Section 1

Rocks and Weathering

Objectives

After this lesson, students will be able to

G.4.1.1 Explain how weathering and erosion affect Earth's surface.

G.4.1.2 Identify what causes mechanical weathering and chemical weathering.

G.4.1.3 Describe the factors that determine how fast weathering occurs.

Target Reading Skill

Relating Cause and Effect Explain that cause is the reason for what happens. The effect is what happens because of the cause. Relating cause and effect helps students relate the reason for what happens to what happens as a result.

Answer

Possible answers:
oxygen
water
acid rain

All in One Teaching Resources

- Transparency G11

Preteach

Build Background Knowledge

L2

Old Headstones

Ask students whether anyone has seen old headstones in a cemetery. Ask: **How would you describe the difference between a new headstone and one that is one hundred years old?** *(A typical answer might describe the old headstone as rounded and crumbling with a faded inscription.)* Invite students to speculate about what processes change a headstone through the years.

Section 1

Rocks and Weathering

Reading Preview

Key Concepts

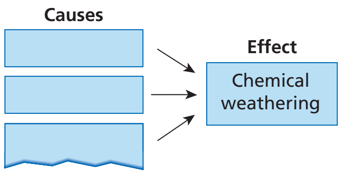
- How do weathering and erosion affect Earth's surface?
- What are the causes of mechanical weathering and chemical weathering?
- What determines how fast weathering occurs?

Key Terms

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

Target Reading Skill

Relating Cause and Effect A cause makes something happen. An effect is what happens. As you read, identify the causes of chemical weathering. Write them in a graphic organizer like the one below.



Lab zone Discover Activity

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 million years. The forces that wear down rock on Earth's surface have had much longer to grind down the Appalachians.

Lab zone Discover Activity

Skills Focus Drawing conclusions L1

Materials 2 fizzing antacid tablets, 2 beakers, warm water, plastic stirring rod, plastic bowl, stopwatch

Time 10 minutes

Tips Demonstrate how to grind up a tablet by using the stirring rod in a plastic bowl. Have students use warm water from the tap. If stopwatches are unavailable, students can observe a second hand on a watch or wall clock.

Expected Outcome Typical dissolving times are 30 seconds for the whole tablet and 10 seconds for the ground-up tablet.

Think It Over The ground-up tablet dissolved faster than the whole tablet. Inferences will vary. Some students might correctly suggest that the ground-up tablet had more surface area exposed to water than the whole tablet did and therefore dissolved faster.

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. Then the forces of erosion carry the pieces away. **Erosion** (ee ROH zhun) is the removal of rock particles by wind, water, ice, or gravity. **Weathering and erosion 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 1
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?*

Differentiated Instruction

English Learners/Beginning L1

Comprehension: Key Concept Explain and clarify the meaning of weathering by asking students to write the word *weathering* in a circle. Then have them list factors that contribute to weathering (heat, cold, and so on) around the circle as you read through the section. **learning modality: logical/mathematical**

English Learners/Intermediate L2

Comprehension: Key Concept Students can expand on the activity described in *Beginning* by using the words they have written around the circle in a sentence. Students can take cues from the visuals in the text to compose their sentences. **learning modality: logical/mathematical**

Instruct

Weathering and Erosion

Teach Key Concepts L2

Effects of Weathering

Focus Remind students that weathering and erosion take place slowly over long periods of time.

Teach Ask: **How much longer has weathering acted on the Appalachian Mountains than on the Sierra Nevada Mountains?** *(More than 240 million years longer)* **Do you think that in another 240 million years the Sierra Nevada Mountains will look like the Appalachian Mountains?** *(Answers will vary. Many students will say yes.)*

Apply Have students give other examples of weathering and erosion in nature. Examples include the Grand Canyon and many of the rock formations that exist in other national parks, such as Canyonlands, Bryce Canyon, and Arches. **learning modality: logical/mathematical**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Rocks and Weathering*

Student Edition on Audio CD

Monitor Progress L2

Oral Presentation Call on students to classify examples as either weathering or erosion. Give each student a brief, general description of an example of weathering or an instance of erosion, without using technical terms.

Answers

Figure 1 The Appalachians are more worn down than the rugged mountains of the Sierra Nevada.

Reading Checkpoint Weathering is a process that breaks down rock and other materials on Earth's surface, and erosion is the movement of rock particles by wind, water, ice, or gravity.

Mechanical Weathering

Teach Key Concepts **L2**

Causes of Mechanical Weathering

Focus Point out that all kinds of mechanical weathering have the same effect: breaking apart rock.

Teach Discuss the five types of mechanical weathering shown in Figure 2, and have volunteers describe the pictures and types of weathering in their own words. Ask: **In which of the different types is the composition of rock different after mechanical weathering occurs?** *(None; in each case, the composition of the rock remains the same.)*

Apply Ask: **What are some examples of each type of mechanical weathering that you have seen?** *(Students might have seen very smooth, rounded rocks at a beach, an example of abrasion; they might have seen cracks in sidewalks because of freezing and thawing or plant growth.)* **learning modality: logical/mathematical**

All in One Teaching Resources

- Transparency G12

Lab zone Teacher Demo

Mechanical Weathering **L1**

Materials two pieces of sandstone, newspaper

Time 5 minutes

Focus Tell students that this activity will demonstrate mechanical weathering.

Teach As students watch, have a volunteer rub two pieces of sandstone together over a sheet of newspaper. Students will observe that particles fall on the paper.

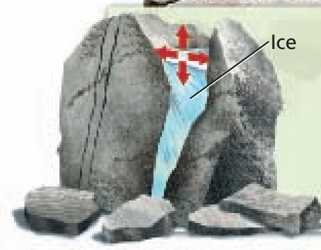
Apply Ask: **What kind of mechanical weathering does this model?** *(Abrasion)* **How could such abrasion occur in nature?** *(Water or wind could carry sand particles into rock, grinding part of it away.)* **learning modality: logical/mathematical**

FIGURE 2

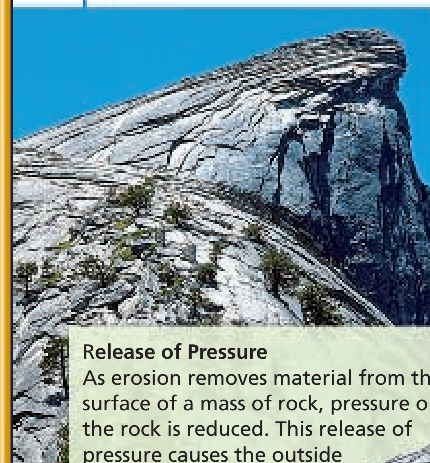
Forces of Mechanical Weathering

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.



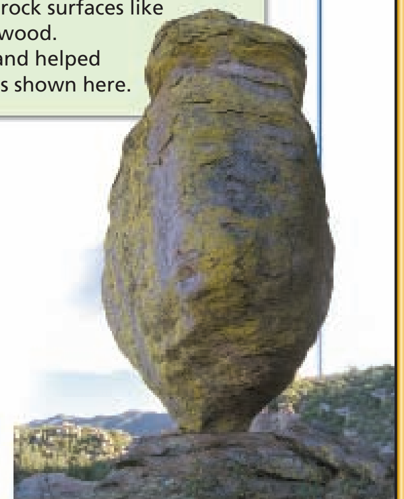
Release of Pressure
As erosion removes material from the surface of a mass of rock, pressure on the rock is reduced. This release of pressure causes the outside of the rock to crack and flake off like the layers of an onion.

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.

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.



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.

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?**

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

Differentiated Instruction

Gifted and Talented L3

Analyzing Visuals Encourage students to look through nature books and magazines to find photographs of the different types of mechanical weathering. Have students classify the type of weathering illustrated and write a sentence explaining why the example demonstrates this type of weathering. Display students' examples on a bulletin board to share with the class.
learning modality: visual

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

Students can review weathering in an online interactivity.

Help Students Read L1

Comparing and Contrasting This technique helps students identify similarities and differences of processes or things. Have students read about mechanical weathering and chemical weathering. After they have read the appropriate passages, have each student draw a Venn diagram that includes ways that the two types of weathering are similar and different.

Monitor Progress L2

Drawing Have students draw pictures illustrating the five types of mechanical weathering. Students can place their drawings in their portfolios. Portfolio

Answers

Figure 2 Definitions will vary but should include a description of the relevant process.

Reading Checkpoint Wedges of ice in the cracks in rock widen and deepen these cracks. When the ice melts, water seeps deeper into the cracks. With repeated freezing and thawing, the rock eventually breaks apart.

Chemical Weathering

Teach Key Concepts

L2

Mechanical Versus Chemical Weathering

Focus Share with students the meanings of the words *mechanical* and *chemical*. The word *mechanical* implies physical processes. The word *chemical* suggests processes related to chemical reactions.

Teach Help clarify the difference between mechanical and chemical weathering by referring to physical and chemical change. Physical changes include changes in size, shape, state, and so on. These changes do not alter the makeup of a substance. Chemical changes, in contrast, are changes resulting from chemical reactions, in which substances change into other substances.

Apply Have students identify the following as examples of mechanical weathering or chemical weathering: **reddish soil** *(Chemical)*, **rock in a desert breaking because of repeated heating and cooling** *(Mechanical)*, **ants making large hills** *(Mechanical)*. **learning modality: logical/mathematical**

Use Visuals: Figure 3

L2

Weathering and Surface Area

Focus Remind students that more surface area means more weathering.

Teach Propose that the faces of the unbroken cube in the figure are each 10 m × 10 m and that the rock is on Earth's surface. Ask: **How many square meters of rock are exposed to the forces of chemical weathering?** *(600 m^2, 6 × 100 m^2, are exposed to weathering.)*

Apply If the rock fractures into eight pieces as shown, how much surface area is exposed? *(Now each face is 5 m × 5 m, or 25 m^2. Therefore, 1200 m^2 would be exposed to chemical weathering; 8 pieces × 6 sides each = 48 sides; 48 sides × 25 m^2/side = 1200 m^2.)* **learning modality: logical/mathematical**

All in One Teaching Resources

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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 Discover activity at the beginning of this section shows how increasing the surface area increases the rate of a chemical reaction.

FIGURE 3
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?*

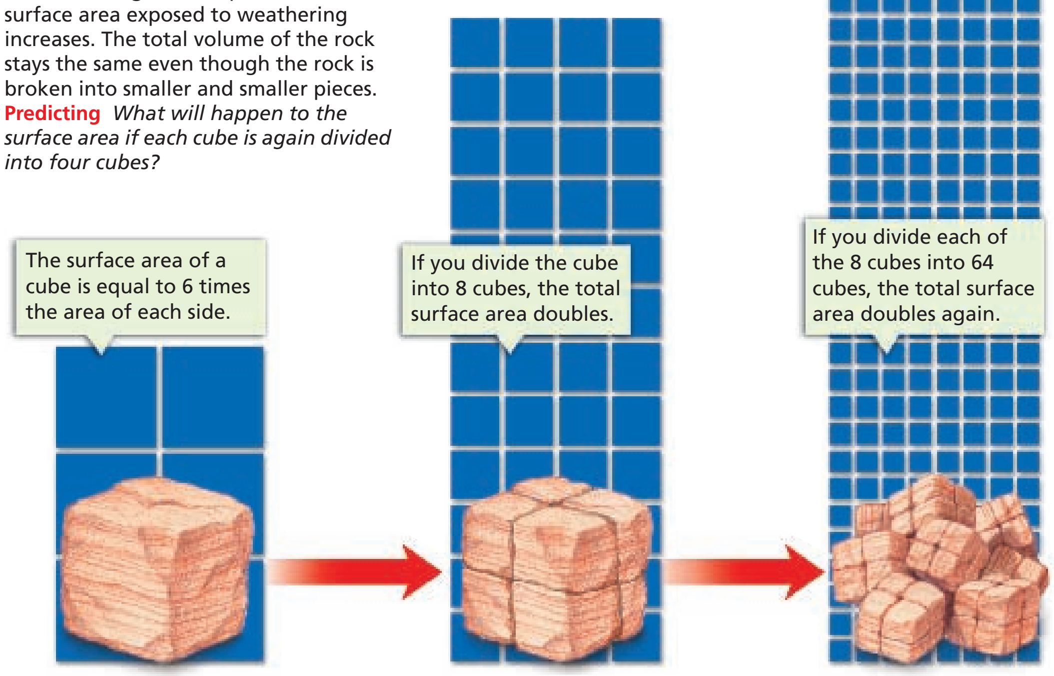


FIGURE 4
Effects of Chemical Weathering
Acid rain chemically weathered these stone gargoyles on the cathedral of Notre Dame in Paris, France.

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 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?

Address Misconceptions L1

Weathering

Focus Some students think that weathering, especially chemical weathering, occurs as large and dramatic events.

Teach Ask: **Has anyone ever seen rock weather?** *(No one will have seen rock weather.)* Emphasize that weathering usually occurs slowly over great spans of time. A person's lifetime is not long enough to observe dramatic changes caused by weathering, such as mountains being worn down.

Apply Ask: **How does weathering differ from processes such as volcanic eruptions or earthquakes?** *(These processes occur in short periods of time. Weathering occurs over long periods of time.)* **learning modality: verbal**

Lab zone **Teacher Demo**

Chemical Weathering L1

Materials samples of limestone and granite, 2 plates, dilute (5%) hydrochloric acid or vinegar, plastic dropper, gloves

Time 5 minutes

Focus Review the causes of chemical weathering.

Teach Display two plates, one with a limestone sample and one with a granite sample. Use the dropper to apply the acid to each rock. The acid on the limestone will fizz as limestone is dissolved and carbon dioxide gas is given off. The acid on the granite will not fizz because granite's minerals are less vulnerable to acid attack.

Apply Ask: **What type of chemical weathering does this model?** *(The way acid rain or natural acids weather limestone)* **learning modality: visual**

Lab zone **Try This Activity**

Skills Focus predicting L2

Materials 2 pads of steel wool, water, jar with lid

Time 5 minutes for setup; 5 minutes a few days later

Tips Do not use steel wool pads that contain soap. To reduce the cost of materials, cut each pad in half.

Expected Outcome It crumbles and stays compacted. The new one springs back. If left in the jar, it will rust, just like rock that has oxidized.

Extend Have students place a pad outside for 2 months and compare it with a control. **learning modality: visual**

Monitor Progress L2

Writing Have students explain in their own words the difference between mechanical weathering and chemical weathering.

Answers

Figure 3 The surface area will increase.

Reading Checkpoint Plants produce acids that slowly dissolve rock around their roots.

Rate of Weathering

Teach Key Concepts L1

Type of Rock and Climate

Focus Ask students to recall the activity with the fizzing antacid tablets that they did at the beginning of this section. Point out that in addition to surface area, the type of rock and climate also affect the rate of weathering.

Teach Ask: **Do you think chemical weathering occurs faster in hot or cold climates?** *(Most students will choose hot.)* **Why?** *(Higher temperatures speed up chemical reactions.)* **Why might different types of rock weather at different rates?** *(The minerals in some rocks are more easily affected by weathering.)*

Apply Display a map of the world, and locate the United States. Ask: **In which countries would you expect weathering to occur more quickly than it does in the United States?** (*Possible answers include countries that are located in the tropics.*) **learning modality: logical/mathematical**

Math Analyzing Data

Math Skill Making and interpreting graphs

Focus Review with students what each axis means and how the graph is structured. Point out that line graphs are a good way to show changes over time.

Teach Ask: **What change is being shown over time?** (*The thickness of stone lost to weathering*) **Why would weathering reduce the thickness of the stone?** *(Because the exposed surfaces of stone dissolve during weathering)*

Answers

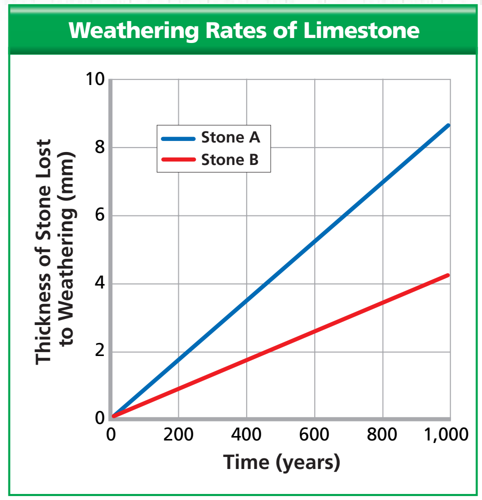
1. Time in years
2. The thickness of stone lost to weathering
3. Stone A lost about 8.5 millimeters; stone B lost slightly more than 4 millimeters.
4. Stone A weathered at a faster rate.
5. They were exposed to different climate conditions.

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?



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.

Differentiated Instruction

English Learners/Beginning L1
Comprehension: Ask Questions To help students understand factors that affect the rate of weathering, distribute a rewritten, simplified version of the content on this page and the next. Then ask students simple questions that can be answered directly from the rewritten text. **learning modality: logical/mathematical**

English Learners/Intermediate L2
Comprehension: Ask Questions Have students read the simplified paragraph that you prepared for *Beginning*. Then challenge students to explain various observations: the inscription on a limestone headstone is less readable than the one on a granite headstone; rock weathers faster in wet climates. **learning modality: logical/mathematical**

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 5
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 1 Assessment

Target Reading Skill **Relating Cause and Effect** Refer to your graphic organizer about the causes of chemical weathering to help you answer Question 2 below.

Reviewing Key Concepts

1. a. **Defining** What is weathering?
   b. **Defining** What is erosion?
   c. **Predicting** Over millions of years, how do weathering and erosion change a mountain made of solid rock?
2. a. **Defining** What is chemical weathering?
   b. **Comparing and Contrasting** Compare and contrast mechanical weathering and chemical weathering.
   c. **Classifying** Classify each as chemical or mechanical weathering: freezing or thawing, oxidation, water dissolving chemicals in rock, abrasion, acid rain.
3. a. **Identifying** What are two factors that affect the rate of weathering?
   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.

Monitor Progress L2

Answers
Figure 5 Marble weathers faster.

Reading Checkpoint Rainfall increases the rate of weathering by providing water that causes chemical changes as well as for freezing and thawing.

Assess

Reviewing Key Concepts

1. a. Weathering is the process that breaks down rock and other substances at Earth's surface. **b.** Erosion is the movement of rock particles by wind, water, ice, or gravity. **c.** The processes of weathering and erosion slowly wear away the solid rock of the mountain.
2. a. Chemical weathering is the process that breaks down rock through chemical changes. **b.** Both types of weathering wear away rock. Mechanical weathering causes rock to change physically, but chemical weathering causes the composition of rock to change. **c.** Freezing and thawing, mechanical; oxidation, chemical; water dissolving chemicals in rock, chemical; abrasion, mechanical; acid rain, chemical
3. a. Type of rock and climate affect the rate of weathering. **b.** Granite weathers very slowly in cool, dry climates. Warmth and moisture increase the rate of weathering.

Reteach L1

Have students name the five kinds of mechanical weathering and give an example of each.

Performance Assessment L2

Skills Check Have students make a compare-contrast table that includes every agent of mechanical and chemical weathering.

All in One Teaching Resources
- Section Summary: *Rocks and Weathering*
- Review and Reinforce: *Rocks and Weathering*
- Enrich: *Rocks and Weathering*

Lab zone At-Home Activity

Ice in a Straw L1 Encourage students to try this model of ice wedging at home. Tell them to use a plastic straw. After freezing the straw overnight, students will observe that the ice has forced one or both of the clay plugs out of the straw because water expands when it freezes.

Lab zone Skills Lab

Rock Shake

L2

Prepare for Inquiry

Key Concept

Mechanical weathering and chemical weathering break down rock into smaller pieces.

Skills Objectives

After this lab, students will be able to

- interpret data about whether acid or water causes more weathering of limestone pieces
- calculate the change in mass of limestone pieces and the percentage change in mass
- draw conclusions about weathering from their data

Prep Time 30 minutes
Class Time 30 minutes on day 1; 30 minutes on day 2

All in One Teaching Resources

- **Lab Worksheet:** *Rock Shake*

Advance Planning

Collect and prepare the pieces of limestone at least one day in advance. Each student will need 80 pieces. Small limestone gravel is the best material to use. Use a hammer to break up any large pieces. Soak the pieces in water for 24 hours.

The cloth students use should measure about 10 × 10 centimeters; cheesecloth will work best. Prepare in advance a vinegar-water solution that is 75 percent white vinegar and 25 percent distilled water. Use distilled water in containers A and B because tap water is slightly acidic.

Because there are many varieties of limestone, you might want to perform the experiment in advance. Some limestone is very susceptible to change from acid, but other limestone is resistant to such change. Some limestone might break up more easily during shaking. By doing the activity in advance, you can determine likely changes in mass for the pieces in each container.

Safety

Caution students that vinegar can irritate the eyes. Make sure that they wear goggles when pouring the vinegar and shaking the containers. Have students check that the caps are screwed on tightly.

Lab zone Skills Lab

Rock Shake

Problem

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

Skills Focus

interpreting data, calculating, drawing conclusions

Materials

- 300 mL of water
- balance
- paper towels
- masking tape
- 2 pieces of thin cloth
- marking pen or pencil
- 300 mL of vinegar, an acid
- plastic graduated cylinder, 250 mL
- 80 small pieces of water-soaked limestone
- 4 watertight plastic containers with screw-on caps, 500 mL

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. Predict the effect of weathering on the mass of the limestone pieces. Which will weather more: the limestone in water or the limestone in vinegar? (*Hint:* Vinegar is an acid.) Also predict the effect of shaking on the limestone in containers B and D. Record your predictions 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)				

Guide Inquiry

Introduce the Procedure

After students have read the procedure, ask: **What variables are you testing in this experiment?** (*The effects of acid and shaking on limestone*) **What is the purpose of container A?** (*Because container A contains no acid and the pieces are not shaken, it is the control.*)

Troubleshooting the Experiment

- On Day 2, have students look at a clock so that they can time the shaking of containers B and D. If students get tired, they can rest, as long as each container is shaken for the same total amount of time.
- Demonstrate how to pour the water through the cloth. Advise students to pick out the 20 largest pieces, ignoring any sediment.

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.

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

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** How correct were your predictions of 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. Design an experiment on the rate of weathering to test the effects of changing one of these variables. *Have your teacher approve your plan before you begin.*

Extend Inquiry

Design an Experiment Encourage students to continue testing limestone or other types of rock. Granite, for example, is more resistant to both acid and shaking.

Expected Outcome

The pieces in container D will show the greatest change in mass because those pieces were subjected to both chemical and mechanical weathering (acid and shaking). The pieces in container A will show little or no change in mass because they were subjected to neither chemical nor mechanical weathering. The pieces in container C will probably show a greater change in mass than the pieces in container B, depending on the type of limestone.

Analyze and Conclude

1. The percent change in mass of the pieces in each container will vary significantly, depending on the type of limestone used, the original mass of the pieces, the strength of the acid, and the amount of shaking. The exact figures are not important but how the figures compare is important.

2. There should be a change in the mass of the pieces in containers B, C, and D. There should be little or no change in mass of the pieces in container A.

3. The pieces in container D should show the greatest change in total mass because they were subjected to both acid and shaking. The pieces in container A should show the least change because they were not subjected to acid or shaking.

4. Most students will have correctly predicted that the acid and shaking will cause the greatest amount of weathering.

5. The mass of the pieces in container D showed the greatest change because those pieces were soaked in acid overnight and shaken the next day.

6. Most students will suggest that the acid was more responsible for breaking down the limestone because the change in mass of the pieces in container C was greater than the change in mass of the pieces in container B.

7. Two variables were tested in this experiment—the effect of shaking and the effect of acid. The two containers that were not shaken differ only in the absence or presence of acid, so this variable is tested exclusively. Shaking the two containers the same amount of time allowed the acidity variable to be tested with shaking. The shaking variable is tested in water by the water, no shaking and water, shaking containers. The shaking variable is tested in acid by the vinegar, no shaking and vinegar, shaking containers.