Weathering, erosion, and deposition shape Earth’s surface.

LESSON 1
Weathering

Main Idea Rocks exposed at Earth’s surface are broken down into sediment and soils by the action of weathering.

LESSON 2
Erosion and Deposition

Main Idea Movement of rock and soil are natural occurrences caused by specific geological conditions.

LESSON 3
Reshaping the California Landscape

Main Idea The geology of California is expressed as mountains, deserts, valleys, and shorelines. These are natural physical features of Earth’s surface.

The Mighty Restless Sea

The endless crashing of waves against these rocks wore away the softest parts, leaving this arch between the land and a sea stack.

Science Journal Make a list of five things you know about the ocean. Select two of them and write a paragraph about each topic. Then, write a third paragraph that compares the two.
Set in Stone?

Have you ever gone to a cemetery and noticed that the writings on some headstones are clear after hundreds of years, while others are so worn that the names can hardly be read? Different types of stone react differently with the environment.

**Procedure**

1. Use the **marble** and **chalk** provided by your teacher.

2. Fill two **clear containers** with 100 mL of **water** each. Fill two more clear containers with 100 mL of **white vinegar** each. Label the jars Water/Marble, Water/Chalk, Vinegar/Marble, and Vinegar/Chalk.

3. Add the marble and chalk to the correctly labeled containers and observe for ten min.

**Think About This**

Analyze Why do you think the marble and the chalk reacted differently?

2.a, 7.a

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**Weathering**

Make the following Foldable to compare and contrast chemical and physical weathering.

**STEP 1** Fold a sheet of paper in half from top to bottom and then in half from side to side.

**STEP 2** Unfold the paper once. Cut along the fold of the top flap to make two flaps.

**STEP 3** Label the flaps as shown.

**Compare and Contrast**

As you read this chapter, compare and contrast the actions and effects of chemical weathering to those of physical weathering. Include examples of weathering.

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- view Concepts in Motion
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- access content-related Web links
- take the Standards Check
**Learn It!** A *cause* is the reason something happens. The result of what happens is called an *effect*. Learning to identify causes and effects helps you understand why things happen. By using graphic organizers, you can sort and analyze causes and effects as you read.

**Practice It!** Read the following paragraph. Then use the graphic organizer below to show what happens when water freezes in the cracks of rocks.

Water has the unique property of expanding when it freezes. In climates where the temperature drops below the freezing point of water, water that has seeped into the cracks of rocks will freeze and expand. The expanding ice causes pressure to increase. This forces the crack in the rock to open slightly. After many cycles of freezing and thawing, the crack is forced completely to open. The rock breaks into pieces.

—*from page 337*

**Apply It!** As you read the chapter, be aware of causes and effects of gravity and water. Find five causes and their effects.
Target Your Reading

Use this to focus on the main ideas as you read the chapter.

1 **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
   - Write an A if you agree with the statement.
   - Write a D if you disagree with the statement.

2 **After you read** the chapter, look back to this page to see if you’ve changed your mind about any of the statements.
   - If any of your answers changed, explain why.
   - Change any false statements into true statements.
   - Use your revised statements as a study guide.

<table>
<thead>
<tr>
<th>Before You Read A or D</th>
<th>Statement</th>
<th>After You Read A or D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Water, wind, gravity, and ice are weathering agents.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Exposure to atmospheric water and gases causes rocks to change chemically.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Frost wedging is a common method of breaking rocks into fragments in all climates.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Mass wasting is the slow process of changing rock into soil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Movement of water in streams causes them to constantly change their path.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Sand on beaches comes from rock weathered by the ocean.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Flooding is a common feature of all rivers and streams.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Sand dunes are deposits from wind, water, and ice agents.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 The mountains around the Central Valley are uplifted landforms.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Print a worksheet of this page at ca6.msscience.com.
Weathering

Main Idea: Rocks exposed at Earth’s surface are broken down into sediment and soils by the action of weathering.

Real-World Reading Connection: Think about your favorite pair of jeans. Perhaps when they were new they were dark blue, but now they are faded. The knees, pockets, and cuffs might be worn with holes and have large threads hanging from them. These are the effects of wear and aging. Earth shows similar signs of wear. Rocks get worn smooth and cracked open, gullies form as soil gets moved, and minerals corrode and change color. They are all caused by weathering.

What is weathering?

Weathering is the destructive process that breaks down and changes rocks that are exposed at Earth’s surface. Weathering is caused by the action of water, wind, ice, and gravity. They are referred to as agents of weathering. These agents create two different weathering processes that can change rocks. The processes are chemical weathering and physical weathering. An example of weathering is shown in Figure 1. Weathering has slowly destroyed the features of the Sphinx, which was carved out of limestone in Egypt 7,000 to 9,000 years ago.

Figure 1 Predict how precipitation might contribute to the weathering of the Sphinx.

Vocabulary
weathering
chemical weathering
physical weathering
frost wedging
soil

Review Vocabulary
mineral: naturally occurring, inorganic solid that has a definite chemical composition and an orderly atomic structure (p. 87)
Chemical Weathering

Chemical weathering results when minerals and rocks at Earth’s surface are weakened and broken down from exposure to water and gases in the atmosphere. This exposure causes the composition of the minerals of a rock to change. The result is the formation of new minerals such as the iron oxide, or rust, on the cars shown in Figure 2.

What causes rock surfaces to break down?

Water

The most common agent of chemical weathering is water. Rocks and minerals that dissolve in water are said to be soluble. When water mixes with carbon dioxide from the air, carbonic acid is formed. This is the same weak acid found in carbonated soft drinks. Most rainwater contains some dissolved carbon dioxide from the air. This makes rainwater slightly acidic. Carbonic acid in water is a more destructive weathering agent than pure water.

Figure 2  What does oxidation of iron or steel look like?
Acid

What happens when slightly acidic rainwater comes in contact with rock? It reacts with the minerals in the rock, such as in feldspar. Feldspar weathers rapidly, changing into clay minerals. The formation of clay is one of the most common results of chemical weathering.

Human-made pollution, like that produced from burning coal, can cause chemical weathering to occur even more rapidly. When coal is burned, sulfur dioxide is released into the atmosphere. The sulfur dioxide combines with water vapor in the air, creating sulfuric acid. This ultimately becomes acid rain.

When acid rain reaches the ground, it damages rocks and buildings. Plants, soil, and lake habitats also are affected by the increase in the acidity of the soil and water.

Oxygen

When oxygen that is dissolved in water comes in contact with compounds of some metals, a chemical reaction occurs, forming a new substance. The greenish color on the statue in Figure 3 is a substance that formed from a reaction of water and oxygen with copper compounds on this bronze statue. Other metals may get a white or gray powder on their surface.

Rock Type and Weathering

The type of rock also determines how quickly its surface is chemically weathered. Compare the two old headstones shown in Figure 4. They are about the same age and have been exposed to the same climate. However, the carved details of the top headstone are still clear after 100 years. This headstone is made of a rock that resists chemical weathering. The headstone on the bottom has lost most of the carved detail because of chemical weathering.
Physical Weathering

Physical weathering is the breaking of rock into smaller pieces without changing its mineral composition. Processes of physical weathering include frost wedging and the work of plants and animals. These are described below.

Frost Wedging

Frost wedging occurs when water freezes, expands, and melts in the cracks of rocks. Water has the unique property of expanding when it freezes. In climates where the temperature drops below the freezing point of water, water that has seeped into the cracks of rocks will freeze and expand. The expanding ice causes pressure to increase. This forces the crack in the rock to open slightly. After many cycles of freezing and thawing, the crack is forced completely open. The rock breaks into pieces. An example of frost wedging is shown in Figure 5.

Plants and Animals

The breaking down of rock into smaller pieces also can be caused by plants and animals. Have you ever noticed a sidewalk that is broken and buckled upward? An example is shown in Figure 5. This occurs because as the tree grows, the roots also grow bigger. Over time, the increase in the size of the root forces the concrete to crack. Plant roots in search of water can also grow into cracks within rocks. As the plant roots grow in size, they eventually wedge the rocks apart.

Burrowing animals can move loose rocks and dirt to the surface. The material is exposed to wind and water. This causes the weathering process to increase.

**Figure 5** What caused the rock to break in the left photo?

**Figure 5** Like frost wedging, plants can break rocks into fragments with root pressure.

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**ACADEMIC VOCABULARY**

**contact (KON takt)**

(noun) a union or junction of surfaces

The foul occurred when the two players made contact.
Soil Formation

The weathering of rock on Earth’s surface produces soil. Soil is a mixture of weathered rock, minerals, and organic matter, such as decaying plants and animals. Water and air fill the spaces between soil particles. Figure 6 shows how soil forms through physical and chemical weathering. The formation of soil is affected by several factors, such as the type of rock, the climate, the length of time a rock has been weathering, and the interaction of plants and animals with the soil.

Remember that most rocks contain the mineral feldspar, which typically breaks down through chemical weathering to form clay minerals. This explains why clay is one of the most abundant ingredients in soils. Soil is important because it contains the nutrients necessary for plant growth and food crop production. In addition to being anchored in the soil, plants growing in soil help to keep it from eroding away.

What is soil made of?

Composition of Soil

If soil remains in the same location where it formed, it is called a residual soil. The composition of the soil matches the composition of the rock from which it formed. For example, granite contains quartz. Quartz is resistant to weathering. A soil that develops from granite will be sandy because of the sand-sized grains of quartz it contains. But a soil developed from basalt, which contains large amounts of feldspar, will have sticky clay particles instead. Transported soils develop from weathered material that has been moved to a new location by wind, water, or glaciers. The composition of the soil does not match the composition of the rock beneath it.

Figure 6 How do plants help create soil?
Visualizing Soil Formation

Figure 6
Thousands of years of weathering solid rock results in the formation of soil. Soil is made up of mineral fragments, bits of rock, and the remains of dead plants and animals. Water and air fill the spaces between the particles.

A Natural acids in rainwater weather the surface of exposed bedrock. Frost-wedging can enlarge a crack, causing rocks to fracture and break apart. The inset photo shows weathered rock in the Tien Shan Mountains of Central Asia.

B Plants take root in the cracks and among the bits of weathered rock—shown in the inset photo above. As they grow, plants absorb mineral from the rock, weakening it. Along with other natural forces, the process of breaking down rocks continues and a thin layer of soil begins to form.

C Like the grub in the inset photo, insects, worms, and other living things take up residence among plant roots. Their wastes, along with dead plant material, add organic matter to the soil.

D As organic matter increases and the underlying bedrock continues to break down, the soil layer thickens. Rich topsoil supports trees and other plants with large root systems.
Soil Layers

If you have ever dug a deep hole, you might have noticed layers with different colors and appearances. These layers are called soil horizons. They can take thousands of years to develop. Three soil horizons make up a complete soil profile, as shown in Figure 7.

What are layers in a soil profile called?

**A Horizon** The topmost soil horizon is called the A horizon. It contains small rocks, minerals, and different amounts of decomposed plant material called humus. This horizon is usually a dark color because it contains organic matter. Water seeping through this horizon dissolves minerals from it, resulting in the bottom of the A horizon being light in color.

**B Horizon** The dissolved minerals are deposited in the next soil horizon, called the B horizon. This layer contains large amounts of clay and commonly is stained red or brown.

**C Horizon** Below the B horizon is the C horizon. The C horizon consists of partly weathered parent material or bedrock. Below this horizon is unweathered parent material, solid rock.

![Figure 7](image_url)

A soil profile is divided into layers called horizons.

- **A Horizon** This top layer is thin and usually dark colored due to organic material. This layer has changed the most since it was weathered.
- **B Horizon** Often called subsoil, chemically weathered material from the A horizon gets deposited here. Clay or calcite may build up here giving it a lighter appearance.
- **C Horizon** Partly weathered parent material lies on top of parent bedrock. The characteristics are halfway between parent material and soil.
Weathering and Landforms

The processes of chemical and physical weathering work together to break down rocks. Chemical weathering changes the composition of rocks. Physical weathering breaks down rocks without changing the composition. Rocks that have been broken into smaller and smaller pieces by physical weathering have more surface area that can be exposed to chemical weathering. The process of weathering helps to form soil. Soils develop in layers called horizons. Weathering and other factors influence the character of the soil that forms.

LESSON 1 Review

Summarize
Create your own lesson summary as you write a newsletter.

1. Write this lesson title, number, and page numbers at the top of a sheet of paper.
2. Review the text after the red main headings and write one sentence about each. These will be the headlines of your newsletter.
3. Review the text and write 2–3 sentences about each blue subheading. These sentences should tell who, what, when, where, and why information about each headline.
4. Illustrate your newsletter with diagrams of important structures and processes next to each headline.

Standards Check

Using Vocabulary

1. Breaking rocks into pieces by physical and chemical means is called _______.
2. _______ occurs when water in a cracked rock freezes and expands.

Understanding Main Ideas

3. Compare and contrast chemical and physical weathering processes.

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences</th>
</tr>
</thead>
</table>

4. Draw and label a complete soil profile.
5. Construct a diagram with arrows showing three weathering processes that could act on a rock that is exposed on Earth’s surface.

6. Differentiate between a soil profile from the rain forest and a soil profile from the Great Plains.
7. Which of the following is not a factor in the effect of weathering?
   A. rock type
   B. acidity of rain water
   C. climate
   D. soil type

Applying Science

8. Hypothesize how a soil profile from a warm, humid, tropical environment would differ from a soil profile from a dry, desert environment.
9. Infer how a river could cause both physical and chemical weathering.

Science Online

For more practice, visit Standards Check at ca6.msscience.com.
Erosion and Deposition

Main Idea: Movement of rock and soil are natural occurrences caused by specific geological conditions.

Real-World Reading Connection: The city of LaConchita, California, experienced a mudslide in January 2005. This area has a history of mudslides dating back to the 1800s. Why might some areas be more prone to geological events such as these?

What are erosion and deposition?

If you ever have seen a river or stream, you may have noticed that the flowing water can move pieces of rock and soil downstream. Recall that the process of moving weathered material from one location to another is called erosion. Erosion can be caused by running water, rain, waves, glaciers, wind, and in the case of landslides, gravity. When sediments are laid down in a new location by one of these processes, it is called deposition. Figure 8 shows Laguna Beach in southern California, where a landslide occurred on June 1, 2005. Erosion of this type is very rapid, but normal erosion may take years to move this much soil and rock.

Figure 8: Landslides commonly occur during rainy periods in southern California.

Consider: What factors might have contributed to the occurrence of this landslide?

Reading Guide

What You’ll Learn

Tell how the land surface is changed by water action.

Describe stream formation.

Discuss mass wasting and how it relates to land use in California.

Explain erosion and deposition.

Why It’s Important

Landscapes are the result of erosion and deposition.

Vocabulary

erosion flood

deposition flood plain

mass wasting beach

landslide glacier

meander

Review Vocabulary

sediment: rock that is broken down into smaller pieces or is dissolved in water (p. 99)
Mass wasting

Mass wasting is a form of erosion caused mainly by gravity. It involves the downhill movement of rocks and/or soil in one large mass. Mass wasting commonly occurs when the ground becomes soaked with rainwater. This weakens the forces that hold the various material on the hillside together. The steeper the slope of hillside, the more likely or frequently mass wasting will occur. When the weight of the soil and water becomes too great, the mass of soil will begin to slide. As the soil and water mix more evenly it may then begin to flow like a liquid.

Mass wasting also can occur from vibrations, such as shaking from earthquakes, heavy machinery, blasting, or even thunder. Several types of mass wasting are described below.

What can cause mass wasting to occur?

Fast Mass Wasting

Landslides are rapid, gravity-caused events that move soil, loose rock, and boulders. Mudslides, like the one in La Conchita, contain mixtures of soaked soil and rock material. Rock falls involve loosened rock falling from steep cliffs. The result of a rock fall in Utah is shown in Figure 9. Finally, slumps occur when a block of rock and the overlying soil slide down a slope as one large mass. Slumping can also involve soil movement only.

Figure 9 These episodes of mass wasting each occurred under different geological conditions.

Infer Which of the mass wasting events might have been triggered by wet ground?
Creep

Sometimes mass wasting does not occur quickly. It occurs over long periods of time. Sediment moves slowly downhill, pulled by the force of gravity. This is called creep and is the slowest form of mass wasting. As shown in Figure 10, signs of creep include the tilting of telephone poles, trees, or fences in the downhill direction. Creep often results from freezing and thawing and burrowing animals.

Figure 10 Describe a physical weathering process that may have caused the trees to tilt.

Climate and Erosion

The climate of an area determines the amount of water that a region receives. Regions that receive large amounts of rainfall are more likely to experience mass wasting than areas with dry climates. Climate also influences the type and abundance of vegetation. The presence of thick vegetation on slopes tends to prevent landslides because the root systems of the plants help to hold sediment in place. Vegetation also acts as a cushion for falling raindrops which reduces their erosive effect.

How does vegetation help to prevent mass wasting?
Water and Erosion

What happens to water that does not soak into the ground or evaporate into the air? It flows over Earth’s surface into lakes, streams, and rivers, and ultimately into the oceans. Streams and rivers are active systems that erode the land, transport sediment, and deposit sediment in new locations.

Stages of Stream Development

Have you ever noticed that waterfalls and rapids occur in steep mountain regions rather than in flat valleys? This is because the characteristics of rivers change as water moves from high in the mountains down to lakes or oceans at sea level. Rainfall and melting snow feed streams that originate in hills and mountains. The steep slopes allow the water to flow downhill rapidly. This produces a high level of energy that erodes the bottom of the stream more than the sides. These streams cut steep, V-shaped valleys and have white-water rapids and waterfalls.

Development of Meanders

When a stream has eroded the steep valleys to gentler slopes, the stream flows more slowly. Now water in the stream erodes along the sides of the stream bed rather than along the stream bottom. This causes the stream to develop meanders. Meanders (mee AN durs) are the curves in the stream, as shown in Figure 11. Once a stream develops meanders, the curves tend to become wider and wider. This is because the speed of the water is greatest at the outside of a bend. Figure 11 also illustrates the erosion that occurs at the outside of the meanders. On the other hand, the water flows more slowly on the inside of the meanders. Deposition, the dropping of sediment being carried by the stream, occurs on the inside of a meander.

Where does erosion in a meander occur?

Figure 11 A. Erosion occurs on the outside of a bend and deposition occurs on the inside of a bend. B. When the erosion of the river brings the outside bends close together, it leaves a narrow piece of land called a neck. C and D. When the neck is eroded away the river deposits silt and mud to create an oxbow lake.
Deposition and Water

The sediment and rock that are eroded and carried by river systems are transported, or moved. Eventually they are deposited at a new location. Deposition might occur anywhere along a stream where the water slows down. Slowing reduces the amount of energy that the stream has to carry sediment.

Deposited sediments can form distinct features. Deposition on the inside of a meander can cut off a large U-shaped meander from a river, producing a small lake called an oxbow lake. This is illustrated in Figure 11 on the previous page. When a stream or river reaches a large body of water, such as a lake or ocean, it slows down. Most of the sediment drops out, forming a triangular-shaped deposit called a delta. Figure 12 shows an example of a delta. When rivers empty from steep narrow canyons out onto flat plains at the foot of mountains, they form a similar triangular deposit called an alluvial fan. The alluvial fan in Figure 12 is in the Mojave Desert. Table 1 shows how the steepness of the slope affects the river as it develops.

Figure 12 In the top photo, the Mississippi delta forms as the river enters the Gulf of Mexico. The bottom photo shows how the Sheep Creek alluvial fan sediment is deposited on land in the Mojave Desert. 

**Explain** What causes sediment to drop out when a river reaches the ocean?
**Stream Development**

Streams develop as water falls on Earth’s surface and runs off. Steep slopes increase the erosion power of water. V-shaped valleys result. As the land flattens out, the water slows down into S-shaped meanders.

<table>
<thead>
<tr>
<th>What Happens</th>
<th>What It Looks Like</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain streams flow in steep valleys, have V-shaped stream beds, and are often rocky and filled with rapids.</td>
<td>![Image of mountain stream]</td>
</tr>
<tr>
<td>Farther downstream, rivers become wider and less steep. Their stream beds are wider with fewer rocks and rapids in them.</td>
<td>![Image of river meanders]</td>
</tr>
<tr>
<td>On the plains, river beds flatten and the rivers develop wide floodplains, meanders, and oxbow lakes. There are no rapids.</td>
<td>![Image of oxbow lake]</td>
</tr>
</tbody>
</table>

**Interactive Table**
Organize information about stream shape, slope, and speed at [ca6.msscience.com](ca6.msscience.com).
A **flood** occurs when the water level in a river rises above the usual height and overflows the sides of its banks. Floods are caused by major rain storms or rapid melting of winter snow. During times of flooding, water spills onto the floodplain. The **floodplain** is a wide, flat valley that is located along the sides of some rivers and streams. Floodplains form from the side-to-side erosional action of a meandering stream, as shown in Figure 13. Yearly flooding supplies these areas with mineral-rich, fertile soils that are ideal for farming.

**Preventing Flooding** Sediment carried by floodwaters is deposited along both sides of the river into long, low ridges on the floodplain. These natural levees protect the area from flooding. Artificial levees sometimes are built along the banks of a river to help control floodwaters. In New Orleans, a break in the artificial levee, shown in Figure 14, allowed the river to flood the nearby region. In urban areas such as Los Angeles, lining small streams and rivers with concrete has reduced flood hazards. Such a structure is called an aqueduct. Because floods are unpredictable, building on floodplains or near dams and levees is not a good idea. All geological factors need to be considered before any construction begins.

**Figure 14** Sometimes water soaks into a levee and weakens it. The weakest spots may break open like this levee that broke after Hurricane Katrina in 2005.
Shorelines and Erosion

California has 1,100 miles of shoreline along the Pacific Ocean. If you ever have had a chance to swim in the ocean, you know that waves are incredibly powerful forces. The energy produced by the constant action of waves continuously changes the shape of the shore. This change occurs because of rocks breaking into smaller pieces, transporting and grinding sediment, and depositing material farther along the shore.

Beaches and Wave Erosion

A beach is a landform consisting of loose sand and gravel. It is located along a shore. Beaches are dynamic, actively changing systems. Most of California’s steep shores have been formed by beach erosion. Sand is also supplied by the continuous flow of rivers to the oceans. Sediment carried by the rivers gets deposited on the beach. Wave action then moves it along the shore.

Where does beach sand come from?

Erosion Features

Cliffs are formed by the cutting action of waves at the base of rocks that are exposed along the coasts. Figure 15 shows what happens when a cliff is eroded. It moves back from the shoreline, leaving behind a flat area called a wave-cut platform. Sometimes these platforms can be lifted above the water level by upward movement along faults. The platform then is called a marine terrace. Erosional features with unusual shapes such as sea caves, sea stacks, and sea arches can form when waves erode the softer or more fractured portions of rocks.
The Longshore Current

Figure 16 shows that waves approach the shore in a three-step process. They usually come in at an angle to the shore. The friction of hitting the beach at an angle causes the waves to bend until they are approximately parallel to the coast. Finally, they retreat from the beach perpendicular to the shore. This process is called longshore transport. The movement of the water is called the longshore current. It is this current that moves vast amounts of sediment along coasts.

How do waves change direction as they approach the shore?

Preventing Erosion

There are several ways that beaches can be protected from erosion. Shoreline armoring is the name applied to the building of structures to help reduce erosion. These structures include retaining walls, harbor channels, and groins like those shown in Figure 17. Groins are positioned at right angles and placed at certain intervals along the shore. As the longshore current moves sediment along the shore, the groins trap the sediment. Shoreline armoring changes natural shoreline processes. But in some cases, it is absolutely necessary to prevent the collapse of cliffs or the complete destruction of a beach.

What are glaciers?

You have read of water’s weathering power and its effect on erosion. Ice is also a strong eroding agent. Glaciers are large masses of ice and snow. They form on land in areas where the amount of winter snowfall is greater than the amount of summer melting. It takes hundreds to thousands of years to form a glacier. Although glaciers may appear to be motionless, they actually move very slowly, at a rate of about 2.5 cm per day. Glacial ice makes up about 2 percent of all the water on Earth. That is roughly 66 percent of the freshwater.
**Types of Glaciers**

There are two types of glaciers. Valley glaciers, or alpine glaciers, form in existing stream valleys high in the mountains. They flow from high to low elevations. There are more than 100,000 of this type of glacier on Earth today. Continental glaciers, or ice sheets, are several kilometers thick and cover entire land areas. The only continental glaciers on Earth today are in Antarctica and Greenland. Geological evidence indicates that these were the types of glaciers that covered portions of Earth during past ice ages.

Where do valley glaciers form?

**Glaciers Eroding Land**

Glaciers erode the surface as they pass over it. Rocks and boulders that are trapped at the bottom of the ice create grooves and scratches. This is similar to how sandpaper leaves scratches on wood. These grooves can be used to determine the direction the glacier was moving. Erosion by valley glaciers produces the distinct features shown in Figure 18. The presence of these features are evidence that valley glaciers once covered an area.

**Depositing Sediment**

As glaciers melt, they deposit sediment that had been frozen in the ice. Till and outwash are two types of sediment deposited by glaciers. Figure 18 shows that till often builds up along the sides and fronts of glaciers into long, high ridges called moraines. It also shows that till can be molded beneath the glacier into a variety of landforms. Outwash consists mostly of sand and gravel. Many of these deposits have been quarried for use as construction materials.
Wind

Have you read about the Great Dust Bowl of the 1930s? This event occurred when the southern Great Plains of the United States were devastated for an entire decade by a drought. Deeply plowed fields and overgrazed pastures left soil unprotected and exposed to the elements. As shown in Figure 19, strong winds removed this soil and carried it into the air. Skies were blackened by great wind-generated dust storms.

Why was the soil so easily eroded during the Great Dust Bowl?

Wind Erosion and Deposition

Wind lifts and redeposits loose material. There are two common types of wind-blown deposits. Sand dunes are shown in Figure 20. These mounds and ridges form from heavier sediment that blows along the ground surface. Eventually it is pushed into piles and dunes form. Loess (LUHS) is the second type of wind-blown deposit. It consists of wind-blown silt that was carried in the air. Loess is the smallest grain size produced by glacial erosion. Strong winds that blow across glacial outwash pick up the loess and redeposit it elsewhere. As wind-blown sediment is carried along, it cuts and polishes exposed rock surfaces.
Shaping by Erosion and Deposition

Several geologic processes are involved in erosion and deposition. Mass wasting causes landslides, rock falls, mudslides, and more. Climate and the amount of rainfall an area receives are directly related to mass wasting. Rivers erode streambeds and transport sediment to new locations. Their erosive power changes the shape of their streambeds. Wave action on ocean shores breaks up rocks and creates distinct features along beaches. Erosion and deposition by glaciers create familiar mountain scenery. Wind can be strong enough to cause erosion and to form dunes. The results of all these processes are seen in the landscapes present in California today.
Sorting It Out

When rivers flood they carry a lot of sediment and debris with them because they move with high energy. Along the shore the water loses energy, slows down, and drops its load of sediment.

**Data Collection**

1. Read and complete a lab safety form.
2. Create a data table to record your predicted time and your measured time.
3. Measure 50 g of each of the sediments provided.
4. Use a paper cone to pour the sediments into a 2-L plastic bottle.
5. Fill the bottle with water, leaving an air space at the top.
6. Predict and record how long you think the sediments will remain in suspension after shaking them.
7. After shaking the bottle for 30 s, start a timer.
8. Record how long it takes for each of the sediments to settle down to the bottom.

<table>
<thead>
<tr>
<th>Sample Data Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Sediment</strong></td>
</tr>
<tr>
<td>White sand</td>
</tr>
<tr>
<td>Beach sand</td>
</tr>
<tr>
<td>Gravel</td>
</tr>
</tbody>
</table>

**Data Analysis**

Create a class data table. Average the data and make a bar graph. How close were your predictions?

**Science Content Standards**

2.c Students know beaches are dynamic systems in which the sand is supplied by rivers and moved along the coast by the action of waves.

7.g Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions).
Reshaping the California Landscape

Main Idea: The geology of California is expressed as mountains, deserts, valleys, and shorelines. These are natural physical features of Earth’s surface.

Real-World Reading Connection: California’s early farmers and gold miners headed west following the California Trail to get to their final destinations. In this lesson, you will read about some of the landscapes they had to cross as they searched for the best place to settle.

Mountain Landscapes

The landscapes of California can be divided into a number of different regions. Figure 21 shows how California can be divided into four major types of landscapes: mountains, deserts, the Central Valley, and the coast. Mountain ranges cover most of California. Many of the rocks within the ranges formed below Earth’s surface hundreds of millions of years ago. They have been uplifted and exposed at the surface by tectonic processes.
**Figure 22** U-shaped valleys have been scoured out by glacial ice.

Glaciated Mountains

During the last 2.5 million years, glaciers have carved many features in the Sierra Nevada and Klamath Mountains. The scenery of the Yosemite valley in the Sierra Nevada, shown in Figure 22, is the result of glacial erosion. U-shaped valleys and hanging valleys, such as those shown in Figure 22, are common in Yosemite National Park. The largest present-day glacier in California is the Palisade Glacier in the Sierra Nevada. It is estimated to be about 3 km long and several hundred meters thick. Recall that glaciers deposit material as well as erode and move rock. Depositional features in California’s mountains include moraines that were produced when the glaciers melted and deposited their till.

What types of glacial features are present in the Sierra Nevada?

Other Erosional Features

California mountain ranges have other types of erosional features that are not related to glaciers. Remember that streams and rivers change as water moves from the mountains to the oceans. Steep white-water streams in V-shaped valleys, as shown in Figure 23, are common in the high, steep parts of mountains. Wider and more meandering rivers, like that shown in Figure 23, are more common in the plains. Landslides and rockfalls also are common in California’s mountains.

What features are present along this river?
Desert Landscapes

Refer to Figure 21, which shows that the deserts of California are primarily located in the southeastern corner of the state. The deserts consist of flat, sandy valleys and dry lake-beds called playas. The Mojave Desert, located in California, is an example of a desert landscape. It is sometimes referred to as the high desert because of its high elevation and little vegetation. In contrast is the Colorado Desert, which lies as much as 75 m below sea level and is referred to as the low desert. The Colorado Desert has become an agricultural area thanks to irrigation from the nearby Colorado River.

Features of the Desert

Alluvial fans, like the one shown in Figure 24, are common depositional features in the deserts. Wind-blown sand dunes are common in the desert as well. Some regions have such consistent, strong winds that hundreds of windmills are used to generate electricity for nearby towns. The windmills shown in Figure 25 provide electricity for the popular vacation community of Palm Springs.

Why is wind-generated power so successful in Palm Springs?
The Basin and Range

The Basin and Range is a large area of north-south trending mountain ranges and valleys. It is primarily located in Nevada and Utah. You can refer to Figure 21 to determine its location. Most of this area has a desert climate. At the western edge of the Basin and Range in California is Death Valley.

What geologic features make up the basin and range?

Death Valley Gold-seekers named Death Valley in 1849 because of the valley’s harsh conditions. The part of Death Valley known as Badwater is the lowest point in the western hemisphere at 86 m below sea level. Death Valley contains little vegetation to stop erosion during storms. The area contains many arroyos, which are streambeds that only contain water during heavy rains or floods. During these times, rock and sediment are transported downstream. The Amargosa River, shown in Figure 26, is an arroyo. In addition to present-day alluvial fans, ancient alluvial fan deposits are also present in Golden Canyon in Death Valley. The alluvial fan deposits shown in Figure 27, formed about six million years ago and have turned into rock.
The Central Valley

Refer to Figure 21 to locate the Central Valley of California. It is also called the Great Valley. It is about 800 km long and 50 km wide. It is a fault-bounded valley. This means that the mountains around it have been uplifted along faults while the Central Valley has dropped to lower elevations.

Rivers in the Central Valley

Rivers in the Central Valley have meanders and flow slowly along shallow slopes. There are two major rivers that flow through the Central Valley. The south-flowing Sacramento River shown in Figure 28 is in the north part of the valley. The north-flowing San Joaquin River is in the south part of the valley. The rivers meet and form a delta into the Pacific Ocean through San Francisco Bay, shown in Figure 29.

What features do the rivers of the Central Valley have?

Figure 28 The Sacramento River originates in the northern part of the Great Valley and flows to the Pacific Ocean through San Francisco Bay. Notice the lush agricultural region along the river’s floodplains.

Consider Why is this area so good for farming?

Figure 29 The Sacramento and San Joaquin Rivers of the Central Valley join and flow into the Pacific Ocean where they deposit sediment to form the Sacramento River Delta.
Deposition in the Central Valley

The Central Valley receives abundant sediment from the rivers flowing into it from the surrounding mountains. This sediment provides the valley with a thick fertile soil and has made it the most productive agricultural area in California. In fact, the Central Valley provides half the produce in the United States.

Why is this region so good for farming and agriculture?

Coastal Landscapes

California is known for its sandy beaches, which can change appearance significantly during different seasonal conditions. For example, Figure 30 shows how the beach changed at Point Reyes National Seashore over a six-month period. Stormy El Niño conditions during the 1997–1998 winter caused many landslides and general erosion near the shore. This provided more sediment to the shore for waves to transport and deposit along beaches. California's rocky coasts have many erosional features described earlier in this chapter. Baker Beach is shown in Figure 31. Can you identify the sea stacks, arches, and cliffs discussed earlier? All of these are common along California's coast.
California’s Landscapes

California has a variety of landscapes. Mountains formed either by tectonic uplift or by the formation of volcanoes. Glaciers, wind, streams, and mass wasting have carved the mountains into the shapes they are today. Deserts experience strong winds and erosion that form dunes. The Basin and Range formed from tectonic activity. Fertile soils and wide rivers cover the Central Valley. The coast of California has beaches and rocky shorelines.

LESSON 3 Review

Summarize
Create your own lesson summary as you design a study web.
1. Write the lesson title, number, and page numbers at the top of a sheet of paper.
2. Scan the lesson to find the red main headings.
3. Organize these headings clockwise on branches around the lesson title.
4. Review the information under each red heading to design a branch for each blue subheading.
5. List 2–3 details, key terms, and definitions from each blue subheading on branches extending from the main heading branches.

Using Vocabulary
1. Use the term arroyo in a sentence.
2. The region in California that consists of long mountain ranges and valleys is called the ______.

Understanding Main Ideas
3. Name one erosional feature and one depositional feature you might expect to find (a) along the coast, (b) in a desert, and (c) in the mountains.
4. Interview three people to find out if they have visited each of the various types of California landscapes. Construct a table summarizing which erosional/depositional features (if any) they each noticed during their visits.

<table>
<thead>
<tr>
<th>Site</th>
<th>Erosional</th>
<th>Depositional</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

5. Determine which type of landscape you live in. Include three pieces of evidence for your choice.
6. Distinguish two erosional and two depositional features in Death Valley from those in the Central Valley.

Applying Science
7. Design the shortest driving trip possible that would take you from where you live through each of the different types of California landscapes.
8. Recommend the best locations closest to where you live to see the following features: (a) sea arches, (b) alluvial fans, (c) sand dunes, and (d) cirque. Be specific about location names; you may need to check a map.

Science Online
For more practice, visit Standards Check at ca6.msscience.com.
Will it slump, or will it creep?

Thin soils, steep slopes, and rainfall lead to mass movements of the land. What causes a hillside to slump or creep?

**Procedure**
1. Read and complete a lab safety form.
2. Obtain a *stream table* set up from the teacher.
3. Cover one-third of one end with a layer of packed *sand*.
4. Place a piece of *foil or plastic wrap* over the sand.
5. Loosely cover the foil with sand to a depth of 3–5 cm.
6. Raise the sand end of the stream table using *three books*.
7. Predict what will happen when the upper layer of sand becomes wet.
8. Gently pour *water* on the sand until it moves.
9. Repeat steps 5–8 with a steeper angle (*six books*).

**Analysis**
1. Compare and contrast movements of the sand when the slopes are different.
2. Infer how you could keep the sand from moving.
3. Form a hypothesis about the cause of the wet sand movement. Was it slump or creep?

**Science Content Standards**
- 2.a Students know water running downhill is the dominant process in shaping the landscape, including California’s landscape.
- 2.d Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.
- 7.a Develop a hypothesis.
- 7.e Recognize whether evidence is consistent with a proposed explanation.
Erosion Rates

California’s Big Sur coast is affected by erosion due to landslides that cause the cliffs to retreat. The graphs show loss rate in inches per year for three areas of Big Sur—Big Slide-Pitkins Curve, Grayslip, and Hurricane Point.

![Rates of Landsliding and Cliff Retreat, Big Sur Coast](image)

How much more erosion loss is there in Grayslip than Hurricane Point in the years 1976–1987?

**What you know:**
- Erosion rate for Grayslip: 6.5 cm/yr
- Erosion rate for Hurricane Point: 1.0 cm/yr

**What you need to find:**
- The difference in erosion rates

**Subtract:**
6.5 \( \div \) 1.0 = 5.5 cm/yr.

**Answer:** The difference in erosion rates is 5.5 cm/yr.

**Practice Problems**

1. In the years 1993–2001, how much more erosion occurred at Grayslip than Hurricane Point?
2. Which span of years and location has the most loss due to erosion?
Problem
Erosion is an important agent of change in the landscape. As you learned in the previous lesson, water can carry sediments, and often those sediments are from the surrounding land. The movement of sediment is part of erosion. How does water move sediment? What affects the movement of sediments? What formations are created by the movement?

Collect Data and Make Observations
1. Complete a lab safety form.
2. Your teacher will supply you with materials and instructions to assemble a stream table.
3. Record the size of the bottle you will be using.
4. Shake the sand and gravel together in the box. Slide the mixture to one end of the box and form a “mountain slope.”
5. What do you think will happen when you add water to your mountain?
6. Fill the bottle with water and stretch the rubber tubing over the mouth. Place the other end of your tubing on top of your mountain and turn the bottle upside down. Let the water run until the bottle is empty.
7. Draw or photograph the results.
8. In part of the sand that is undisturbed, trace out a streambed. Make a new hypothesis about the results of adding more water.
9. Repeat step 6 introducing water to the streambed.
10. Draw or photograph the results.
11. Add stones to the streambed; vary the slope of the mountain, or change another variable you might want to test.
12. Repeat steps 5–6.
13. Draw or photograph the results of each test.

Materials
stream table
plastic bottles (1-L and 2-L)
pieces of rubber tubing (2)
sand, gravel, and rock
water
bucket
clamps (2, optional)
incline materials

Safety Precautions

Science Content Standards
7.b Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
Analyze and Conclude

1. Describe the differences between your first and other trials. Did you correctly predict what would happen in your stream table? Did any of the trials form recognizable formations?

2. Compare and contrast your drawings with other students. What bottle size moved the most sediment?

Communicate

WRITING in Science

Erosion occurs in areas that humans have settled. Coastal real estate disappears every year in some areas, while harbors get filled in with sediment in other areas. Private land and parkland bordering rivers experience trouble with flooding and deposition of silt.

How do communities deal with erosion? Research a community or engineering strategy that is used in California to combat erosion. Make a report explaining how land owners or park custodians could use the strategy to prevent erosion.
Environmental engineers work to prevent air and water pollution. Some environmental engineers design, build, or repair structures to prevent soil erosion. Many of these projects require you to work outdoors and travel to new places. To become an environmental engineer, you will need to take science, math, and computer courses in high school to prepare for a four-year college degree.

Visit Careers at ca6.msscience.com to learn more about the work of environmental engineers. Think about a river or stream near your school. Research three different dam types and decide which would be the most economical and practical for the stream. Decide what purpose the dam would have.

You can build dams!

The sand on beaches naturally moves over time—sometimes parallel to the beach with the longshore current and sometimes perpendicular to the beach. This is only a problem for human-made structures such as houses, roads, boardwalks, and lighthouses. Oceanfront home owners and ocean-side towns risk loss of property and tourist revenue with each winter storm. Many different ways to prevent beach erosion have been developed to reduce these losses.

Visit Technology at ca6.msscience.com to explore different ways to prevent beach erosion. Evaluate some methods of preventing beach erosion according to cost and time constraints.
Fossils at Lyme Regis

The woman in the photo is examining soft shales at Lyme Regis. The cliffs at Lyme Regis on the coast of Great Britain contain millions of fossils from the Jurassic period. The cliffs have been etched by wind and tides for millions of years, exposing layers of sediment. In the nineteenth century, fossil collector Mary Anning was born and raised in Lyme Regis. She spent her childhood collecting fossils, and when she was about 11, she uncovered the first ichthyosaur known to the British scientific community. She took over the family fossil business, became an expert paleontologist.

Visit History at ca6.msscience.com to find out more about Mary Anning and her fossil business. Imagine you are Mary Anning. Write a journal entry about a discovering a fossil and deciding what to do with it.

Acid Rain

Acid rain is caused when air pollution mixes with rain. The acid that results damages ecosystems, humanmade structures, and farmable soil. Most acid rain is produced by power plant and road vehicle emissions. Because air does not stop at state or national boundaries, acid rain may fall hundreds of miles from the pollution source. Certain solutions have been proposed to diminish the creation of acid rain, but most are expensive or require a change in our habits.

Visit Society at ca6.msscience.com to research acid rain. Work in small groups to generate a list of ideas that individuals, businesses, utilities, and the government can implement to prevent acid rain. Select your group’s three best solutions considering cost, effectiveness, and ease of implementation. Present your solutions to the class.
Weathering, erosion, and deposition shape Earth’s surface.

**Lesson 1 Weathering**

- **Main Idea**: Rocks exposed at Earth’s surface are broken down into sediment and soils by the action of weathering.
  - Chemical and physical weathering break down rocks and minerals.
  - Exposure to water and gases in the atmosphere causes chemical weathering.
  - Frost wedging, burrowing animals, and the growth of tree and plant roots cause physical weathering.
  - Soil contains weathered rock and minerals, organic matter, water, and air.
  - Soil profiles have distinct layers called soil horizons.

**Lesson 2 Erosion and Deposition**

- **Main Idea**: Movement of rock and soils are natural occurrences caused by specific geological conditions.
  - Mass wasting is the downhill movement of sediments. It includes landslides, mudslides, creep, and slump. Steepness of a slope, the presence or absence of vegetation, and the climate affect mass wasting.
  - Rivers begin in V-shaped valleys and end in flatter, wider plains. Rivers form meanders, floodplains, oxbow lakes, and deltas.
  - Ocean waves erode shorelines and create sediment and unusual landforms. Waves constantly move and redeposit sediment along coastlines.
  - Glaciers are large masses of ice and snow that form on land. They are strong agents of erosion. They deposit two types of sediment called till and outwash.
  - The two most common types of wind deposits are dunes and loess.

**Lesson 3 Reshaping the California Landscape**

- **Main Idea**: The geology of California is expressed as mountains, deserts, valleys, and shorelines. These are natural physical features of Earth’s surface.
  - California’s landscape is made up of mountains, coasts, deserts, and a central valley. The mountains have features made from both rivers and glaciers.
  - Wind erosion, sand dunes, arroyos, and alluvial fans are desert features.
  - The Basin and Range consists of mountains and valleys.
  - The Central Valley has thick, fertile soil.
  - Erosion along rocky coasts produces sea stacks, sea arches, and sea cliffs.

**Terms**

- chemical weathering (p. 335)
- frost wedging (p. 337)
- physical weathering (p. 337)
- soil (p. 338)
- weathering (p. 334)

- beach (p. 349)
- deposition (p. 342)
- erosion (p. 342)
- flood (p. 348)
- floodplain (p. 348)
- glacier (p. 350)
- landslide (p. 343)
- mass wasting (p. 343)
- meander (p. 345)

- arroyo (p. 358)
- basin and range (p. 358)
Linking Vocabulary and Main Ideas

Use vocabulary terms from page 368 to complete this concept map.

Using Vocabulary

Fill in each blank with the correct vocabulary term.

9. ______ is the total effects of sun, rain, snow, and humidity on the erosion of rocks into tiny bits and pieces.

10. The weathering process during which water freezes in the cracks of rocks, causing the cracks to expand, is called ______.

11. An example of mass wasting is ______.

12. A river delta is formed by the process of ______.

13. Longshore transport is a process that moves sediment along a(n) ______.

14. A desert stream channel that usually contains water only during flash floods is known as a(n) ______.

15. The accumulation of grains and particles of rock mixed with dead organic material is called ______.
Understanding Main Ideas

Choose the word or phrase that best answers the question.

1. What is the cycle of freezing and thawing that breaks rocks called?
   A. rock cycle
   B. frost wedging
   C. exfoliation
   D. root pressure

2. Which causes most chemical weathering?
   A. oxidation.
   B. air pollution
   C. water
   D. biological activity

3. What is another term for decayed organic matter?
   A. humus
   B. soil
   C. worms
   D. sediment

4. The photo below shows a soil profile.

Which soil horizons contains mostly unweathered rock with no organic matter?
   A. A horizon
   B. B horizon and C horizon
   C. C horizon
   D. A horizon and B horizon

5. One type of mass wasting is shown below.

The tilted tree is a sign of which type of mass wasting?
   A. landslide
   B. creep
   C. slump
   D. mudslide

6. Which valleys have been eroded by glaciers?
   A. V-shaped valleys
   B. S-shaped valleys
   C. U-shaped valleys
   D. C-shaped valleys

7. In which type of landscape do more than half of all Californians live?
   A. coast
   B. mountains
   C. deserts
   D. Central Valley

8. In which type of landscape does most agricultural activity occur in California?
   A. coast
   B. mountains
   C. deserts
   D. Central Valley

9. Which feature is erosional?
   A. alluvial fan in Mojave Desert
   B. floodplain along the Sacramento River
   C. glacial moraines in the Sierra Nevada
   D. sea arch at Point Lobos State Reserve
Applying Science

10. **Prioritize** four concerns you might have related to chemical and physical weathering processes if you were involved in plans to build a new school on a sea cliff overlook the ocean.  

11. **Hypothesize** why loess deposits travel farther than sand dune deposits.

12. **Design** an experiment to test the effectiveness of different kinds of retaining walls (such as solid versus wire mesh) to prevent mass wasting.

The diagram below shows longshore transport. Use it to answer questions 13 and 14.

13. **Identify** the directions of water and sand as the longshore current moves the sediment.

14. **Predict** how the placement of a groin will affect the sand movement. Illustrate the movement of the sand before placement, after placing one groin, and after placing two groins.

15. **Design** a class field trip to the beach to investigate erosional and depositional features. What would you look for and how would you have the class record their observations?

16. **Compile** a list of at least five hazardous erosional or depositional conditions that would be worse during a particularly stormy, rainy season.

**WRITING in Science**

17. **Predict** how the landscapes of California might change if another ice age occurred that brought large ice sheets from the north into the state. Write a paragraph describing where you think the ice would go and the kinds of features it would produce.

Cumulative Review

18. **Compare and contrast** a volcanic lahar and a mudslide.

19. **Predict** During an earthquake, sand can be thrown up from the ground in a sand boil. Why might it be difficult to locate a sand boil a year after the earthquake?

Applying Math

Use the graphs below to answer questions 20–22.

20. In the years 1976–1987, how much more erosion occurred at Grayslip than Big Slide–Pitkins Curve?  

21. In the years 1993–2001, how much more erosion occurred at Grayslip than Big Slide–Pitkins Curve?  

22. Which span of years and location has the least loss due to erosion?
### 1. Which is an example of mechanical weathering?
- A. creep
- B. frost wedging
- C. oxidation
- D. slump

### 2. Which forms as a glacier moves into a stream valley?
- A. cirque
- B. outwash
- C. U-shaped valley
- D. V-shaped valley

### 3. Which factor in soil formation deals with the slope of the land?
- A. climate
- B. parent rock
- C. time
- D. topography

### 4. Which is a mixture of weathered rock, organic matter, water, and air?
- A. humus
- B. organisms
- C. parent rock
- D. soil

### 5. Which type of erosion occurs when a thin sheet of water flows downhill?
- A. creep
- B. gulley erosion
- C. runoff
- D. sheet erosion

### 6. What causes potholes to form in roadways?
- A. creep
- B. frost wedging
- C. oxidation
- D. slump

Use the illustration below to answer questions 7 and 8.

![Illustration of mass movement](image)

### 7. Which form of mass movement is shown in this picture?
- A. creep
- B. mudslide
- C. rockslide
- D. slump

### 8. Which agent of erosion causes this effect?
- A. gravity
- B. ice
- C. water
- D. wind
9. What form of mass movement occurs when a pasty mix of water and sediment moves downhill?
   A. creep
   B. mudflow
   C. rockslide
   D. slump

10. Which climate conditions produce the most rapid chemical weathering of rock?
    A. cold and dry
    B. cold and wet
    C. hot and dry
    D. hot and wet

11. What type of erosion can make pits in rocks and produce smooth, polished surfaces?
    A. abrasion
    B. deflation
    C. glaciation
    D. sedimentation

12. If an iron-containing mineral is exposed to rain, a rustlike material forms on its surface. Which best explains this?
    A. chemical weathering involving carbon dioxide and water
    B. chemical weathering involving oxygen and water
    C. mechanical weathering caused by strong winds
    D. mechanical weathering caused by rain

13. Which area is likely to be most affected by soil erosion?
    A. a steep slope after a fire burned the vegetation
    B. a section of low-elevation tropical rain forest
    C. a meadow with several kinds of grasses
    D. a hillside that has been terrace-farmed

14. Which statue is likely to be affected the most by chemical weathering?
    A. a marble statue in a cool, dry climate
    B. a granite statue in a cool, dry climate
    C. a marble statue in a warm, wet climate
    D. a granite statue in a warm, wet climate

15. What is the main reason that plants benefit from the presence of decaying organic material in the soil?
    A. It adds nutrients to the soil.
    B. It encourages mechanical weathering.
    C. It speeds the rate of evaporation from soil.
    D. It protects the plants from harmful insects.
Narrative Nonfiction

The Buried City of Pompeii: What It Was Like When Vesuvius Exploded, by Shelly Tanaka, makes the events surrounding the volcanic eruption of Mount Vesuvius in A.D. 79 come alive. This book describes what might have occurred on that day. The content of this book is related to Science Standard 6.1.

Fiction

The Big Wave, by Pearl Buck, describes life and the events following a tsunami. Kino lives in the shadow of a volcano and his friend Jiya lives by the sea. When the big wave destroys both the village and Jiya’s family, the boys learn important lessons about sorrow and acceptance. The content of this book is related to Science Standard 6.1.

Nonfiction

Exploring Caves: Journeys into the Earth, by Nancy Aulenback, describes adventures exploring different types of caves including those in Greenland’s ice cap, Mexico’s Yucatan Peninsula, and the Grand Canyon. This book includes views of rock formations and the animals that live there. Information on cave formation and mapping are included. The content of this book is related to Science Standard 6.2.

Nonfiction

Earthquakes, by Mark Maslin, is an informative overview of the causes and the detection of earthquakes. This book contains photographs, colorful diagrams, quotes from eyewitnesses, and excerpts from news accounts of earthquakes. Details about well-known earthquakes and their devastation are included throughout the book to illustrate specific concepts. The content of this book is related to Science Standard 6.2.

Are you interested in learning more about how Earth’s surface is shaped and reshaped by geologic events, weathering, and erosion? If so, check out these great books.
Choose the word or phrase that best answers the question.

1. The photo below shows a fault in which the rock above the fault surface is moving down relative to the rock below the fault surface.

   Tension forces pull rocks apart.

   Normal fault surface

   What kind of fault is shown above?
   A. normal
   B. strike-slip
   C. reverse
   D. shear

2. What type of boundary is associated with composite volcanoes?
   A. plates moving apart
   B. plates sticking and slipping
   C. plates moving together
   D. plates sliding past each other

3. What type of magma produces violent volcanic eruptions?
   A. those rich in silica
   B. those with low viscosity
   C. those forming shield volcanoes
   D. those rich in iron

4. Which is the area of land from which a stream collects runoff?
   A. drainage basin
   B. gully
   C. runoff
   D. underground

Write your responses on a sheet of paper.

5. Analyze how soil erosion reduces the quality of soil.

6. Sequence the process through which earthquakes occur. Include a description of how energy builds up in rocks and is later released.

7. Explain how some volcanoes occur where one plate sinks beneath another plate. Support your answer with a labeled diagram.

8. Discuss how volcanoes affect humans and wildlife. List four safety precautions for people living in volcanic areas.

9. The map below shows three circles drawn around three different seismograph stations. The circles have radii equal to the distance between the seismograph station and the earthquake’s epicenter.

   Identify which labeled point on the map represents the earthquake’s epicenter? Explain.

10. Discuss what humans can do to control flood waters.

11. Explain how waves and longshore currents affect sand and sediments.