

1.3

KEY CONCEPT

Fresh water flows underground.

BEFORE, you learned

- Water flows in river systems on Earth's surface
- Water collects in ponds and lakes on Earth's surface

NOW, you will learn

- How water collects and flows underground
- How underground water reaches the surface in springs and by wells

VOCABULARY

groundwater p. 24
permeable p. 24
impermeable p. 25
water table p. 25
aquifer p. 26
spring p. 28
artesian well p. 28

EXPLORE Flow of Water

What does water flow through?

PROCEDURE

- 1 Fill the cup with water.
- 2 Have a partner hold the filter open over a sink, bucket, or pan while you pour water into it.

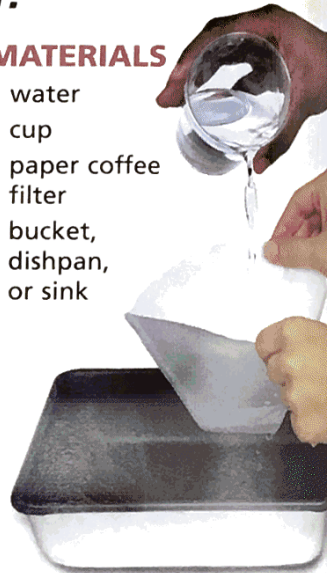
WHAT DO YOU THINK?

- Why did the water remain in the cup before you poured it?
- What route did the water take to pass through the filter?

CHALLENGE What other materials might hold water? allow water to flow through?

MATERIALS

- water
- cup
- paper coffee filter
- bucket, dishpan, or sink

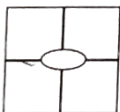
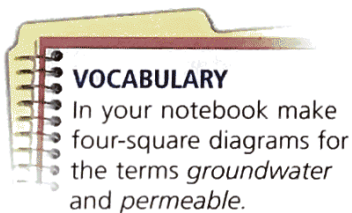


Water fills underground spaces.

After a rainstorm, water does not stay on the ground for long. What happens to this water? It flows along Earth's surface into a river or reservoir, evaporates, or sinks into the soil. Plants use some of the water that sinks into the ground, and the rest of it sinks deeper into Earth. Water held underground is called **groundwater**. The ground under your school may seem too solid to hold water, but it is likely that groundwater sits or moves under the surface.

To understand how groundwater collects, you need to know the difference between permeable and impermeable materials. The ground beneath your feet is made of both permeable and impermeable materials.

A **permeable** substance is a substance that liquids can flow through. Liquids flow through a coffee filter because the filter is permeable. Soil,



sand, and gravel are permeable because there are spaces between the particles. Water flows into and through these spaces. The bigger the particles, the more easily water can flow. Gravel and larger rocks have large spaces between them, so water flows quickly through. Sandy soil also has many pores, or spaces. Some rocks, such as sandstone, are permeable although the spaces in these rocks are extremely small.

An **impermeable** substance is a substance that liquids cannot flow through. A drinking glass holds orange juice because the material of the glass is impermeable. Rocks such as granite are impermeable. Unless granite has cracks, it has no spaces for water to go through. Many impermeable materials are hard, but not all of them. Clay is soft, but it is nearly impermeable. Water can get between its particles, but the overlapping of the particles stops the water from flowing through.

How does groundwater collect? Gravity causes rainwater to sink into the soil. If it rains heavily, all the spaces in the soil fill with water. Eventually the water reaches impermeable rock. There it is held in place or forced to flow in a different direction.

Even when the soil on Earth's surface is dry, huge amounts of groundwater may be stored below. The top of the region that is saturated, or completely filled with water, is called the **water table**. The saturated region below the water table is called the saturation zone.

READING TIP

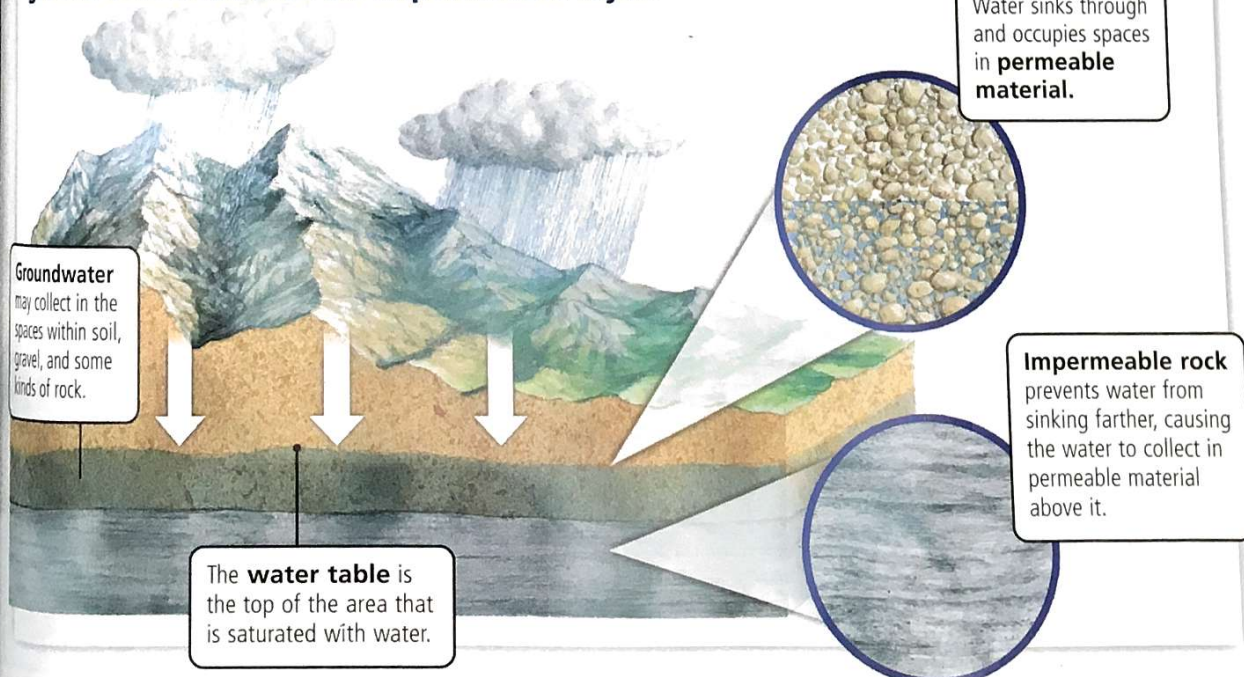
The prefix *im* in *impermeable* means "not."

CHECK YOUR READING

What prevents groundwater from sinking farther down?

Groundwater

Pulled down by gravity, water sinks through permeable ground until it reaches an impermeable layer.



i **SIMULATION**
CLASSZONE.COM

Explore how groundwater fills in aquifers.

Aquifers

An **aquifer** is an underground layer of permeable rock or sediment that contains water. Some aquifers lie deep under layers of impermeable rock. Other aquifers lie just beneath the topsoil.

Aquifers can be found all over the world. They lie under deserts as well as wet regions. As the map below shows, they are found in many areas of the United States. An aquifer might be a bed of sand or gravel only a few meters thick. Or it might be an enormous layer of sandstone, several hundred meters thick, holding water in countless pore spaces. The Ogallala Aquifer is the largest aquifer in North America. It covers 450,000 square kilometers (176,000 mi²), from South Dakota to Texas.

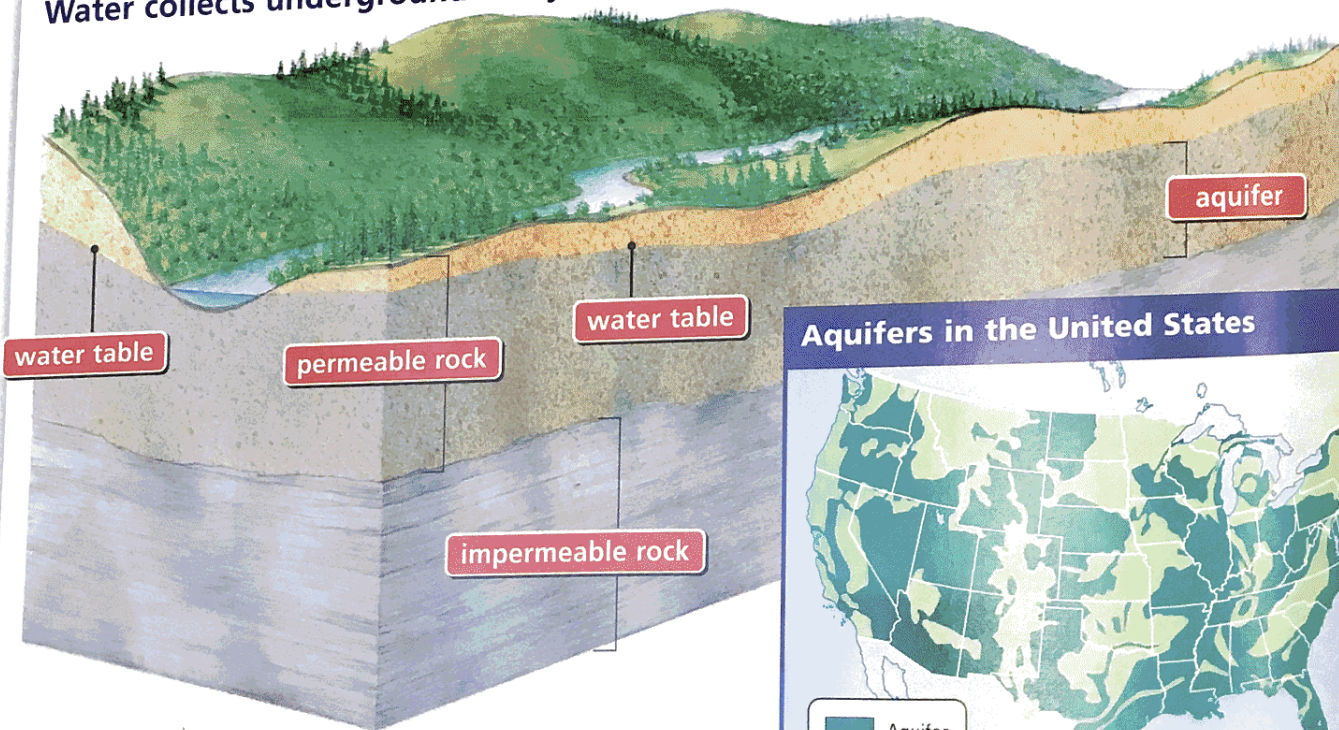
For an aquifer to form, three things are needed:

- A layer of permeable material holds the water. Groundwater is stored in the pore spaces of gravel, sand, or rock.
- A neighboring area of impermeable rock keeps the water from draining away. Sometimes impermeable rock lies both above and below an aquifer.
- A source of water replenishes or refills the aquifer. Like any body of water, an aquifer can be emptied.

You know that fresh water on land flows toward the ocean. Water that is underground acts like slow-motion streams, rivers, and lakes. Underground water moves slowly. The water is under pressure

Aquifers

Water collects underground in layers of permeable material.



from all sides, and it must go around endless tiny corners and passageways in rock. Unlike the water in an aboveground river, groundwater moves sideways, down, and even up. In some areas, groundwater is pushed upward so that it flows from a hillside. Because it moves so slowly, much of the water in an aquifer may have been there for thousands of years.

The Importance of Aquifers

When water sinks into land, the ground acts like a giant filter. Stones and sand in the ground can filter out bacteria and other living organisms. This ground filter also removes some harmful chemicals and minerals. The filtering process can make groundwater clear and clean and ready to drink. If it is not polluted, groundwater may not need expensive treatment. It is one of our most valuable natural resources.

Many big cities collect water from rivers and store it in reservoirs above the ground. However, about one-fifth of the people in the United States get their fresh water from underground. Most people who live in rural areas pump groundwater from wells. In many desert regions people depend on sources of underground water.

INVESTIGATE Aquifer Filtration

How can the ground filter water?

PROCEDURE

- 1 Cap the top of the bottle. Invert it and add to it a layer of gravel, then a layer of sand, then a layer of soil.
- 2 Slowly pour water onto the soil until a water table becomes visible in the sand beneath it.
- 3 Add the pollutants pepper, cocoa, and food coloring to the bottle top. Slowly unscrew the cap so that water trickles into the bucket.
- 4 Observe the water that filtered through.
- 5 Pour more water onto the soil and let water trickle out.

WHAT DO YOU THINK?

- Which pollutants were filtered out before reaching the "aquifer"? Which ones reached the aquifer?
- What effect does pollution have on drinking water that comes from aquifers?

CHALLENGE What could you do to clean up an aquifer?

SKILL FOCUS Making models

MATERIALS

- water
- 1L plastic bottle with bottom cut off
- gravel
- sand
- soil
- pepper
- cocoa
- food coloring
- bottle bottom or bucket

TIME

30 minutes



Underground water can be brought to the surface.

MAIN IDEA AND DETAILS

In your notebook, fill out a chart for this main idea.

If you had lived in colonial America or in ancient Greece, your daily chore might have been to haul water home from a well. You would have lowered a bucket into a pit until it reached the water table, then pulled the filled bucket up with a rope. Or you might have worked at digging a well, hacking away at the ground with a shovel until water flowed into the hole you dug.

Today's technology makes it easier to bring groundwater to the surface. Powerful drills bore through rock, and motors pump groundwater to the surface and to kitchen sinks. Scientists study the sizes and areas of aquifers. They know where to get water and how much to expect.

Springs and Wells

Underground pressure causes this artesian well to shoot water 18 meters (60 ft) into the air.



Groundwater can be collected from springs and wells. A **spring** is a flow of water from the ground at a place where the surface of the land dips below the water table. In some springs, the water bubbles up, then sinks back into the soil. In others, the water flows into a stream or lake. Spring water has a fresh clean taste, and many water companies bottle this water to sell.

A well is a hole in the ground that reaches down to the saturation zone—the wet region below the water table. Usually, a pump is used to draw the water out of the ground, and a screen is used to filter out particles of sand and gravel. If the water table is near the surface, a well can be dug by hand. The part of the well beneath the water table will fill with water.

Most modern wells are dug with motorized drills. A drill digs through soil and rock into the saturation zone; then a pipe is lowered into the drill hole. A pump is used to raise the water from the ground. Some wells are more than 300 meters (1000 ft) deep.

One kind of well does not need a pump. An **artesian well** is a well in which water flows to the surface naturally because it is under pressure. In places where impermeable rock dips into an aquifer, the water directly below the rock is pushed to a lower

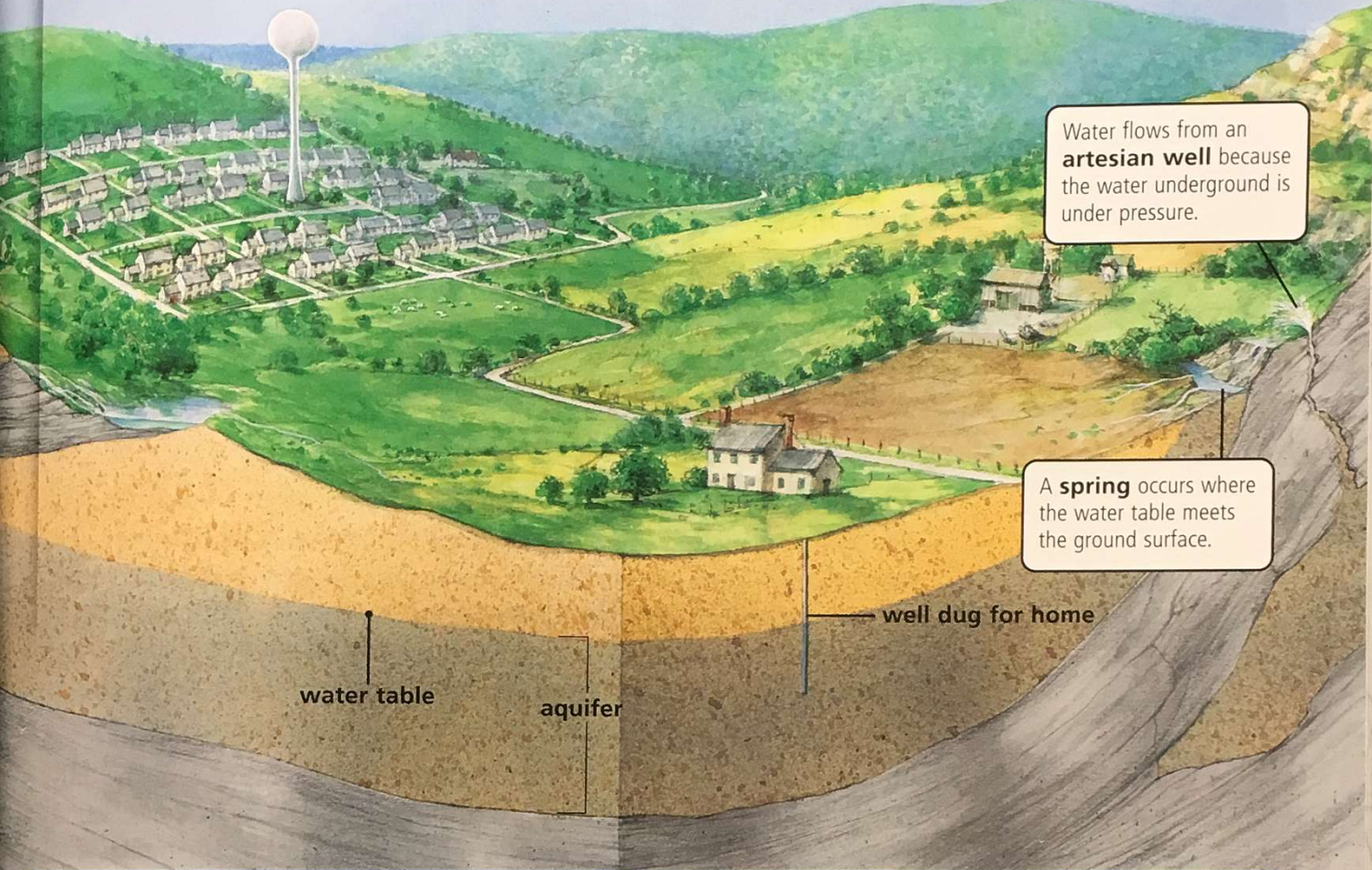
level than the water on either side. When a well is drilled into the water beneath the rock, the weight of the surrounding water pushes the water upward.

CHECK YOUR READING

What makes water flow upward out of an artesian well?

Springs and Wells

Water is brought up from the ground in various ways.



Water flows from an **artesian well** because the water underground is under pressure.

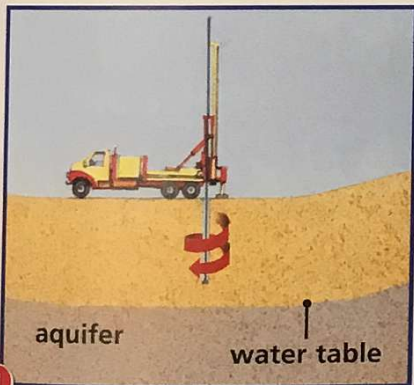
A **spring** occurs where the water table meets the ground surface.

water table

aquifer

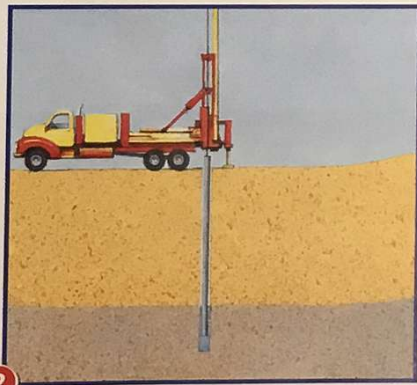
well dug for home

How to Make a Well



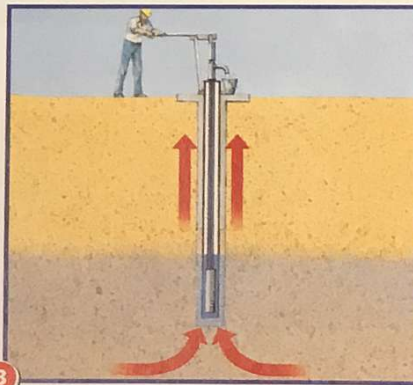
1

Drill into the ground with special machinery.



2

When the drill hole reaches below the water table, lower a pipe into it.



3

At the top of the well, install a pump powered by a motor or human effort to pull up water.

READING VISUALS

Look at the top illustration. What would happen if the water table dropped below the bottom end of the well?

The depth of the water table in a particular place can vary from season to season, depending on how much rain falls and how much water is used. When water is taken from an aquifer, the water table might drop. When it rains or snows, some of the water filters back into the aquifer, replacing what has been taken. If water is used faster than it is replaced, wells may run dry. Low groundwater levels can also cause the ground to settle and damage the environment.

As more and more people live on Earth, the amounts of groundwater used to irrigate crops increase. In some states where crops are grown in dry areas, as much as 70 percent of all the groundwater brought to the surface is used for irrigation. Water used for irrigation is recycled back into the water cycle. In some places it sinks back into the ground and filters into aquifers. In other regions much of the water evaporates or flows away, and the groundwater levels are lowered.

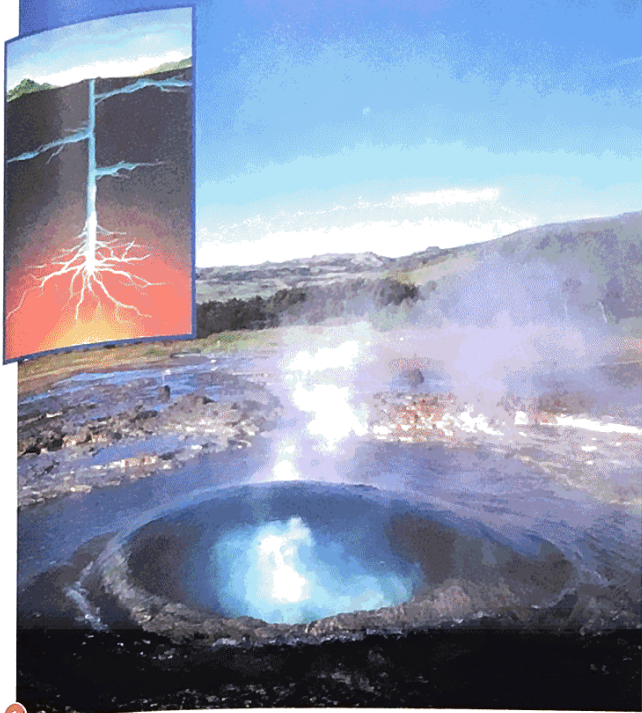
Hot Springs

Yellowstone National Park sits atop the remains of an ancient volcano. The rain and melted snow that sink into the ground there eventually reach depths of more than 3000 meters (10,000 feet), where the rocks are extremely hot. The water heats up and reaches the boiling point. Then it becomes even hotter while remaining liquid because it is under such great pressure from the rocks pushing on it from all sides.

The hot water deep underground is like water in an enormous boiling pot—with a lid 3000 meters thick. The water expands the only way that it can, by pushing upward through weak places in the rocks. A place where the water surfaces is a hot spring. A hot spring has a continual flow of hot water.

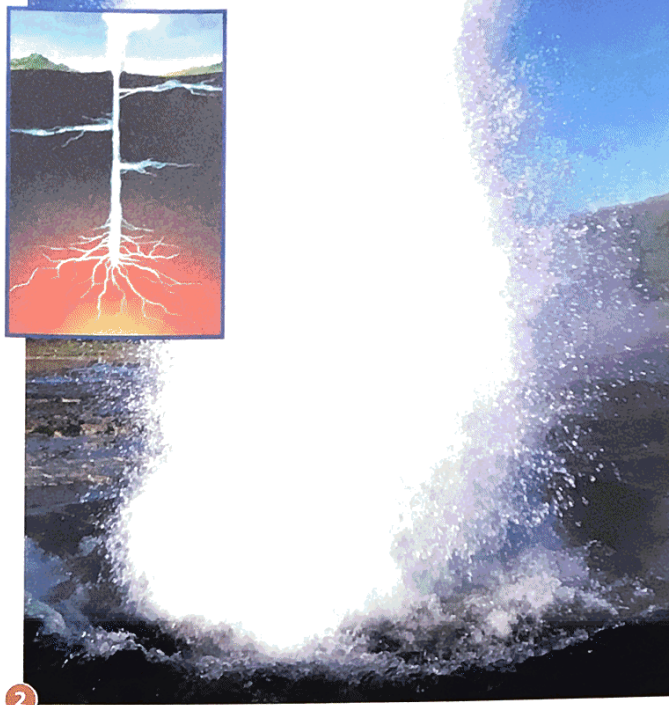
Vapor rises from these hot springs in Yellowstone National Park in Wyoming.





1

In a geyser, water heats underground. The diagram shows the underground “plumbing” of a geyser in Iceland.



2

Hot water and steam are pushed up to the surface where they erupt.

A geyser is a kind of hot spring. The illustrations above show how a geyser works. Beneath the surface, there are underground channels in the rock. The rising hot water is forced to travel through these narrow passages. Like water in a garden hose, the water moves with force because it is under pressure. When it finally reaches Earth’s surface, the pressure makes it burst out. It shoots into the air as a dramatic fountain of water and steam. In Yellowstone National Park there are more than 300 geysers. One of the largest, Old Faithful, shoots a jet of hot water and steam about 20 times a day. The eruptions last from 1.5 to 5 minutes, and reach heights of 30 to 55 meters (106 to 184 ft).



Learn more about geysers and hot springs.

CHECK YOUR READING Why does water shoot out of Old Faithful with such great force?

1.3 Review

KEY CONCEPTS

1. Draw a diagram that shows how water collects underground.
2. What is the difference between a spring and a well?
3. What causes water to rise out of the ground in hot springs and geysers?

CRITICAL THINKING

4. **Connect** Is a T-shirt permeable or impermeable? How about a raincoat? Explain why.
5. **Infer** Would you expect to find a spring on the very top of a hill? Why or why not?

CHALLENGE

6. **Sequence** On a blank sheet of paper, draw a cartoon strip that shows how aquifers collect and store water and how people bring the water to the surface. Show at least five steps in the process. Write captions for your drawing to explain the steps.