UNIT 3

Earth's History

FLORIDA BIG IDEA 6

Earth Structures

Florida's unique topography answers questions about Florida's past.

What Do You Think?

Earth's landscape is constantly changing. But Earth's history has not been erased. Look closely at the prominent features of this saber-toothed cat skull. What might the environment have been like when this animal was alive? As you explore this unit, gather evidence to state and support your claim.

UNIT 3

Earth's History

CITIZEN **SCIENCE**

Preserving the Past

Fossils are found throughout Florida. These fossils contain information about the organisms that lived both on land and in the ocean. How would you research Florida's fossil history?

1 Think About It

Where can people find fossils?

What are the most common types of fossils found in Florida?

Many important fossil discoveries have been made in Florida. Use the internet to research a fossil discovery site in Florida. Take notes on your findings on a separate sheet of paper.

Scientists use grids to record where things are found.

2 Ask A Question

Is your area home to fossils?

As a class, evaluate the area in which you live and determine the likelihood of fossils being present. Consider natural changes like weather or earthquakes that might ruin fossil sites, as well as human factors like construction.

What to consider

- ☐ What kind of rock is common in your area?
- ☐ Are there any undeveloped areas that will have undisturbed rock?

3 Apply Your Knowledge

A List the kinds of rock in which fossils are found in Florida.

B Use a geologic map to determine where rock that contains fossils can be found close to where you live. Determine how long it will take to travel to one of these sites.

C If you can, plan a trip to a site where you can find fossils. Describe how you will search for fossils.

Take It Home!

What was your local community like long ago? Research to find out what the most common fossils from your area are. How were the fossils formed?

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.

(bkgd) ©Jim West/Alamy

SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions. **SC.7.N.1.5** Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. **SC.7.E.6.4** Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes.

Lesson Labs

Quick Labs

- Fossil Flipbook
- Connecting Fossils to Climates
- Timeline of Earth's History

S.T.E.M. Lab

- Exploring Landforms

(inset) ©Ltrendo nature/Getty Images

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.

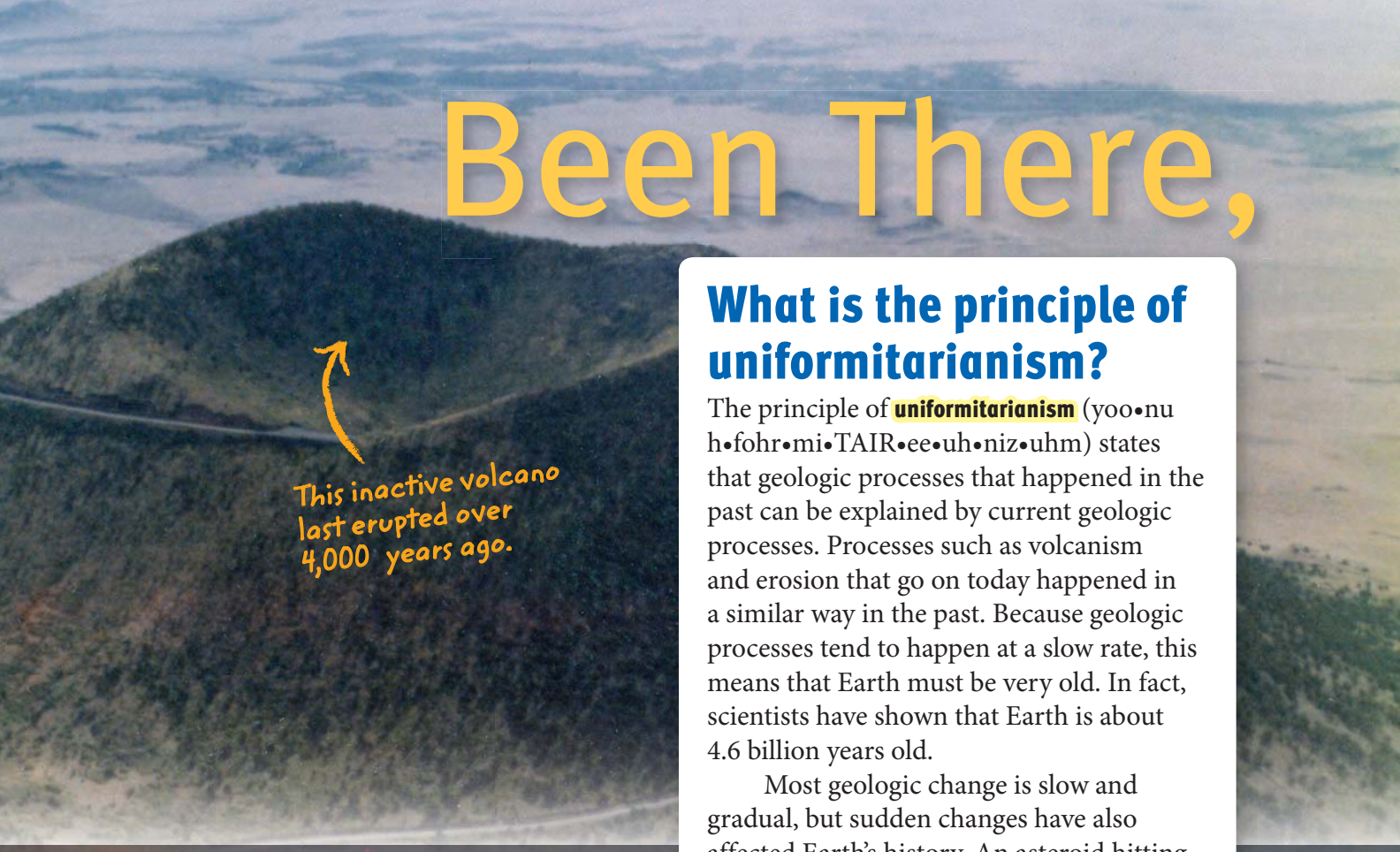
uniformitarianism:

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•nu h•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?

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.

This ant was preserved 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.

This water beetle was preserved in asphalt.

8 Claims • Evidence • Reasoning Make a claim about how this organism became a fossil. Support your claim with evidence, and explain your reasoning.

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.

Ammonites once lived in shells in ancient seas.

Visualize It!

9 Gather Evidence What part of the organism was preserved as a fossil in this rock? Support your claim with evidence.

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.

This frozen mammoth was discovered in Siberia.

Visualize It!

10 Compare What information can this fossil give that fossils preserved in rock cannot?

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.

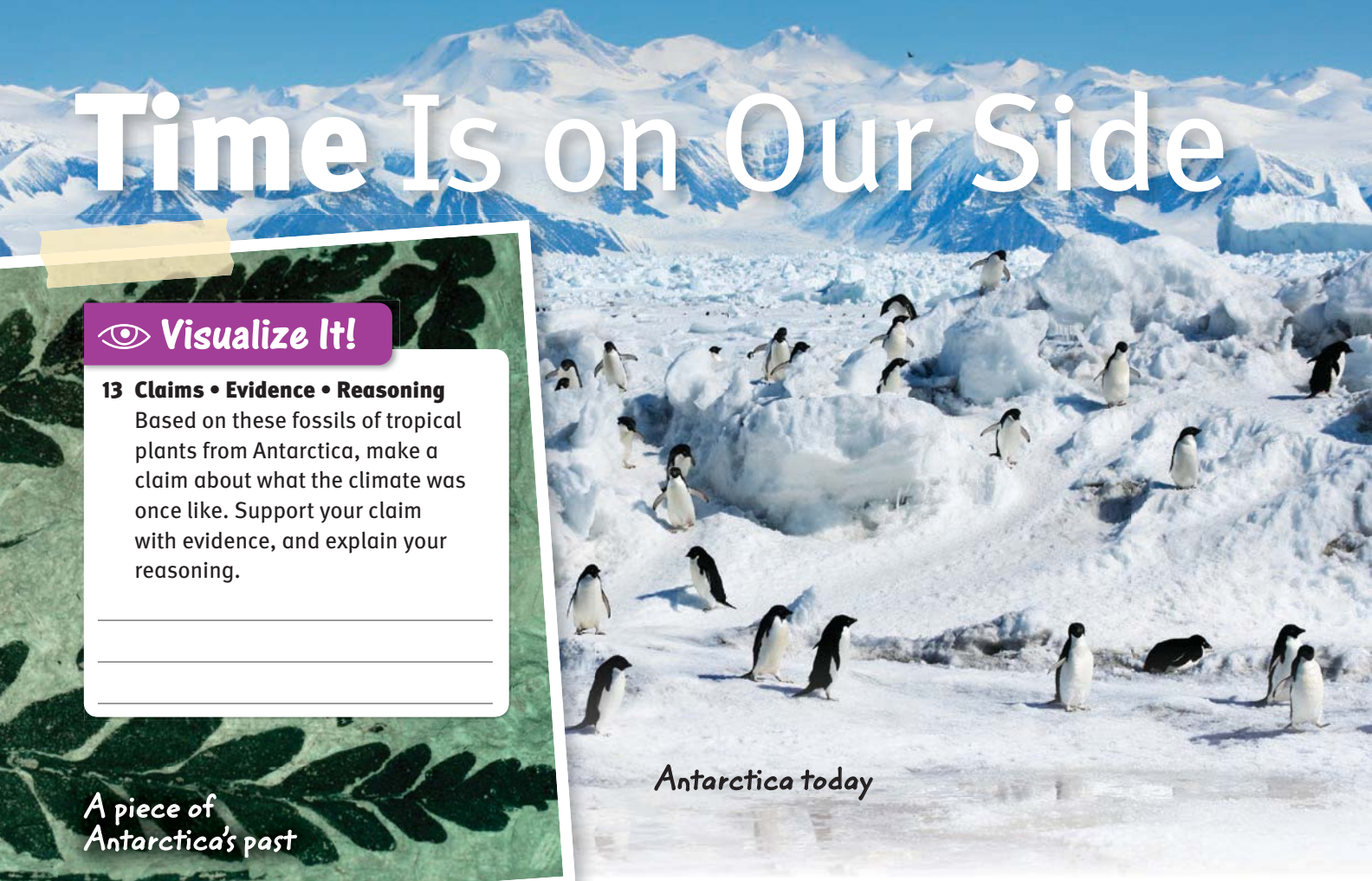
Visualize It!

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



Visualize It!

13 Claims • Evidence • Reasoning Based on these fossils of tropical plants from Antarctica, make a claim about what the climate was once like. Support your claim with evidence, and explain your reasoning.

What can fossils tell us?

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.

ACTIVE READING

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

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.

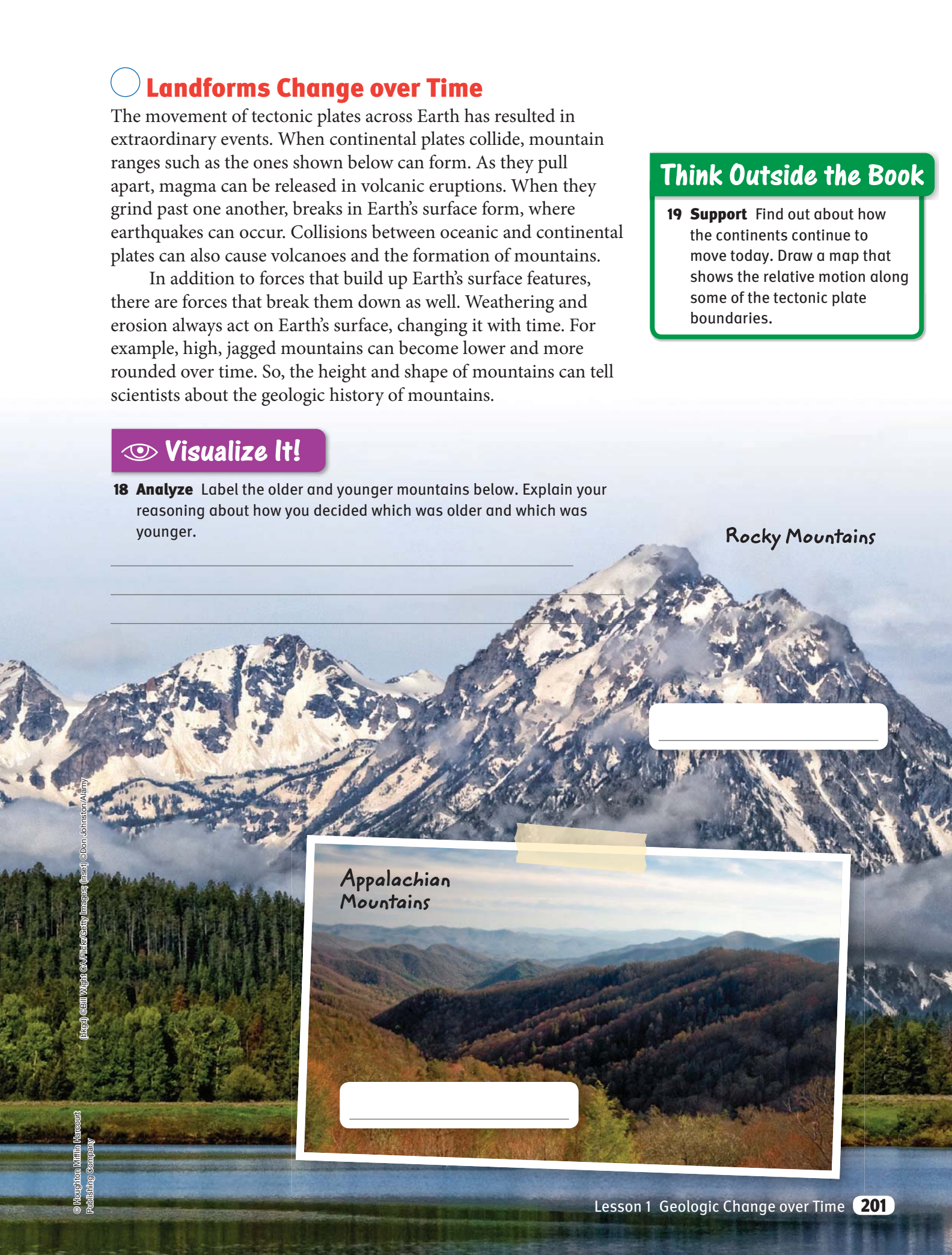
In addition to forces that build up Earth's surface features, there are forces that break them down as well. Weathering and erosion always act on Earth's surface, changing it with time. For example, high, jagged mountains can become lower and more rounded over time. So, the height and shape of mountains 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 your reasoning about how you decided which was older and which was younger.



Back to the Future

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

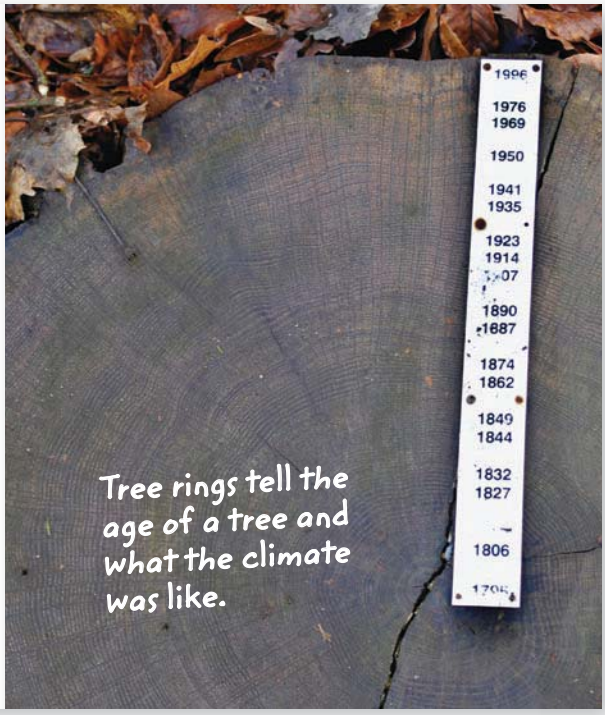
The **climate** of an area describes the weather conditions in the area over a long period of time. Climate is mostly determined by temperature and precipitation. In addition to using fossils, scientists also analyze other materials to study how Earth's climate and environmental conditions have changed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

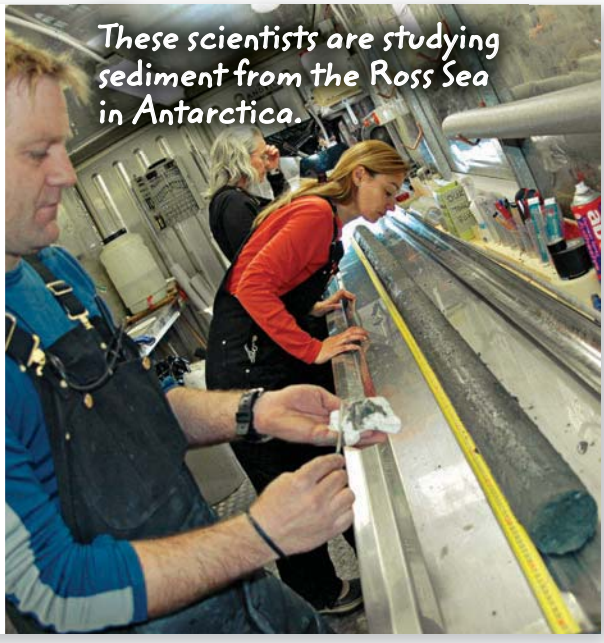


Visualize It!

21 Claims • Evidence • Reasoning What is the time frame for which this tree can give information about Earth's climate? Use evidence to support your claim, and explain your reasoning.

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 State Your Claim Fill in the table by reading the evidence and making a claim about 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. 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

27 Claims • Evidence • Reasoning At one point in history, Florida was completely submerged in water. Use evidence to support a claim about which material (wood, sea-floor sediments, ice) would be the most useful in studying Florida's fossil record. Explain your reasoning.

Lesson Review

LESSON 1

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 Claims • Evidence • Reasoning Make a claim about whether or not a piece of pottery is an example of a fossil? Summarize evidence to support your claim and explain your reasoning.

Use this photo to answer the following questions.

10 Synthesize How does the erosion of these mountains support the principle of uniformitarianism? Explain your reasoning.

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

LESSON 2

Relative Dating

ESSENTIAL **QUESTION**

How are the relative ages of rock measured?

By the end of this lesson, you should be able to summarize how scientists measure the relative ages of rock layers and identify gaps in the rock record.

SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. **SC.7.E.6.3** Identify current methods for measuring the age of Earth and its parts, including the law of superposition and radioactive dating.

Lesson Labs

Quick Labs
- Layers of Sedimentary Rock
- Ordering Rock Layers

Exploration Lab
- Earth's History

Engage Your Brain

1 Describe Fill in each blank with the word or phrase that you think completes the following sentences.

An example of something young is

_____

An example of something old is

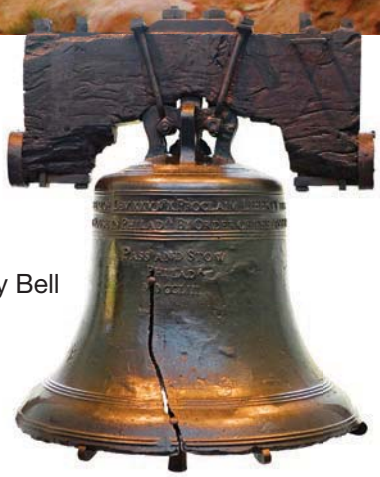
_____

An example of something that is horizontal is

_____

An example of something older than you is

_____



The Liberty Bell

2 Explain Which came first, the bell or the crack in the bell? Explain your reasoning.

_____

_____

_____

_____

ACTIVE READING

3 Synthesize You can often define an unknown word if you know the meaning of its word parts. Use the word parts below to make an educated guess about the meaning of the word *superposition*, when used to describe layers of rock.

Word part	Meaning
super-	above
-position	specific place

superposition:

_____

_____

Vocabulary Terms

- **relative dating**
- **fossil**
- **superposition**
- **geologic column**
- **unconformity**

4 Apply As you learn the definition of each vocabulary term in this lesson, make your own definition or sketch to help you remember the meaning of the term.

Who's First?

What is relative dating?

Imagine that you are a detective at a crime scene. You must figure out the order of events that took place before you arrived. Scientists have the same goal when studying Earth. They try to find out the order in which events happened during Earth's history. Instead of using fingerprints and witnesses, scientists use rocks and fossils. Determining whether an object or event is older or younger than other objects or events is called **relative dating**.

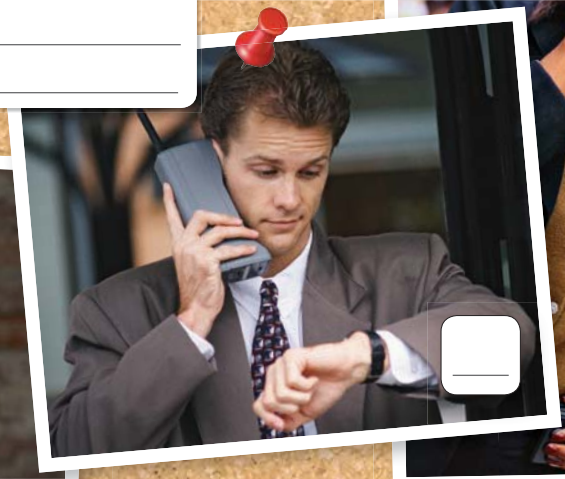
The telephones shown below show how technologies have changed over time. Layers of rock also show how certain things took place in the past. Using different pieces of information, scientists can find the order in which rock layers formed. Once they know the order, a relative age can be determined for each rock layer. Keep in mind, however, that this does not give scientists a rock's age in years. It only allows scientists to find out what rock layer is older or younger than another rock layer.

Think Outside the Book

5 Model In groups of 6–10 people, form a line. Place the oldest person in the front of the line and the youngest person at the end of the line. What is your relative age compared to the person in front of you? Compared to the person behind you?

Visualize It!

6 Explain Use the numbers 1, 2, and 3 to rate these telephones from oldest (1) to youngest (3). Explain your reasoning. Does this tell you the years that the telephones were made?



How these telephones look is a clue to their relative ages.

How are undisturbed rock layers dated?

To find the relative ages of rocks, scientists study the layers in sedimentary rocks. Sedimentary rocks form when new sediments are deposited on top of older rock. As more sediment is added, it is compressed and hardens into rock layers.

Scientists know that gravity causes sediment to be deposited in layers that are horizontal (hohr•ih•ZAHN•tuhl). Over time, different layers of sediment pile up on Earth's surface. Younger layers pile on top of older ones. If left undisturbed, the sediment will remain in horizontal layers. Scientists use the order of these layers to date the rock of each layer.

ACTIVE READING

7 Explain Why does gravity cause layers of sediment to be horizontal? Explain your reasoning.

Using Superposition

Suppose that you have a brother who takes pictures of your family and piles them in a box. Over time, he adds new pictures to the top of the pile. Where are the oldest pictures—the ones taken when you were a baby? Where are the most recent pictures—the ones taken last week? The oldest pictures will be at the bottom of the pile. The youngest pictures will be at the top of the pile. Layers of rock are like the photographs shown below. As you go from top to bottom, the layers get older.

This approach is used to determine the relative age of sedimentary rock layers. The law of **superposition** (soo•per•puh•ZISH•uhn) is the principle that states that younger rocks lie above older rocks if the layers have not been disturbed.

Visualize It!

8 Claims • Evidence • Reasoning Make a claim about the relative ages of these rock layers. Support your claim with evidence. Explain your reasoning.

How Disturbing!

How are sedimentary rock layers disturbed?

If rock layers are not horizontal, then something disturbed them after they formed. Forces in Earth can disturb rock layers so much that older layers end up on top of younger layers. Some of the ways that rock layers can be disturbed are shown below and on the next page.

By Tilting and Folding

Tilting happens when Earth's forces move rock layers up or down unevenly. The layers become slanted. *Folding* is the bending of rocks that can happen when rock layers are squeezed together. The bending is from stress on the rock. Folding can cause rock layers to be turned over by so much that older layers end up on top of younger layers.

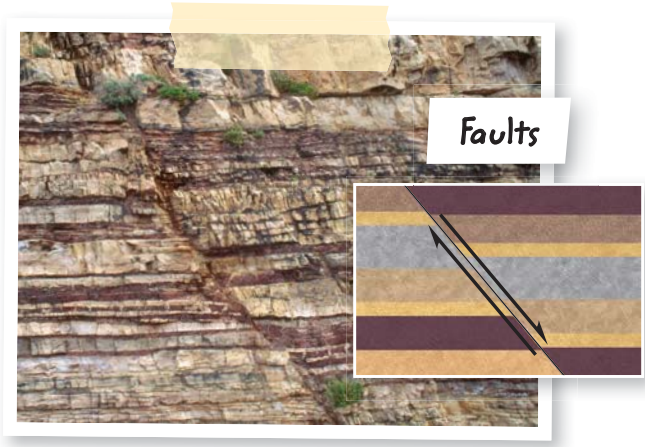
By Faults and Intrusions

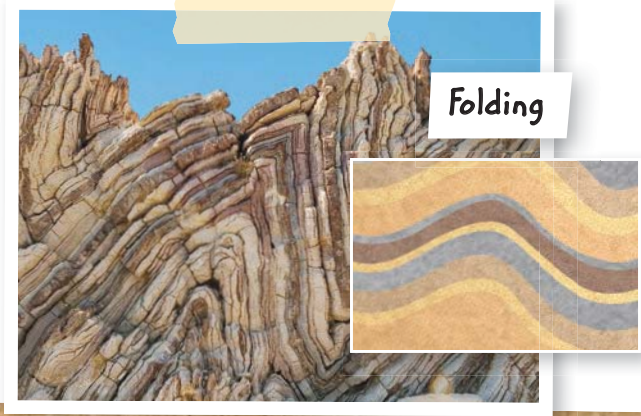
Scientists often find features that cut across existing layers of rock. A *fault* is a break or crack in Earth's crust where rocks can move. An *intrusion* (in•TROO•zhuhn) is igneous rock that forms when magma is injected into rock and then cools and becomes hard.

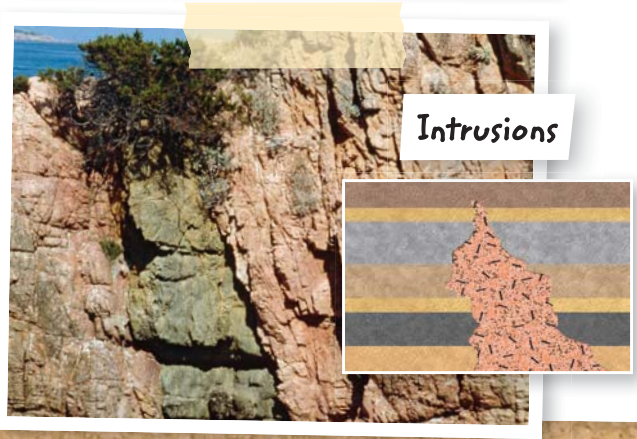
Folding, tilting, faults, and intrusions can make finding out the relative ages of rock layers difficult. This can be even more complicated when a layer of rock is missing. Scientists call this missing layer of rock an *unconformity*.

Visualize It!

9 Describe Write a caption for this group of images.

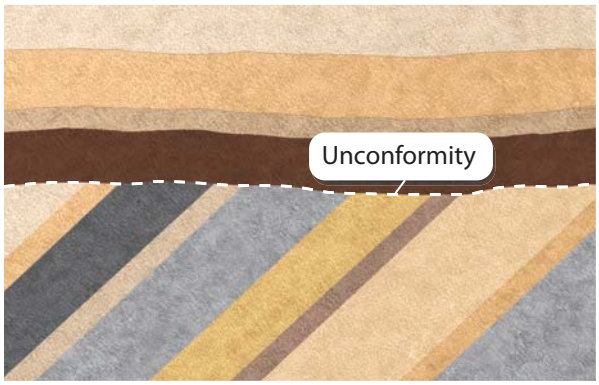






By Unconformities

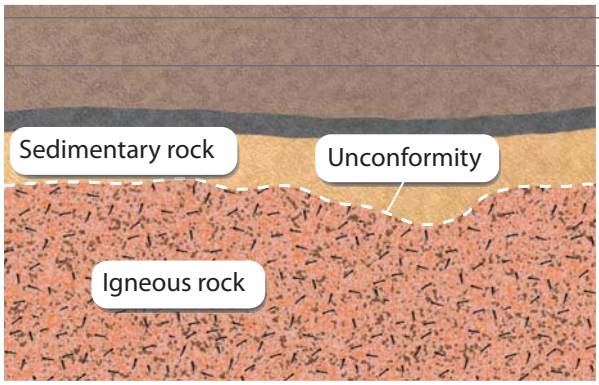
A missing layer of rock forms a gap in Earth's geologic history, also called the geologic record. An **unconformity** (uhn•kuhn•FAWR•mih•tee) is a break in the geologic record that is made when rock layers are eroded or when sediment is not deposited for a long period of time. When scientists find an unconformity, they must question if the "missing layer" was simply never present or if it was removed. Two examples of unconformities are shown below.



An unconformity can happen between horizontal layers and layers that are tilted or folded. The older layers were tilted or folded and then eroded before horizontal layers formed above them.

ACTIVE READING

10 Claims • Evidence • Reasoning Make a claim about two ways that a rock layer can cause a gap in the geologic record. Support your claim with evidence, and explain your reasoning.



An unconformity can also happen when igneous or metamorphic rocks are exposed at Earth's surface and become eroded. Later, deposited sediment causes the eroded surface to become buried under sedimentary rock.

11 Illustrate Choose two of the following: tilting, folding, fault, intrusion, and an unconformity. Draw and label each one.

I'm Cutting In!

How are rock layers ordered?

Often, the order of rock layers is affected by more than one thing. Finding out what happened to form a group of rock layers is like piecing together a jigsaw puzzle. The law of superposition helps scientists to do this.

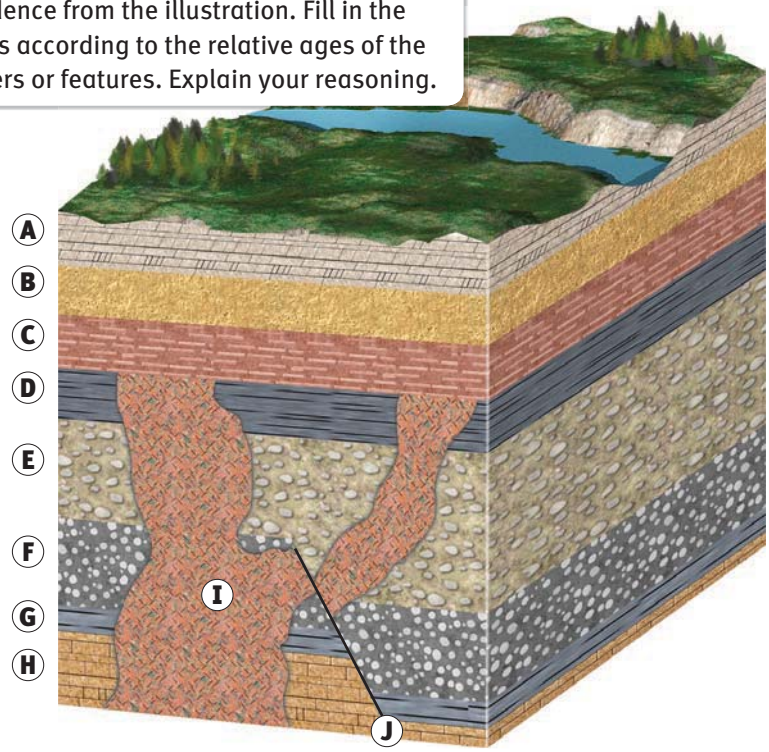
The idea that layers of rock have to be in place before anything can disturb them is also used. The law of crosscutting relationships states that a fault or a body of rock, such as an intrusion, must be younger than any feature or layer of rock that the fault or rock body cuts through. For example, if a fault has broken a rock layer, the fault is younger than the rock layer. If a fault has broken through igneous rock, the igneous rock must have been in place, and cool, before it could have been broken. The same is true for an unconformity. Look at the image below and use the laws of superposition and crosscutting relationships to figure out the relative ages of the rock layers and features.

ACTIVE READING

12 Identify As you read, underline the law of crosscutting relationships.

Visualize It!

13 Claims • Evidence • Reasoning Make a claim about the order in which features A through J formed. Support your claim with evidence from the illustration. Fill in the lines according to the relative ages of the layers or features. Explain your reasoning.



Youngest

_____

_____

_____

_____

_____

_____

_____

_____

_____

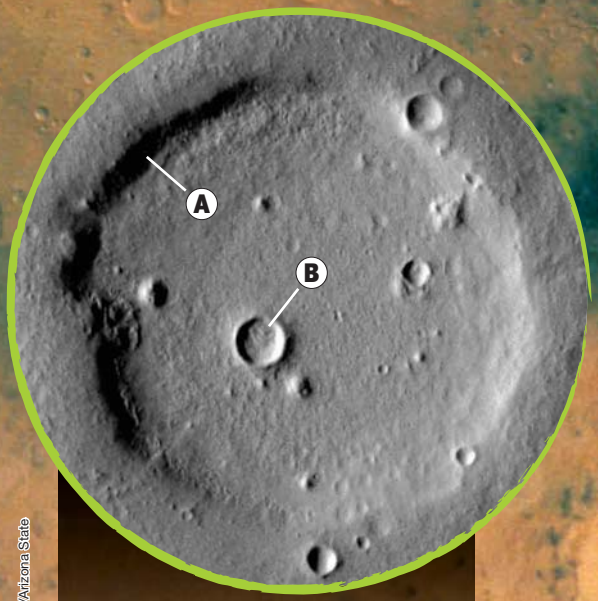
Oldest

WHY IT **MATTERS**

Dating Mars

WEIRD SCIENCE

NASA's Mars Odyssey orbiter and the Hubble Space Telescope have produced a large collection of images of the surface of Mars. These are studied to find the relative ages of features on Mars, using the laws of superposition and crosscutting relationships. Here are two examples of crosscutting relationships.



Crater in a Crater
A crater (A) can be cut by another crater (B) that formed from a later impact.

The Crater Came First
A crater can be cut by another feature, such as a fracture.

Hellas Crater
The many craters on Mars are studied to determine relative ages of features. This is Hellas Impact Basin, which is almost 2100 km wide.

Extend

14 Claims • Evidence • Reasoning Make a claim about the relative ages of crater A and crater B. Provide evidence to support your claim, and explain your reasoning.

15 Apply How can scientists use erosion as a way to determine the relative ages of craters on Mars? Describe how erosion could change the appearance of a crater over time.

16 Research Find out how scientists have used relative dating to study the geologic history of other planets, such as Venus. Present what you found out by drawing a graphic novel or making a poster.

So Far Away

How are fossils used to determine relative ages of rocks?

Fossils are the traces or remains of an organism that lived long ago, most commonly preserved in sedimentary rock. Fossil forms of plants and animals show change over time, as they evolve. Scientists can classify fossilized (FAHS•uh•lyzd) organisms based on these changes. Then they can use that classification of fossils to find the relative ages of the rocks in which the fossils are found. Rock that contains fossils of organisms similar to those that live today is most likely younger than rock that contains fossils of ancient organisms. For example, fossilized remains of a 47 million-year-old primate are shown below. Rock that contains these fossils is younger than rock that contains the fossils of a dinosaur that lived over 200 million years ago.

17 Claims • Evidence • Reasoning Make a claim about whether fossils of species that did not change noticeably over time would be useful in determining the relative ages of rocks. Summarize your evidence to support your claim, and explain your reasoning.

This is a fossil of a dinosaur that lived over 200 million years ago.

This is a fossil of a primate that lived about 47 million years ago.

How are geologic columns used to compare relative ages of rocks?

Relative dating can also be done by comparing the relative ages of rock layers in different areas. The comparison is done using a geologic column. A **geologic column** is an ordered arrangement of rock layers that is based on the relative ages of the rocks, with the oldest rocks at the bottom of the column. It is made by piecing together different rock sequences from different areas. A geologic column represents an ideal image of a rock layer sequence that doesn't actually exist in any one place on Earth.

The rock sequences shown below represent rock layers from different outcrops at different locations. Each has certain rock layers that are common to layers in the geologic column, shown in the middle. Scientists can compare a rock layer with a similar layer in a geologic column that has the same fossils or that has the same relative position. If the two layers match, then they probably formed around the same time.

ACTIVE READING

18 Identify As you read, underline the description of how rock layers are ordered in a geologic column.

Visualize It!

19 Identify Draw lines from the top and bottom of each outcrop to their matching positions in the geologic column.

Outcrop 1

Geologic Column

Outcrop 2

Rock layers from different outcrops can be compared to a geologic column.

Visual Summary

To complete this summary, circle the correct words. You can use this page to review the main concepts of the lesson.

If undisturbed, sedimentary rock exists as horizontal layers.

20 For undisturbed rock layers, younger rocks are above/below older rocks.

Forces in Earth can cause horizontal layers of rock to be disturbed.

21 This photo shows folding/tilting.

Relative Dating

Fossils can be used to determine the relative ages of rock layers.

22 In undisturbed rock layers, fossils of a more recent organism will be in rock that is above/below rock containing fossils of older organisms.

Rock layers from different areas can be compared to a geologic column.

23 In geologic columns, the oldest rock layers are at the bottom/top.

24 Claims • Evidence • Reasoning Make a claim as to how the law of superposition relates to a stack of magazines that you have been saving over the past few years. Use evidence to support your claim and explain your reasoning.

Lesson Review

LESSON 2

Vocabulary

In your own words, define the following terms.

1 relative dating

2 unconformity

Key Concepts

3 Describe How are sedimentary rock layers deposited?

4 List Name five ways that the order of rock layers can be disturbed.

5 Explain How are the laws of superposition and crosscutting relationships used to determine the relative ages of rocks?

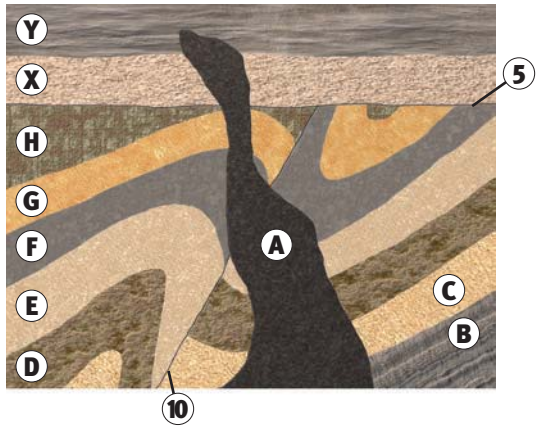
6 Explain How can fossils be used to determine the relative ages of rock layers?

7 Describe How is the geologic column used in relative dating?

Critical Thinking

8 Claims • Evidence • Reasoning Make a claim about which types of rocks the law of crosscutting relationships involves. Summarize evidence to support your claim and explain your reasoning.

Use this image to answer the following questions.



9 Analyze Is intrusion A younger or older than layer X? Explain your reasoning.

10 Analyze What feature is marked by 5?

11 Analyze Other than intrusion and faulting, what happened in layers B, C, D, E, F, G, and H? Support your claim with evidence.

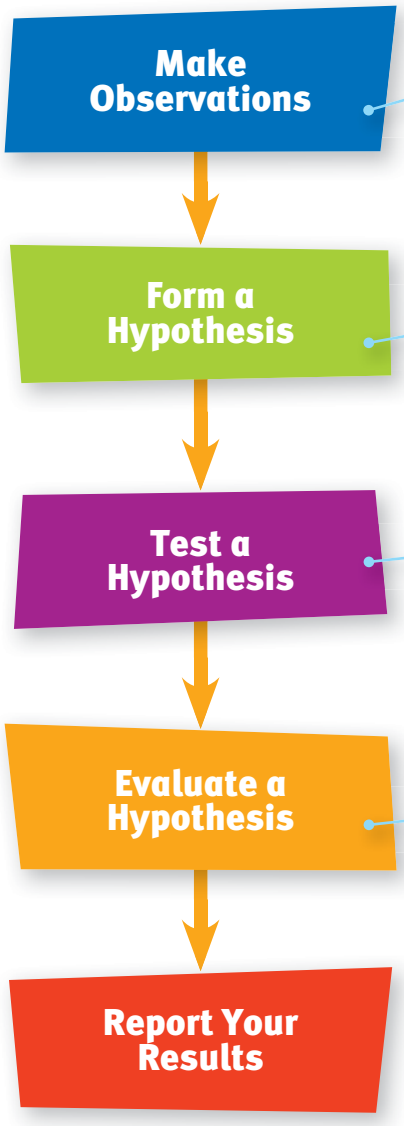
SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

Forming a Hypothesis

When conducting an investigation to test a hypothesis, a scientist must not let personal bias affect the results of the investigation. A scientist must be open to the fact that the results of an investigation may not completely support the hypothesis. They may even contradict it! Revising or forming a new hypothesis may lead a scientist to make a breakthrough that could be the basis of a new discovery.

Tutorial

The following procedure explains the steps that you will use to develop and evaluate a hypothesis.



1 Making Observations Scientific investigations commonly begin with observations. Your observations may lead to a question. For example, you may wonder how, why, or when something happens.

2 Forming a Hypothesis To answer your question, you can start by forming a hypothesis. A hypothesis is a clear statement of what you expect will be the answer to your question. Start to form a hypothesis by stating the probable answer to your question based on your observations.

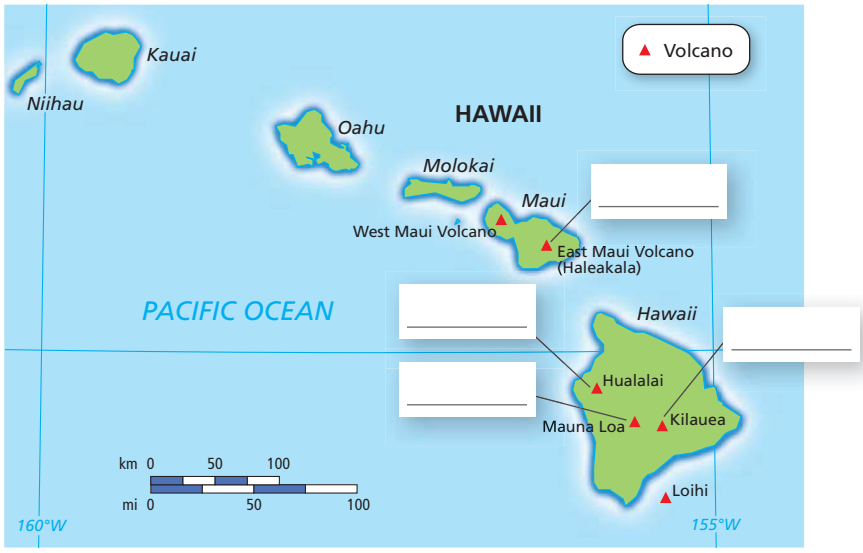
3 Testing a Hypothesis A useful hypothesis must be testable. To determine whether your hypothesis is testable, identify experiments that you can perform or observations that you can make to find out whether the hypothesis is supported or not.

4 Evaluating a Hypothesis After analyzing your data, you can determine if your results support your hypothesis. If your data support your hypothesis, you may want to repeat your observations or experiments to verify your results. If your data do not support your hypothesis, you may have to check your procedure for errors. You may even have to reject your hypothesis and form a new one.

You Try It!

The table provides observations about the latest eruptions of several volcanoes in Hawai'i.

Latest Eruption of Volcanoes in Hawai'i	
Volcano	**Year**
East Maui (Haleakala)	1460
Hualalai	1801
Mauna Loa	1984
Kilauea	still active



1 Making Observations On the map, label the volcanoes with the years shown. What do you observe about the dates and the locations of the volcanoes?

2 Forming a Hypothesis Use the observations above to form a hypothesis about the history of the area. Focus on the relationship between the activity of the volcanoes and the location of the volcanoes. Your hypothesis should be supported by all of your data. Summarize your completed hypothesis in a single paragraph.

3 Claims • Evidence • Reasoning Loihi is currently active, but West Maui has not erupted in recent history. Make a claim about whether these new observations support your hypothesis or disprove it. Support your claim with evidence, and explain your reasoning.

4 Revising a Hypothesis Share your hypothesis with your classmates. Rewrite your hypothesis so that it includes the changes suggested by your classmates.

Take It Home!

While you already know the word *hypothesis*, you might not know the word *hypothetical*. Use the dictionary to look up the meaning of the suffix *-ical*. Combine the meanings of these two word parts, and write an original definition of *hypothetical* in your notebook.

LESSON 3

Absolute Dating

ESSENTIAL **QUESTION**

How is the absolute age of rock measured?

By the end of this lesson, you should be able to summarize how scientists measure the absolute age of rock layers, including by radiometric dating.

A clock is one way of measuring absolute time.

(bkg) ©James Strachan/Stone/Getty Images

SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. **SC.7.E.6.3** Identify current methods for measuring the age of Earth and its parts, including the law of superposition and radioactive dating.

Lesson Labs

Quick Labs

- Radioactive Decay
- Index Fossils

Engage Your Brain

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

T	F	
☐	☐	All rocks are made of matter and all matter is made of atoms.
☐	☐	We use calendars to measure the absolute age of people.
☐	☐	Someone tells you that he is older than you are. This tells you his absolute age.
☐	☐	If you cut a clay ball in two and then cut one of the halves in two, you will end up with four pieces of clay.

2 Explain What is the age of this person? Explain your reasoning.

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 phrase *radiometric dating*.

Word part	Meaning
radio-	relating to radiation
-metric	relating to measurement

Example sentence

By using radiometric dating, the scientist found that the rock was 25 million years old.

radiometric dating:

Vocabulary Terms

- **absolute dating**
- **half-life**
- **radioactive decay**
- **radiometric dating**

4 Apply As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.

It's About

How can the absolute age of rock be determined?

Determining the actual age of an event or object in years is called **absolute dating**. Scientists use many different ways to find the absolute age of rock and other materials. One way is by using radioactive isotopes (ray•dee•oh•AK•tiv EYE•suh•tohpz).

Using Radioactive Isotopes

Atoms of the same element that have a different number of neutrons are called isotopes. Many isotopes are stable, meaning that they stay in their original form. But some isotopes are unstable, and break down to form different isotopes. The unstable isotopes are called *radioactive*. The breakdown of a radioactive isotope into a stable isotope of the same element or of another element is called **radioactive decay**. As shown on the right, radioactive decay for many isotopes happens when a neutron is converted to a proton, with the release of an electron. A radioactive isotope is called a *parent isotope*. The stable isotope formed by its breakdown is called the *daughter isotope*.

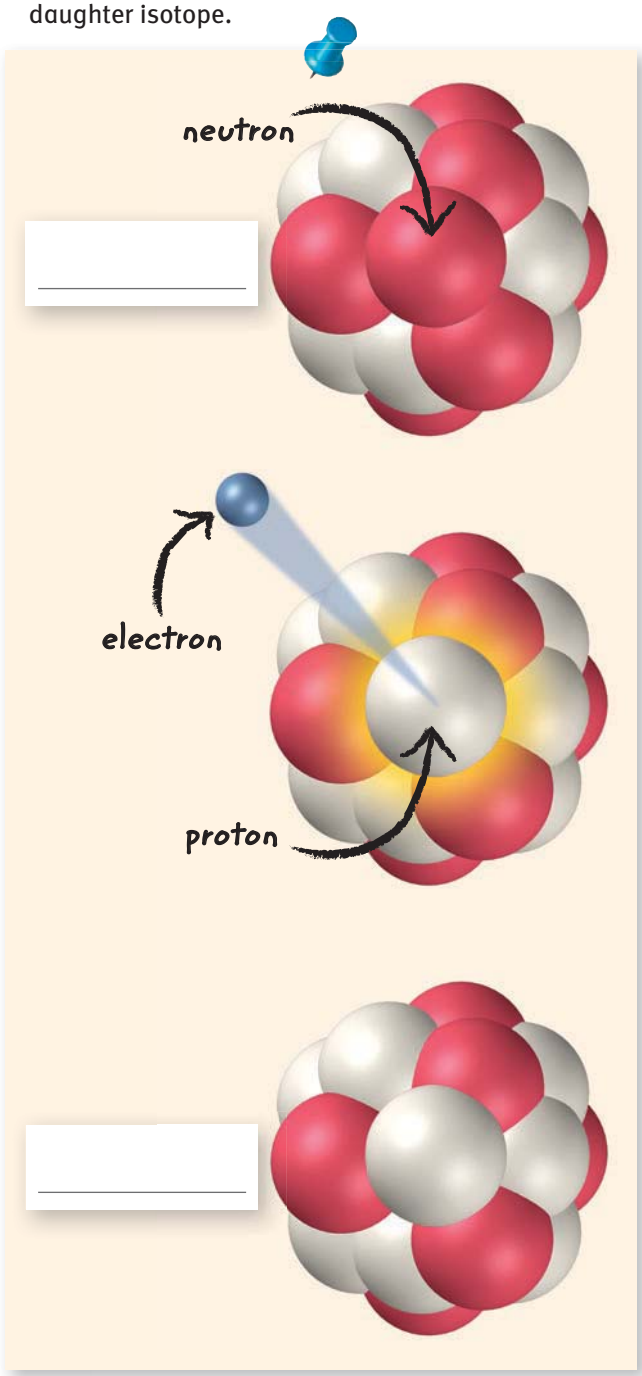
Each radioactive isotope decays at a specific, constant rate. **Half-life** is the time needed for half of a sample of a radioactive substance to undergo radioactive decay to form daughter isotopes. Half-life is always given in units of time.

ACTIVE READING

5 Claims • Evidence • Reasoning Make a claim about how much of a radioactive parent isotope remains after one half-life has passed? Use evidence to support your claim, and explain your reasoning.

Visualize It!

6 Identify Label the parent isotope and the daughter isotope.



Time!

By Radiometric Dating

Some radioactive isotopes in mineral crystals can act as clocks. These mineral crystals record the ages of the rocks in which the minerals formed. Scientists study the amounts of parent and daughter isotopes to date samples. If you know how fast a radioactive isotope decays, you can figure out the sample's absolute age. Finding the absolute age of a sample by determining the relative percentages of a radioactive parent isotope and a stable daughter isotope is called **radiometric dating** (ray•dee•oh•MET•rik DAYT•ing). The figure on the right shows how the relative percentages of a parent isotope and a daughter isotope change with the passing of each half-life.The following is an example of how radiometric dating can be used:

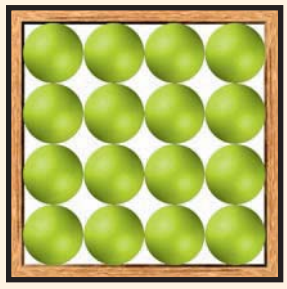
- You want to determine the age of a sample that contains a radioactive isotope that has a half-life of 10 million years.
- You analyze the sample and find equal amounts of parent and daughter isotopes.
- Because 50%, or ½, of the parent isotope has decayed, you know that 1 half-life has passed.
- So, the sample is 10 million years old.

What is the best rock for radiometric dating?

Igneous rock is often the best type of rock sample to use for radiometric dating. When igneous rock forms, elements are separated into different minerals in the rock. When they form, minerals in igneous rocks often contain only a parent isotope and none of the daughter isotope. This makes the isotope percentages easier to interpret and helps dating to be more accurate.

Visualize It!

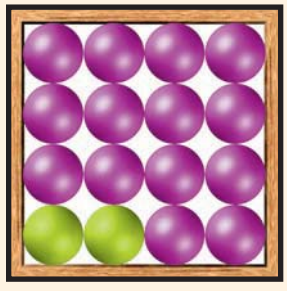
7 Calculate Fill in the number of parent isotopes and daughter isotopes in the spaces beside the images below.



0 years
Parent isotope = 16
Daughter isotope = 0
100% of the sample is parent isotope.

After 1 half-life
Parent isotope = 8
Daughter isotope = 8
50%, or $\frac{1}{2}$, of the sample is parent isotope.

After 2 half-lives
Parent isotope = 4
Daughter isotope = ___
25%, or $\frac{1}{4}$, of the sample is parent isotope.

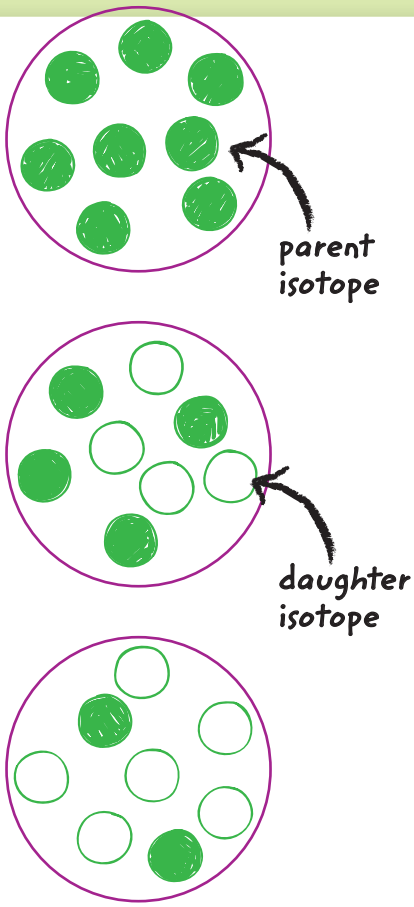


After 3 half-lives
Parent isotope = ___
Daughter isotope = ___
12.5%, or $\frac{1}{8}$, of the sample is parent isotope.

Do the Math

Sample Problem

A crystal contains a radioactive isotope that has a half-life of 10,000 years. One-fourth (25%) of the parent isotope remains in a sample. How old is the sample?



Identify

A. What do you know? Half-life = 10,000 years, parent isotope = 25%

B. What do you want to find out? How old the sample is. So, you need to know how many half-lives have gone by since the crystal formed.

Plan

C. Draw the parent-to-daughter isotope ratios for each half-life.

Solve

D. The third drawing on the right shows a sample that contains 25% parent isotope. This amount is present after 2 half-lives have passed.

E. Find the age of the sample. Because the half-life of the radioactive isotope is 10,000 years and 2 half-lives have passed, the age of the sample is: $2 \times 10{,}000 \text{ years} = 20{,}000 \text{ years}$

Do the Math

You Try It

8 **Claims • Evidence • Reasoning** A crystal contains a radioactive isotope that has a half-life of 20,000 years. You analyze a sample and find that one-eighth (12.5%) of the parent isotope remains. Make a claim about the age of the sample. Support your claim with mathematical evidence, and explain your reasoning.

Identify

A. What do you know? _____

B. What do you want to find out? _____

Plan

C. Draw the parent-to-daughter isotope ratios on the right.

Solve

D. Figure out how many half-lives have passed: _____

E. Find the age of the sample: _____

Answer: _____

Time for a Change

What are some radiometric dating methods?

Scientists use many different isotopes for radiometric dating. The half-life of an isotope is very important in determining the time range that it is useful for dating. If the half-life is too short compared with the age of the sample, there will be too little parent isotope left to measure. If the half-life is too long, there will not be enough daughter isotope to measure. Also, different methods may only be useful for certain types of materials.

ACTIVE READING

9 Identify As you read, underline the time frame for which radiocarbon dating is useful.

Radiocarbon Dating

The ages of wood, bones, shells, and other organic remains can be found by radiocarbon dating. The radioactive isotope carbon-14 combines with oxygen to form radioactive carbon dioxide, CO_2. Most CO_2 in the atmosphere contains nonradioactive carbon-12, but radioactive carbon-14 is also present.

Plants absorb CO_2 from the atmosphere, which they use to build their bodies through photosynthesis. As long as a plant is alive, the plant takes in carbon dioxide with the same carbon-14 to carbon-12 ratio. Similarly, animals convert the carbon from the food they eat into bone and other tissues. So, animals inherit the carbon isotope ratio of their food sources.

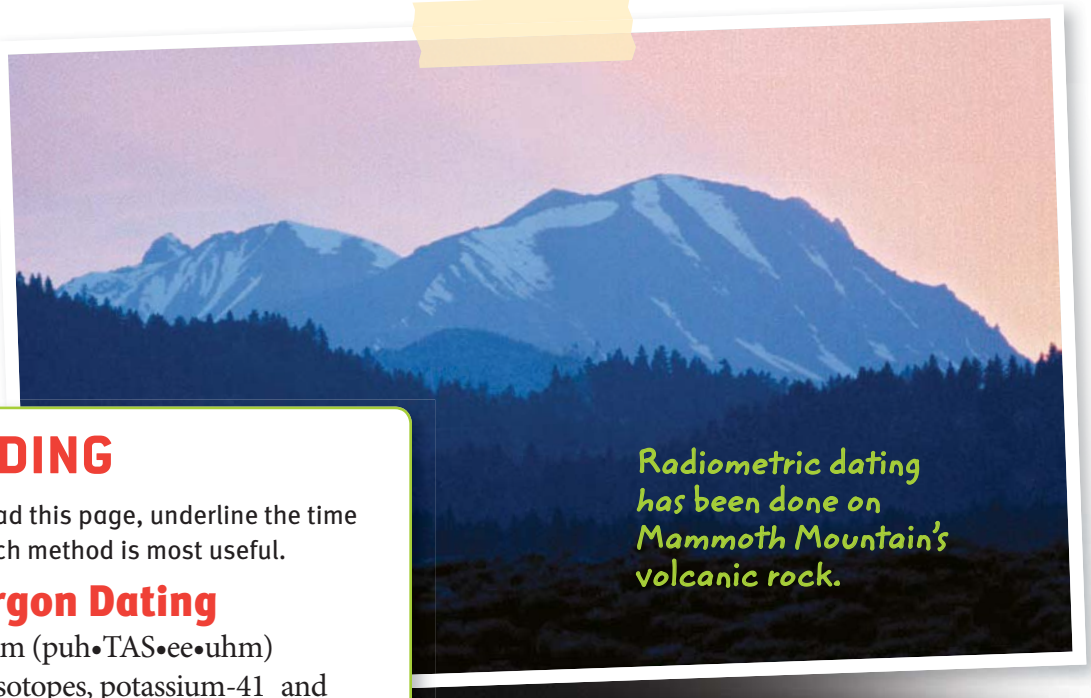
Once a plant or animal dies, carbon is no longer taken in. The ratio of carbon-14 to carbon-12 decreases in the dead organism because carbon-14 undergoes radioactive decay to nitrogen-14. The half-life of carbon-14 is only 5,730 years. Also, radiocarbon dating can only be used to date organic matter. So this method is used to date things that lived in the last 45,000 years.

Materials such as these woolly mammoth teeth can be radiocarbon dated.

©Kevin Schafer/Corbis

ACTIVE READING

10 Claims • Evidence • Reasoning You have found a bone in a layer of rock that you think is about 500,000 years old. Make a claim about whether you would use radiocarbon dating to find the age of this bone. Use evidence to explain your reasoning. Why or why not? _____



Radiometric dating has been done on Mammoth Mountain's volcanic rock.

ACTIVE **READING**

11 Identify As you read this page, underline the time frame for which each method is most useful.

Potassium-Argon Dating

The element potassium (puh•TAS•ee•uhm) occurs in two stable isotopes, potassium-41 and potassium-39, and one radioactive isotope that occurs naturally, potassium-40. Potassium-40 decays to argon and calcium. It has a half-life of 1.25 billion years. Scientists measure argon as the daughter isotope. Potassium-argon dating is often used to date igneous volcanic rocks. This method is used to date rocks that are between about 100,000 years and a few billion years old.

Scientist and astronaut Harrison Schmitt collected samples of rock on the moon during the Apollo 17 mission in 1972.

Uranium-Lead Dating

An isotope of uranium (yoo•RAY•nee•uhm), called uranium-238, is a radioactive isotope that decays to lead-206. Uranium-lead dating is based on measuring the amount of the lead-206 daughter isotope in a sample. Uranium-238 has a half-life of 4.5 billion years.

Uranium-lead dating can be used to determine the age of igneous rocks that are between 100 million years and billions of years old. Younger rocks do not have enough daughter isotope to be accurately measured by this method. Uranium-lead dating was used to find the earliest accurate age of Earth.

Time Will Tell

How is radiometric dating used to determine the age of Earth?

Radiometric dating can be used to find the age of Earth, though not by dating Earth rocks. The first rocks that formed on Earth have long ago been eroded or melted, or buried under younger rocks. So, there are no Earth rocks which can be directly studied that are as old as our planet. But other bodies in space do have rock that is as old as our solar system.

Meteorites (MEE•tee•uh•rytz) are small, rocky bodies that have traveled through space and fallen to Earth's surface. Scientists have found meteorites on Earth, such as the one shown below. Rocks from the moon have also been collected. Radiometric dating has been done on these rocks from other parts of our solar system. The absolute ages of these samples show that our solar system, including Earth, is about 4.6 billion years old.

ACTIVE READING

12 Identify As you read, underline the reason why scientists cannot use rocks from Earth to measure the age of Earth.

Think Outside the Book

13 Model Develop a way to help people understand how large the number 4.6 billion is.

This 4.5 billion-year-old rock is part of a meteorite that landed in Antarctica. It is thought to be from Mars.

Showing Your **Age**

How can fossils help to determine the age of sedimentary rock?

Sedimentary rock layers and the fossils within these layers cannot be dated directly. But igneous rock layers on either side of a fossil layer can be dated radiometrically. Once the older and younger rock layers are dated, scientists can assign an absolute age range to the sedimentary rock layer that the fossils are found in.

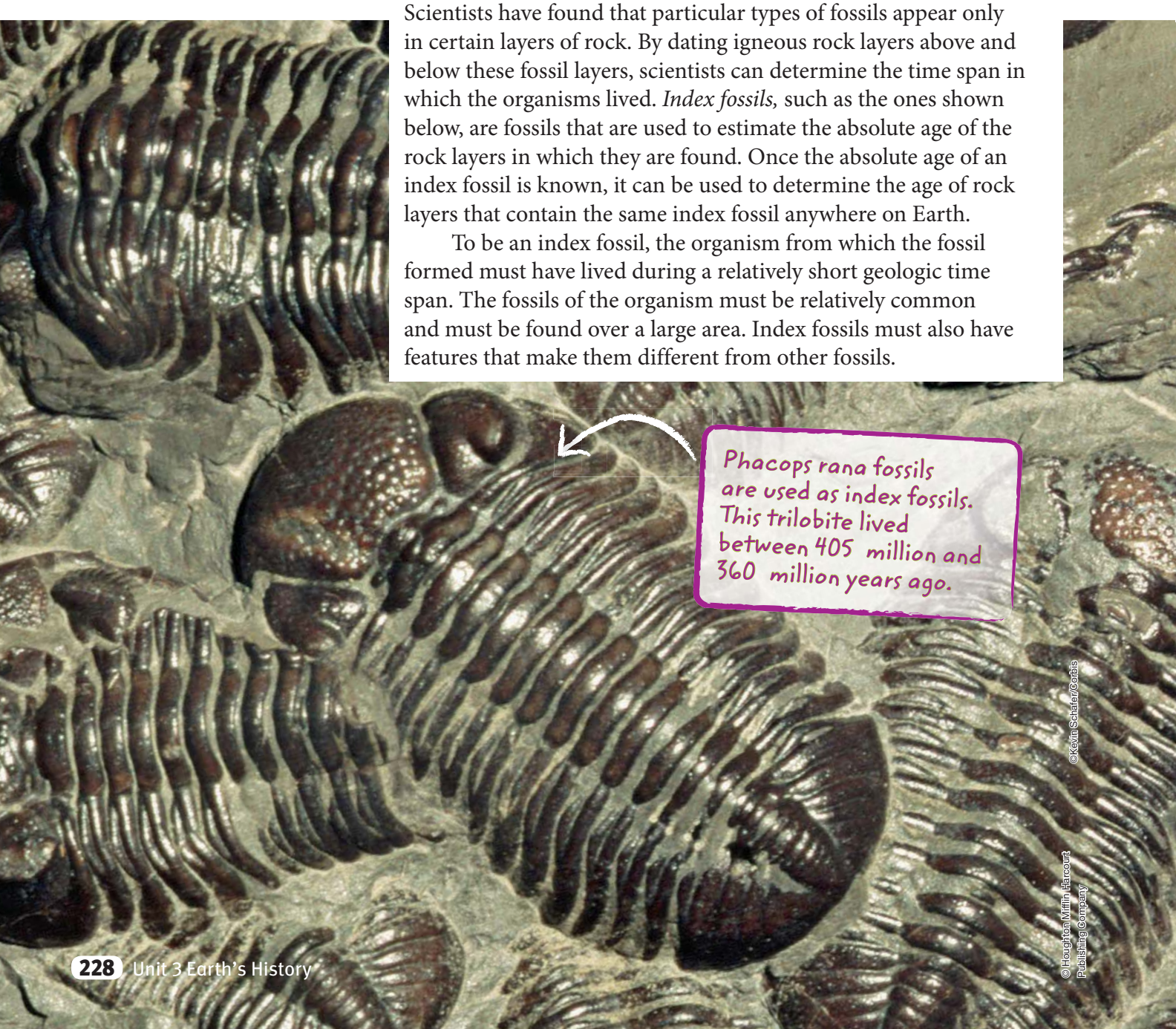
ACTIVE **READING**

14 Identify As you read, underline the requirements for a fossil to be an index fossil.

Using Index Fossils

Scientists have found that particular types of fossils appear only in certain layers of rock. By dating igneous rock layers above and below these fossil layers, scientists can determine the time span in which the organisms lived. *Index fossils,* such as the ones shown below, are fossils that are used to estimate the absolute age of the rock layers in which they are found. Once the absolute age of an index fossil is known, it can be used to determine the age of rock layers that contain the same index fossil anywhere on Earth.

To be an index fossil, the organism from which the fossil formed must have lived during a relatively short geologic time span. The fossils of the organism must be relatively common and must be found over a large area. Index fossils must also have features that make them different from other fossils.



How are index fossils used?

Index fossils act as markers for the time that the organisms lived on Earth. Organisms that formed index fossils lived during short periods of geologic time. So, the rock layer that an index fossil is found in can be dated accurately. For example, ammonites were marine mollusks, similar to a modern squid. They lived in coiled shells in ancient seas. The ammonite *Tropites* (troh•PY•teez) lived between 230 million and 208 million years ago. So, whenever scientists find a fossil of *Tropites*, they know that the rock layer the fossil was found in formed between 230 million and 208 million years ago. As shown below, this can also tell scientists something about the ages of surrounding rock layers.

Trilobite (TRY•luh•byt) fossils are another example of a good index fossil. The closest living relatives of trilobites are the horseshoe crab, spiders, and scorpions. *Phacops rana* is a trilobite that lived between 405 million and 360 million years ago. The *Phacops rana* fossil, shown on the previous page, is the state fossil of Pennsylvania.

Index fossils can also be used to date rock layers in separate areas. The appearance of the same index fossil in rock of different areas shows that the rock layers formed at about the same time.

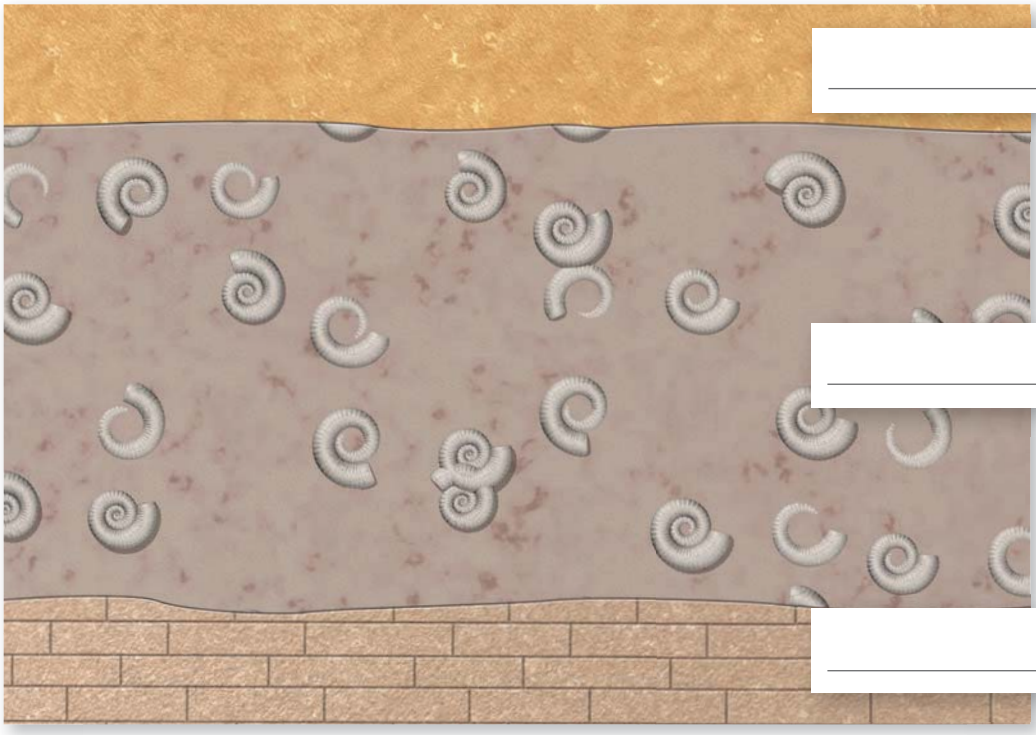
ACTIVE READING

15 Identify As you read, underline examples of organisms whose fossils are index fossils. Include the time frame for which they are used to date rock.

Visualize It!

16 Explain Your Reasoning *Tropites* fossils are found in the middle rock layer shown below. Place each of the following ages beside the correct rock layer: 215 million/500 million/100 million. Explain your reasoning.

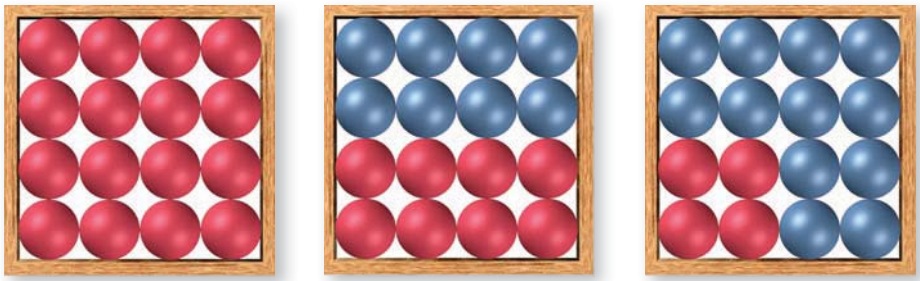
Fossils of a genus of ammonites called Tropites are good index fossils.



Visual Summary

To complete this summary, fill in the blanks with the correct word or phrase. You can use this page to review the main concepts of the lesson.

Radiometric dating can be used to find the absolute ages of materials such as igneous rocks. This method uses the radioactive decay of an isotope.



17 During radioactive decay, the amount of _____ isotope decreases by one-half after every _____

Absolute Dating

Index fossils can be used to estimate the absolute ages of some sedimentary rocks.

18 Four things that index fossils should be:

A _____

B _____

C _____

D _____

(b) ©Kevin Schafer/Corbis

19 Claims • Evidence • Reasoning Make a claim about how the use of radioactive decay in absolute dating is similar to how you use a clock. Summarize evidence to support your claim and explain your reasoning.

Lesson Review

LESSON 3

Vocabulary

Fill in each blank with the term that best completes the following sentences.

1 The breakdown of a radioactive isotope into a stable isotope is called _____

_____

2 The _____ is the time needed for half of a sample of a radioactive isotope to break down to form daughter isotopes.

3 _____ is a method used to determine the absolute age of a sample by measuring the relative amounts of parent isotope and daughter isotope.

Key Concepts

4 Summarize How are radioactive isotopes used to determine the absolute age of igneous rock? Name two radiometric methods that are used.

5 Describe What happens to an isotope during radioactive decay?

6 Claims • Evidence • Reasoning Make a claim about why igneous rocks are the best type of rock sample for radiometric dating. Support you claim with evidence, and explain your reasoning.

7 Describe How old is Earth and how did scientists find this out?

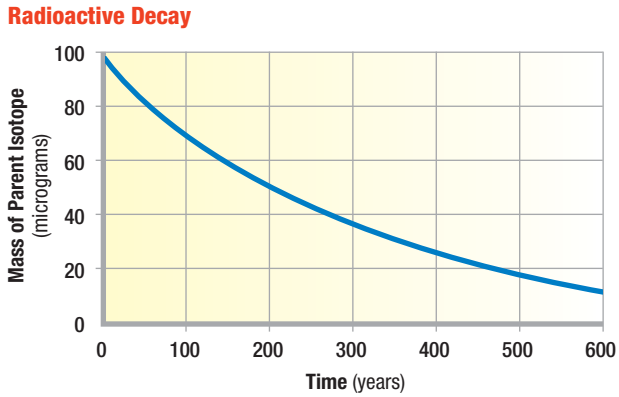
8 Explain What are index fossils and how are they used to determine the absolute age of sedimentary rock?

Critical Thinking

9 Claims • Evidence • Reasoning An igneous rock sample is about 250,000 years old. Make a claim about whether you would use uranium-lead radiometric dating to find its age. Summarize evidence to support your claim and explain your reasoning.

10 Calculate A sample of wood contains 12.5% of its original carbon-14. What is the estimated age of this sample? Show your work.

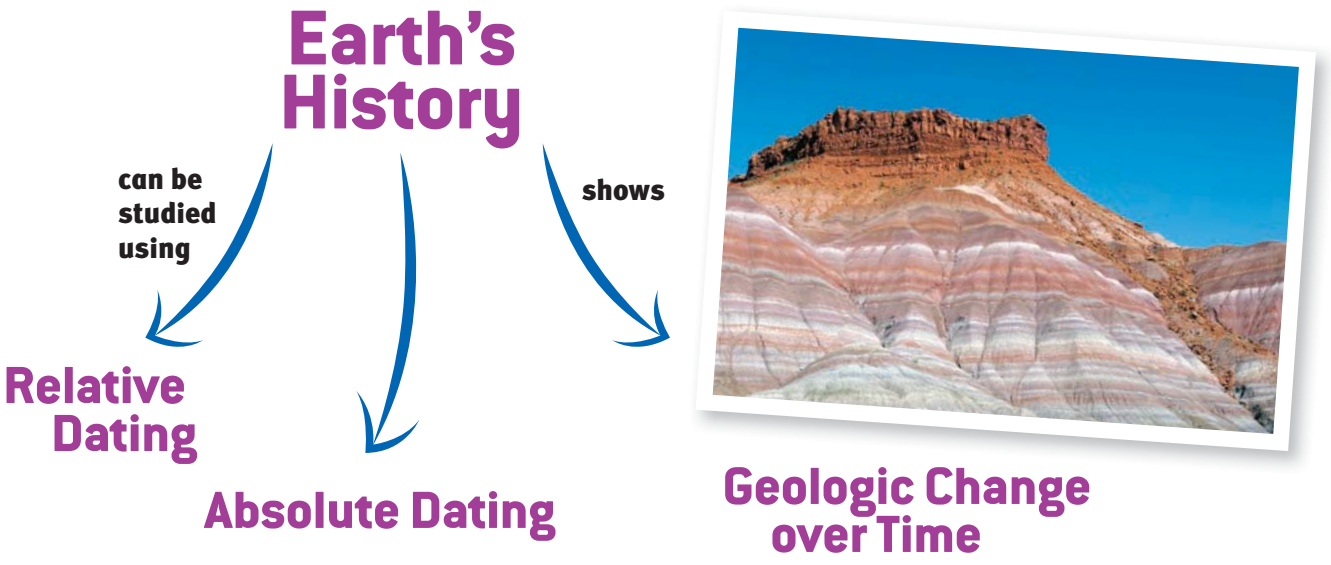
Use this graph to answer the following questions.



11 Analyze What is the half-life of the radioactive isotope? Explain your reasoning.

12 Analyze What mass of radioactive isotope will be left after three half-lives? Explain your reasoning.

UNIT 3 Summary



1 Claims • Evidence • Reasoning As shown in the Graphic Organizer above, both relative and absolute dating are used to study Earth's history. Make a claim about how both techniques could be used together to date igneous and sedimentary rock that are found together. Summarize your evidence to support your claim and explain your reasoning.

2 Apply How can scientists determine the age of Earth?

3 Relate What does sedimentary rock tell us about past environments on Earth?

Benchmark Review

Name _____

Vocabulary

Fill in each blank with the term that best completes the following sentences.

1 A _____ is the remains of a once-living organism found in layers of rock, ice, or amber.

2 The time required for half the quantity of a radioactive material to decay is its _____.

3 _____ is the theory stating that Earth's lithosphere is made up of large plates that are in constant motion.

4 _____ is the process in which a radioactive isotope tends to break down into a stable isotope.

5 _____ is the scientific study of the origin, physical history, and structure of Earth and the processes that shape it.

Key Concepts

Identify the choice that best completes the statement or answers the question.

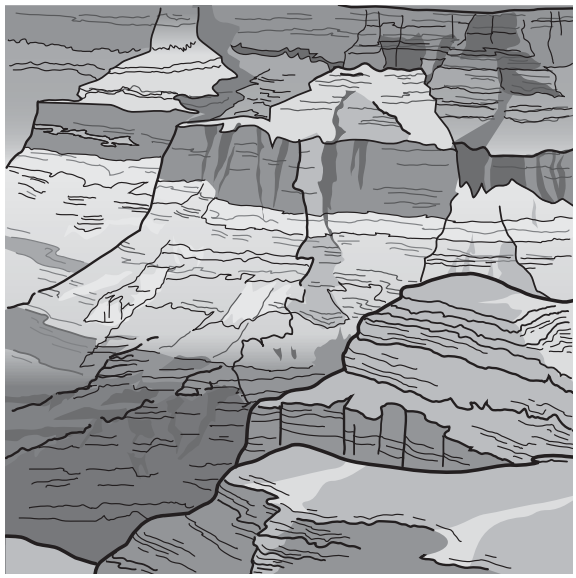
6 A trace fossil includes no physical remains of the organism's body but only a mark or structure that the organism left behind. Which of these choices is not an example of a trace fossil?

A footprint in sediment
B coprolite in sediment
C burrow in the sea floor
D insect in amber

7 Weather is not the same as climate. What is the main difference between these two concepts?

F The main difference is how both are measured.
G Only weather includes information about the temperature.
H Only climate includes information about the precipitation.
I The main difference is the length of time over which both are measured.

8 Ava visited the Grand Canyon. She was very impressed by the rock formations and decided to sketch them. This figure shows what she drew.



What type of rock did Ava see?

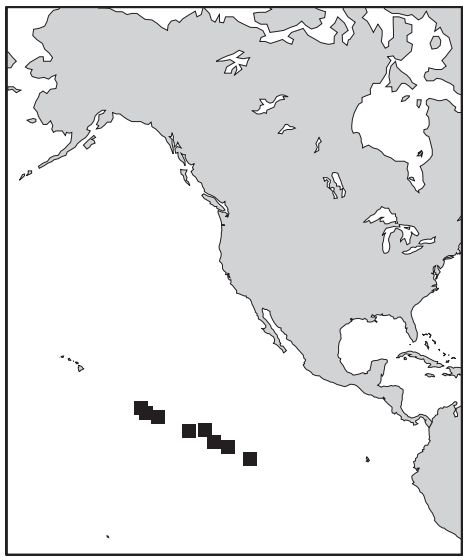
A fossilized

B igneous

C metamorphic

D sedimentary

9 A team of scientists is searching for specimens to understand how Earth's climate has changed in the past. The black boxes in the figure below show where this team has drilled to obtain such specimens.



What were these scientists drilling for?

F ice cores

G surface landforms

H sea-floor sediments

I fossils preserved in amber

Name _____

10 Tiny fossils provide evidence that life on Earth began at least 3.5 billion years ago. According to this fossil evidence, about how old was Earth when life first appeared on the planet?

A 4.6 billion years
C 2.3 billion years
B 3.5 billion years
D 1.1 billion years

11 A team of geologists compared the rock layers found in Florida to those found in northwest Africa. They placed all of the rock layers from the two regions in order from youngest to oldest. What did the team make?

F a geologic record
H a geologic column
G a fossil reference
I a topographic map

12 Jacob has one older brother and one younger sister. He wants to explain relative dating to them using their ages as an example. Which of these statements describes their ages using relative dating?

A Their ages are 14, 12, and 9.

B They are all about the same age.

C The boys have different ages than the girl.

D Jacob is younger than his brother but older than his sister.

13 Basalt is a gray or black igneous rock. Pilar uses an absolute dating method to study a sample of basalt. What will the method help her learn about the basalt sample?

F the age of the sample

G the composition of the sample

H the physical structure of the sample

I the geographic distribution of the sample

14 Scientists have determined an approximate age for Earth. To do this, they tested samples of meteorites, rocks from the moon, and rocks from other parts of the solar system. Which method could be used to determine the age of these samples?

A radiocarbon dating
C sedimentary rock dating
B index fossil dating
D uranium-lead dating

15 Which type of evidence acts as a record of changes in species over time and indicates major changes in Earth's surface and climate?

F fossil record

G movement of continents

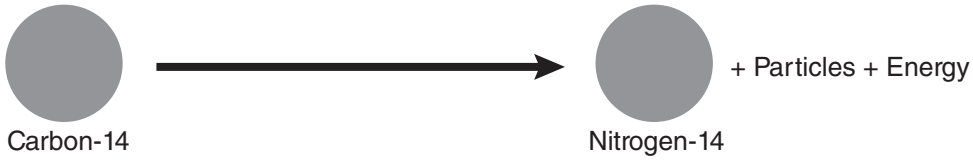
H ripple marks and mud cracks

I composition of ice core samples

Critical Thinking

Answer the following questions in the space provided.

16 Scientists study how radioactive isotopes in rocks, such as carbon-14, decay to tell the age of the rock.



Does knowing the half-life of Carbon 14 help scientists determine the absolute or relative age of a rock? State your claim. Use evidence to support your claim and explain your reasoning.

17 Explain how fossils and other materials can tell us about the conditions of an area at the times it existed. Then explain how you could find the ages of these fossils and other materials.