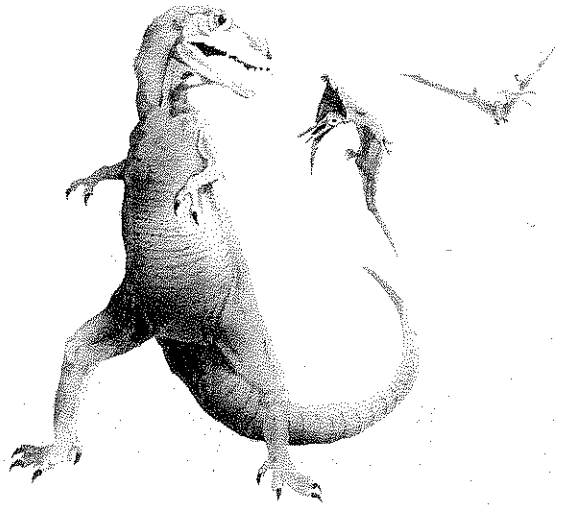
9-1 What are fossils?



Objective ▸ Describe how different kinds of fossils formed.

TechTerms

- **cast:** mold that has filled with sediments
- **fossil** (FOSS-il): remain or trace of a living thing that lived long ago
- **mold:** cavity, or opening, in a rock that has the shape of an extinct organism

Fossils Have you ever gone to a natural history museum? If you have, you probably saw many **fossils** (FOSS-ilz). Fossils are the remains, or traces, of organisms (OWR-guh-niz-umz) that lived long ago. Organisms are living things. A fossil can be a bone, a footprint, or a shell. A fossil can even be the body of an extinct (ik-STINKT) organism. Extinct organisms are organisms that once lived on the earth, but are no longer found alive. Dinosaurs are extinct organisms. Remains of dinosaurs have been found in many places.

Observe: How many extinct organisms are shown on pages 166-167? 4

Fossils in Rocks Most fossils are found in sedimentary rocks that once were under water. Fossils take millions of years to form. Only dead organisms that are buried quickly or are protected from decay become fossils. A fossil begins to form when an organism is buried by sediment soon after it dies. The soft parts of the organism decay. Only the hard parts, such as shells and bones, are left. The sediments harden into rock. The organism is now preserved, or kept, as a fossil.

Name: In what kind of rock are most fossils found? sedimentary rock

Molds and Casts Two types of fossils are **molds** and **casts.** Molds form when an organism is buried by sediments, and the sediments change into rock. The organism decays, and leaves a cavity, or opening, in the rock. The cavity is a mold. Sometimes, the mold fills with sand or muc The sand or mud hardens and a cast is formed.

Analyze: Study the fossils in Figure 1. Which is the mold? Which is the cast? mold-left; cast right

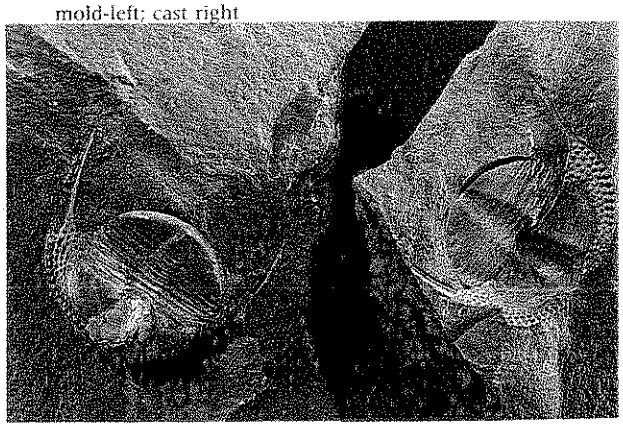


Figure 1

Imprints Some fossils are imprints. Imprint usually are made from the soft parts of organisms Scientists have found many leaf and fish imprints Some leaf imprints even show the veins of the lea Footprints also are imprints. They were mad when an animal stepped into soft mud. The mu hardened, and the footprint was preserved.

Describe: What is an imprint? trace of an organism that lived in the past

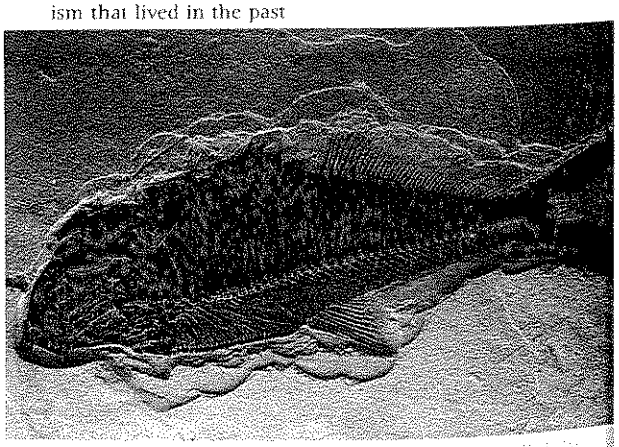


Figure 2

Name _____ Class _____ Date _____

9–1 What are fossils?

Lesson Review

Part A *Match each term in Column B with its description in Column A. Write the correct letter in the space provided.*

Column A	Column B
_____ 1. remains or traces of past life	a. imprint
_____ 2. mold filled with sediments	b. mold
_____ 3. rock cavity shaped like a once-living organism	c. extinct organism
_____ 4. organism no longer found living	d. fossils
_____ 5. footprint	e. cast

Part B *Circle the term that makes each statement true.*

1. Most fossils take (hundreds, millions) of years to form.
2. A fossil begins to form when a dead organism is buried by (sediment, water).
3. For an organism to become a fossil, it must be buried (quickly, slowly).
4. Imprints usually form from the (soft, hard) parts of organisms.
5. Molds and casts usually form from the (soft, hard) parts of organisms.

Skill Challenge

Skills: *interpreting diagrams, sequencing*

Complete each caption. Then, write the letter of the caption that best matches each diagram in the space provided.

Captions

a. An organism decays and leaves a cavity called a _____ in a rock.

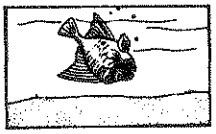
b. A dead organism is buried by _____.

c. Sand or mud fills the cavity and hardens to form a _____.

d. Eventually, the sediment hardens into _____.

1. _____

2. _____



3. _____

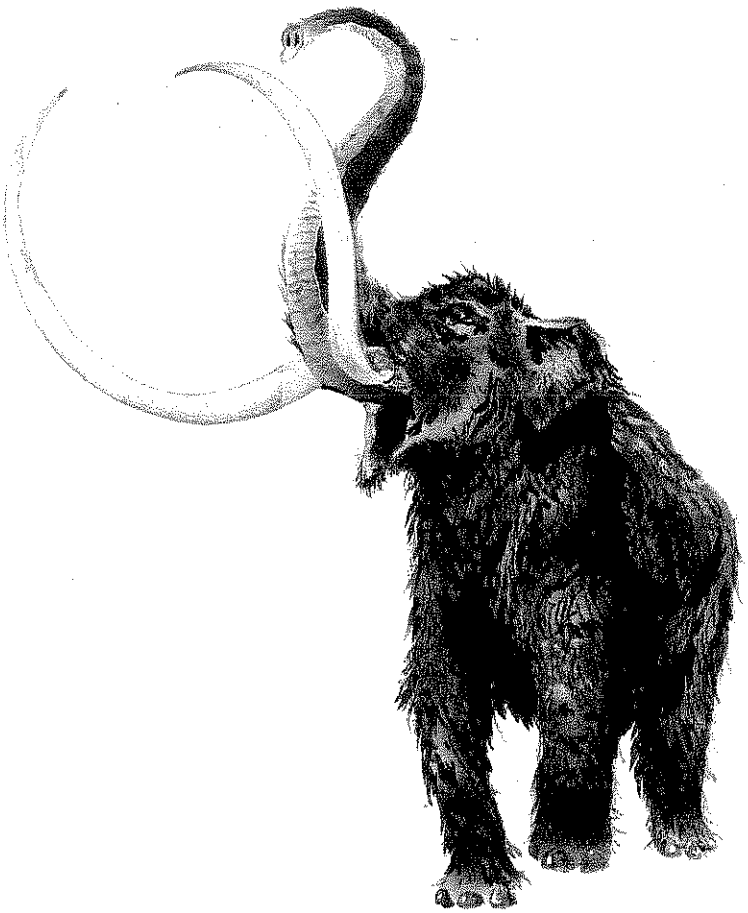
4. _____

9-2 How were entire organisms preserved?

Objective ▸ Describe different ways entire organisms were preserved as fossils.

TechTerm

▸ **amber:** hardened tree sap



Fossils in Ice You probably know that freezing helps preserve things by preventing decay. Many food products are frozen to help preserve them. Some extinct animals have been preserved by freezing. The bodies of 50 wooly, elephantlike animals called mammoths (MAM-uths) were found frozen in soil and ice in Siberia and Alaska. These animals had hair and skin on them. Furry rhinoceroses (ry-NAHS-ur-us-es) also have been found.

Identify: What is a mammoth? wooly, elephant-like animal

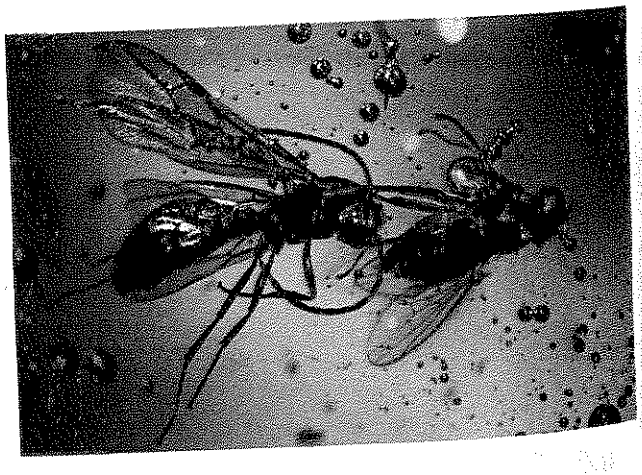
Fossils in Tar The remains of animals also have been found in pits of thick, sticky tar. Tar for paving streets is taken from tar pits. Tar pits often were covered with water. Animals that came to the tar pits to drink the water, were trapped in the tar. Other animals came to the tar pits to eat the trapped animals. These animals also became trapped. The animals sank into the tar, and were preserved.

Hundreds of thousands of bones from extinct organisms have been found in tar pits. In the LaBrea Tar Pits in southern California, the bones of animals such as saber-toothed cats have been found. The bones of extinct camels, wolves, vultures, and bison also have been found in these tar pits. In Poland, entire furry rhinoceroses have even been found in tar pits.

Locate: Where are the LaBrea Tar Pits? southern California

Fossils in Amber Flies, bees, wasps, and other insects have been found preserved in hardened tree sap. Hardened tree sap is called **amber.** A clear, sticky sap flows from some kinds of trees. Millions of years ago, insects were trapped in the sticky sap. More sap covered the insects. The sap hardened. The insects, including their wings and legs, were perfectly preserved in the amber.

Define: What is amber? hardened tree sap



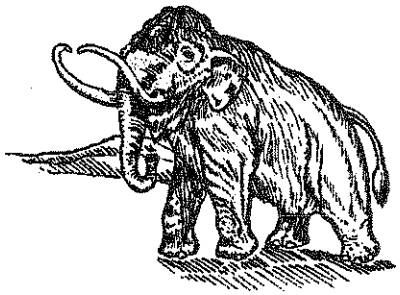
Name _____ Class _____ Date _____

9–2 How were entire organisms preserved?

Lesson Review

Write the term or terms that best complete each statement in the spaces provided.

1. Three substances that can preserve the remains of living things are _____, _____ and _____.
2. Amber is hardened _____.
3. Freezing helps preserve organisms by preventing _____.
4. Many animals that became trapped in tar pits had come there for the _____ which covered the pits.
5. The LaBrea Tar Pits are located in southern _____.
6. The animal shown in the illustration at the right is a _____.



Skill Challenge

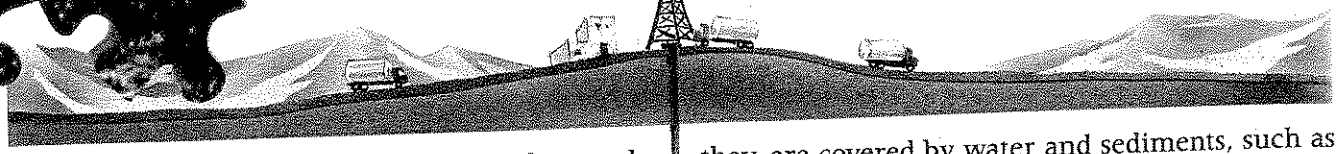
Skills: *identifying, classifying*

Complete the table by filling in the numbered spaces. Do not use the name of any animal that is already listed in the table.

Table 1 Preservation of Animal Remains

Animal	Probably Preserved In	Animal	Probably Preserved In
mammoth	1. _____	wolf	2. _____
3. _____	amber	4. _____	tar
bee	5. _____	6. _____	ice
bison	7. _____	8. _____	amber
9. _____	ice	mosquito	10. _____

9-3 What are fossil fuels?



Objective ▸ Describe how coal, oil, and natural gas formed.

TechTerm

▸ **fossil fuels** (FEWLS): natural fuels that come from the remains of living things

Fossil Fuels Most of the energy that you use comes from **fossil fuels** (FEWLS). Fossil fuels are natural fuels that come from the remains of living things. A fuel is a substance that gives off energy when it is burned. A fuel may be a solid, a liquid, or a gas. Coal and natural gas are fossil fuels. The liquid fuel, petroleum (puh-TRO-lee-um), also is a fossil fuel.

Infer: Which fossil fuel is a solid? coal

Hydrocarbons Fossil fuels are made up mostly of hydrocarbons (hy-druh-KAR-buns). Hydrocarbons are compounds made up of hydrogen and carbon. Hydrocarbons contain energy. The energy was obtained from sunlight by plants and animals that lived millions of years ago. When hydrocarbons are burned, they give off this energy as light and heat.

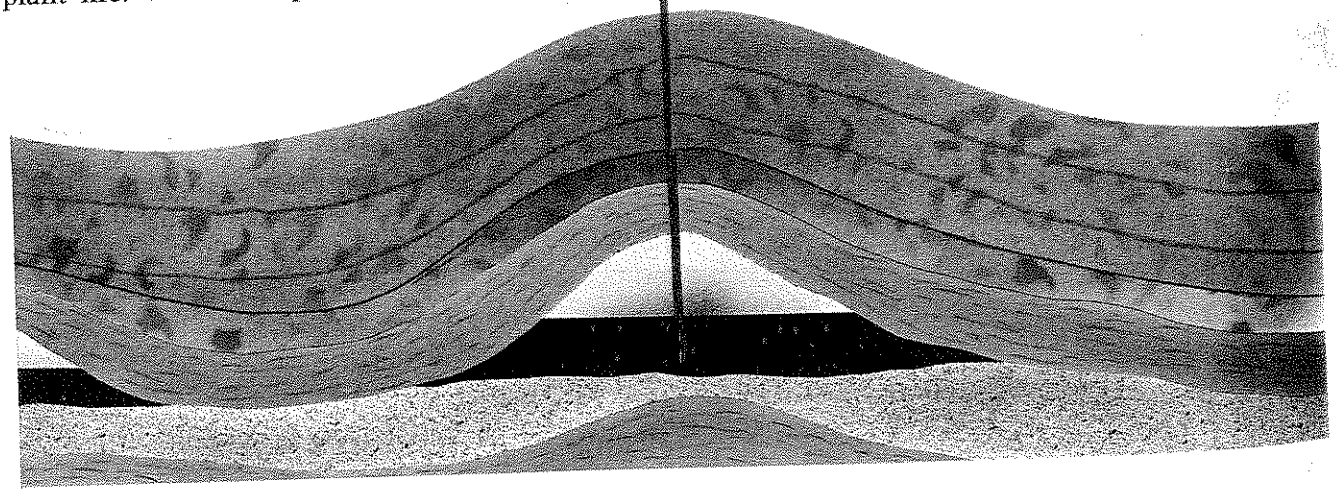
Name: What two forms of energy are given off when hydrocarbons are burned? light and heat

Forming Coal Coal is formed in swamps. Swamps are areas of shallow water with a lot of plant life. When the plants in the swamps die, they are covered by water and sediments, such as mud. Bacteria, pressure, and heat slowly cause chemical changes to take place in the plants. After many, many years, the decaying plant material changes to peat. Peat is the first stage in coal formation. After millions of years, peat changes into soft coal. Very high heat and pressure change soft coal into hard coal. Soft and hard coal are mostly carbon, so they give off a lot of heat when they burn.

Analyze: What are the three types of coal? peat, soft and hard

Forming Oil and Gas Geologists think that petroleum, or crude oil, and natural gas formed from decaying sea plants and animals. When these sea plants and animals died, they were covered with sediments. The sediments changed into sedimentary rock. Just like coal, bacteria, heat, and pressure helped to form petroleum and natural gas. Petroleum moved with water through the cracks and holes in rock. When the petroleum reached a rock layer it could not pass through, the petroleum and water began to collect. Petroleum is usually found in oil pools. Oil pools are usually found in rock layers of shale or sandstone. The petroleum floats on water. If natural gas is formed, it is on top of the petroleum. To get to the crude oil and natural gas, it is necessary to drill into the earth's crust.

List: What are three names for liquid fossil fuel? petroleum, oil, crude oil



Name _____ Class _____ Date _____

9–3 What are fossil fuels?

Lesson Review

Part A *Match each in Column B with its description in Column A. Write the correct letter in the space provided.*

Column A	Column B
_____ 1. first stage in coal formation	a. fossil fuel
_____ 2. fuel formed from the remains of living things	b. peat
_____ 3. forms of energy given off by fossil fuels	c. hydrocarbon
_____ 4. compound made up of hydrogen and carbon	d. petroleum
_____ 5. crude oil	e. light and heat

Part B Complete the table by placing check marks in the correct columns.

Table 1 Fossil Fuels

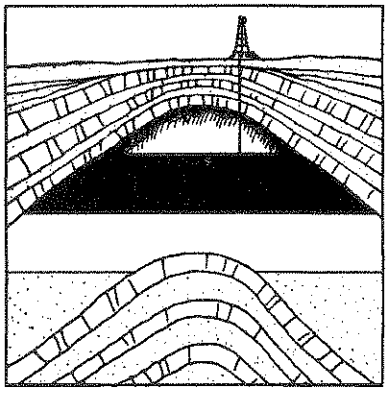
	Description	Coal	Petroleum	Natural Gas
1.	Made up of hydrocarbons			
2.	Forms on top of crude oil			
3.	Liquid fossil fuel			
4.	Forms from decayed plants			
5.	Forms from decayed sea animals			
6.	Solid fossil fuel			
7.	Floats on water			
8.	Forms in swamps			

Skill Challenge

Skills: *identifying, labeling a diagram*

Label the parts of the diagram. Use the labels listed in the box on the left.

Labels
sandstone
water
natural gas
petroleum



9-4 Why do scientists study fossils?

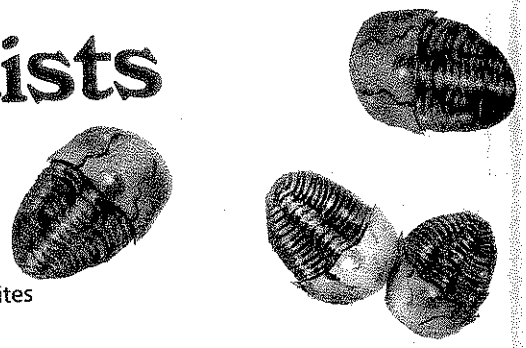


Figure 1 Trilobites

Objective ▸ Understand how fossils are clues to the earth's history.

Clues to Living Things Fossils show that many kinds of organisms lived at different times in the earth's history. Many of these organisms are extinct. Dinosaurs lived between 65 million and 100 million years ago. There were hundreds of kinds of dinosaurs, but not one dinosaur lives on the earth today. Other extinct animals are saber-toothed cats, giant sloths, and trilobites (TRY-loh-bites). Trilobites were small, shelled animals. There were many different kinds of trilobites.

Name: What are some extinct animals that are preserved as fossils? Answers may include dinosaurs, giant sloths, saber-toothed cats, and trilobites.

Clues to the Past Fossils show that the earth's climate and surface have changed. Fossils of alligatorlike animals have been found in Canada. Today, alligators live in warm climates. The fossils in Canada indicate that at some time in the earth's history, Canada had a warmer climate then it does today. Fossil ferns have been found in Antarctica. The fern fossils indicate that Antarctica was once very warm. Today, Antarctica is covered with ice and snow. Coral fossils have been found in the Arctic. In 1835, fossils of ocean animals were found in the Andes Mountains in South America. The Andes are more than 4000 m above sea level. Scientists infer that this land was once covered by an ocean.

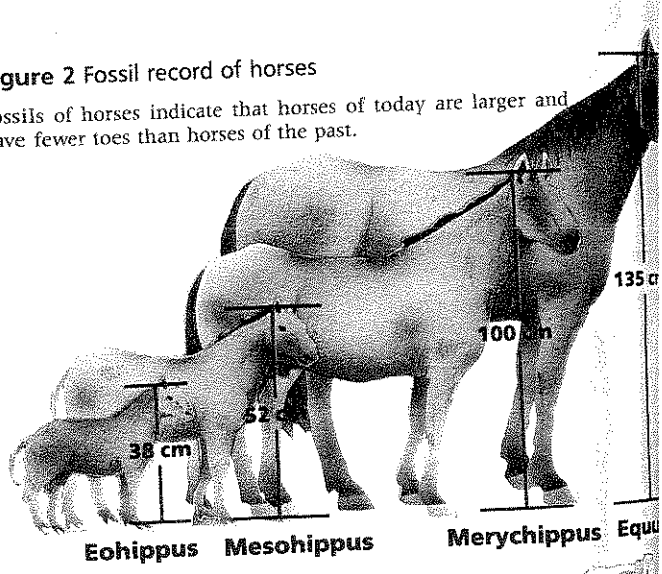
Compare: Based on fossil records, describe the climate of Canada millions of years ago and today. Canada was warm millions of years ago and is cold today.

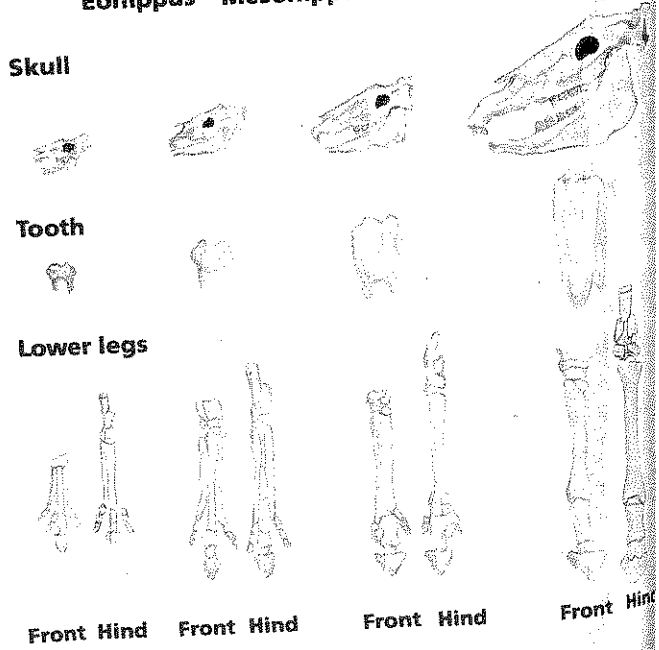
Clues to Changes Fossils show that living things have changed over time. For example, many fossils of horses have been found. These fossils show changes in the animals' size and the number of toes. Scientists have found fossils of a four-toed horse that was about the size of a large cat. Fossils of horses also show changes in teeth and in the size and shape of the legs. Today, horses have one large hoof and are quite large. Other fossils show that animals such as elephants, giraffes, and camels also are related to animals that are now extinct.

Explain: How do scientists infer that the horse has changed during millions of years?

Figure 2 Fossil record of horses

Fossils of horses indicate that horses of today are larger and have fewer toes than horses of the past.





Name _____ Class _____ Date _____

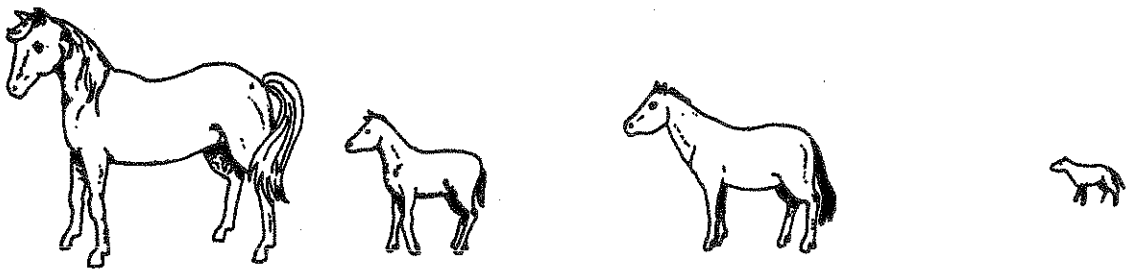
9–4 Why do scientists study fossils?

Lesson Review

Part A *Circle the name of the animal that lived at an earlier time in the earth's history.*

1. dinosaur, alligator
2. two-toed horse, four-toed horse
3. camel, giant sloth
4. Equus, Mesohippus
5. trilobite, graptolite
6. 38-cm horse, 135-cm horse
7. camel, sabre-toothed cat
8. Merychippus, Eohippus
9. Mesohippus, Merychippus
10. fossil fern, camel

Part B *Place the horses in order from oldest (A) to most recent (D). Write the correct letter in the space below each illustration.*



1. _____ 2. _____ 3. _____ 4. _____

Skill Challenge

Skill: *inferring*

In the space provided, explain what inference can be made from each fossil discovery.

DISCOVERY	INFERENCE
• Fossils of alligatorlike animals are discovered in Canada.	1. _____
• Fossils of sea animals are found in the Andes Mountains.	2. _____
• Fossils of four-toed horses that were about the size of a cat are discovered.	3. _____
• Fossil ferns are discovered in Antarctica.	4. _____

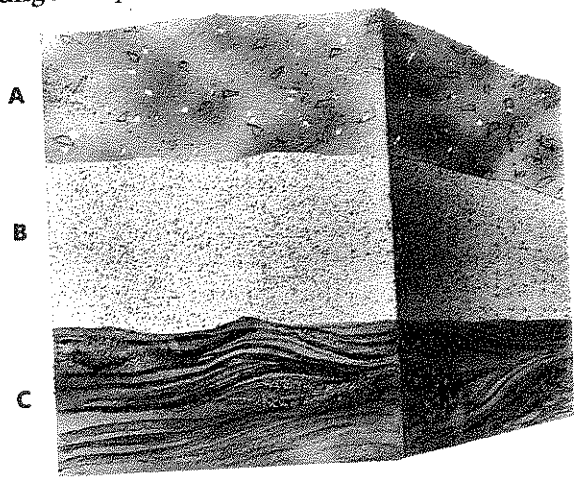
9-5 How can the relative ages of rocks be determined?

Objective ▸ Understand how the relative age of fossils and rock layers can be determined.

TechTerms

- **index fossil:** remains of an organism that lived only during a short part of the earth's history
- **relative age:** age of an object compared to the age of another object

Reading Rock Layers Sediments are carried from one place and deposited in another. These sediments pile up layer upon layer. The bottom layer is deposited first. Each layer is deposited on top of other layers. The sediments are pressed together and harden into sedimentary rock layers, or beds. The law of superposition (SOO-pur-puh-zish-un) is used by scientists to read the rock layers. The law of superposition states that each rock layer is older than the one above it. Each rock layer also is younger than the layers below it. Where would you expect to find the oldest layer? Usually, the bottom layer is the oldest layer. The youngest layer is the top layer.



Observe: Which rock layer is the youngest in this rock bed? Layer A

Relative Age Using the law of superposition, scientists can tell the **relative age** of a rock layer. Relative age is the age of an object compared to the age of another object. The relative age of a rock tells scientists that one rock layer is older or younger than another rock layer. Relative age does not tell the exact age of a rock.

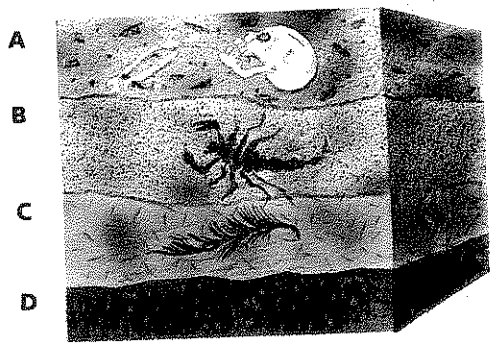


Figure A

Infer: What is the relative age of rock layer C? Layer C is older than A and B, and younger than D.

Index Fossils Certain fossils can be used to help find the relative age of rock layers. These fossils are called **index fossils.** To be an index fossil, an organism must have lived only during a short part of the earth's history. Many fossils of the organisms have to be found in rock layers. The fossils must be found over a wide area of the earth. The fossil organisms also must be unique.

Graptolites (GRAP-tuh-lites) and trilobites (TRY-luh-bites) are two large groups of index fossils. The trilobites appeared about 590 million years ago and lived until 250 million years ago. The graptolites appeared about 500 million years ago and lived until 335 million years ago. Individual species lived for short periods of time. Scientists can date rock layers by these short-lived species. Index fossils also can be used to date rock layers from two different parts of the world. Suppose rock layers found in different places contain the same type of trilobite fossils. Scientists can infer that the layers are about the same age.

Explain: What are fossils that scientists cal index fossils used for?

Name _____ Class _____ Date _____

9–5 How can the relative ages of rocks be determined?

Lesson Review

Use the diagrams to answer the questions.

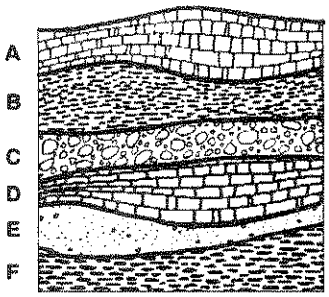


Figure 1

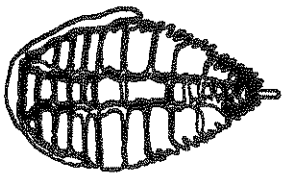


Figure 2

Figure 3

1. Write the order in which the rock layers in Figure 1 were laid down. _____

2. Which rock layer in Figure 1 is oldest? Use the Law of Superposition to explain your answer.

_____

3. a. What organism is shown in Figure 2? _____ b. Figure 3? _____

4. How can the organisms in Figures 2 and 3 be used to determine the relative ages of rock layers?

_____

_____

Skill Challenge

Skills: *analyzing, inferring*

Use the diagrams to answer the questions.

Rock Layers

A	Graptolite fossils
B	
C	
D	Trilobite fossils
E	

Figure 1 Rock layers in China

Rock Layers

F	Human skull
G	
H	Graptolite fossils
I	Trilobite fossils
J	Trilobite fossils

Figure 2 Rock layers in Africa

1. Which rock layers in Figure 1 have the same relative ages as those in Figure 2? _____

2. Which country has the older rock bed? Explain. _____

3. What inference can you make about the two layers of rock that contain trilobite fossils in Figure 2? _____

9-6 How is absolute age determined?

Objective ▸ Describe ways used to measure absolute age.

TechTerms

- **absolute age:** specific age of a rock or a fossil
- **half-life:** length of time it takes for one-half the amount of a radioactive element to change into another element

Absolute Age How old are you? How do you measure your age? You use the number of years since you were born. This number is your exact age. Scientists need to find out the number of years ago rock layers were formed. They also want to find out the age of fossils. The specific age of a rock layer or a fossil is called its **absolute age.** Absolute age is a more exact age than relative age. Absolute age tells scientists the number of years ago a rock layer formed or an organism lived.

Describe: What is meant by absolute age? specific or exact age

Natural Clocks The process of a radioactive element changing into another element is called radioactive decay. Radioactive elements were discovered in 1896. They are elements that give off particles and energy. As a radioactive element gives off particles and energy, new elements form. The new elements are not radioactive. The rate at which radioactive decay happens can be measured. Each radioactive element decays at a regular, steady rate. So the radioactive elements are like natural clocks.

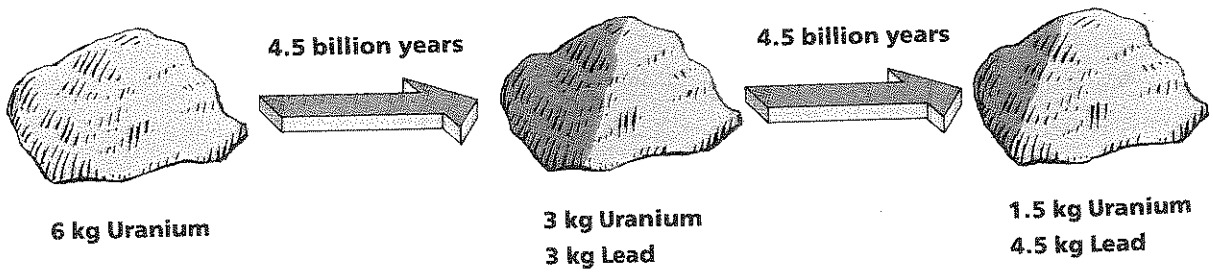
Explain: What is radioactive decay? process of a radioactive element changing into another element

Half-life The **half-life** of a radioactive element is the length of time it takes for half the mass of a sample radioactive element to decay. Each element has a different half-life. Uranium is a radioactive element. It slowly decays into lead. It takes 4.5 billion years for one half the uranium in a rock to decay into lead. If you begin with 6 kg of uranium, 3 kg will decay into lead after one half-life. After a second half-life, only 1.5 kg of uranium would be left. By comparing the amount of the radioactive element in a rock to its decay element, scientists can find the absolute age of a rock or fossil.

Measure: If a rock has equal amounts of lead and uranium in it, how old is the rock? 4.5 billion years

Carbon-14 Carbon-14 is used to date the remains of living things. When living things are alive, they take in carbon-14. Carbon-14 is a radioactive form of carbon. It decays into nitrogen. The half-life of carbon-14 is 5800 years. Carbon-14 is used to find out the absolute ages of wood, bones, skulls, and so on. It also is used to date "young" fossil samples. If a sample is more than 50,000 years old, almost all of the carbon-14 has decayed into nitrogen.

Describe: What is carbon-14? radioactive form of carbon



Name _____ Class _____ Date _____

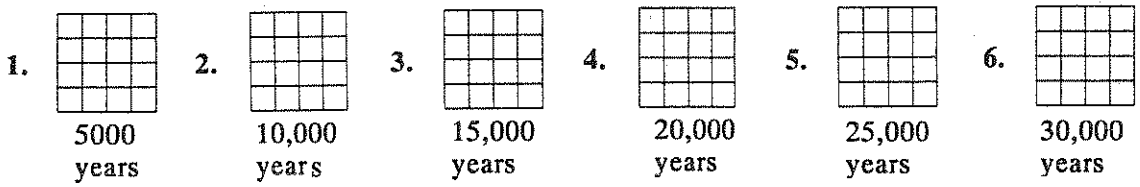
9–6 How is absolute age determined?

Lesson Review

Part A *Complete the following. Write your answers in the spaces provided.*

1. The specific age of a rock or fossil is its _____ age.
2. The length of time it takes for one-half of a radioactive element to change into another element is its _____.
3. The decay element of uranium is _____.
4. The decay element of carbon-14 is _____.

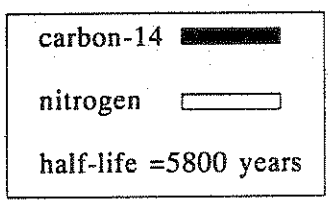
Part B *The half-life of element X is 5000 years. The decay element of X is element Y. Shade in the part of each box that has changed to element Y after the time period indicated.*

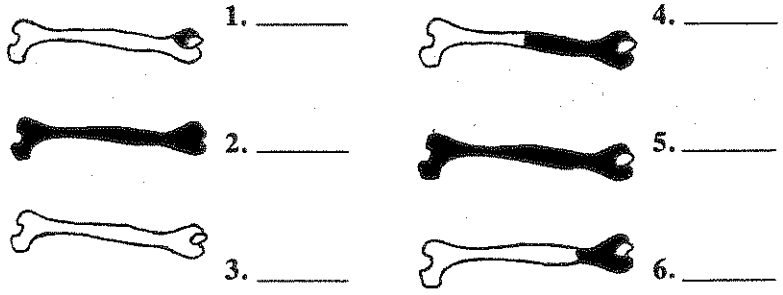


Skill Challenge

Skills: *applying concepts, analyzing, sequencing*

Use the key to place the fossils in order from youngest (A) to oldest (F). Then, answer the questions.





7. Which fossil bone do you think is oldest? Why? _____
8. Which fossil bone do you think is youngest? Why ? _____

_____

9. Which of the fossil bones are more than 5800 years old? _____

_____

10. Which of the fossil bones are less than 5800 years old? _____

Name _____ Class _____ Date _____

9–7 What is the geologic time scale?

Lesson Review

Complete the following. Write your answers in the spaces provided.

1. What is the geologic time scale? _____

_____

2. What is the largest division of geologic time? _____
3. What is the smallest division of geologic time? _____
4. How old do scientists estimate the earth to be? _____
5. During which period of geologic time are you living? _____
6. How many eras of geologic time has the earth passed through? _____
7. How have scientists been able to develop a geologic time scale? _____

_____

_____

_____

Skill Challenge

Skills: *classifying, organizing, researching*

Classify each organism listed in the table in the era of geologic time in which it lived or first appeared on earth. Place a check mark in the proper column. Use your textbook or library resources for help if necessary.

Table 1 Living Things and Geologic Time

	Organism	Cenozoic	Mesozoic	Paleozoic	PreCambrian
1.	Algae				
2.	Trilobite				
3.	Human				
4.	Flowering plant				
5.	Wooly mammoth				
6.	Graptolite				
7.	Tyrannosaurus Rex				
8.	Fish				
9.	Horse				
10.	Whale				

9-7 What is the geologic time scale?

Objective ▸ Describe and read the geologic time scale.

TechTerm

▸ **geologic** (jee-uh-LAJ-ik) **time scale:** outline of the major events in the earth's history

Age of the Earth Scientists use radioactive dating to help them find the ages of rocks found on the earth and the moon. The oldest rocks found on the earth are about 4 billion years old. Moon rocks are older. Scientists think the earth and moon were formed at about the same time. Using the age of the moon and earth rocks, scientists estimate that the earth may be more than 4.6 billion years old.

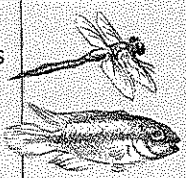
Describe: About how old is the earth? 4.6 billion years

Geologic Time Scale By making many observations of rocks and fossils, geologists have developed a **geologic** (jee-uh-LAJ-ik) **time scale.** The geologic time scale is an outline of the major events in the earth's history. The time scale also outlines the kinds of organisms that lived on the earth in the past. The geologic time scale begins when the earth was formed and goes on until the present.

Describe: What is the geologic time scale? outline of the major events in the earth's history

Divisions of Geologic Time How is a year divided? It is divided into units called months, weeks, and days. Geologic time also is divided into units. The largest unit is an era. Each era lasted for millions of years. There are four eras in geologic time. The eras are divided into periods. The more recent periods are divided into epochs (EP-uks). The divisions of geologic time are based on changes that occurred on the earth.

Name: What are the divisions of geologic time? era, periods, epochs

ERA	PERIOD	EPOCH	START DATE (MILLIONS OF YEARS AGO)	ORGANISMS
Cenozoic 	Quaternary	Recent	0.025	Modern Humans
		Pleistocene	1.75	Mammoths
	Tertiary	Pliocene	14	Large carnivores
		Miocene	26	Many land mammals
		Oligocene	40	Primitive apes
		Eocene	55	Early horses
		Paleocene	65	Primates
Mesozoic	Cretaceous		130	Flowering plants
	Jurassic		180	Dinosaurs, birds
	Triassic		225	Conifers
Paleozoic	Permian		275	Seed Plants
	Carboniferous		345	Reptiles
	Devonian		405	Insects, amphibians
	Silurian		435	Fishes
	Ordovician		480	Algae, fungi
	Cambrian		600	Invertebrates
Precambrian			4,600	Bacteria, blue-green algae