Lesson 1

Essential Question

What Is the Geologic Column?

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

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.

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?

Procedure

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

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?

Fossils **Explain**

Scripture Spotlight

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

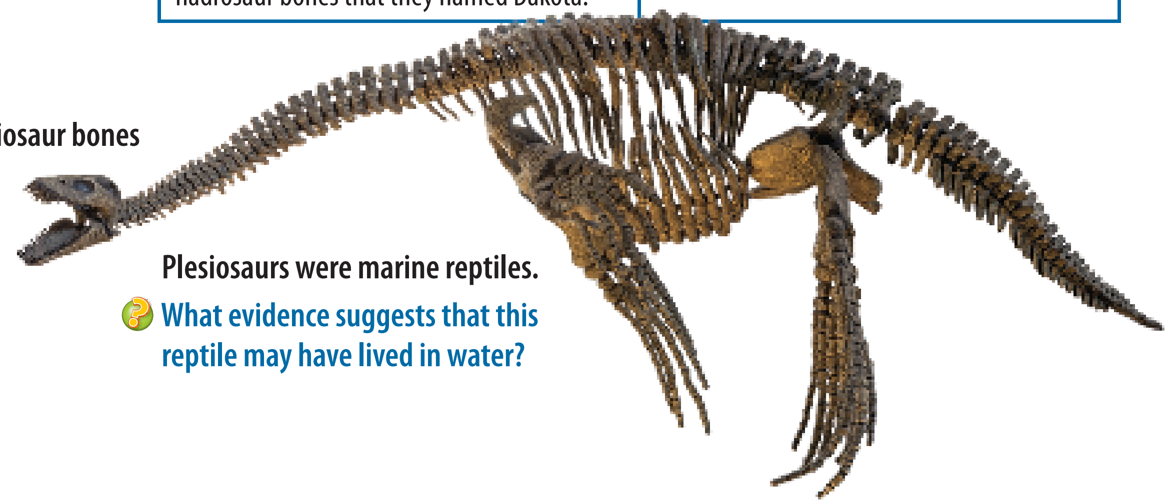
Usually when a living organism dies, it decomposes. However, if an organism is buried rapidly before it can decompose, there is a chance it may be preserved. These preserved remains are called **fossils**. Scientists understand that most types of animals are fossilized fairly quickly or not at all. This 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?

<table>
<tr><th colspan="2">Types of Fossils</th></tr>
<tr><th>Petrified Fossils</th><th>Burrows and Borings</th></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><th colspan="2">Fossilized Eggs and Fossilized Nests</th></tr>
<tr><td colspan="2">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.</td></tr>
<tr><th>Fossil Molds and Casts</th><th>Fossilized Wastes</th></tr>
<tr><td>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.</td><td rowspan="3">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.</td></tr>
<tr><th>Carbon Films</th></tr>
<tr><td>Carbon forms very thin sheets that were once a part of a plant or animal.</td></tr>
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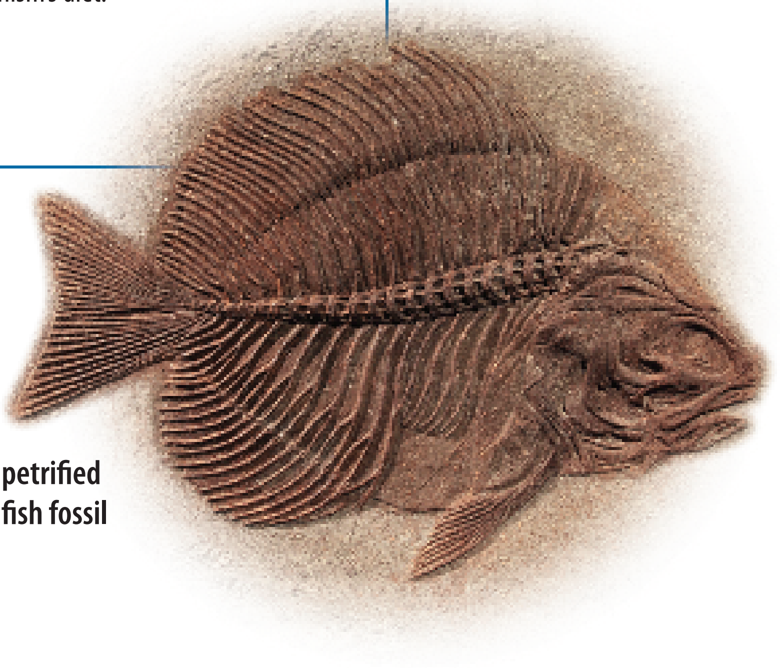
petrified ammonite fossil


fossilized egg


petrified wood

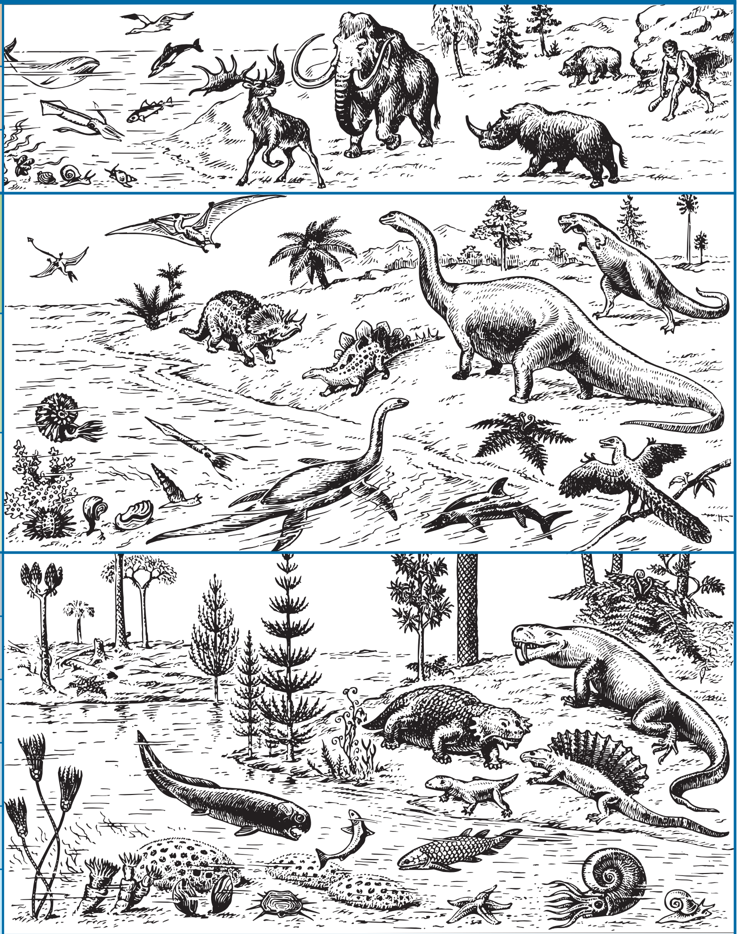

petrified fish fossil

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?

Geologic Column

Phanerozoic	Cenozoic	Quaternary
		Neogene
		Paleogene
	Mesozoic	Cretaceous
		Jurassic
		Triassic
	Paleozoic	Permian
		Carboniferous
		Devonian
		Silurian
		Ordovician
		Cambrian
Precambrian (very few fossils are available for study from this time period)		



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?

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.

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?

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

Science Journal

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

Extend

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?

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?

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?