SECTION 1

READING WARM-UP

Terms to Learn

weathering
mechanical weathering
abrasion
chemical weathering
acid precipitation
oxidation

What You'll Do

- Describe how ice, rivers, tree roots, and animals cause mechanical weathering.
- Describe how water, acids, and air cause chemical weathering of rocks.

Weathering

Weathering is the breakdown of rock into smaller and smaller pieces. Rocks on Earth's surface are undergoing weathering all the time, either by mechanical means or by chemical means. You will learn the difference as you read on. You will also learn how these processes shape the surface of our planet.

Mechanical Weathering

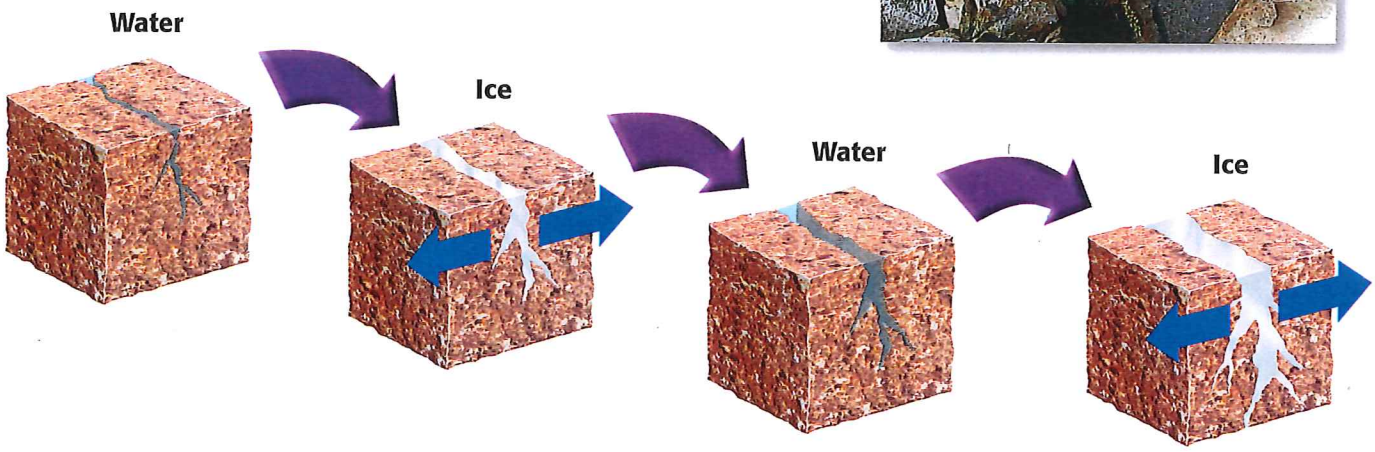
If you were to crush one rock with another rock, you would be demonstrating one type of mechanical weathering. **Mechanical weathering** is simply the breakdown of rock into smaller pieces by physical means. Agents of mechanical weathering include ice, wind, water, gravity, plants, and even animals.

Ice As you know, water has the unusual property of expanding when it freezes. (This is just the opposite of most substances.) When water seeps into a crack in a rock during warm weather and then freezes during cold weather, it expands. And when it expands, it pushes against the sides of the crack, forcing it to open wider. This process is called *ice wedging*. **Figure 1** shows how ice wedging occurs over time.

Chemistry CONNECTION

Almost all liquids contract when they freeze to form a solid—their volume decreases and their density increases. When these substances freeze, the frozen solid sinks. Just the opposite occurs to water when it freezes. Water expands and becomes less dense, which is why ice floats in water.

Figure 1 *The granite at right has been broken down by repeated ice wedging, as shown in the illustration below.*



Wind, Water, and Gravity When you write on a chalkboard, a process called *abrasion* takes place. As you scrape the piece of chalk against the chalkboard, some of the chalk rubs off to make a line on the board. As particles of chalk are worn off, the piece of chalk wears down and becomes more rounded at the tip. The same thing happens to rocks. In nature, **abrasion** is the action of rocks and sediment grinding against each other and wearing away exposed surfaces.

Abrasion can happen in many ways. For example, when rocks and pebbles roll along the bottom of swiftly flowing rivers, they bump into and scrape against each other. They eventually become river rocks, as shown in **Figure 2.**

Wind also causes abrasion. For example, when wind blows sand against exposed rock, the sand eventually wears away the rock's surface. **Figure 3** shows what this kind of sandblasting can do.

Abrasion also occurs when rocks fall on one another. **Figure 4** shows a rock slide. You can imagine the forces rocks exert on each other as they tumble down a mountainside. In fact, any time one rock hits another, abrasion takes place.

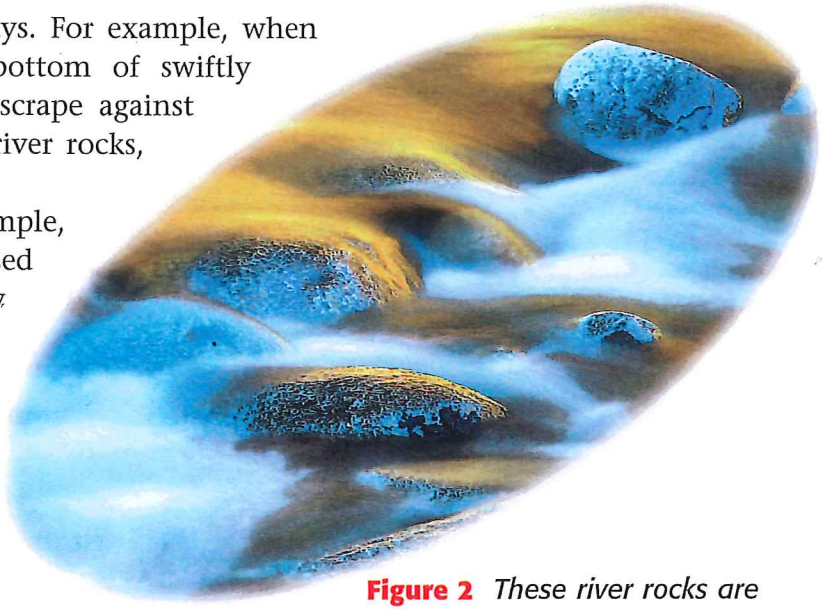


Figure 2 *These river rocks are rounded because they have been tumbled in the riverbed by fast-moving water for many years.*

Figure 3 *This rock has been shaped by blowing sand. Such rocks are called* ventifacts.

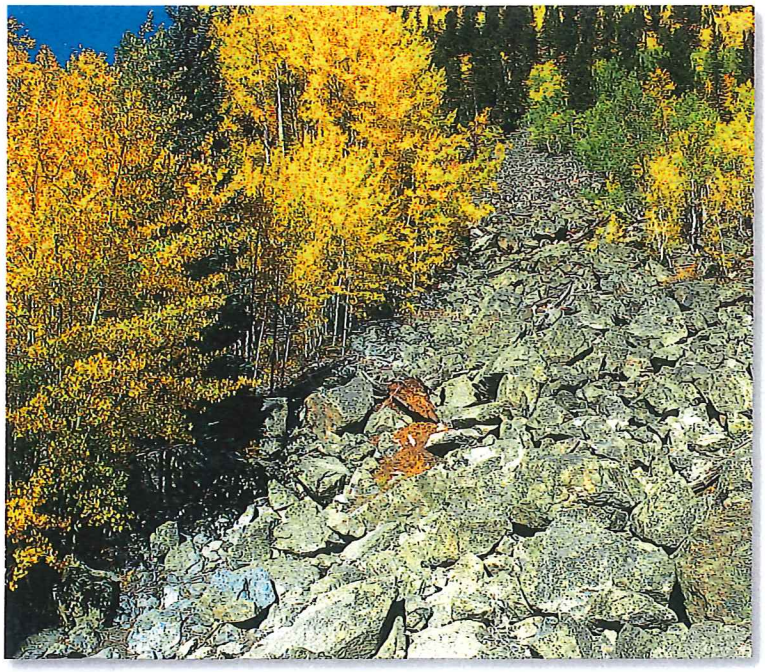


Figure 4 *Rocks grind against each other in a rock slide, creating smaller and smaller rock fragments.*

Figure 5 *Although they grow slowly, tree roots are strong enough to break solid rock.*

Plants You may not think of plants as being strong, but some plants can easily break rocks. Have you ever seen how tree roots can crack sidewalks and streets? Roots aren't fast, but they certainly are powerful! Plants often send their roots into existing cracks in rocks. As the plant gets bigger, the force of the expanding root becomes so strong that the crack is made larger. Eventually, the entire rock can split apart, as you can see in **Figure 5.**

Animals Believe it or not, earthworms cause a lot of weathering! They burrow through the soil and move soil particles around. This exposes fresh surfaces to continued weathering. Would you believe that some kinds of tropical worms move an estimated 100 metric tons of soil per acre every year? Almost any animal that burrows causes mechanical weathering. Ants, mice, coyotes, and rabbits all make their contribution. **Figure 6** shows some of these animals in action. The mixing and digging that animals do often contribute to another type of weathering, called *chemical weathering*. You will learn about this next.

Self-Check

Describe the property of water that causes ice wedging. *(See page 120 to check your answer.)*

Figure 6 *Animals that live in the soil cause a lot of weathering.*

Chemical Weathering

If you place a drop of strong acid on a rock, it will probably "eat away" a small part of the rock. This is an example of chemical weathering. **Chemical weathering** is the chemical breakdown of rocks and minerals into new substances. The most common agents of chemical weathering are water, weak acids, air, and soil. **Figure 7** shows the chemical weathering of granite.

Water If you drop a sugar cube into a glass of water, it will dissolve after a few minutes. If you drop a piece of chalk into a glass of water, it will also dissolve, only much slower than a sugar cube. Both cases are examples of chemical weathering. Even hard rock, like granite, is broken down by water; it just may take a few thousand years.

Acid Precipitation A car battery contains sulfuric acid, a very dangerous acid that should never touch your skin. A weaker form of sulfuric acid can be found in nature. In fact, precipitation such as rain and snow is naturally acidic and contains carbonic acids. Small amounts of sulfuric and nitric acids from natural sources, such as volcanoes, can make precipitation even more acidic. These acids can slowly break down rocks and other matter.

Precipitation that contains acids due to air pollution is called **acid precipitation.** Acid precipitation contains more acid than normal precipitation, so it can cause very rapid weathering of rock. Even the bronze statue shown in **Figure 8** is being chemically weathered by acid precipitation.

Figure 8 *This statue is being damaged by acid precipitation.*

Figure 7 *After thousands of years of chemical weathering, even hard rock, like granite, can turn to sediment.*

QuickLab

Acids React!

Have you ever heard someone refer to a certain food as being "acidic"? You consume acids in your food every day. For example, ketchup contains weak acids that can react with certain substances in a rather dramatic way. Try this:

1. Take a **penny** that has a dull appearance, rub **ketchup** on it for several minutes, and then rinse it off.
2. Where did all the grime go?
3. How is this similar to what happens to a rock when it is exposed to natural acids during weathering?

TRY at HOME

Acid precipitation starts with the burning of fossil fuels such as coal and oil. When these fuels are burned, they give off gases, including sulfur oxides, nitrogen oxides, and carbon oxides. When these compounds combine with water in the atmosphere, they can fall back to the ground in rain and snow. When the acidity is too high, acid precipitation can be harmful to vegetation and wildlife such as fish, amphibians, and insects.

Acid in Ground Water In certain places ground water contains weak acids, such as carbonic or sulfuric acid. When this ground water comes in contact with limestone, the limestone breaks down. Over a long period of time, this can have some spectacular results. Enormous caverns, like the one shown in **Figure 9,** can form as the limestone is eaten away. Limestone, you may remember, is made of calcite, which reacts strongly with acid.

Figure 9 *Papoose Room, Carlsbad Caverns. Carlsbad Caverns National Park, New Mexico.*

Acids in Living Things Another source of acids for weathering might surprise you. Take a look at **Figure 10.** Lichens produce organic acids that can slowly break down rock. If you have ever taken a walk in a park or forest, you have probably seen lichens growing on the sides of trees or rocks. Lichens can also grow in places where some of the hardiest plants cannot. Lichens can be found in deserts, in arctic areas, and in areas high above timberline, where even trees don't grow.

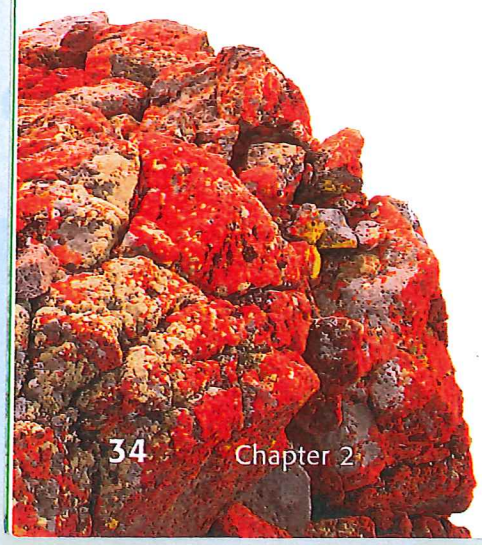


Figure 10 *Lichens, which consist of fungi and algae living together, contribute to chemical weathering.*

Air The car shown in **Figure 11** is undergoing chemical weathering due to the air. The oxygen in the air is reacting with the iron in the car, causing the car to rust. Water speeds up the process, but the iron would rust even if no water were present. This process also happens in certain types of rocks, particularly those containing iron, as you can see in **Figure 12.** Scientists call this process *oxidation.*

Oxidation is a chemical reaction in which an element, such as iron, combines with oxygen to form an oxide. (The chemical name for rust is *iron oxide.*) Oxidation is a common type of chemical weathering, and rust is probably the most familiar result of oxidation.

Activity

Imagine that you are a tin can—shiny, new, and clean. But something happens, and you don't make it to a recycling bin. Instead, you are left outside at the mercy of the elements. In light of what you have learned about physical and chemical weathering, write a story about what happens to you over a long period of time. What is your ultimate fate?

TRY at HOME

Figure 12 *The red color of the rock at Capitol Reef National Park is due to the oxidation of iron.*

Figure 11 *Rust is a result of chemical weathering.*

SECTION REVIEW

1. Describe three ways abrasion occurs in nature.
2. Describe the similarity between the ways tree roots and ice mechanically weather rock.
3. **Making Generalizations** Why does acid precipitation weather rocks faster than normal precipitation does?

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