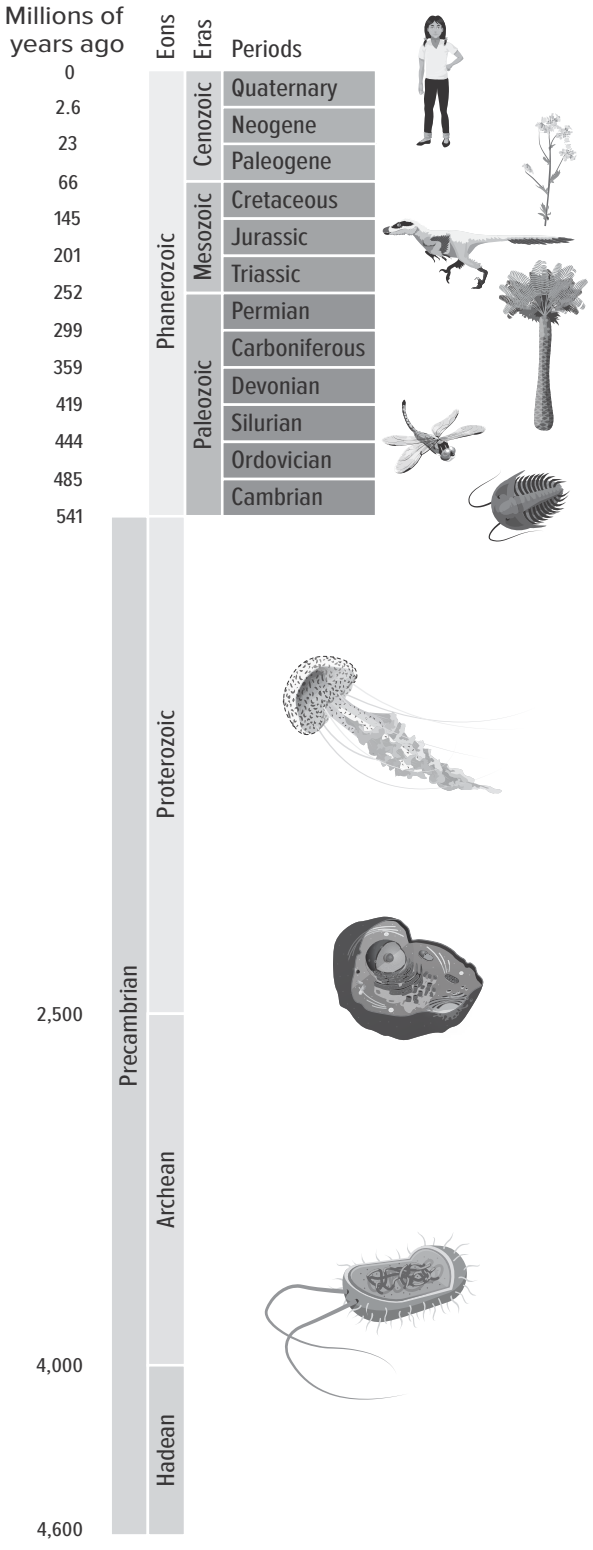
Dividing Time

Look at the figure of the geologic time scale on the next page. You might have noticed that eons and eras can have very different lengths. When scientists began figuring out the geologic time scale in the 1800s, they did not have ways for finding absolute age. To mark time boundaries, they used fossils. Scientists knew that different rock layers had different types of fossils. Some of the fossils scientists use to mark the time boundaries are shown in the figure.

Often, a type of fossil found in one rock layer was not in layers above it. Even more surprising, entire groups of fossils found in one layer were sometimes missing from layers above them. It seemed as if whole communities of living organisms had suddenly disappeared. What could have caused them to disappear?

6. What do scientists use to mark boundaries in the geologic time scale?

The Geologic Time Scale



Math Skills

Numbers that refer to the ages of Earth's fossils are very large, so scientists use scientific notation to work with them. For example, mammals appeared on Earth about 200 mya or 200,000,000 years ago. Change this number to scientific notation using the following process. Move the decimal point until only one nonzero digit remains on the left.

200,000,000 = 2.00000000

Count the number of places you moved the decimal point (8) and use that number as a power of ten.

200,000,000 = 2.0×10^8 years

7. Use Scientific Notation

The first vertebrates appeared on Earth about 490,000,000 years ago. Express this time in scientific notation.

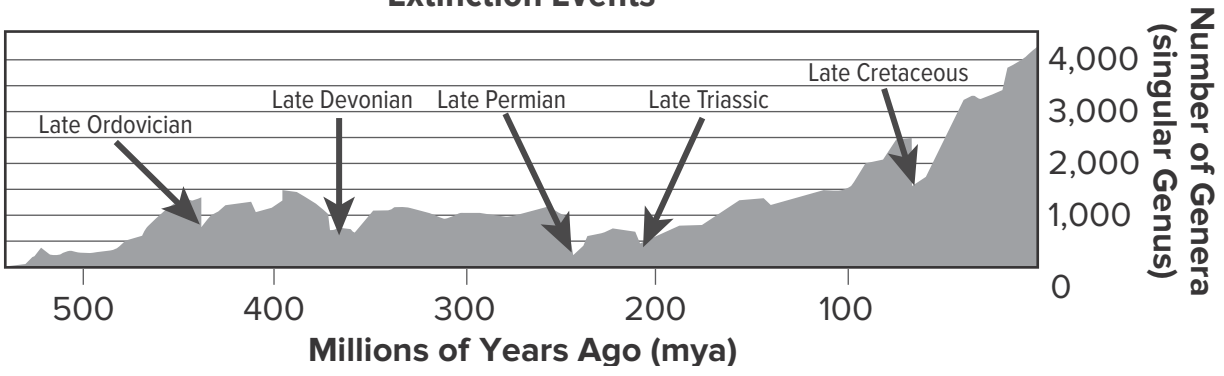
Relate

8. How does the fossil record provide evidence of extinctions?

Extinctions

Scientists now understand that sudden disappearances of fossils in rock layers show that there might have been an extinction (ihk STINGK shun) event. **Extinction** *occurs when the last individual organism of a species dies.* A mass extinction occurs when many different kinds of living things become extinct within a few million years or less. The fossil record shows that five mass extinctions have occurred during the Phanerozoic eon, as shown below. Smaller extinctions occurred at other times. Clues from the fossil record suggest extinctions have been common throughout Earth's history.

Extinction Events



Environmental Change

What causes extinctions? Populations of organisms get food and shelter from their environment. Sometimes environments change. After a change occurs, individual organisms of a species might not be able to find what they need to survive. When this happens, the organisms die, and the species becomes extinct.

Sudden Changes Extinctions can occur when environments change quickly. A volcanic eruption or a meteorite hitting Earth can throw ash and dust into the air, blocking sunlight for many years. This can affect the world's climate and food webs. Scientists hypothesize that a huge meteorite hit Earth 65 million years ago and helped cause the extinction of dinosaurs.

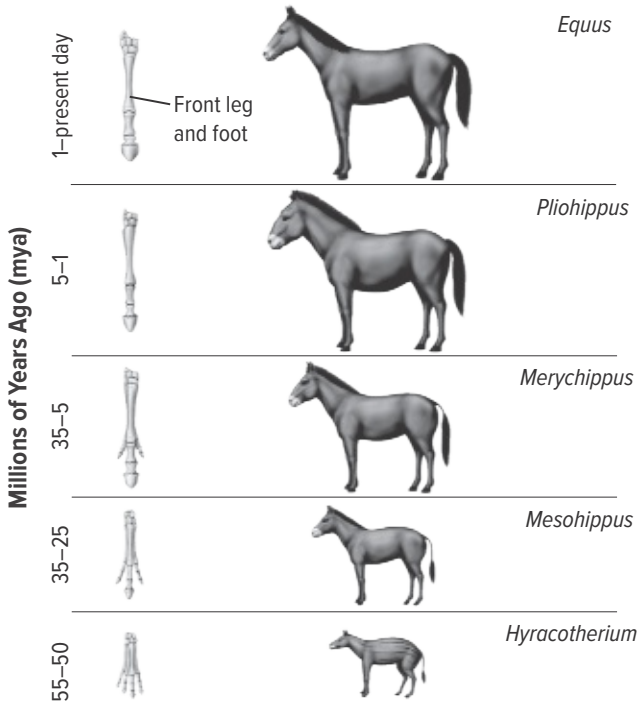
Gradual Changes Not all environmental change is sudden. Earth's tectonic plates can move between 1 and 15 cm each year. As plates move and collide with each other over time, new mountains and oceans form. If a mountain range or an ocean separates a species, the species might become extinct if it cannot find resources to live. Species also might become extinct if sea level changes.

Extinctions and Evolution

The fossil record has obvious clues about the extinction of species over time. But it also has clues about the appearance of many new species. How do new species form?

Many early scientists thought that each species appeared on Earth independently of every other species. However, as scientists found more fossils, they began to see patterns in the fossil record. Many fossil species in nearby rock layers had similar body plans and similar body parts. These similar species seemed to be related to each other. For example, the series of horse fossils in the figure below suggests that the modern horse is related to other extinct species.

These species changed over time in what appeared to be a sequence. Change over time is evolution. **Biological evolution** *is the change over time in populations of related organisms.* Charles Darwin developed a theory about how species evolve from other species. You will read about Darwin's theory in the next lesson.



NGSSS Check

9. How are fossils evidence of biological evolution? **SC.7.L.15.1**

After You Read

Mini Glossary

biological evolution: the change over time in populations of related organisms

cast: a fossil copy of an organism in a rock

extinction (ihk STINGK shun): when the last individual organism of a species dies

fossil record: all the fossils ever discovered on Earth

geologic time scale: a chart that divides Earth's history into different time units

mold: the impression of an organism in a rock

trace fossil: the preserved evidence of the activity of an organism

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains the difference between a cast and a mold.

2. Fill in the graphic organizer to identify five different types of fossils. Two have been done for you.

3. How do scientists use the fossil record to understand the geologic time scale?

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

END OF LESSON