Chapter 2

Weathering and Soil

CALIFORNIA Standards Preview

S 6.2 Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:

a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.

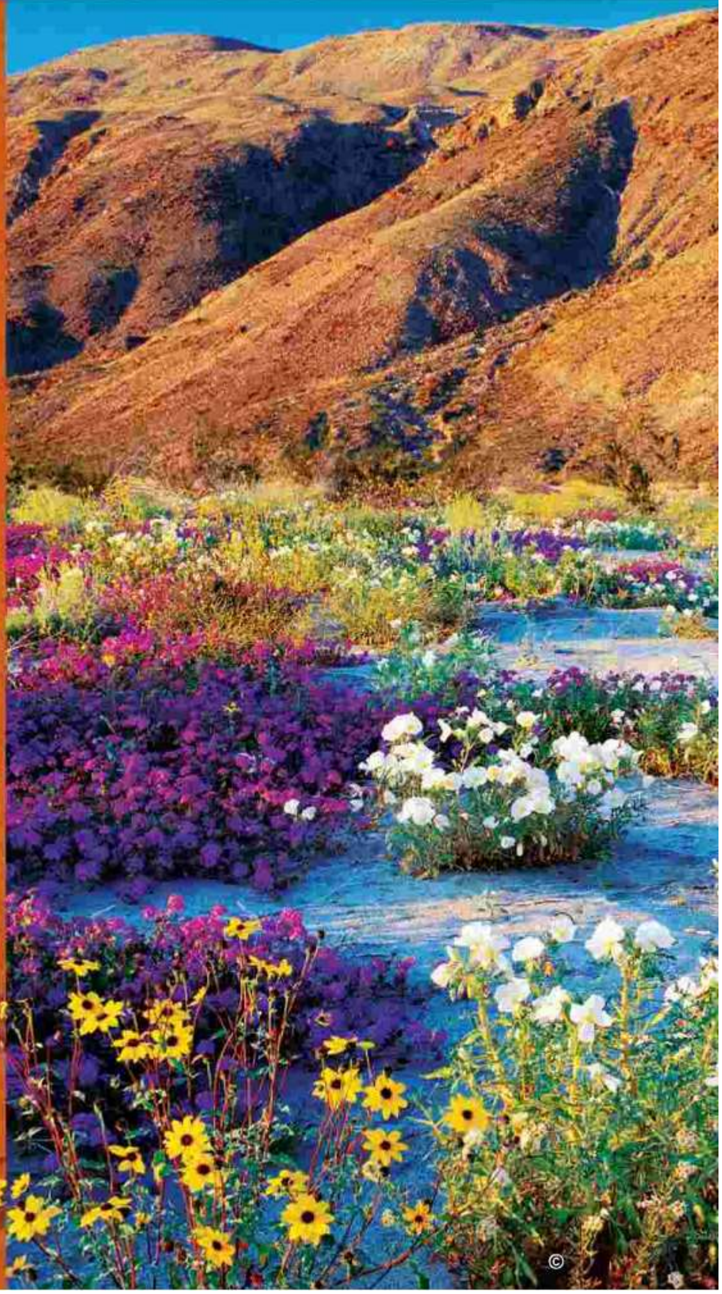
Framework Water contributes to two processes that help shape the landscape—the breaking down of rock into smaller pieces by mechanical and chemical weathering and the removal of rock and soil by erosion.

S 6.5.e Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Framework To support vigorous plant growth, soils must contain sufficient minerals (e.g., nitrogen, phosphorus, potassium) and humus (decomposed organic materials) without excess acidity or alkalinity.

S 6.6 Sources of energy and materials differ in amounts, distribution, usefulness, and time required for their formation. As a basis for understanding this concept:

b. Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.



Wildflowers bloom in the Anza-Borrego Desert State Park, California. ▶

Video Preview
Discovery Channel School
Weathering and Soil Formation

Focus on the
BIG Idea

S 6.2.a

How does the weathering of rock help to reshape Earth's topography and form soil?

Check What You Know

Suppose that you carve a model of a mountain in a bar of soap. Then, you leave the model outside in the rain overnight. Based on what you think would happen to the model, predict how rock on Earth's surface might change over time.

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

Suffixes

A suffix is a letter or group of letters added to the end of a word to change its meaning and usually its part of speech. The suffixes *-ation* or *-ing* added to a verb can form a noun that means "process of" or "action of." For example, the suffix *-ation* added to the verb *observe* forms the noun *observation*.

Example: Students in the lab will record their observations.

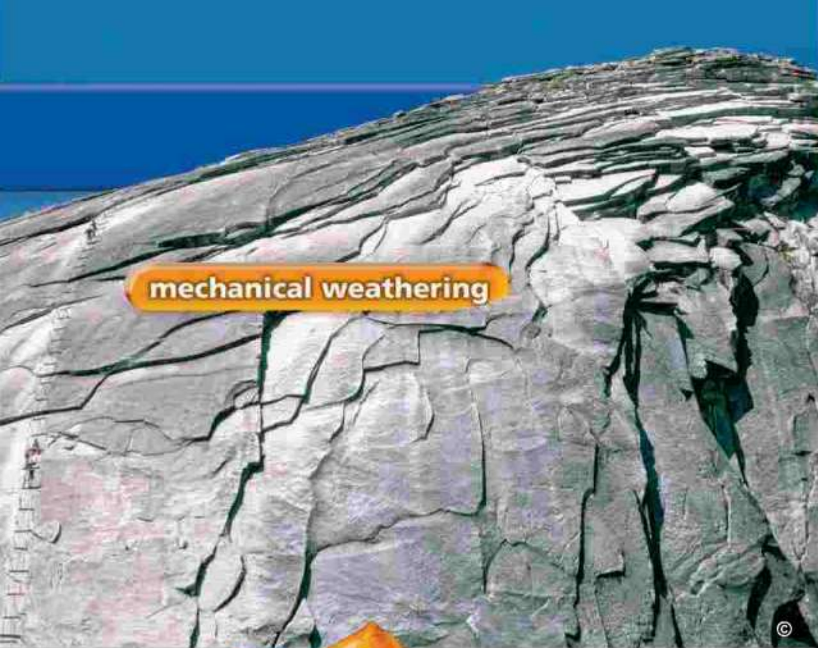
In this chapter, you will learn key terms that have the suffixes *-ation*, *-sion*, and *-ing*.

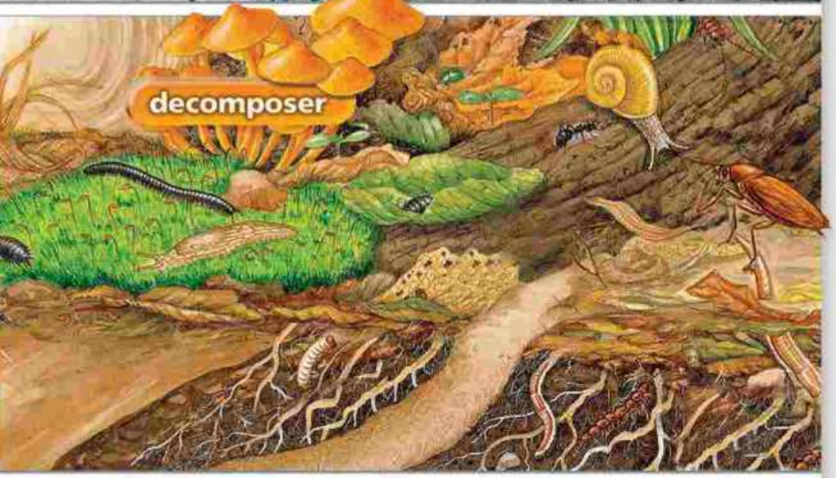
Suffix	Meaning	Part of Speech	Key Terms
-ation	Process of, action of	Noun	Conservation, oxidation, rotation
-sion	Process of, action of	Noun	Abrasion, erosion
-ing	Showing continuous action	Noun or adjective	Melting, plowing, smelting, weathering, wedging

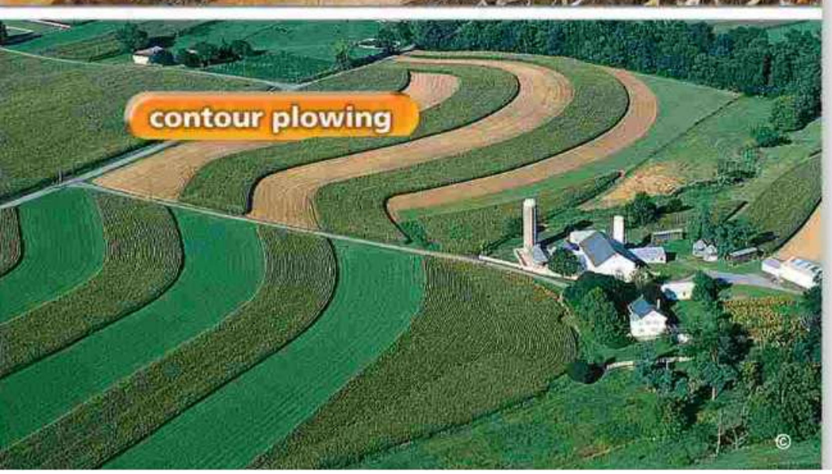
Apply It!

Complete the sentences with the correct words.

1. People who ________ electricity are contributing to energy ________. (*conserve/conservation*)
2. Rain, snow, and other types of ________ contribute to the ________ of Earth's surface. (*weather/weathering*)







Chapter 2 Vocabulary

Section 1 (page 48)

mineral
crystal
rock cycle
igneous rock
sedimentary rock
sediment
metamorphic rock
nonrenewable resource
ore
smelting

Section 2 (page 56)

weathering
erosion
uniformitarianism
mechanical weathering
abrasion
ice wedging
chemical weathering
oxidation
permeable

Section 3 (page 66)

soil
natural resources
bedrock
humus
fertility
loam
soil horizon
topsoil
subsoil
acidic
basic
litter
decomposer

Section 4 (page 74)

sod
natural resource
Dust Bowl
soil conservation
contour plowing
conservation plowing
crop rotation

Interactive Textbook
Build Science Vocabulary *Online*
Use interactive flashcards

How to Read Science

Reading Skill

Preview Visuals

Before you read your science textbook, it's important to take the time to preview the visuals. Visuals are photographs, graphs, tables, diagrams, and illustrations. Visuals contain important information that helps you understand the content. Follow these steps to preview visuals.

- Read the title.
- Read labels and captions.
- Ask yourself questions about the visuals to give yourself a purpose for reading.

Preview the illustration titled The Rock Cycle, Figure 6. Use a graphic organizer like this one to ask questions about the rock cycle.

The Rock Cycle
Q: What is the subject of this illustration?
A:
Q: Why are there a lot of different arrows?
A:
Q: What processes do the arrows show?
A:
Q: What do the four diagrams show about the rock cycle?
A:

Apply It!

Copy the graphic organizer into your notebook. Look carefully at the illustration and write the answer to the question "What processes do the arrows show?"

After you read Section 1, complete your graphic organizer and revise it as necessary. Before you read Section 3, create graphic organizers to preview the visuals.

Lab zone Standards Investigation

S 6.5.e, Framework

Soil for Seeds

The process of weathering affects all rocks exposed on Earth's surface. Weathering breaks rock into smaller and smaller particles. When the rock particles mix with other ingredients, such as leaves, the mixture is called soil. In this investigation, you will test how soil and other growing materials affect the growth of plants.

Your Goal

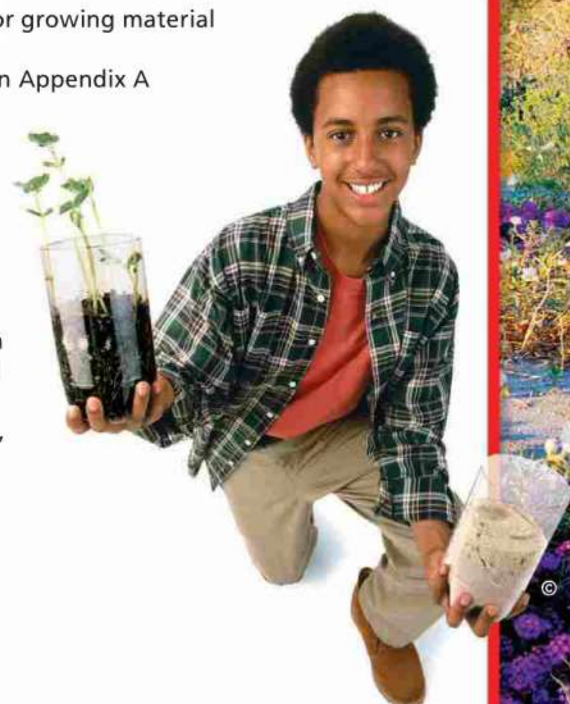
To determine how soil composition affects the growth of bean seeds

To complete this investigation, you must

- compare the particle size, shape, and composition of different growing materials
- compare how bean seeds grow in several different growing materials
- determine what type of soil or growing material is best for young bean plants
- follow the safety guidelines in Appendix A

Plan It!

In a group, brainstorm what types of soil and other growing materials you will use in your experiment. What are the different variables that affect the growth of plants? How will you measure the growth of your bean plants? Plan your experiment and obtain your teacher's approval. As you carry out your experiment, observe and record the growth of your plants. Then present your results to your class.



Section 1

Minerals and Rocks

CALIFORNIA Standards Focus

S 6.6.b Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

c. Students know the natural origin of materials used to make common objects.

- What is a mineral?
- What are the three major groups of rock, and how do they form through the rock cycle?
- How are minerals and rocks used and processed?

Key Terms

- mineral
- crystal
- rock cycle
- igneous rock
- sedimentary rock
- sediment
- metamorphic rock
- nonrenewable resource
- ore
- smelting

Lab zone Standards Warm-Up

What's a Rock?

1. Your teacher will give you three different rocks.
2. Observe each rock under a hand lens. In your notebook, describe the color or colors that you see in the rocks. Also describe any shapes or patterns in the rocks.
3. Make a sketch of each of your rocks.
4. Are your rocks made up of one material or several materials? How can you tell?
5. How are the rocks similar? How are they different?

Forming Operational Definitions Based on your observations, how would you define the word *rock*?

You may think of a golf course as a place covered by smooth, green grass. But that's not true of the Devil's Golf Course in Death Valley National Park. Instead of grass, a jagged crust of salt covers this "golf course." The salt forms lacy sheets, spikes, and other strange shapes.

Where did the salt that forms the Devil's Golf Course come from? About 3,000 years ago, a large lake filled the area. The lake's water contained dissolved salt. Over time, the climate became drier and the lake slowly dried up. As the water evaporated, the salt was left behind. This salt, the same as ordinary table salt, is also called halite. To a geologist, halite is a mineral.

FIGURE 1
Devil's Golf Course
The fantastic shapes on this dry lake bed in Death Valley National Park, California, are formed mostly of salt crystals.

What Is a Mineral?

Minerals can be as rare as a precious diamond. Or they can be as common as the halite that makes up the Devil's Golf Course. Geologists have identified more than 3,000 different minerals. But all of these minerals share certain characteristics.

A mineral is a naturally occurring, inorganic solid that forms on or beneath Earth's surface. Almost all minerals have a crystal shape. Each mineral also has a definite chemical composition. For a substance to be a **mineral,** it must have all five of these characteristics.

Inorganic Solid Halite occurs naturally in areas once occupied by lakes or seas. Halite is inorganic. This means that the mineral did not form from materials that were once part of a living thing. If you pour some halite into your hand, you can see that it is made up of small, solid particles.

Crystal Shape Halite also has a crystal shape. In Figure 2, you can see that halite crystals are shaped like cubes. A **crystal** is a solid made up of particles that line up in a pattern that repeats over and over again.

Definite Chemical Composition Halite has a definite chemical composition. This means that it is made up of certain elements in definite proportions. Halite is made up of one atom of sodium for every atom of chlorine. Many other minerals are made up of several elements. A few minerals are made up of only one element. Copper, silver, gold, and sulfur sometimes occur naturally in this form.

Each mineral has different properties depending on its chemical composition. For example, minerals differ in color, hardness, and crystal shape.

Reading Checkpoint What is a crystal?

FIGURE 2
Mineral Crystals
Crystals of the mineral halite—which you know as table salt—are shaped like cubes.

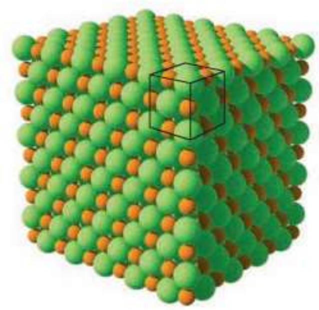
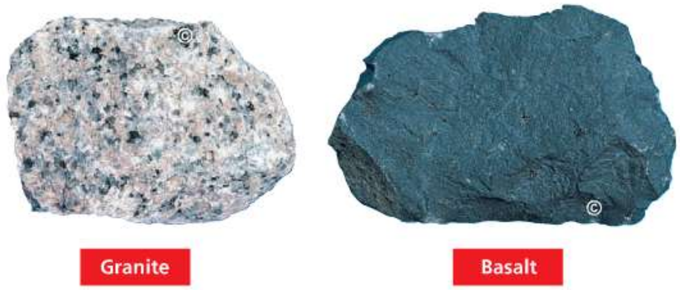


FIGURE 3
Granite and Basalt
Granite is made up of large crystals of several minerals, including quartz, mica, and feldspar. The crystals in basalt are too small to be seen without a hand lens.



Rocks and the Rock Cycle

Minerals are one of the main building blocks of rock. Rock is the solid material made up of one or more minerals or other substances. Rock makes up Earth's hard crust. How do the different kinds of rocks form? Forces deep inside Earth and at the surface produce a slow cycle that builds, destroys, and changes rocks. The **rock cycle** is a series of processes on and beneath Earth's surface that slowly change rocks from one kind to another. **Geologists classify rocks into three major groups: igneous rock, sedimentary rock, and metamorphic rock. The rocks in each group form through different steps in the rock cycle.**

Forming Igneous Rock The rock cycle begins when molten material forms inside Earth. Then, this material slowly cools and hardens at or beneath the surface. The result is **igneous rock** (IG nee us). The granite in Figure 3 formed when molten material cooled slowly beneath the surface. Because it cools slowly, granite is made up of large crystals.

Other igneous rocks form when molten material erupts onto Earth's surface. Basalt forms when molten material cools and hardens on the surface. Because it cools quickly, basalt is made up of very small crystals.

Forming Sedimentary Rock The rock cycle continues as **sedimentary rock** (sed uh MEN tur ee) forms. Water and weather cause rocks on Earth's surface to break down, forming sediment. **Sediment** is small, solid pieces of material that come from rocks or living things.

Water and wind carry sediment and deposit it in layers. Layers of sediment build up and are squeezed together by their own weight. At the same time, minerals in the rock slowly dissolve in water. These minerals harden and glue the sediment together. Over millions of years, the sediment slowly changes to sedimentary rock.

Lab zone Try This Activity

Rock Absorber

Here's how to find out if water can soak into rock.

1. Using a hand lens, compare samples of sandstone and shale.
2. Use a balance to measure the mass of each rock.
3. Place the rocks in a pan of water and watch closely. Which sample has bubbles escaping? Predict which sample will gain mass.
4. Leave the rocks submerged in the pan overnight.
5. The next day, remove the rocks from the pan and find the mass of each rock.

Drawing Conclusions How did the masses of the two rocks change after soaking? What can you conclude about each rock?

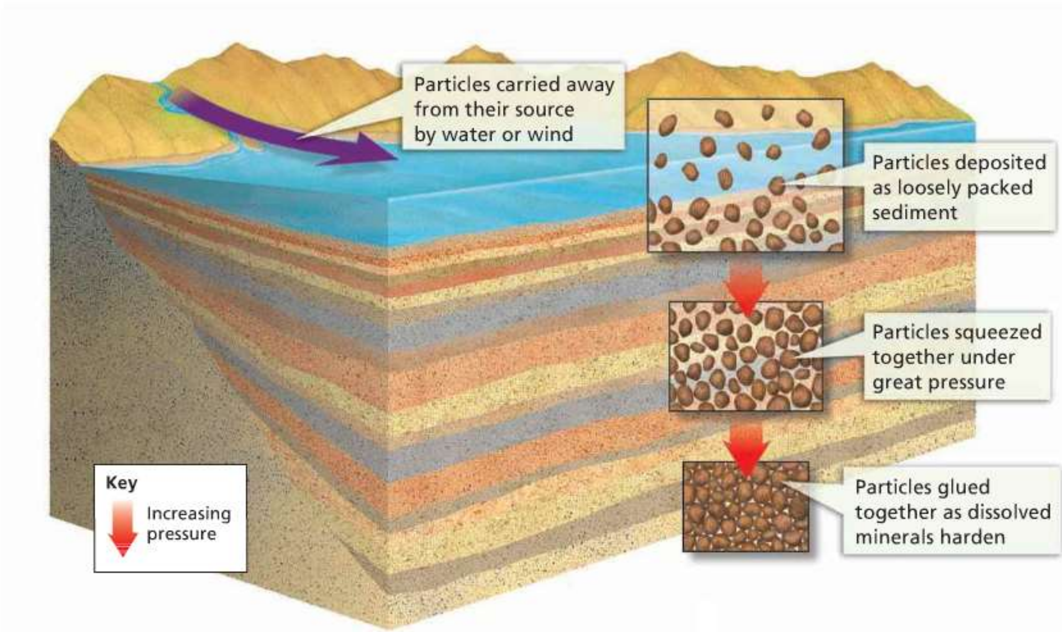


FIGURE 4
How Sedimentary Rocks Form
Sedimentary rocks form over millions of years as particles of sediment are deposited and then squeezed and glued together.
Relating Cause and Effect *What conditions are necessary for sedimentary rocks to form?*

Some sedimentary rocks, such as sandstone, are made up of particles of other rocks. The remains of plants and animals can also form sedimentary rock. For example, limestone forms in the oceans from the shells and skeletons of coral and other animals. Another type of sedimentary rock forms when minerals dissolved in water form crystals. That's how rock salt, made of the mineral halite, is formed.

Forming Metamorphic Rock As the rock cycle continues, any rock can change into **metamorphic rock** (met uh MAWR fik). Forces inside Earth can push rocks down toward the heat of Earth's interior. The deeper a rock is buried, the greater the pressure on that rock. Under great heat and pressure, the minerals in a rock can be changed into other minerals. The rock has become metamorphic rock. For example, heat and pressure can change granite into gneiss, as shown in Figure 5.

Reading Checkpoint **What is sediment?**

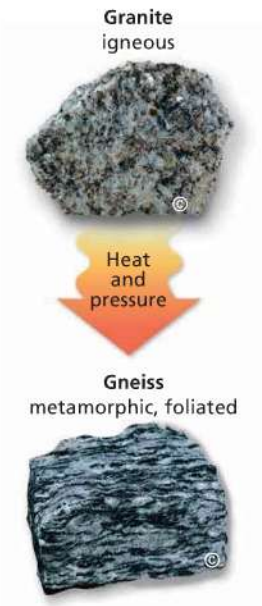
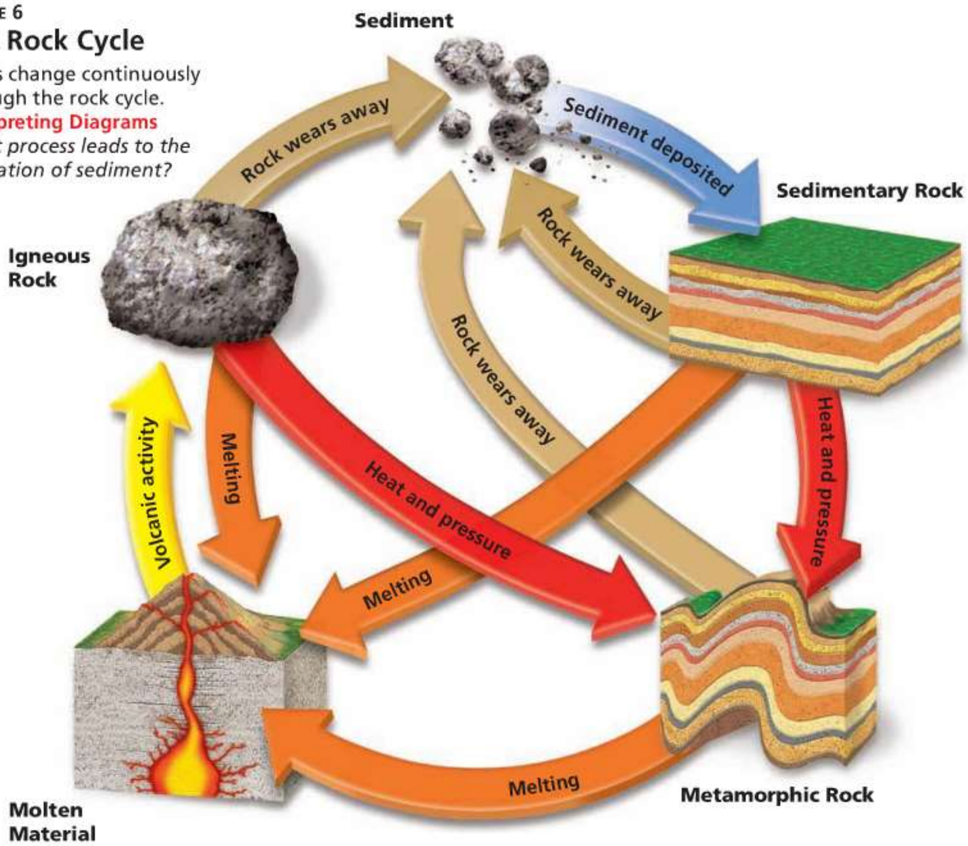


FIGURE 5
Forming Metamorphic Rock
Heat and pressure change granite to a metamorphic rock, gneiss.

FIGURE 6
The Rock Cycle
Rocks change continuously through the rock cycle.
Interpreting Diagrams *What process leads to the formation of sediment?*



Pathways of the Rock Cycle As you can see in Figure 6, there are many pathways through the rock cycle. Here is one possible pathway: The igneous rock granite formed beneath the surface millions of years ago. Then, the forces of mountain building slowly pushed the granite upward, forming a mountain. Slowly, water and weather wore away the granite, forming sand. Streams carried the sand to the ocean.

Over millions of years, layers of sandy sediment piled up on the ocean floor. Slowly the sediments were pressed together and cemented to form sandstone, a sedimentary rock. Over time, the sandstone became deeply buried. Heat and pressure changed the rock's texture from gritty to smooth. Over millions of years, the sandstone changed into the metamorphic rock quartzite.

Metamorphic rock does not end the rock cycle. For example, the heat of Earth's interior could melt the rock. This molten material could then form new igneous rock.

Using Minerals and Rocks

People use minerals and rocks in thousands of ways. But because minerals and rocks can take millions of years to form, they are considered nonrenewable resources. A **nonrenewable resource** is one that is not replaced in a useful time frame.

Uses of Minerals You might be surprised at how many common products contain minerals. **Minerals are the source of gemstones, metals, and other materials used to make many products.**

Gemstones such as rubies and sapphires have amazed people throughout the ages. Usually, a gemstone is a hard, colorful mineral. Gemstones are used mainly for jewelry. They are also used for mechanical parts and for grinding and polishing.

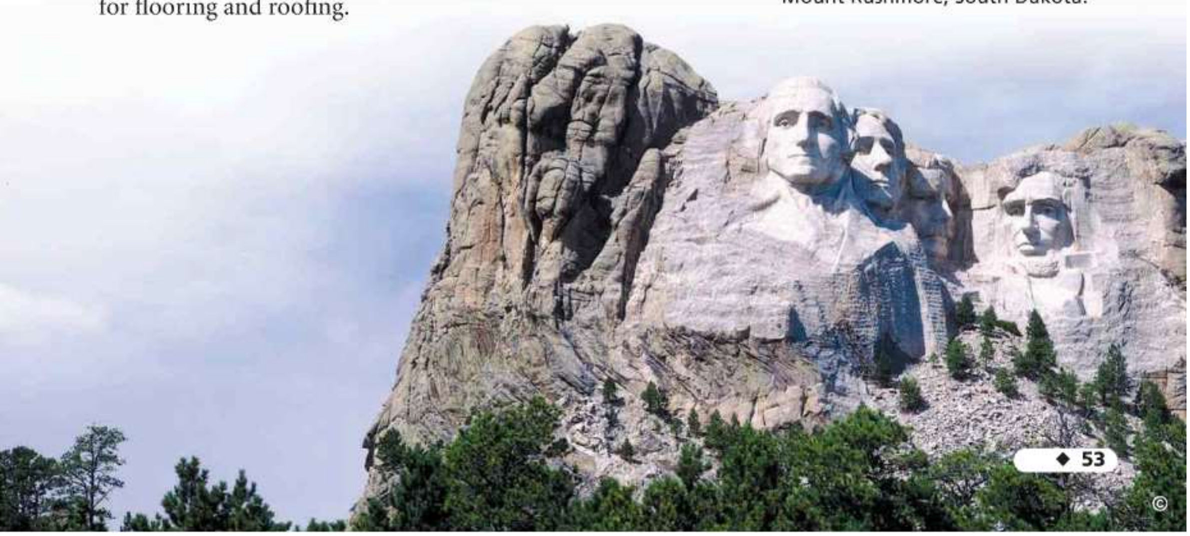
Minerals are also the source of metals such as iron, copper, and silver. Metal tools, aluminum foil, and the steel used to make cars all began as minerals. Many other minerals are used in foods, medicines, fertilizers, and building materials. Quartz, a mineral found in sand, is used in making glass. Gypsum, a soft, white mineral, is used to make wallboard and cement.

FIGURE 7
Gemstones
Minerals have many uses. Precious gems like the rubies and emeralds in this necklace are used in jewelry.

Reading Checkpoint **What are gemstones?**

Uses of Rocks Throughout history, people have found many uses for rocks. For thousands of years, people made arrowheads out of flint, a sedimentary rock. **Today, people use rocks for building materials and in industrial processes.** Hard, durable granite is used in curbstones, floors, and kitchen counters. Limestone can be cut easily into blocks or slabs for use in buildings. Limestone is also used in making cement and steel. Slate splits easily into flat pieces. These pieces can be used for flooring and roofing.

FIGURE 8
Durable Granite
The faces of four presidents were carved in granite on Mount Rushmore, South Dakota.



Lab zone **Try This Activity**

Products From Minerals

To understand how minerals must be processed before they are used, compare bauxite and an aluminum can.

1. Examine a piece of the mineral bauxite carefully. Describe its properties, such as color, texture, and hardness.
2. Examine an aluminum can. (The metal aluminum comes from bauxite.) Compare the properties of the aluminum can with the properties of bauxite.

Posing Questions
To understand how bauxite is made into a useful material, what questions would you need to ask?

Producing Metals From Ores

A rock that contains a metal or other useful mineral that can be mined and sold at a profit is called an **ore.** Most metals do not occur in a pure form. A metal usually occurs as a mineral that is a combination of that metal and other elements. Copper often comes from ores containing iron and sulfur as well as copper.

How is an ore made into a finished product? **To produce metal from an ore, the ore must be mined, or removed from the ground. Then the ore must be processed to extract the metal.**

Mining Once geologists locate an ore deposit, miners decide how to remove the ore from the ground. There are three types of mines: strip mines, open-pit mines, and shaft mines. In strip mining, earthmovers scrape away soil to expose ore. In open-pit mining, miners use giant earthmoving equipment to dig a huge pit. Then they remove the ore deposits. For ore deposits that occur in veins, miners dig shaft mines. Shaft mines often have a network of tunnels that extend deep into the ground.

Each type of mining has environmental effects. For example, strip mines expose the soil, which can then be blown or washed away. Plants may not be able to grow in a strip-mined area for many years. To restore the land, mine operators replace soil removed during mining. Then they plant grass and trees.

Smelting Ores must be smelted before the metals they contain can be used. In the process of **smelting,** an ore is mixed with other substances and then melted to separate the useful metal from other elements the ore contains. For example, iron ores must be smelted to separate the iron from the oxygen and other substances in the ores.

Smelting releases gases and particles of metals into the air and water. Some of these substances can be harmful to living things. Smelters often have devices called "scrubbers" located on exhaust vents to reduce the release of harmful substances.

Reading Checkpoint **What is smelting?**

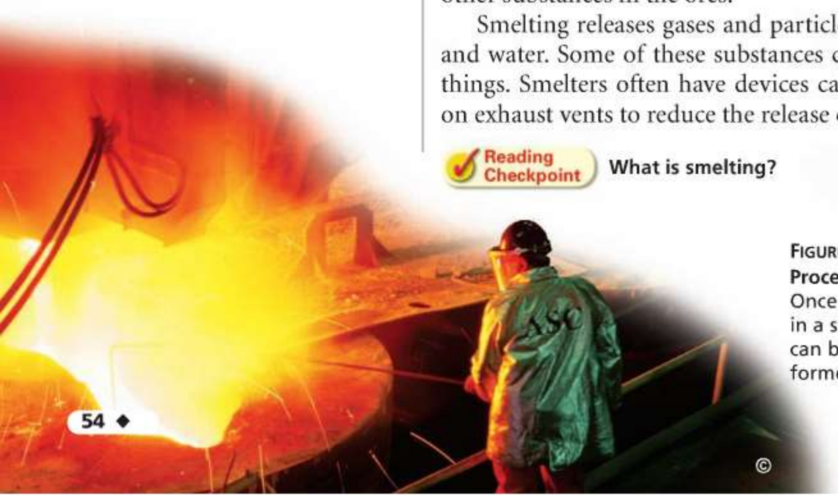
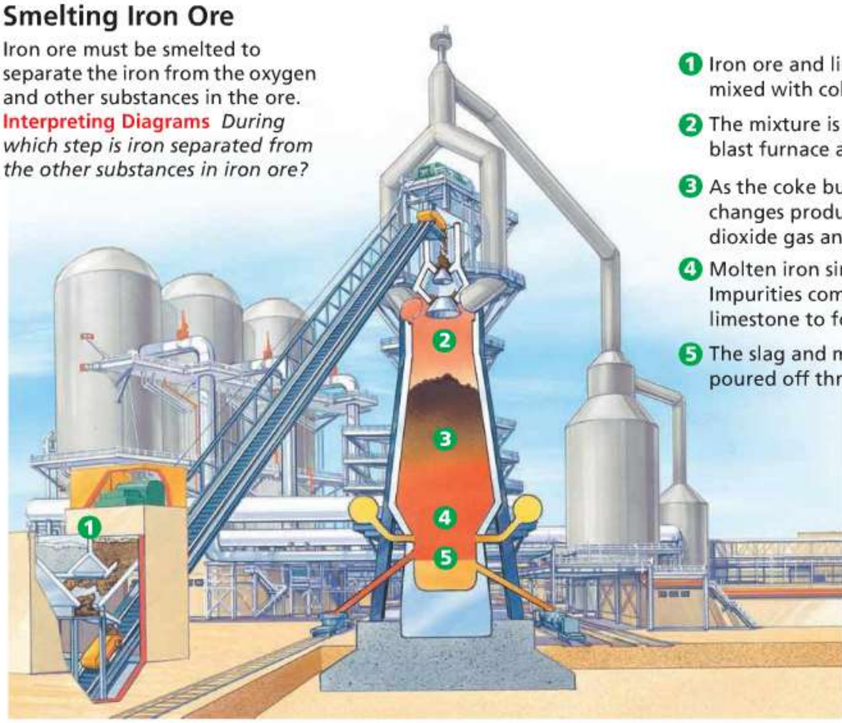


FIGURE 9
Processing Ore
Once an ore has been processed in a smelter, the molten metal can be poured into a mold and formed into bars called ingots.

FIGURE 10

Smelting Iron Ore

Iron ore must be smelted to separate the iron from the oxygen and other substances in the ore. **Interpreting Diagrams** *During which step is iron separated from the other substances in iron ore?*



1. Iron ore and limestone are mixed with coke (baked coal).
2. The mixture is placed in the blast furnace and heated.
3. As the coke burns, chemical changes produce carbon dioxide gas and molten iron.
4. Molten iron sinks to the bottom. Impurities combine with the limestone to form slag.
5. The slag and molten iron are poured off through taps.

Section 1 Assessment

S 6.6.b, S 6.6.c
E-LA: Reading 6.2.0

Target Reading Skill Preview Visuals Review your questions and answers about the rock cycle. What are two processes that occur during the rock cycle?

Reviewing Key Concepts

HINT **1. a. Listing** List the five characteristics of a mineral.

HINT **b. Explaining** What does it mean to say that a mineral is inorganic?

HINT **c. Classifying** Coal is a solid, naturally occuring substance. Coal forms from the remains of plants and animals. Is coal a mineral? Explain.

HINT **2. a. Defining** Write a definition of the rock cycle.

HINT **b. Explaining** What must happen for any rock in the rock cycle to form sedimentary rock?

HINT **c. Sequencing** Begin with an igneous rock and explain how it could change through two more steps in the rock cycle.

3. a. Listing List three main uses of minerals and two main uses of rocks. HINT

b. Identifying What is an ore? HINT

c. Summarizing Explain the steps that must take place before an ore can be made into a product. HINT

Lab zone At-Home Activity

The Rocks Around Us Many common household products contain minerals found in igneous rock. For example, glass contains quartz, which is found in granite. Research one of the following materials and the products in which it is used: garnet, granite, perlite, pumice, or vermiculite. Explain to family members how the rock or mineral formed and how it is used.

Section 2

Rocks and Weathering

CALIFORNIA Standards Focus

S 6.2 Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:

a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.

- How do weathering and erosion affect Earth's surface?
- What are the causes of mechanical weathering and chemical weathering?
- What determines how fast weathering occurs?

Key Terms

- weathering
- erosion
- uniformitarianism
- mechanical weathering
- abrasion
- ice wedging
- chemical weathering
- oxidation
- permeable

Lab zone Standards Warm-Up

How Fast Can It Fizz?

1. Place a fizzing antacid tablet in a small beaker. Then grind up a second tablet and place it in another beaker. The whole tablet is a model of solid rock. The ground-up tablet is a model of rock fragments.
2. Add 100 mL of warm water to the beaker containing the whole tablet. Then stir with a stirring rod until the tablet dissolves completely. Use a stopwatch to time how long it takes.
3. Add 100 mL of warm water to the beaker containing the ground-up tablet. Then stir until all of the ground-up tablet dissolves. Time how long it takes.

Think It Over

Drawing Conclusions Which dissolved faster, the whole antacid tablet or the ground-up tablet? What variable affected how long it took each of them to dissolve?

Imagine a hike that lasts for months and covers hundreds of kilometers. Each year, many hikers go on such treks. They hike trails that run the length of America's great mountain ranges. For example, the John Muir Trail follows the Sierra Nevada mountains. The Sierras extend about 640 kilometers along the eastern side of California. In the east, the Appalachian Trail follows the Appalachian Mountains. The Appalachians stretch more than 3,000 kilometers from Alabama to Canada.

The two trails cross very different landscapes. The Sierras are rocky and steep, with many peaks rising 3,000 meters above sea level. The Appalachians are more rounded and gently sloping, and are covered with soil and plants. The highest peaks in the Appalachians are less than half the elevation of the highest peaks in the Sierras. Which mountain range do you think is older? The Appalachians formed more than 250 million years ago. The Sierras formed only within the last 10 to 20 million years. The forces that wear down rock on Earth's surface have had much longer to grind down the Appalachians.

Weathering and Erosion

The process of mountain building thrusts rock up to the surface of Earth. There, the rock is exposed to weathering. **Weathering** is the process that breaks down rock and other substances at Earth's surface. Heat, cold, water, and ice all contribute to weathering. So do the oxygen and carbon dioxide in the atmosphere. Repeated freezing and thawing, for example, can crack rock apart into smaller pieces. Rainwater can dissolve minerals that bind rock together. You don't need to go to the mountains to see examples of weathering. The forces that wear down mountains also cause bicycles to rust, paint to peel, sidewalks to crack, and potholes to form.

The forces of weathering break rocks into smaller and smaller pieces of sediment. Then the forces of erosion carry the pieces away. **Erosion** (ee ROH zhun) is the transportation of sediment by wind, water, ice, or gravity. **Topography is reshaped by weathering and erosion. These processes work together continuously to wear down and carry away the rocks at Earth's surface.** The weathering and erosion that geologists observe today also shaped Earth's surface millions of years ago. How do geologists know this? Geologists make inferences based on the principle of **uniformitarianism** (yoon uh fawrm uh TAYR ee un iz um). This principle states that the same processes that operate today operated in the past.

There are two kinds of weathering: mechanical weathering and chemical weathering. Both types of weathering act slowly, but over time they break down even the biggest, hardest rocks.

Reading Checkpoint **What is the difference between weathering and erosion?**

FIGURE 11
Effects of Weathering
The jagged peaks of the Sierra Nevadas (bottom) formed within the last 10 million years. The more gently sloping Appalachians (top) have been exposed to weathering for 250 million years.
Inferring *How can you tell that the Sierra Nevadas formed much more recently than the Appalachians?*

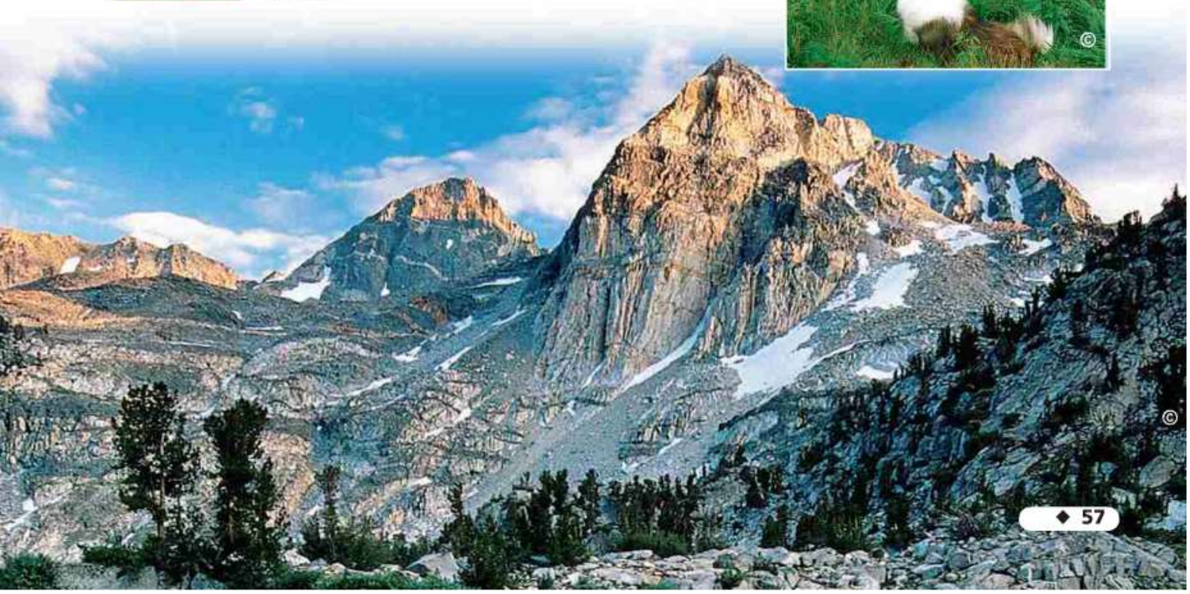
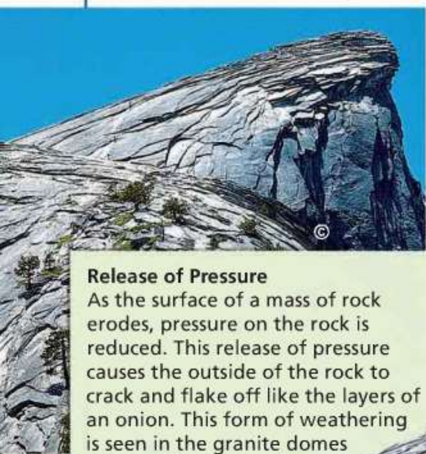


FIGURE 12
Forces of Mechanical Weathering

Mechanical weathering affects all the rock on Earth's surface.

Forming Operational Definitions *Study the examples of mechanical weathering. Then write a definition of each term in your own words.*

Freezing and Thawing
When water freezes in a crack in a rock, it expands and makes the crack bigger. The process of ice wedging also widens cracks in sidewalks and causes potholes in streets.



Release of Pressure
As the surface of a mass of rock erodes, pressure on the rock is reduced. This release of pressure causes the outside of the rock to crack and flake off like the layers of an onion. This form of weathering is seen in the granite domes of Yosemite National Park in California.

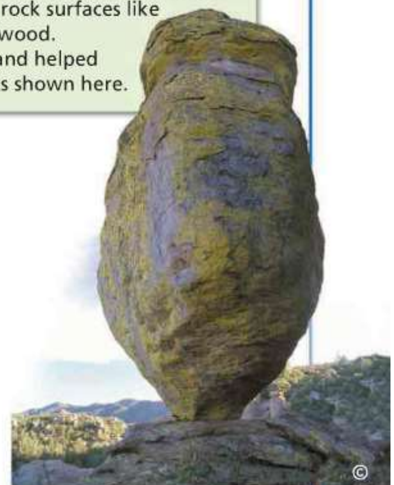
Animal Actions
Animals that burrow in the ground—including moles, gophers, prairie dogs, and some insects—loosen and break apart rocks in the soil.

Mechanical Weathering

If you hit a rock with a hammer, the rock may break into pieces. Like a hammer, some forces of weathering break rock into pieces. The type of weathering in which rock is physically broken into smaller pieces is called **mechanical weathering.** These smaller pieces of rock have the same composition as the rock they came from. If you have seen rocks that are cracked or split in layers, then you have seen rocks that are undergoing mechanical weathering. Mechanical weathering works slowly. But over very long periods of time, it does more than wear down rocks. Mechanical weathering eventually wears away whole mountains.

Plant Growth
Roots of trees and other plants enter cracks in rocks. As roots grow, they force the cracks farther apart. Over time, the roots of even small plants can pry apart cracked rocks.

Abrasion
Sand and other rock particles that are carried by wind, water, or ice can wear away exposed rock surfaces like sandpaper on wood. Wind-driven sand helped shape the rocks shown here.



The causes of mechanical weathering include freezing and thawing, release of pressure, plant growth, actions of animals, and abrasion. The term **abrasion** (uh BRAY zhun) refers to the grinding away of rock by rock particles carried by water, ice, wind, or gravity.

In cool climates, the most important force of mechanical weathering is the freezing and thawing of water. Water seeps into cracks in rocks and then freezes when the temperature drops. Water expands when it freezes. Ice therefore acts like a wedge that forces things apart. Wedges of ice in rocks widen and deepen cracks. This process is called **ice wedging.** When the ice melts, the water seeps deeper into the cracks. With repeated freezing and thawing, the cracks slowly expand until pieces of rock break off.

Reading Checkpoint How does ice wedging weather rock?

Go Online
PHSchool.com
For: More on weathering
Visit: PHSchool.com
Web Code: cfd-2021

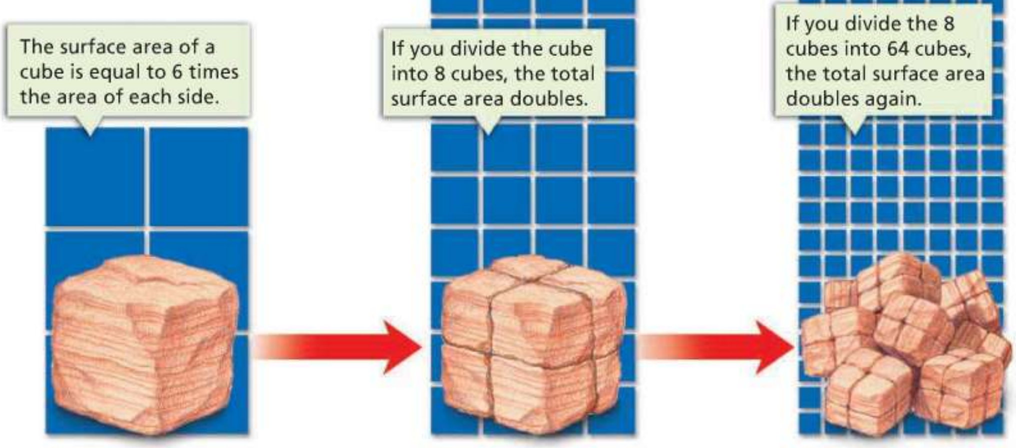
Chemical Weathering

In addition to mechanical weathering, another type of weathering attacks rock. **Chemical weathering** is the process that breaks down rock through chemical changes. **The causes of chemical weathering include the action of water, oxygen, carbon dioxide, living organisms, and acid rain.**

Each rock is made up of one or more minerals. Chemical weathering can produce new minerals as it breaks down rock. For example, granite is made up of several minerals, including feldspar, quartz, and mica. As a result of chemical weathering, granite eventually changes the feldspar minerals to clay minerals.

Chemical weathering creates holes or soft spots in rock, so the rock breaks apart more easily. Chemical and mechanical weathering often work together. As mechanical weathering breaks rock into pieces, more surface area becomes exposed to chemical weathering. The Standards Warm-Up activity at the beginning of this section shows how increasing the surface area increases the rate of a chemical reaction.

FIGURE 13
Weathering and Surface Area
As weathering breaks apart rock, the surface area exposed to weathering increases. The total volume of the rock stays the same even though the rock is broken into smaller and smaller pieces.
Predicting *What will happen to the surface area if each cube is again divided into four cubes?*



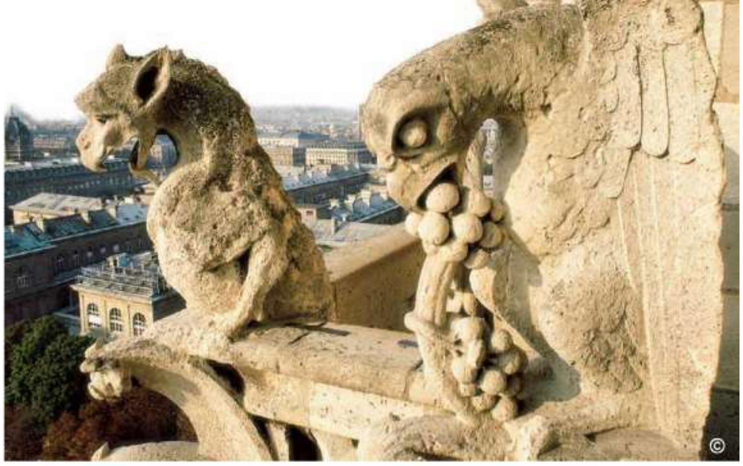


FIGURE 14
Effects of Chemical Weathering
Acid rain chemically weathered these stone gargoyles on the cathedral of Notre Dame in Paris, France.

Water Water is the most important cause of chemical weathering. Water weathers rock by dissolving it. When a rock or other substance dissolves in water, it mixes uniformly throughout the water to make a solution. Over time, many rocks will dissolve in water.

Oxygen The oxygen gas in air is an important cause of chemical weathering. If you have ever left a bicycle or metal tool outside in the rain, then you have seen how oxygen can weather iron. Iron combines with oxygen in the presence of water in a process called **oxidation.** The product of oxidation is rust. Rock that contains iron also oxidizes, or rusts. Rust makes rock soft and crumbly and gives it a red or brown color.

Carbon Dioxide Another gas found in air, carbon dioxide, also causes chemical weathering. Carbon dioxide dissolves in rainwater and in water that sinks through air pockets in the soil. The result is a weak acid called carbonic acid. Carbonic acid easily weathers rocks such as marble and limestone.

Living Organisms Imagine a seed landing on a rock face. As it sprouts, its roots push into cracks in the rock. As the plant's roots grow, they produce weak acids that slowly dissolve rock around the roots. Lichens—plantlike organisms that grow on rocks—also produce weak acids that chemically weather rock.

Acid Rain Over the past 150 years, people have been burning large amounts of coal, oil, and gas for energy. Burning these fuels can pollute the air with sulfur, carbon, and nitrogen compounds. Such compounds react chemically with the water vapor in clouds, forming acids. These acids mix with raindrops and fall as acid rain. Acid rain causes very rapid chemical weathering.

Reading Checkpoint **How can plants cause chemical weathering?**

Lab zone Try This Activity

Rusting Away

Here's how you can observe chemical weathering.

1. Moisten some steel wool and place it in a closed container so it will not dry out.
2. Observe the steel wool after a few days. What has happened to it?
3. Take a new piece of steel wool and squeeze it between your fingers. Remove the steel wool from the container and squeeze it between your fingers. What happens? Wash your hands when you have finished.

Predicting If you kept the steel wool moist for a longer time, what would eventually happen to it? How is the weathering of steel wool like the weathering of a rock?

Math: Algebra and Functions 6.2.2

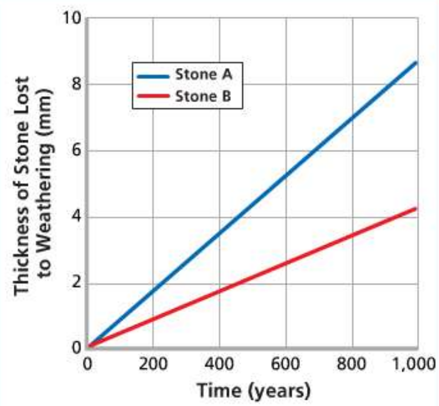
Math Analyzing Data

Which Weathered Faster?

The graph shows the rate of weathering for two identical pieces of limestone that weathered in different locations.

1. **Reading Graphs** What does the *x*-axis of the graph represent?
2. **Reading Graphs** What does the *y*-axis of the graph represent?
3. **Reading Graphs** How much thickness did Stone A lose in 1,000 years? How much thickness did Stone B lose in the same period?
4. **Drawing Conclusions** Which stone weathered at a faster rate?
5. **Inferring** Since the two identical pieces of limestone weathered at different rates, what can you infer caused the difference in their rates of weathering?

Weathering Rates of Limestone



Rate of Weathering

Visitors to New England's historic cemeteries may notice a surprising fact. Slate tombstones carved in the 1700s are less weathered and easier to read than marble gravestones from the 1800s. Why is this so? Some kinds of rocks weather more rapidly than others. **The most important factors that determine the rate at which weathering occurs are the type of rock and the climate.**

Type of Rock The minerals that make up the rock determine how fast it weathers. Rock made of minerals that do not dissolve easily in water weathers slowly. Rock made of minerals that dissolve easily in water weathers faster.

Some rock weathers more easily because it is permeable. **Permeable** (PUR mee uh bul) means that a material is full of tiny, connected air spaces that allow water to seep through it. Permeable rock weathers chemically at a fast rate. Why? As water seeps through the spaces in the rock, it dissolves and removes material broken down by weathering.

Climate Climate refers to the average weather conditions in an area. Both chemical and mechanical weathering occur faster in wet climates. Rainfall provides the water needed for chemical changes as well as for freezing and thawing.

Chemical reactions occur faster at higher temperatures. That is why chemical weathering occurs more quickly where the climate is both hot and wet. Granite, for example, is a very hard rock that forms when molten material cools inside Earth. Granite weathers so slowly in cool climates that it is often used as a building stone. But in hot and wet climates, granite weathers more rapidly and eventually crumbles apart.

Reading Checkpoint **How does rainfall affect the rate of weathering?**

FIGURE 15
Which Rock Weathers Faster?
These two tombstones are about the same age and are in the same cemetery, yet one has weathered much less than the other.
Inferring *Which type of stone weathers faster, granite or marble? Explain.*

Section 2 Assessment

S 6.2, S 6.2.a
E-LA: Reading 6.1.0

Vocabulary Skill **Suffixes** Complete the sentence with the correct words (*wedges/ice wedging*). _____ of ice in rocks widen and deepen cracks in the process of _____.

Reviewing Key Concepts

HINT
1. a. Defining What is weathering?
HINT
b. Defining What is erosion?
HINT
c. Predicting Over millions of years, how do weathering and erosion change a mountain made of solid rock?
HINT
2. a. Defining What is chemical weathering?
HINT
b. Comparing and Contrasting Compare and contrast mechanical weathering and chemical weathering.
HINT
c. Classifying Classify each as chemical or mechanical weathering: freezing or thawing, oxidation, water dissolving chemicals in rock, abrasion, acid rain.
HINT
3. a. Identifying What are two factors that affect the rate of weathering?
HINT
b. Relating Cause and Effect A granite monument is placed outside for 200 years in a region with a cool, dry climate. What would its rate of weathering be? Explain.

Lab zone At-Home Activity

Ice in a Straw Demonstrate one type of weathering for your family. Plug one end of a drinking straw with a small piece of clay. Fill the straw with water. Now plug the top of the straw with clay. Make sure that the clay plugs do not leak. Lay the straw flat in the freezer overnight. Remove the straw the next day. What happened to the clay plugs? What process produced this result? Be sure to dispose of the straw so that no one will use it for drinking.

Lab zone **Skills Lab**
Guided Inquiry

S 6.2, 6.7.a

Rock Shake

Materials


4 watertight plastic containers with screw-on caps, 500 mL


marking pen or pencil and masking tape


80 small pieces of water-soaked limestone

plastic graduated cylinder, 250 mL


300 mL of water


300 mL of vinegar, an acid


balance

2 pieces of thin cloth

paper towels

Problem

How will shaking and acid conditions affect the rate at which limestone weathers?

Skills Focus

developing hypotheses, interpreting data, calculating, drawing conclusions

Procedure

PART 1 Day 1

1. Using masking tape, label the four 500-mL containers A, B, C, and D.
2. Separate the 80 pieces of limestone into four sets of 20.
3. Copy the data table in your notebook. Then place the first 20 pieces of limestone on the balance and record their mass in the data table. Place the rocks in container A.
4. Repeat Step 3 for the other sets of rocks and place them in containers B, C, and D.
5. Pour 150 mL of water into container A and container B. Put caps on both containers.
6. Pour 150 mL of vinegar into container C and container D. Put caps on both containers.
7. Develop a hypothesis explaining the effect of weathering on the mass of the limestone pieces. Predict which will weather more: the limestone in water or the limestone in vinegar. (*Hint:* Vinegar is an acid.) Also develop a hypothesis explaining the effect of shaking on the limestone in containers B and D. Record your hypotheses in your notebook.
8. Allow the pieces to soak overnight.

Data Table

Container	Total Mass at Start	Total Mass Next Day	Change in Mass	Percent Change in Mass
A (water, no shaking)				
B (water, shaking)				
C (vinegar, no shaking)				
D (vinegar, shaking)				

PART 2 **Day 2**

9. Screw the caps tightly on containers B and D. Shake both containers for 10 to 15 minutes. Make sure that each container is shaken for exactly the same amount of time and at the same intensity. After shaking, set the containers aside. Do not shake containers A and C.
10. Open the top of container A. Place one piece of thin cloth over the opening of the container. Carefully pour all of the water out through the cloth into a waste container. Be careful not to let any of the pieces flow out with the water. Dry these pieces carefully and record their mass in your data table.
11. Next, determine how much limestone was lost through weathering in container A. (*Hint:* Subtract the mass of the limestone pieces remaining on Day 2 from the mass of the pieces on Day 1.)
12. Repeat Steps 10 and 11 for containers B, C, and D.

Analyze and Conclude

1. **Calculating** Calculate the percent change in mass of the 20 pieces for each container.

$$\% \text{ change} = \frac{\text{Change in mass X 100}}{\text{Total mass at start}}$$

Record the results in the data table.

2. **Interpreting Data** Do your data show a change in mass of the 20 pieces in each of the four containers?
3. **Interpreting Data** Is there a greater change in total mass for the pieces in one container than for the pieces in another? Explain.
4. **Drawing Conclusions** Did your results support your hypotheses explaining how shaking and acid would affect the weathering of limestone? Explain.
5. **Developing Hypotheses** If your data showed a greater change in the mass of the pieces in one of the containers, how might this change be explained?
6. **Drawing Conclusions** Based on your data, which variable do you think was more responsible for breaking down the limestone: the vinegar or the shaking? Explain.
7. **Communicating** Write a paragraph that explains why you allowed two of the containers to stand without shaking, and why you were careful to shake the other two containers for the same amount of time.

Design an Experiment

Would your results for this experiment change if you changed the variables? For example, you could soak or shake the pieces for a longer time, or test rocks other than limestone. You could also test whether adding more limestone pieces (30 rather than 20 in each set) would make a difference in the outcome. Develop a new hypothesis to explain the effects of changing one of those variables on the rate of weathering. Then design an experiment to test your hypothesis. *Have your teacher approve your plan before you begin.*

Section 3

How Soil Forms

CALIFORNIA Standards Focus

S 6.6.b Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

- What is soil made of, and how does it form?
- How do scientists classify soils?
- What is the role of plants and animals in soil formation?

Key Terms

- soil
- bedrock
- humus
- fertility
- loam
- soil horizon
- topsoil
- subsoil
- acidic
- basic
- litter
- decomposer

Lab zone **Standards Warm-Up**

What Is Soil?

1. Use a toothpick to separate a sample of soil into individual particles. With a hand lens, try to identify the different types of particles in the sample. Wash your hands when you are finished.
2. Write a "recipe" for the sample of soil, naming each of the "ingredients" that you think the soil contains. Include what percentage of each ingredient would be needed to make up the soil.
3. Compare your recipe with those of your classmates.

Think It Over

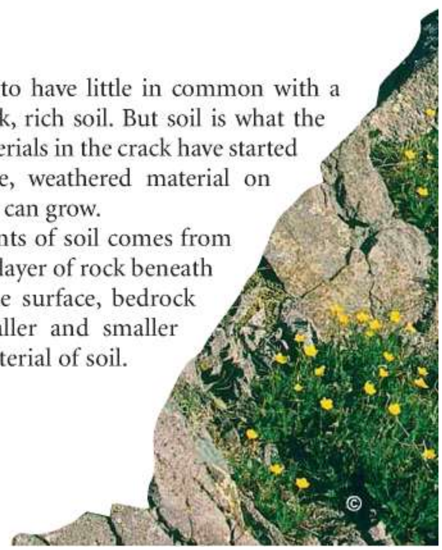
Forming Operational Definitions Based on your observations, how would you define the word *soil*?

A bare rock surface does not look like a spot where a plant could grow. But look more closely. In that hard surface is a small crack. Over many years, mechanical and chemical weathering will slowly enlarge the crack. Rain and wind will bring bits of weathered rock, dust, and dry leaves. The wind also may carry tiny seeds. With enough moisture, a seed will sprout and take root. Then, a few months later, the plant blossoms.

What Is Soil?

The crack in the rock seems to have little in common with a flower garden containing thick, rich soil. But soil is what the weathered rock and other materials in the crack have started to become. **Soil** is the loose, weathered material on Earth's surface in which plants can grow.

One of the main ingredients of soil comes from bedrock. **Bedrock** is the solid layer of rock beneath the soil. Once exposed at the surface, bedrock gradually weathers into smaller and smaller particles that are the basic material of soil.



Soil Composition Soil is more than particles of weathered bedrock. **Soil is a mixture of rock particles, minerals, decayed organic material, water, and air.** Together, sand, silt, and clay make up the portion of soil that comes from weathered rock.

The decayed organic material in soil is called humus. **Humus** (HYOO mus) is a dark-colored substance that forms as plant and animal remains decay. Humus helps create spaces in soil for the air and water that plants must have. Humus also contains substances called nutrients, including nitrogen, sulfur, phosphorus, and potassium. Plants need nutrients in order to grow. As plants grow, they absorb nutrients from the soil.

Fertile soil is rich in the nutrients that plants need to grow. The **fertility** of soil is a measure of how well the soil supports plant growth. Soil that is rich in humus has high fertility. Sandy soil containing little humus has low fertility.

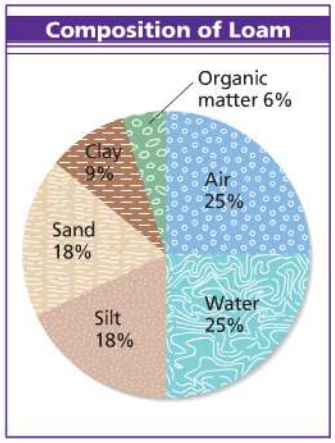


Figure 16
Loam, a type of soil, is made up of air, water, and organic matter as well as materials from weathered rock. **Interpreting Graphs** *What two materials make up the major portion of this soil?*

Soil Texture Sand feels coarse and grainy, but clay feels smooth and silky. These differences are differences in texture. Soil texture depends on the size of individual soil particles.

The particles of rock in soil are classified by size. As you can see in Figure 17, the largest soil particles are gravel. The smallest soil particles are clay. Clay particles are smaller than the period at the end of this sentence.

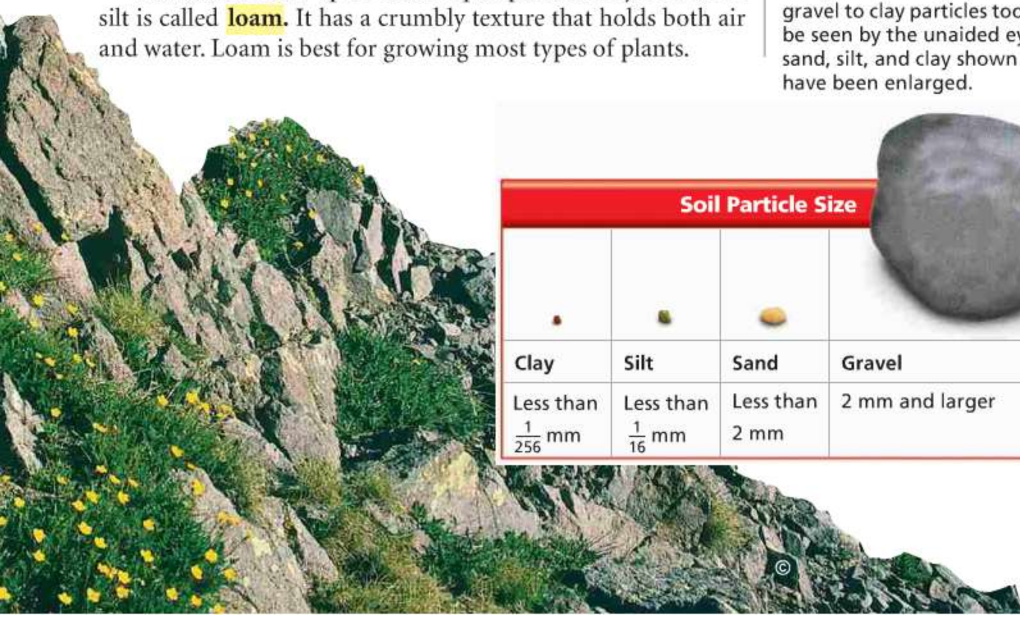
Soil texture is important for plant growth. Soil that is mostly clay has a dense, heavy texture. Some clay soils hold a lot of water, so plants grown in them may "drown" for lack of air. In contrast, sandy soil has a coarse texture. Water quickly drains through it, so plants may die for lack of water.

Soil that is made up of about equal parts of clay, sand, and silt is called **loam.** It has a crumbly texture that holds both air and water. Loam is best for growing most types of plants.

Figure 17
Soil particles range in size from gravel to clay particles too small to be seen by the unaided eye. The sand, silt, and clay shown here have been enlarged.

Soil Particle Size

Clay	Silt	Sand	Gravel
Less than $\frac{1}{256}$ mm	Less than $\frac{1}{16}$ mm	Less than 2 mm	2 mm and larger



The Process of Soil Formation

Soil forms as rock is broken down by weathering and mixes with other materials on the surface. Soil is constantly being formed wherever bedrock is exposed. Soil formation continues over a long period of time.

Gradually, soil develops layers called horizons. A **soil horizon** is a layer of soil that differs in color and texture from the layers above or below it.

If you dug a hole in the ground about half a meter deep, you would see the different soil horizons. Figure 18 shows how soil scientists classify the soil into three horizons. The A horizon is made up of **topsoil,** a crumbly, dark brown soil that is a mixture of humus, clay, and other minerals. The B horizon, often called **subsoil,** usually consists of clay and other particles washed down from the A horizon, but little humus. The C horizon contains only partly weathered rock.

The rate at which soil forms depends on the climate and type of rock. Remember that weathering occurs most rapidly in areas with a warm, rainy climate. As a result, soil develops more quickly in these areas. In contrast, weathering and soil formation take place slowly in areas where the climate is cold and dry.

Some types of rock weather and form soil faster than others. For example, limestone, a type of rock formed from the shells and skeletons of once-living things, weathers faster than granite. Thus, soil forms more quickly from limestone than from granite.

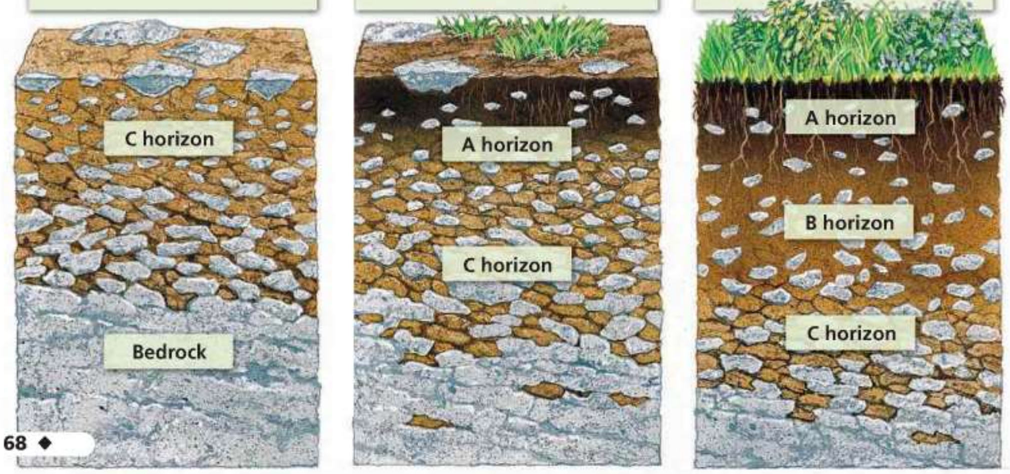
Go Online
active art
For: Soil Layers activity
Visit: PHSchool.com
Web Code: cfp-2022

FIGURE 18
Soil Layers
Soil horizons form in three steps.
Inferring *Which soil horizon is responsible for soil's fertility? Explain.*

1 The C horizon forms as bedrock weathers and rock breaks up into soil particles.

2 The A horizon develops as plants add organic material to the soil and plant roots weather pieces of rock.

3 The B horizon develops as rainwater washes clay and minerals from the A horizon to the B horizon.



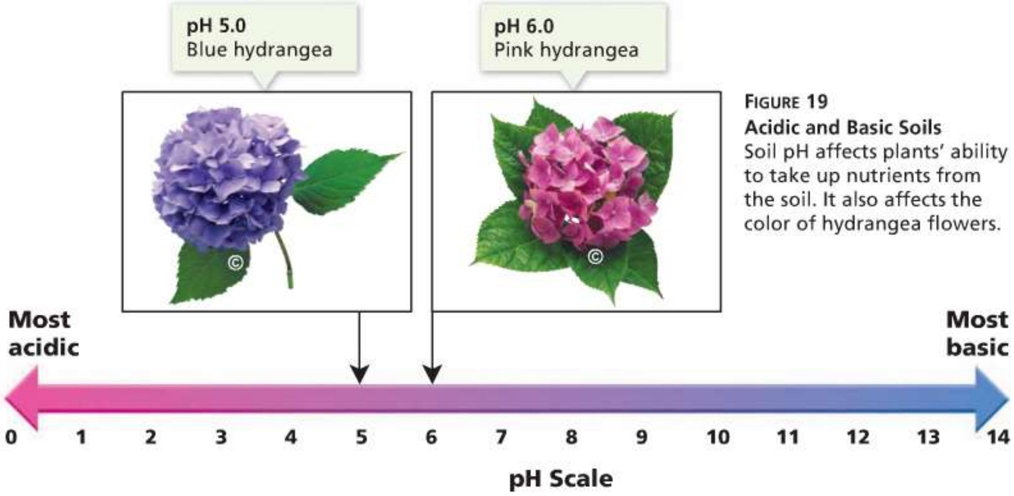


FIGURE 19
Acidic and Basic Soils
Soil pH affects plants' ability to take up nutrients from the soil. It also affects the color of hydrangea flowers.

Soil Types

There are thousands of different soil types. **Scientists classify the different types of soil into major groups based on climate, plants, soil composition, and whether the soil is acidic or basic.** Fertile soil can form in regions with hot, wet climates, but rain may wash humus and minerals out of the A horizon. In mountains and polar regions with cold, dry climates, the soil is often very thin. The thickest, most fertile soil forms in climate regions with moderate temperatures and rainfall.

The most common plants found in a region are also used to help classify the soil. For example, grassland soils are very different from forest soils. In addition, scientists classify soil by its composition—whether it is rocky, sandy, or rich in clay.

Soils can also be classified as either acidic or basic. A substance is **acidic** if it reacts strongly with some metals and changes blue litmus paper red. A substance is **basic** if it feels slippery and changes red litmus paper blue. Scientists use the pH scale, shown in Figure 19, to measure how acidic or basic a substance is. A substance with a pH of 0 is strongly acidic. A substance with a pH of 14 is strongly basic. A substance with a pH of 7 is neutral. This means that it is in between acidic and basic. For plants to grow well, soil must not be too acidic or too basic. Most garden plants grow best if the soil's pH is between 6 and 7.5, or slightly acidic to slightly basic. But some soils can have a pH as low as 4, which is quite acidic.

Reading Checkpoint **What does the pH scale measure?**

Lab zone Try This **Activity**

Red or Blue?

You can use litmus paper to determine whether soil is acidic or basic. **CAUTION:** Never taste a substance to test whether it is acidic or basic. Strongly acidic or basic substances are poisonous and can cause burns.

1. Place a small spoonful of soil in a plastic cup, add enough water to fill the cup halfway, and stir carefully for 10 seconds.
2. Dip a strip of blue litmus paper in the mixture of soil and water.
3. Observe the color change in the litmus paper.
4. Repeat Steps 2 and 3 using red litmus paper.

Inferring What can you infer about the pH of the soil?

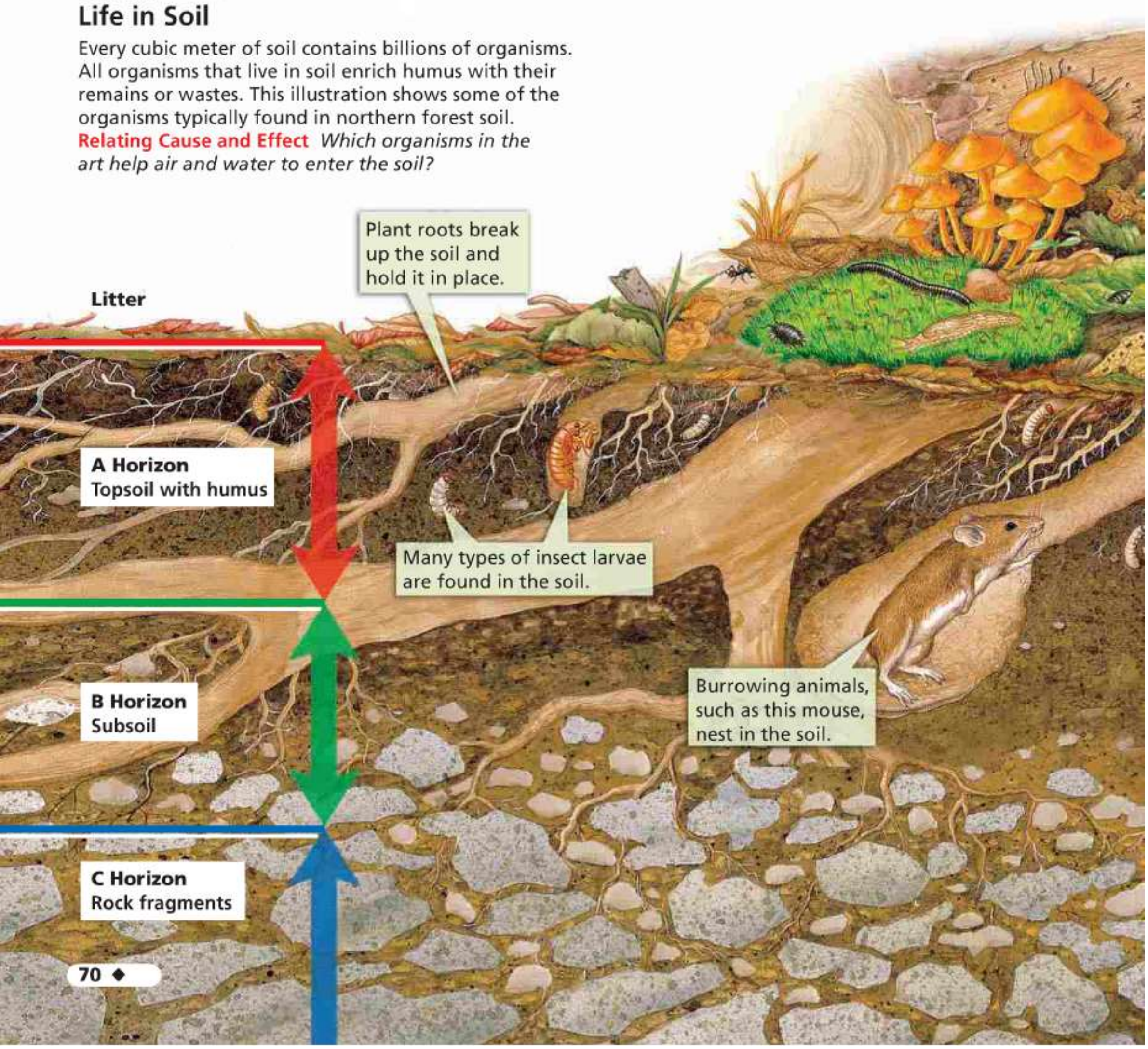
Living Organisms in Soil

If you look closely at soil, you can see that it is teeming with living things. **Some soil organisms make humus, the material that makes soil fertile. Other soil organisms mix the soil and make spaces in it for air and water.**

Forming Humus Plants contribute most of the organic remains that form humus. As plants shed leaves, they form a loose layer called **litter.** When plants die, their remains fall to the ground and become part of the litter. Plant roots also die and begin to decay underground. Although plant remains are full of stored nutrients, they are not yet humus.

FIGURE 20
Life in Soil

Every cubic meter of soil contains billions of organisms. All organisms that live in soil enrich humus with their remains or wastes. This illustration shows some of the organisms typically found in northern forest soil.
Relating Cause and Effect *Which organisms in the art help air and water to enter the soil?*



Humus forms in a process called decomposition. During decomposition, organisms that live in soil turn dead organic material into humus. These organisms are called decomposers. **Decomposers** are the organisms that break the remains of dead organisms into smaller pieces and digest them with chemicals.

Soil decomposers include fungi, bacteria, worms, and other organisms. Fungi are organisms such as molds and mushrooms. Fungi grow on, and digest, plant remains. Bacteria are microscopic decomposers that cause decay. Bacteria attack dead organisms and their wastes in soil. Very small animals, such as mites and worms, also decompose dead organic material and mix it with the soil.

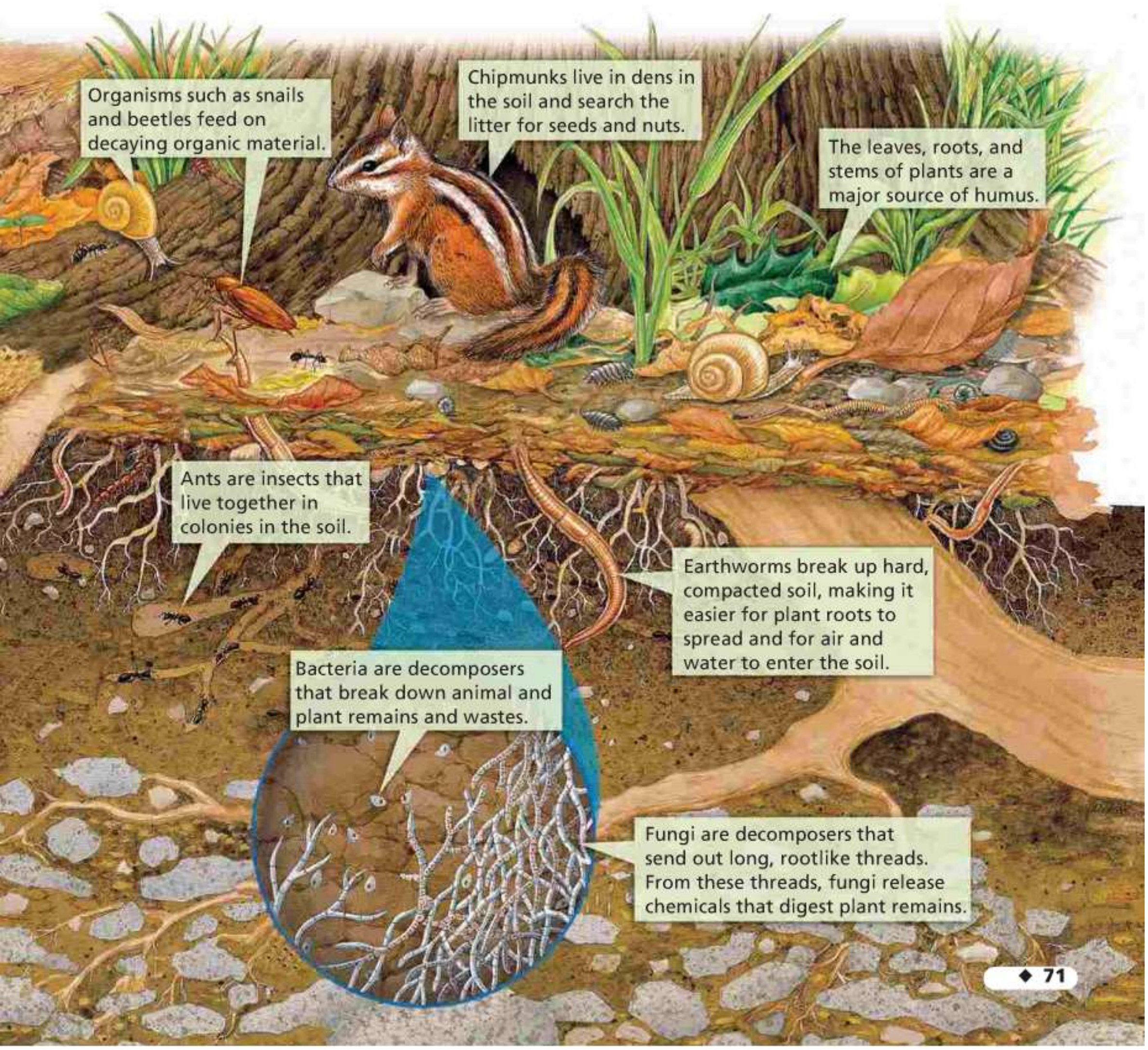


FIGURE 21
Soil Mixers
Earthworms break up the soil, allowing in air and water. An earthworm eats its own weight in soil every day. **Predicting** *How fertile is soil that contains many earthworms likely to be? Explain.*

Mixing the Soil Earthworms do most of the work of mixing humus with other materials in soil. As earthworms eat their way through the soil, they carry humus down to the subsoil and subsoil up to the surface. Earthworms also pass out the soil they eat as waste. The waste soil is enriched with substances that plants need to grow, such as nitrogen.

Many burrowing mammals such as mice, moles, prairie dogs, and gophers break up hard, compacted soil and mix humus through it. These animals also add nitrogen to the soil when they produce waste. They add organic material when they die and decay.

Earthworms and burrowing animals also help to aerate, or mix air into, the soil. Plant roots need the oxygen that this process adds to the soil.

Reading Checkpoint **Which animals are most important in mixing humus into the soil?**

Section 3 Assessment

S 6.6.b, E-LA: Reading 6.2.0, Writing 6.2.0

Target Reading Skill **Preview Visuals** Review your questions and answers for Figure 20, Life in Soil. What two organisms in the illustration are decomposers?

Reviewing Key Concepts

HINT 1. a. **Describing** What five materials make up soil?

HINT b. **Explaining** How do soil horizons form?

HINT c. **Sequencing** Place these terms in the correct order starting from the surface: C horizon, subsoil, bedrock, topsoil.

HINT 2. a. **Reviewing** What are four main factors used to classify soils?

HINT b. **Classifying** The pH values of four soil samples are Sample 1, 7.7; Sample 2, 6.0; Sample 3, 7.0; and Sample 4, 4.9. Classify the samples as acidic, basic, or neutral. (*Hint:* Refer to the pH scale in Figure 19.)

3. a. **Identifying** What are two main ways in which soil organisms contribute to soil formation? HINT

b. **Describing** Give examples of three types of decomposers and describe their effects on soil. HINT

c. **Predicting** What would happen to the fertility of a soil if all decomposers were removed? Explain. HINT

Writing in Science

Product Label Write a product label for a bag of topsoil. Your label should give the soil a name that will make consumers want to buy it, state how and where the soil formed, give its composition, and suggest how it can be used.

Lab zone

Consumer Lab

Guided Inquiry

S 6.5.e, 6.7.b

Comparing Soils

Materials

20–30 grams of local soil

graph paper ruled with 1- or 2-mm spacing

plastic petri dish or jar lid

plastic spoon and plastic dropper

water

stereomicroscope

20–30 grams of bagged topsoil

Problem

What are the characteristics of two samples of soil?

Skills Focus

observing, inferring, developing hypotheses

Procedure

1. Obtain a sample of local soil. As you observe the sample, record your observations in your lab notebook.
2. Spread half of the sample on the graph paper. Spread the soil thinly so that you can see the lines on the paper through the soil. Using the graph paper as a background, estimate the sizes of the particles that make up the soil.
3. Place the rest of the sample in the palm of your hand, rub it between your fingers, and squeeze it. Is it soft or gritty? Does it clump together or crumble when you squeeze it?
4. Place about half the sample in a plastic petri dish. Using the dropper, add water one drop at a time. Watch how the sample changes. Does any material in the sample float? As the sample gets wet, do you notice any odor? (*Hint:* If the wet soil has an odor or contains material that floats, it is likely to contain organic material.)
5. Look at some of the soil under the stereomicroscope. (*Hint:* Use a toothpick to separate the particles in the soil.) Sketch what you see. Label the particles, such as gravel, organic matter, or strangely shaped grains.
6. Repeat Steps 1–5 with the topsoil. Be sure to record your observations.
7. Clean up and dispose of your samples as directed by your teacher. **CAUTION:** *Wash your hands when you finish handling the soil.*

Analyze and Conclude

1. **Observing** Did you observe any similarities between the local soil sample and the topsoil? Any differences?
2. **Inferring** What can you infer about the composition of both types of soil from the different sizes of their particles? From your observations of texture? From how the samples changed when water was added?
3. **Inferring** Do you think that both types of soil were formed in the same way? Explain.
4. **Developing Hypotheses** Based on your observations and study of the chapter, develop a hypothesis to explain which soil would be better for growing a specific vegetable.
5. **Communicating** Write a report for consumers that summarizes the steps in your analysis of the two soil samples and your results. Be sure to describe what factors you analyzed and give a suggestion for which soil consumers should use for growing flowers and vegetables.

Design an Experiment

Design an experiment to test the hypothesis that you developed for Question 4. Be sure to indicate how you would control variables. *After you receive your teacher's approval, carry out your experiment.*

Section 4

Soil Conservation

CALIFORNIA Standards Focus

S 6.6 Sources of energy and materials differ in amounts, distribution, usefulness, and the time required for their formation. As a basis for understanding this concept:

b. Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

- Why is fertile soil considered a nonrenewable resource?
- How can soil lose its value?
- What are some ways that soil can be conserved?

Key Terms

- sod
- natural resource
- Dust Bowl
- soil conservation
- contour plowing
- conservation plowing
- crop rotation

Lab zone Standards Warm-Up

How Can You Keep Soil From Washing Away?

1. Pour about 500 mL of soil into a pie plate, forming a pile.
2. Devise a way to keep the soil from washing away when water is poured over it. To protect the pile of soil, you may use craft sticks, paper clips, pebbles, modeling clay, strips of paper, or other materials approved by your teacher.
3. After arranging your materials to protect the soil, hold a container filled with 200 mL of water about 20 cm above the center of the soil. Slowly pour the water in a stream onto the pile of soil.
4. Compare your pan of soil with those of your classmates.

Think It Over

Observing Based on your observations, what do you think is the best way to prevent soil on a slope from washing away?

Suppose you were a settler traveling west in the mid 1800s. Much of your journey would have been through vast, open grasslands called prairies. After the forests and mountains of the East, the prairies were an amazing sight. Grass taller than a person rippled and flowed in the wind like a sea of green.

The prairie soil was very fertile. It was rich with humus because of the tall grass. The **sod**—the thick mass of tough roots at the surface of the soil—kept the soil in place and held on to moisture.

The prairies covered a vast area in the American Midwest. Today, farms growing crops such as corn, soybeans, and wheat have replaced the prairies. But prairie soils are still among the most fertile in the world.

Prairie grasses and wildflowers ▼

Soil as a Resource

A **natural resource** is anything in the environment that humans use. Soil is one of Earth's most valuable natural resources because everything that lives on land, including humans, depends directly or indirectly on soil. Plants depend directly on the soil to live and grow. Humans and animals depend on plants—or on other animals that depend on plants—for food.

Fertile soil is valuable because there is a limited supply. Less than one eighth of the land on Earth has soils that are well suited for farming. Soil is also in limited supply because it takes a long time to form. It can take hundreds of years for just a few centimeters of soil to form. The thick, fertile soil of the prairies took many thousands of years to develop. **Because fertile soil is in limited supply and takes a long time to form, it is considered a nonrenewable resource.**

Video Field Trip
Discovery Channel School
Weathering and Soil Formation

Soil Damage and Loss

Human activities and changes in the environment can affect the soil. **The value of soil is reduced when soil loses its fertility and when topsoil is lost due to erosion.**

Loss of Fertility Soil can be damaged when it loses its fertility. Soil that has lost its fertility is said to be exhausted. This type of soil loss occurred in large parts of the South in the late 1800s. Soils in which only cotton had been grown were exhausted. Many farmers left their farms. Early in the 1900s in Alabama, a scientist named George Washington Carver developed new crops and farming methods that helped to restore soil fertility in the South. Peanuts were one crop that helped make the soil fertile again. Peanut plants are legumes. Legumes have small lumps on their roots that contain nitrogen-fixing bacteria. These bacteria make nitrogen, an important nutrient, available in a form that plants can use.

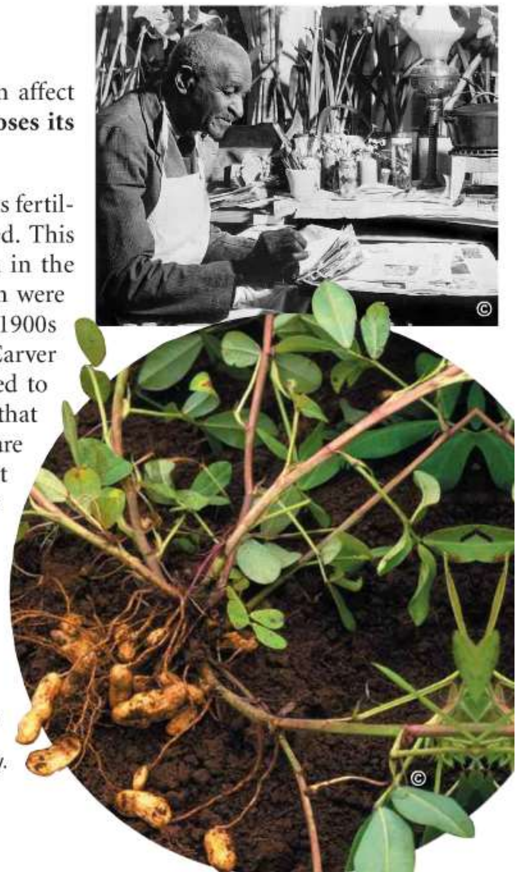


FIGURE 22
Restoring Soil Fertility
George Washington Carver (1864–1943) taught new methods of soil conservation. He also encouraged farmers to plant peanuts, which helped restore soil fertility.
Applying Concepts *What nutrient do peanut plants add to the soil?*

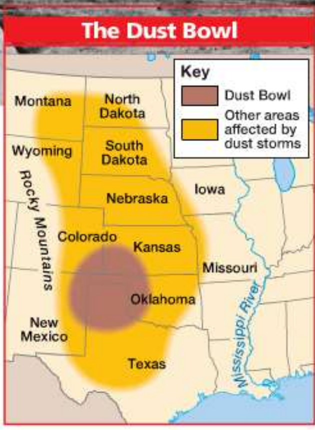


FIGURE 23
The Dust Bowl
The Dust Bowl ruined farmland in western Oklahoma and parts of the surrounding states. Wind blew dry particles of soil into great clouds of dust that traveled thousands of kilometers.

Loss of Topsoil Where soil is exposed, water and wind can quickly carry soil away in the process of erosion. Plant cover can protect soil from erosion. Plants break the force of falling rain, and plant roots hold the soil together. Wind also causes soil loss. Wind erosion is most likely in areas where farming methods are not suited to dry conditions. For example, wind erosion led to the Dust Bowl on the Great Plains.

Soil Loss in the Dust Bowl Toward the end of the 1800s, farmers settled the Great Plains. The soil of the Great Plains is fertile. But rainfall decreases steadily from east to west across the Great Plains. The region also has droughts—years when rainfall is scarce. Plowing removed the grass from the Great Plains and exposed the soil. In times of drought, the topsoil quickly dried out, turned to dust, and blew away.

By 1930, almost all of the Great Plains had been turned into farms or ranches. Then, a long drought turned the soil on parts of the Great Plains to dust. The wind blew the soil east in great, black clouds that reached Chicago and New York City. The erosion was most serious in the southern Plains states. This area, shown in Figure 23, was called the **Dust Bowl.** The Dust Bowl helped people appreciate the value of soil. With government support, farmers in the Great Plains and throughout the country began to take better care of their land. They adopted methods of farming that helped save the soil. Some methods were new. Others had been practiced for hundreds of years.

Reading Checkpoint What caused the Dust Bowl?

Go Online
SCI LINKS NSTA
For: Links on soil conservation
Visit: www.SciLinks.org
Web Code: scn-0723

Soil Conservation

Since the Dust Bowl, farmers have adopted modern methods of soil conservation. **Soil conservation** is the management of soil to prevent its destruction. **Soil can be conserved through contour plowing, conservation plowing, and crop rotation.**

In **contour plowing,** farmers plow their fields along the curves of a slope. This helps slow the runoff of excess rainfall and prevents it from washing the soil away.

In **conservation plowing,** farmers disturb the soil and its plant cover as little as possible. Dead weeds and stalks of the previous year's crop are left in the ground to help return soil nutrients, retain moisture, and hold soil in place. This method is also called low-till or no-till plowing.

In **crop rotation,** a farmer plants different crops in a field each year. Different types of plants absorb different amounts of nutrients from the soil. Some crops, such as corn and cotton, absorb large amounts of nutrients. The year after planting these crops, the farmer plants crops that use fewer soil nutrients, such as oats, barley, or rye. The year after that the farmer sows legumes such as alfalfa or beans to restore the nutrient supply.

Reading Checkpoint **How does conservation plowing help conserve soil?**

FIGURE 24
Soil Conservation Methods
This farm's fields show evidence of contour plowing and crop rotation. **Predicting** *How might contour plowing affect the amount of topsoil?*

Section 4 Assessment

S 6.6.b; E-LA: Reading 6.1.0

Vocabulary Skill **Suffixes** Complete the following sentence with the correct word (*conserve/conservation*). Farmers can ______ soil by crop rotation.

Reviewing Key Concepts

HINT HINT
1. a. **Reviewing** What is a natural resource?
   b. **Explaining** Why is fertile soil considered a nonrenewable resource?

HINT HINT
2. a. **Listing** What are two ways in which the value of soil can be reduced?
   b. **Explaining** Explain how topsoil can be lost.
   c. **Relating Cause and Effect** What caused the Dust Bowl?

HINT HINT HINT
3. a. **Defining** What is soil conservation?
   b. **Listing** What are three methods by which farmers can conserve soil?
   c. **Problem Solving** A farmer growing corn wants to maintain soil fertility and reduce erosion. What conservation methods could the farmer try? Explain.

Writing in Science

Public Service Announcement
A severe drought in a farming region threatens to produce another Dust Bowl. Write a paragraph about soil conservation to be read as a public service announcement on radio stations. The announcement should identify the danger of soil loss due to erosion. It should also describe the steps farmers can take to conserve the soil.

Chapter 2 Study Guide

The BIG Idea The weathering of rock helps to reshape Earth's topography and form soil.

1 Minerals and Rocks

Key Concepts — S 6.6.b

- A mineral is a naturally occurring, inorganic solid that forms on or beneath Earth's surface. Almost all minerals have a crystal shape. Each mineral also has a definite chemical composition.
- Geologists classify rocks into three groups: igneous rock, sedimentary rock, and metamorphic rock. The rocks in each group form through different steps in the rock cycle.
- Minerals are the source of gemstones, metals, and other materials used to make products.
- People use rocks for building materials and in industrial processes.
- To produce metal from an ore, the ore must be mined and then smelted to extract the metal.

Key Terms

• mineral • crystal • rock cycle
• igneous rock • sedimentary rock • sediment
• metamorphic rock • nonrenewable resource
• ore • smelting

2 Rocks and Weathering

Key Concepts — S 6.2, 6.2.a

- Weathering and erosion work together continuously to wear down and carry away the rocks at Earth's surface.
- The causes of mechanical weathering include freezing and thawing, release of pressure, plant growth, actions of animals, and abrasion.
- The causes of chemical weathering include the action of water, oxygen, carbon dioxide, living organisms, and acid rain.
- The most important factors that determine the rate at which weathering occurs are the type of rock and the climate.

Key Terms

• weathering • erosion • uniformitarianism
• mechanical weathering • abrasion
• ice wedging • chemical weathering
• oxidation • permeable

3 How Soil Forms

Key Concepts — S 6.6.b

- Soil is a mixture of rock particles, minerals, decayed organic material, water, and air.
- Soil forms as rock is broken down by weathering and mixes with other materials on the surface. Soil is constantly being formed wherever bedrock is exposed.
- Scientists classify the different types of soil into major groups based on climate, plants, soil composition, and whether the soil is acidic or basic.
- Some soil organisms make humus, the material that makes soil fertile. Other soil organisms mix the soil and make spaces in it for air and water.

Key Terms

• soil • bedrock • humus • fertility • loam
• soil horizon • topsoil • subsoil • acidic
• basic • litter • decomposer

4 Soil Conservation

Key Concepts — S 6.6.b

- Because fertile soil is in limited supply and takes a long time to form, it is considered a nonrenewable resource.
- The value of soil is reduced when soil loses its fertility and when topsoil is lost due to erosion.
- Soil can be conserved through contour plowing, conservation plowing, and crop rotation.

Key Terms

• sod • natural resource • Dust Bowl
• soil conservation • contour plowing
• conservation plowing • crop rotation

Review and Assessment

Go Online PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cwa-1020

Target Reading Skill

Previewing Visuals Complete your graphic organizer for Life in Soil with more questions and answers to show that you understand the role of organisms in forming soil.

Life in Soil

Q. What is the subject of this illustration?
A.
Q. What kinds of organisms live underground?
A.
Q.
A.

Reviewing Key Terms

Choose the letter of the best answer.

HINT **1.** In the rock cycle, a rock that is changed by heat and pressure becomes a(n)
- **a.** sedimentary rock.
- **b.** metamorphic rock.
- **c.** chemical rock.
- **d.** igneous rock.

HINT **2.** The process that splits rock through freezing and thawing is called
- **a.** erosion.
- **b.** chemical weathering.
- **c.** ice wedging.
- **d.** abrasion.

HINT **3.** Soil that is made up of roughly equal parts of clay, sand, and silt is called
- **a.** sod.
- **b.** loam.
- **c.** tropical soil.
- **d.** subsoil.

HINT **4.** The B horizon consists of
- **a.** subsoil.
- **b.** topsoil.
- **c.** litter.
- **d.** bedrock.

HINT **5.** The humus in soil is produced by
- **a.** mechanical weathering.
- **b.** bedrock.
- **c.** chemical weathering.
- **d.** decomposers.

Complete the following sentences so that your answers clearly explain the key terms.

6. Minerals and rocks are considered **nonrenewable resources,** which means __________. HINT

7. One way rock breaks down is through **mechanical weathering,** which is __________. HINT

8. Rock that is **permeable** weathers easily because __________. HINT

9. Fertile soil is rich in **humus,** which is __________. HINT

10. In **conservation plowing,** farmers conserve soil fertility by __________ . HINT

Writing in Science

Journal Entry You are a farmer on the tall grass prairie in the midwestern United States. Write a journal entry describing prairie soil. Include the soil's composition, how it formed, and how animals helped it develop.

Video Assessment
Discovery Channel School
Weathering and Soil Formation

Review and Assessment

Checking Concepts

11. What is a crystal?

12. How are granite and basalt similar? How are they different? Explain.

13. What are the environmental effects of mining and smelting?

14. What is the principle of uniformitarianism?

15. Explain how plants can act as agents of both mechanical and chemical weathering.

16. What is the role of gases such as oxygen and carbon dioxide in chemical weathering?

17. Briefly describe how soil is formed.

18. Which contains more humus, topsoil or subsoil? Which has higher fertility? Explain.

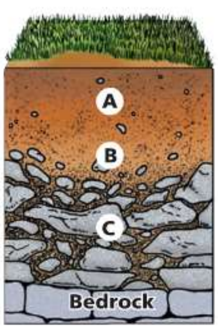
19. What role did grass play in conserving the soil of the prairies?

20. How do conservation plowing and crop rotation contribute to soil conservation?

Thinking Critically

21. **Predicting** If mechanical weathering breaks a rock into pieces, how would this affect the rate at which the rock weathers chemically?

22. **Comparing and Contrasting** Compare the layers in the diagram below in terms of their composition and humus content.

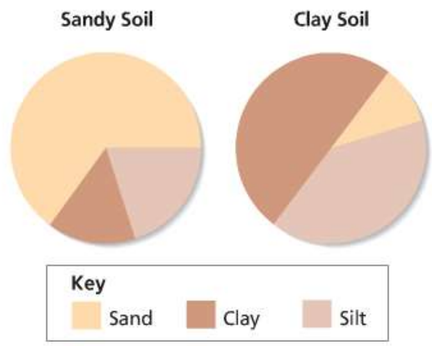


23. **Making Judgments** The mineral calcite forms large, glassy crystals that can be scratched by a copper penny. Would calcite be useful as a gemstone? Explain.

Applying Skills

Use the following information to answer Questions 24–26.

You have two samples of soil. One is mostly sand and one is mostly clay.



24. **Predicting** Which soil sample would lose water more quickly? Why?

25. **Designing Experiments** Design an experiment to test how quickly water passes through each soil sample.

26. **Posing Questions** A farmer wants to grow soybeans in one of these two soils. What questions would the farmer need to answer before choosing where to plant the soybeans?

Lab zone Standards Investigation

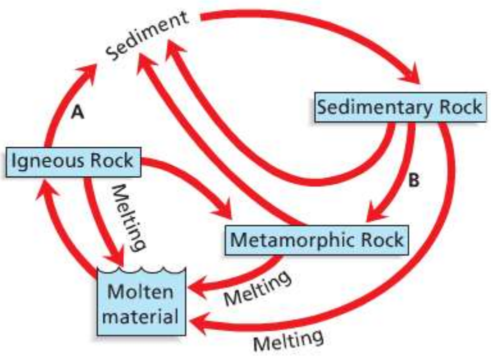
Performance Assessment You are ready to present your data and conclusions about what type of material is best for growing bean plants. How did your group's results compare with those of the other groups in your class? What did you learn from this investigation about soil characteristics that help plants to grow? How could you improve your experiment?

CALIFORNIA Standards Practice

Success Tracker™
Online at PHSchool.com

Choose the letter of the best answer.

Use the diagram below and your knowledge of science to answer Questions 1 and 2.



1. In the rock cycle, molten material forms through the melting of
- **A** igneous rock.
- **B** sedimentary rock.
- **C** metamorphic rock.
- **D** all of the above **S 6.2**

2. In the rock cycle diagram, what does the letter B represent?
- **A** melting
- **B** cooling and hardening
- **C** heat and pressure
- **D** formation of sediment **S 6.2**

3. Which of the following is a type of mechanical weathering?
- **A** abrasion
- **B** freezing and thawing
- **C** plant growth
- **D** all of the above **S 6.2**

4. A plant grows best in soil with a pH of 6. The pH of this soil can be described as
- **A** slightly basic.
- **B** neutral.
- **C** slightly acidic.
- **D** strongly acidic. **S 6.5.e**

Soil Erosion by State

State	Tons per Acre per Year		
	Water Erosion	Wind Erosion	Total Erosion
Montana	1.08	3.8	4.9
Wyoming	1.57	2.4	3.97
Texas	3.47	14.9	18.4
New Mexico	2.00	11.5	13.5
Colorado	2.5	8.9	11.4
Tennessee	14.12	0.0	14.12
Hawaii	13.71	0.0	13.71

Use the data table above and your knowledge of science to answer Questions 5 and 6.

5. Of the states listed in the table, which two have the greatest amount of erosion by water?
- **A** Texas and Tennessee
- **B** Texas and Hawaii
- **C** New Mexico and Colorado
- **D** Tennessee and Hawaii **S 6.2.a**

6. Which state in the table has the greatest soil erosion?
- **A** Texas
- **B** Hawaii
- **C** Tennessee
- **D** New Mexico **S 6.2.a**

Apply the BIG Idea

7. Two rocks, each in a different location, have been weathering for the same amount of time. Mature soil has formed from one rock, but only immature soil has formed from the other. What factors might have caused this difference in rate of soil formation? In your answer, include examples of both mechanical and chemical weathering. **S 6.2.a**