Lesson 1

Essential Question

What Is the Geologic Column?

Preview Lesson Content

Read the objectives with students, and help them pronounce each term in the vocabulary list.

Explain

Rock Layers

Objectives

- Describe how rock layers are deposited and change over time.
- Describe the geologic column.

Set Goals

As students study the lesson, point out the three aspects of the geologic column (rock layers, fossils, and time inferences) that will be covered in this section. Help them discover that the three orange headings correspond to these aspects.

Develop Key Vocabulary

strata Explain that *strata* is a Latin word meaning "layered" and refers to the layered arrangement of the rocks in the geologic column.

lithification The term comes from the Greek word *lithos-*, meaning "rock." Explain that this term refers to the way in which sediments become cemented together to form rock layers.

geologic column Remind students that this term is a compound word. Help students understand the word parts. *Geo-* means "Earth" and *-logos* means "study of." A *column* is a vertical stack and refers to the rock strata. So the *geologic column* is the study of the layers of rock that make up our Earth.

Lesson 1

Objectives

- Describe how rock layers are deposited and change over time.
- Describe the geologic column.
- Distinguish between the major types of fossils.
- Explain the relationship between the geologic column and time.

Vocabulary

strata
lithification
geologic column
fossils
index fossil
Precambrian
Paleozoic
Mesozoic
Cenozoic
eons
eras
periods
relative age
relative dating
radiometric dating

Essential Question

What Is the Geologic Column?

Rock layers found all around the world are filled with clues about creatures that lived in the past. What ideas have you heard to explain why some of these creatures are not here anymore? How does a scientist's worldview influence his or her interpretation of the data in the rock layers?

Rock Layers Explain

Rock layers, or **strata**, usually form when sediment is carried along by moving water. When the water slows down, the largest pieces are deposited first followed by increasingly smaller sediment.

Sediments become cemented together and harden into rock layers during **lithification**. The chart below lists some rocks formed by lithification.

Kind of Rock	Interpretation of Formation
Limestone	Mostly formed from the remains of living organisms (like broken seashells)
Sandstone	Often formed in flowing water
Mudstone and Shale	Formed from fine clay particles settling out in quiet water
Conglomerates	Deposited by high-energy flows

Strata are usually laid down horizontally, but they do not always remain in horizontal layers. As you know, the movement of tectonic plates can cause earthquakes, volcanoes, and mountain building. As these processes happen, along with weathering, erosion, and deposition, rock formations change. The evidence left behind provides clues that scientists can study to solve the mystery of the rock's history. What evidence do you think scientists study, and what do they learn?

The rock layers and the fossils found in them make up what we call the **geologic column**. Most of the geologic column is buried out of sight, but where sections of it are visible, people have discovered millions of fascinating fossils.

Science Background

Visible Column Most layers of the geologic column are buried out of sight, but there are places where sections of it are visible and can be studied. There is no one place where all the layers are visible at once, but in the western United States some formations representing the major sections of the geologic column are visible in a series of rock formations stretching all the way from the Grand Canyon in Arizona to Bryce Canyon National Park in Utah. It is called the Grand Staircase.

Structured Inquiry

Discover

Record your work for this inquiry. Your teacher may also assign the related Guided Inquiry.

Science Journal

Putting It Together

How do scientists use fossil bones to reconstruct animals?

Materials
- envelope with fossil bones
- glue or tape
- colored pencils

Procedure

1. For this inquiry, imagine you are an archeologist working at a dig site. Get an envelope from your teacher. Remove three fossil bones from the envelope without looking at the remaining bones in the envelope. These are the first three bones you discover at the dig site! Spend five minutes trying various combinations to fit them together. In your ***Science Journal***, draw your arrangement of the three bones. **Infer** what the animal might be.
2. Your dig site yields three more bones. Remove three more fossil bones from the envelope. Spend five minutes examining your new finds. Try to incorporate them into your **model** fossil reconstruction of the mystery animal. Draw your arrangement of the six bones.
3. It's the last day of the digging season. A teammate finds three more bones. Take three more bones from the envelope. Incorporate your team's latest finds into the **model**. You may wish to glue or tape the bones of the skeleton in place in your ***Science Journal***. Draw your arrangement of the nine bones. **Record** what you think the animal is now.
4. Use colored pencils to make a drawing of your fossil **model** as it might have appeared when the animal was alive.

Analyze Results

Compare your **model** with those of two other teams. **Communicate** any differences among the reconstructions. What might account for the differences?

Create Explanations

1. How do scientists use fossil bones to reconstruct animals?
2. What might account for differences in scientists' interpretations of the fossil record?
3. Looking at the assembled fossil, what can you infer about this animal?

Inquiry Extension

Extend

Geological Dig Experience

Guided Inquiry

How can you excavate buried fossils?

Extend the Structured Inquiry activity by having student teams bury animal bones or a small model or actual fossils in layers of clay or sand in a shoebox.

Teaching Tip Have students exchange their dig sites with another group. Remind students to keep careful records and measurements.

Students may record their work in their ***Science Journals.*** A scoring rubric can be found as an ***Online Teacher Resource.***

Discover

Structured Inquiry

Putting It Together

How do scientists use fossil bones to reconstruct animals?

Preparation and Tips

You will find model bones for this fossil dig exercise in the Blackline Masters at the end of your ***Teacher's Edition.*** Copy the page and cut the bones apart. Place a set in separate envelopes for each group.

Predict **How will your fossil bone arrangements change as you gather more data?**

Science Journal

Have students use their ***Science Journals*** to record their work for this inquiry.

Inquiry Practice Tip

Infer When you infer, you use hints or clues to read between the lines and draw conclusions about events that you have not seen happen. Inferences are based on your experience.

Expected Results

Students may come up with different results depending on what their assumptions were. It's okay if their interpretations are different as long as they have supporting evidence.

Create Explanations

1. Sample answer: The fossil record is like putting together a jigsaw puzzle. Scientists use the available pieces to begin reconstruction of features in the past. They use the same approach to reconstruct fossils.
2. Sample answers: Differences might be based on which bones were examined first, what clues were available, their worldviews, and what assumptions they make.
3. The type of rock in which the bones are found provides clues about the environment in which the animal lived.

Explain

Fossils

Objective

- Distinguish between the major types of fossils.

Develop Key Vocabulary

fossil Explain that *fossil* comes from the Latin word *fossilus,* meaning "to dig." Hence, it refers to the preserved remains of past life forms that are dug up.

Scripture Spotlight

Genesis 7:21–23 describes the death of the creatures that died in the Flood. Many were preserved as fossils.

Teach Science Concepts

Explain that geologists work like detectives to study the rock layers in the geologic column. The sequence of rock strata is used to work out the history of the area. **What might cause other disturbances in the rock layers?** Sample answers: earthquakes or volcanic eruptions

If possible, find animations on the Internet that show the processes of sedimentation and lithification, or about relative dating, to share.

Understand Visuals

What evidence suggests that this reptile may have lived in water? the shape of the body and the webbing of the paddle-like limbs

Lifestyle Challenge

Encourage students to continue their Lifestyle Challenge. Remind them to record their progress, and think about how a healthful lifestyle honors God.

Reminder

Scripture Spotlight

What does **Genesis 7:21–23** describe, and how is it related to what you've been reading?

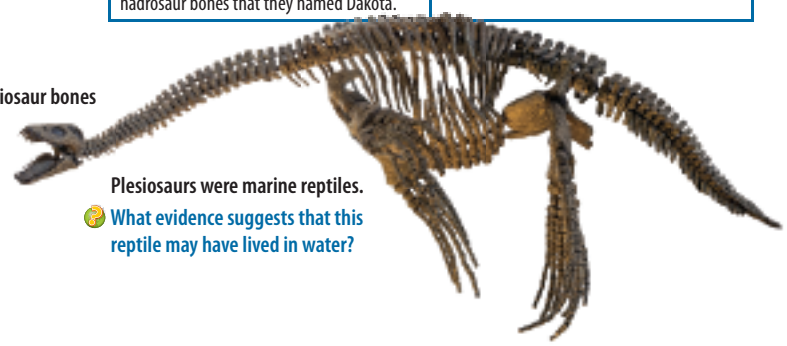
Fossils Explain

Usually when a living organism dies, it decomposes. However, if an organism is buried rapidly before it can decompose, there is a chance it may be preserved. These preserved remains are called **fossils**. Scientists understand that most types of animals are fossilized fairly quickly or not at all. This is especially true if the fossil has preserved soft tissues—like muscle or skin—implying that the animal was buried very rapidly and its remains became mineralized rather than decomposing. In experiments, some types of fossils have been made in the lab in a year or less. Why do you think preservation of a fossil would have to happen quickly?

The following chart details some of the types of fossils scientists find.

Types of Fossils	
Body Fossils	**Trace Fossils**
Preserved remains of animals or plants	Evidence (or traces) of an organism's behavior or activities
Actual Remains	**Footprints and Trails**
Bones and shells are the most common types of fossils. Woolly mammoth fur, skin, and other body parts are sometimes found preserved in ice. Insects can be found preserved in fossilized tree resin called *amber*. A plesiosaur, a marine reptile with a long neck and flippers, was found in tar sands in Alberta, Canada. In North Dakota, scientists found mummified hadrosaur bones that they named Dakota.	Footprints give clues about: • The size of the organism that made them. • Whether it walked on two or four feet. • How quickly or slowly it moved. Trails provide similar clues about snakes, worms, and other footless creatures.

amber



Plesiosaur bones

Plesiosaurs were marine reptiles.

What evidence suggests that this reptile may have lived in water?

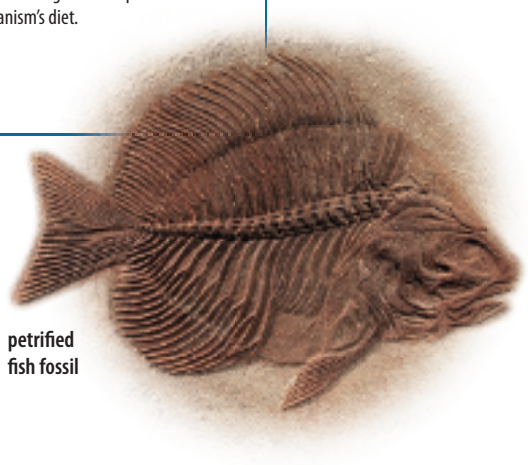
English Language Learners

Affixes Extend the lesson on word meanings and affixes. Explain that the prefixes *micro-,* meaning "tiny," and *macro-,* meaning "large or large-scale," and the suffix *zoic-,* meaning "animal life," are found in terms (microfossils, macrofossils, Paleozoic, Mesozoic, and Cenozoic) used in this lesson. They can also be used to form other words. Have students suggest other words with these affixes and discuss their meanings. They may identify: *micro-* in *microscope, microwave, microphone, microbe, microfilm,* and *microcosm, macro-* in *macrocosm, macrobiotic, macron,* and *macrophage*, and *zoo-* in *zoology, zoological, zoophyte,* and *zooplankton*.

Types of Fossils	
Petrified Fossils	**Burrows and Borings**
When an organism's soft parts are mineralized, they are said to be petrified. Entire petrified trees were found in Petrified Forest National Park in Arizona. Tiny arthropods are beautifully preserved in 3-D in the Orsten fauna in Sweden.	Burrows are holes or small tunnels made by worms and other organisms that lived in mud or soft sand. Borings are holes or tunnels made by organisms that lived in wood or other hard materials. Burrows and borings provide clues about the size of the organisms that made them and sometimes about their feeding habits.
Fossilized Eggs and Fossilized Nests	
These provide evidence about: • The number of offspring an adult may have produced. • The size of the young. • How their parents may have taken care of them.	
Fossil Molds and Casts	**Fossilized Wastes**
A mold is the impression left in sediment by a body part, such as a shell, that is preserved (the body part disappears). A cast forms when a fossil mold becomes filled with minerals or mud.	Coprolites are fossilized dung that often contains bits of other organisms' bones, teeth, or shells. Gastroliths are fossilized gizzard stones that are sometimes found among reptile bones. Coprolites and gastroliths provide clues about an organism's diet.
Carbon Films	
Carbon forms very thin sheets that were once a part of a plant or animal.	

petrified ammonite fossil

fossilized egg



petrified fish fossil

petrified wood

Science Background

Finding Dakota In 2007, a 16-year-old fossil hunter named Tyler Lyson discovered a mummified dinosaur on his uncle's farm in the Hell Creek Formation in North Dakota. The most intact dinosaur mummy to date, 7.5-m (25-ft)-long "Dakota" included not just bones, but fossilized soft tissues like skin, tendons, and ligaments. It is the first-ever find of a dinosaur where the skin "envelope" had not collapsed onto the skeleton, which has allowed scientists to calculate muscle volume and mass for the first time. When you have skin remains, you can begin to figure out what the volume of muscles under the skin might have been. Then, you can determine how fast or strong the dinosaur was.

Teach Science Concepts

Have students use the charts and the images to identify different kinds of body and trace fossils and the kinds of information they provide about past life. Point out that a lot of the information scientists obtain from fossils must be the result of inferences and interpretation of the solid evidence. **How do footprints provide information about the size of the organisms that made them?** Scientists can measure the size of the prints and compare them with the size of the prints of similar organisms living today to figure out the size of the animals that made them. **What about speed?** The distance between tracks can indicate whether they moved quickly or more slowly. **What details can scientists learn from mummified remains, molds, and casts?** They can learn something about the texture of the skin, whether the animal had scales, hair, or feathers, patterning of the animal's hide, and possibly the colors of the skin and hair.

Understand Visuals

Have students continue to examine the charts to identify the kinds of information different fossils provide. **What can be learned from fossil animal burrows and tunnels?** Sample answer: the size of the animal, how the animal might have moved, whether the animal lived in a marine or aquatic environment

Incorporate Inquiry Practice

Practice: Classify Invite interested students to go on an outdoor fossil hunt. With your class, take a walk and hunt for fossils. Students may wish to bring a magnifying glass for observation. Fossils are often found in sedimentary rock areas. You can sometimes find fossils on lake or ocean shorelines. Look for areas that are lighter or darker colored than the rest of the rock. Even a small piece of gravel from the playground is a potential source of fossils. Have students try to identify and classify their discoveries and share them with the class.

Explain *(cont.)*

Studying the Layers

Teach Science Concepts

Point out that a coprolite is preserved animal dung that has hardened and turned to stone, while gastrolithes are small pebbles that birds and other animals without teeth swallow in order to help break apart tough plant matter. Ask students to recall the owl pellets they dissected earlier in Grade 5. **Why might scientists be interested in coprolites and gastrolithes?** The bits of undigested bone, teeth, or shells inside a coprolite would provide evidence about an animal's diet, while the gastrolithes would provide information about the kinds of foods an animal ate. **Why would finding nests with fossilized nestlings be important?** It suggests that some animals cared for their young and did not simply lay the eggs and leave.

Understand Visuals

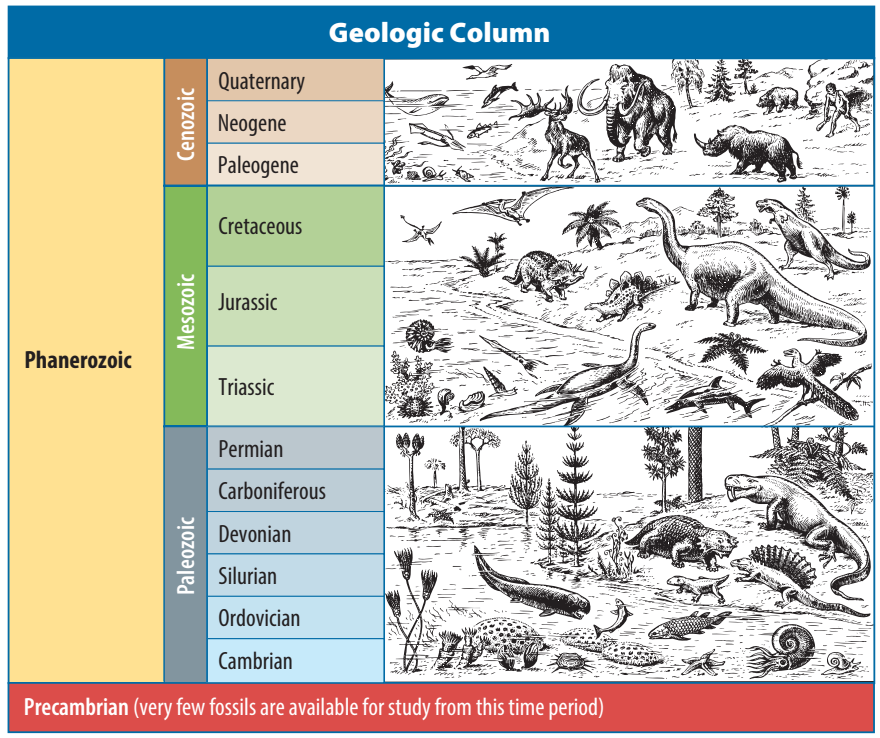
What factors do you think scientists used to separate the Paleozoic, Mesozoic, and Cenozoic eras? Sample answer: They used sections of the rock layers with large amounts of fossils (mass extinctions).

Incorporate Inquiry Practice

Practice: Model Have students use candy molds to model the difference between mold and cast fossils. Students can make candy or simply use clay. If using clay, line the molds with petroleum jelly or mineral oil to prevent sticking. After they make their model fossils, ask students to identify which is the mold (the candy mold) and which is the cast (candy). Once students finish the activity, have them research fossil molds on the Internet. They should develop several points of interest about their subject and be prepared to share the information with the class.

Studying the Layers **Explain**

While William Smith (1769–1839) was supervising the digging of the Somerset Canal in England, he observed that the same kinds of fossils always occurred in a specific order in the rock layers. He used his observations to support the *law of superposition*, which states that newer layers form on top of existing layers. Using this approach, he could successfully predict the type of fossils that would be found above or below any layer he was studying. What scientific skills helped Smith in his work?



Scientists separate geologic column into intervals based on the appearance and disappearance of fossils from the rock record.

What factors do you think scientists used to separate the Paleozoic, Mesozoic, and Cenozoic eras?

Science Background

A Fast Runner It is believed that Dakota's backside is some 25% larger than once thought, which means it might have been able to run about 45 km /hr (28 mi/hr)—faster than the top human sprinters and faster than T-Rex. Dakota contains actual rust-brown mineralized skin complete with microscopic cell-like structures, and it appears that his skin may have been striped. Phillip Manning, a paleontologist at University of Manchester in England, and his team of researchers published their findings about Dakota in 2009. As of 2011, Tyler Lyson was working on his PhD in paleontology at Yale.

Using Smith's principles, Sir Roderick Murchison (1792–1871) carefully collected fossils from different layers. He found that the fossil communities changed as he worked his way down through the layers of rock in Wales. Later, he was invited by the czar to study the fossil communities in Russia. Murchison began to believe that the same sequence of fossil communities was preserved throughout the world. This specific order of fossils is observable data, and other geologists have confirmed Murchison's idea that the same pattern is consistent in the rock layers throughout the world. Fossils that occur consistently in a limited portion of the geologic column, but are abundant and widespread in that limited portion are called **index fossils**.

The lowest section of the geologic column, the **Precambrian**, contains microfossils, but relatively few macrofossils. *Microfossils* are the remains of small organisms—such as bacteria and protists—that can only be studied using a microscope. *Macrofossils* are larger and visible without a microscope.

Above the Precambrian layers, in a subdivision called the **Paleozoic**, various marine fossils are found. These animals include trilobites and fish. In addition, scientists have found amphibians and huge dragonflies with a wingspan of nearly a meter (3 ft). Near the top of the Paleozoic layers, some fossils of land animals appear. A high percentage of fossils found in these lower layers are creatures that are now extinct.

Above the Paleozoic are the **Mesozoic** layers, which contain a mixture of fossils from marine animals, land animals, and some birds. The most well-known animals in these layers are the dinosaurs.

Above the Mesozoic are the **Cenozoic** layers, which contain fossils from many land animals and birds. Among the interesting animals found in these layers are saber-toothed cats, tiny horses, beavers 2–3 m (6–8 ft) tall, woolly mammoths, and sloths the size of elephants. Why do you think the percentage of fossils of creatures that are still alive today increases as you go up the geologic column?

When scientists speak of the *fossil record,* they refer to the fossils, their placement within the strata, and the information that can be derived from them. Rock layers and the fossils found in them are observable data. Some of the data show very clearly that major changes have occurred during Earth's history. Fossil whalebones have been found in deserts. Fossil seashells have been found on mountaintops all over the world. Fossils of broad-leafed evergreen plants that grow in tropical forests have been found in Alaska.

Scripture Spotlight

Read about the Rock of Escape in **1 Samuel 23:19–28**. See how many references you can find to a rock in Psalms.

Science Background

Differing Opinions There seems to be disagreement about how many microfossils there are in the Precambrian rock layers. While it has been suggested that there are millions of microscopic fossils, paleontologists exercise caution about claims of authenticity and even use the terms *pseudofossil* and *dubiofossil* to describe false or dubious fossils. There is agreement, however, about the authenticity of the Ediacaran fossils found near the top of the Precambrian layers, even though paleontologists do not know exactly what kind of creatures these complex, unique, multicelled organisms were. Above the Precambrian, the Phanerozoic is called the "age of visible life" for good reason, as it contains many millions of fossils.

Develop Key Vocabulary

index fossil Explain that the word *index* is a Latin word that means "anything that points out." The word *fossil* is from the Latin word *fossilis*, which means "dug up."

Precambrian The affix *pre-* means "before." This time in history comes before the Cambrian period.

Paleozoic The affix *paleo-* means "ancient." Point out the common suffix of each term on this page, *-zoic*, meaning "animal life."

Mesozoic The affix *meso-* means "middle." The Mesozoic era is used to refer to the middle rock layers or "middle animal life."

Cenozoic The affix *ceno-* means "recent." The Cenozoic era refers to "recent life."

Scripture Spotlight

1 Samuel 23:19–28 describes a dramatic rescue experienced by David in the wilderness. He named the place Rock of Escape. David describes God as a rock many times, including in **2 Sam. 22:47** and **Ps. 31:2, 62:7, 89:26, 94:22,** and **95:1.**

Teach Science Concepts

Explain that the order of the fossil record was also confirmed by oil companies via core samples. Even when certain layers are missing in specific locations, those strata that are present still lie one above another in correct sequence unless mountain building or faulting has clearly disturbed them.

Why do you think the percentage of fossils of creatures that are still alive today increases as you go up the geologic column? Sample answer: Certain environmental conditions that were needed for life no longer existed after the Flood for terrestrial vertebrates from the Paleozoic and Mesozoic, so they became extinct.

Explain *(cont.)*

Time Inferences

Objective

- Explain the relationship between the geologic column and time.

Develop Key Vocabulary

eon Explain that *eon* comes from the Latin word *aeon* as well as the Greek word *aion*, which means "a period of existence."

era Explain that *era* comes from the Latin word *aera*, which means "an era or epoch from which time is reckoned."

period Explain that the word *period* comes from the Greek word *periodos*, which means "period of time."

relative age Explain that the word *relative* comes from the Latin word *relativus*, which means "compared to each other."

relative dating Explain that relative dating is based on the sequence of rocks and the fossils within the rock strata.

Teach Science Concepts

Help students understand that the geologic column by itself is not particularly evolutionary. The rocks and fossils are data that can be interpreted multiple ways. While it has come to be closely associated with millions of years, that is an interpretation of the data based on a certain worldview. In the same way, a scientist who believes the Bible will interpret the data based on his or her worldview.

Understand Visuals

How do scientists divide time in the geologic time scale? Scientists divide time in segments that span millions of years. The longest division of time is an eon, followed by era and period.

Time Inferences **Explain**

The geologic column has come to be closely associated with millions of years of evolutionary history, but it was not that way at first. Most of the scientists who first described and published the relationships between the layers and the fossils believed in the biblical account of Earth's history.

Sometimes the names they assigned to the parts of the geologic column reflected characteristics of the rock layers themselves, like the *Cretaceous* (which means "chalky") or the *Carboniferous* (because of the carbon in the coal found there). Often layers were named after the places where the fossils were first described. The *Jurassic* was named for the Jura Mountains of Switzerland, and the *Permian* was named for the town of Perm in Russia where scientists first described the fossils found in these layers. It was only later that the long ages suggested by some scientists influenced the interpretation of the geologic column. The reason for the fossil sequence and the time span associated with it came to be associated with the newest scientific theory—evolution. As individual layers were grouped into larger categories, they were given names with time connotations.

Now the geologic column is referred to as the geological time scale and uses divisions called eons, eras, and periods.

An **eon** is the longest division of geologic time. There are four eons—Phanerozoic, Proterozoic, Archean, and Hadean. Eons are divided into **eras**, which are still long periods of time, but shorter than eons. For example, the Phanerozoic eon is divided into three eras—Cenozoic, Mesozoic, and Paleozoic. Each of these three eras contain at least three periods. A **period** is the basic unit on the geologic time scale.

Geologic Time Scale

Eon	Era	Period
Phanerozoic	Cenozoic 0–65 Ma	Quaternary
		Neogene
		Paleogene
	Mesozoic 65–250 Ma	Cretaceous
		Jurassic
		Triassic
	Paleozoic 250–540 Ma	Permian
		Carboniferous
		Devonian
		Silurian
		Ordovician
		Cambrian
Proterozoic eon 540–2500 Ma		
Archean eon 2500–4000 Ma		
Hadean eon 4000–4600 Ma		

"Ma" is an abbreviation for *mega-annum*, or one million years.

A breakdown of the geologic column with the estimated time periods used by conventional geologists.

How do scientists divide time in the geologic time scale?

Science Background

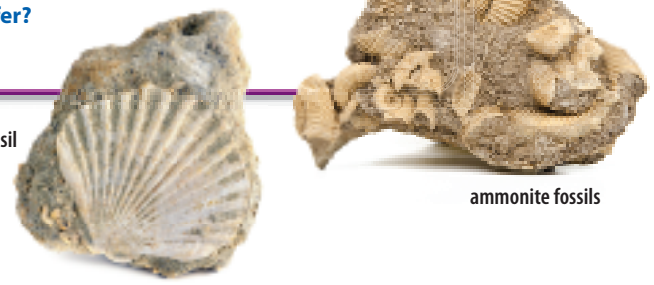
Cambrian Explosion A well-known feature of the Cambrian layers is the Cambrian Explosion, which is the sudden appearance without obvious ancestors of fossils from most of the major phyla. This is a problem for the theory of evolution, because according to it, we should find fossil animals that demonstrate the slow, gradual development from one animal to another. An interpretation proposed by those who believe in the biblical Flood suggests that the Cambrian Explosion is not a record of the first appearance of life, but instead the first burials during a catastrophe.

For more information about the Cambrian Explosion, you might want to watch the video *Darwin's Dilemma* by Illustra Media.

Lesson Activity

Choose two eras and compare them. You may wish to use a graphic organizer, such as a Venn diagram, for this activity. Remember to include details on the types of plants and animals that lived in that time.

How do the fossils of two different eras differ?



shell fossil

ammonite fossils

Study the chart below. Notice how the meanings of the words Cenozoic, Mesozoic, and Paleozoic include the idea of time. Lower layers are considered *older* than higher layers because they were laid down earlier. How does this help in classifying fossils?

	Prefix	Suffix	Meaning
Cenozoic	Ceno = recent	Zoic = animal life	Recent animal life
Mesozoic	Meso = middle	Zoic = animal life	Middle animal life
Paleozoic	Paleo = old	Zoic = animal life	Old animal life

Scientists often refer to the age of one layer in relation to another. **Relative age** is the age of a rock or formation in relation relative to other rocks or formations, usually defined as a zone fossil name. **Relative dating** is the science of determining the relative order of past events, without necessarily determining their absolute age. But just by looking at the layers, we cannot tell how much older one layer is than another. Were the layers deposited millions of years apart or only years, months, or even days apart?

Science Journal

Check out your ***Science Journal*** for a Structured Inquiry exploring how fossils can be classified.

Extend

Science Background

There are two kinds of dating associated with the geologic column. Relative dating simply recognizes the order in which a series of events happened. It makes sense that a lower layer had to have been deposited before a higher layer. The lower layer may be thought of as older while the higher layer may be thought of as younger. In the same way, an earthquake fault that cuts through rock layers would be considered younger than the rocks through which it cut. Talking about certain rocks as older than others does not automatically imply millions of years. Absolute dating seeks to establish actual dates for different rock layers, and scientists do come up with millions of years using radiometric dating. Although a number of lines of scientific evidence seriously challenge the long ages suggested by radiometric dating, Creationists do not have a satisfactory explanation for the ratios at this time.

Lesson Activity

Provide Venn diagram templates for students who need extra support. Students may wish to use a two-column table instead.

How do the fossils of two different eras differ? Students should notice some changes in structure and include examples of the plants and animals from each era.

Extend

Use the inquiry activities as an opportunity for students to perform hands-on investigations and think like a scientist.

Stories in Stone

What information do fossils provide?

Preparation and Tips

Prepare the plaster of Paris so that it is the consistency of a thick milkshake.

Predict **What information do fossils provide?**

Science Journal

Have students use their ***Science Journals*** to record their work for this inquiry.

Inquiry Practice Tip

Compare Have students compare the fossils made in this activity with the real fossils pictured in the lesson. Students should draw a Venn diagram to show similarities and differences.

Expected Results

Students will be able to compare the different types of fossils.

Create Explanations

1. Sample answers: behavior and activities of the organism, size, and feeding habits of the organism
2. Answers will vary.
3. A mold forms first. It is an impression in the sediment. Then, mud fills the mold and forms a cast.

Explain *(cont.)*

Develop Key Vocabulary

radiometric dating Radiometric dating is a way to date materials, such as rocks, and is based on the decay of radioactive atoms in the materials.

Teach Science Concepts

Before students read the section on relative dating, have them perform an ice cube activity. Give each student an ice cube in a bowl. They should watch the ice cube melt throughout the day. You can be as formal or as informal as you wish. Students could measure, estimate, or draw how much has melted after timed intervals. If you do this informally, discuss how they measured the changes in the ice. Students should notice that the ice changes to a puddle of water over time. Then, it will be easier for them to visualize something gradually changing over time in a way that can be measured.

Atoms of the same element that have different atomic masses are called isotopes. A radioactive isotope is an isotope that changes from one isotope (the parent isotope) to an isotope of another element (the daughter isotope) as it loses particles from its nucleus. Most radioactive isotopes have rapid rates of decay (and short half-lives). But others decay more slowly, and several of these are the ones used as geologic clocks.

Explore-a-Lab — Structured Inquiry

Provide sandwich fixings, paper plates, and plastic knives. Allow students to assemble the sandwich fixings in any order that makes sense to them.

How can you use a sandwich to apply the principles of relative dating? Sample answer: The materials that were placed first on the plate are older than the layers on top. This holds true for rock layers as well as sandwiches. Clues might include where the dressing or the pickles (fossils) were placed. Any cuts (or faults or magma) must be younger than the sandwich (rocks) through which they intrude.

Scientists have attempted to assign actual dates to the rock layers using a process called **radiometric dating**, also called absolute dating, is a method of dating that compares the relative proportions of particular radioactive isotopes present in a sample. Certain elements that occur in nature decay predictably over time, changing from what we call a parent isotope to what we call a daughter isotope. The more time that passes, the less parent isotope is left and the more daughter isotope there is. Scientists know the half-lives of various elements. They can compare the ratio of parent isotopes to daughter isotopes in an attempt to figure out the age of the rock layers. How does this help in dating rocks and fossils?

While the ratios of parent isotopes to daughter isotopes are actual data, the interpretation of those ratios as millions of years conflicts with both the biblical history of Earth and scientific evidence that is difficult to explain if the layers were really laid down over millions of years. Short-age geology predicts that there are more discoveries to be made about radiometric dating and that these discoveries will shed light on why these ratios indicate time spans that conflict with the chronological information found in the Bible.

The geologic column, which includes both the rock strata and the fossil record, is observable data. The time inferences associated with the geologic column are interpretations of that data, which are influenced by the worldview of the scientists who make them. What can be done to test these interpretations?

Explore-a-Lab — Structured Inquiry

How can you use a sandwich to apply the principles of relative dating?

Work with a partner to make a sandwich from two slices of bread, sliced cheese, tomatoes, mayo or mustard, and some pickles, or any other ingredients you have. Place the first slice of bread on a plate and assemble the complete sandwich. Which layer of the sandwich was laid down first? Which one was laid down third? Record your observations by making a labeled sketch of the sandwich (model rock) layers. Flip the sandwich over. Could you tell which way was up in the sandwich layers? What clues did you use? Return the sandwich to its original position and cut it in half. Discuss with your partner: How does the timing of the cut (a disturbance in the rock layers) relate to the making of the sandwich? How would a scientist who didn't see how you created or cut the sandwich interpret what layer was laid down first? Switch sandwiches with another group. Record the order that you believe the layers in that sandwich were laid down. Why did you decide on that order?

Science and Technology

Half-Lives and Radioactive Dating In most rocks there are radioactive elements. Over periods of time, these elements break down into more stable elements. Scientists use the rate at which they do this to try to calculate the precise age of the rocks based upon the proportion of radioactive elements the rocks contain. This process is a form of absolute dating. How is this done? When a rock forms it may contain some radioactive elements. After a time known as the half-life, half of the amount of the radioactive element has decayed. After another half-life, half of the remainder has decayed. This continues until less and less of the radioactive element remains in the rock. Scientists measure this amount to calculate the age of the rock. **Do you see any flaws in this dating process?** Sample answer: No one knows exactly how much of the radioactive element was present at the beginning. They have to make assumptions, which could be wrong.

Explore-a-Lab

Structured Inquiry

How can you use pennies to model the principles of relative dating used by geologists?

Work with a partner. Cover a cup of 25 pennies and shake it. After shaking, pour out all of the pennies on the table. Heads-up pennies represent "daughter product" and tails-up pennies represent "parent product" that has not changed. Remove all "daughter product" pennies. Put the unchanged "parent product" pennies back into the cup. Use a chart to keep track of the number of pennies put back into the cup. Shake, pour onto the table, and again, remove "daughter product" pennies. How long can you continue this process until there are no more pennies left? Switch places and keep track of the half-life intervals for your partner.

Concept Check

Assess/Reflect

Summary: What is the geologic column? The geologic column is made up of many different kinds of rock layers as well as the fossils contained in them. Fossils appear in a predictable order around the world and provide evidence that major changes have occurred during Earth's history. Because time inferences have become associated with the geologic column, it is sometimes referred to as the geologic time scale.

1. Explain how rock layers are formed.
2. Define body fossils and trace fossils and give at least two examples of each.
3. Create a chart that includes the four major sections of the geologic column described in this lesson. In each section, describe the kinds of fossils found there. Be sure your chart shows the correct order of the sections.
4. What is the difference between relative dating and absolute dating? Which one is attempted using radiometric dating?

Scaffolded Questions

Approaching Level **How does relative dating differ from radiometric dating?** Relative dating is based on comparing the fossils found in the rock layers; radiometric dating is an attempt to find an absolute time scale.

On Level **Why did scientists develop a geologic time scale?** Sample answer: to divide up Earth's history into divisions based on the geological record and the sequence of fossils found in the rock strata over time

Above Level This chapter described three things in connection with the geologic column: the rock layers, fossils, and the geologic time scale. **Which of these represents data and which are based on interpretation?** Rock layers and the fossils found in them are observable data. The inferences about the time it took for the geologic column to form fall into the category of interpretation.

Explore-a-Lab

Structured Inquiry

Explain to students that there are only two possible outcomes when tossing the coins—heads or tails. Each outcome is equally likely. When shaking the cup, about half would likely be heads and half would likely be tails each time.

How can you use pennies to model the principles of relative dating used by geologists? Before students finish, point out that to demonstrate half-lives, they must have pennies that stay in play and others that decay or are taken out.

Assess/Reflect

Read the essential question and lesson summary with students. You may work through the concept check as a class, or use it as a formal assessment option.

Concept Check

1. Strata usually form when sediment—which can be carried along by water, ice, or wind—is deposited in layers and becomes cemented together and hardens.
2. Sample answers: Body fossils are the actual preserved remains of animals or plants. Examples include fossilized bones and shells. Trace fossils are preserved evidence of an organism's behavior or activities. Examples include fossilized footprints, trails, burrows, and nests.
3. Sample answers: Precambrian: Contains some microfossils but few macroscopic fossils; Paleozoic: Contains marine fossils, including trilobites, fish, and amphibians; Mesozoic: Contains a mixture of marine and land animals (including dinosaurs) and some birds; Cenozoic: Contains land animals and birds
4. Relative dating describes the age of the layers in relation to other layers. Lower layers are considered "older" than upper layers. Scientists attempt to determine actual ages using radiometric dating.