

KEY CONCEPT

13.4

Waters rise and fall in tides.

◀ BEFORE, you learned

- Wind provides the energy to form waves in the ocean
- Ocean waves change near shore
- The ocean is a global body of water

▶ NOW, you will learn

- What causes tides
- How tides affect coastlines
- How tides can be used to generate electricity

VOCABULARY

tide p. 448
tidal range p. 450
spring tide p. 451
neap tide p. 451

THINK ABOUT

What causes water levels to change in the ocean?

These two photographs were taken on the same day at the boat harbor in Lymstone, England. The change in water level in the harbor occurs every day on a regular and predictable basis. What forces cause shifts in such huge volumes of water? How can we explain the clocklike regularity of the flow?



Coastal waters rise and fall each day.

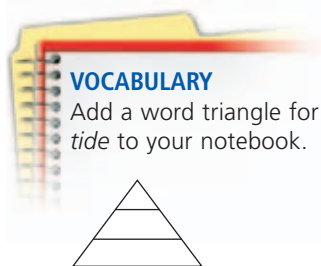
Have you ever spent a day at a beach along the ocean? Perhaps you placed your blanket and beach chairs in the sand close to the water's edge. An hour later, you may have needed to move your blanket and chairs to keep the advancing waves from washing them away. The water level on coastlines varies with the time of day. This periodic rising and falling of the water level of the ocean is called the **tide**. The water level along a coast is highest at high tide, submerging parts of the coastline. The water level is lowest at low tide, exposing more of the coastline.

What in the world could cause such dramatic changes in the ocean's level? The answer is, nothing in this world. Read on to find out how out-of-this-world objects cause tides.



CHECK YOUR READING

How does the water level along a coast differ at high tide and at low tide?



VOCABULARY

Add a word triangle for *tide* to your notebook.



The gravity of the Moon and the Sun causes tides.

Over 2000 years ago, people knew that the Moon and the tide were related. But 1700 years passed before the connection was explained in the terms of modern science. In 1687, Sir Isaac Newton developed his theories of gravity and linked the tide to the Moon's gravitational pull. Gravity is a force of attraction between objects. Earth's gravity pulls things toward its center—including you.

The gravity of the Sun and the gravity of the Moon also pull on objects on Earth. In response to the Moon's gravitational pull, Earth's water bulges on the side facing the Moon. The Moon's gravity also pulls on Earth itself. Earth gets pulled toward the Moon, leaving a second bulge of water on the side of Earth facing away from the Moon. The Sun's gravity pulls too, but with less effect because the Sun is so far away.

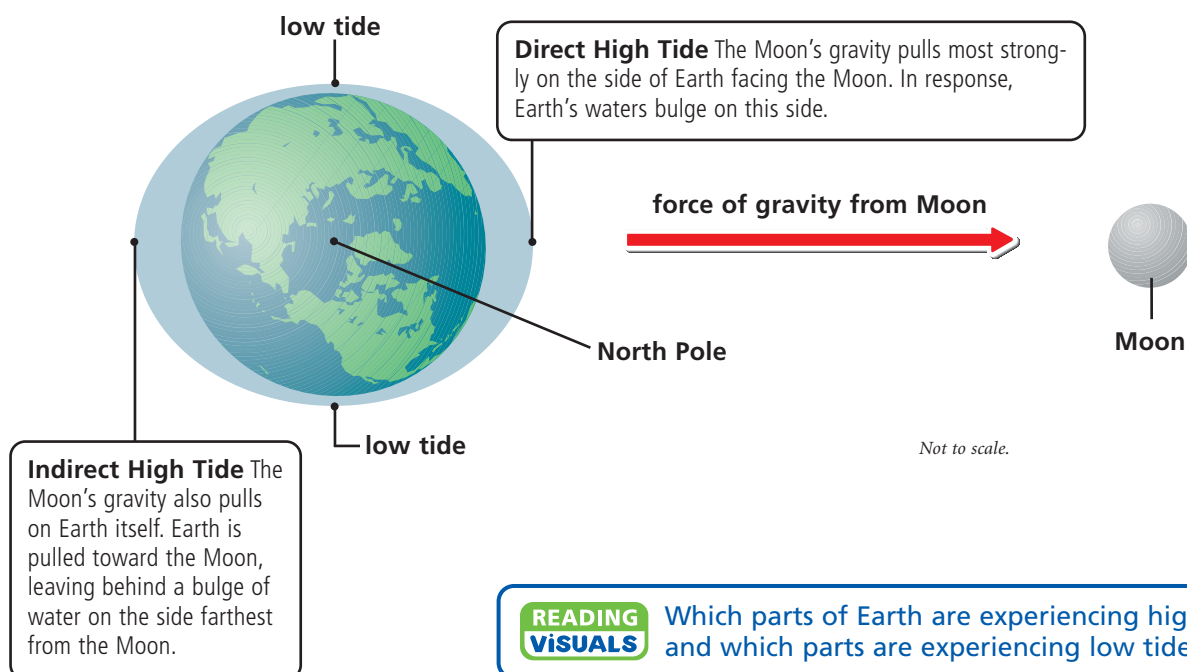
Daily Tides

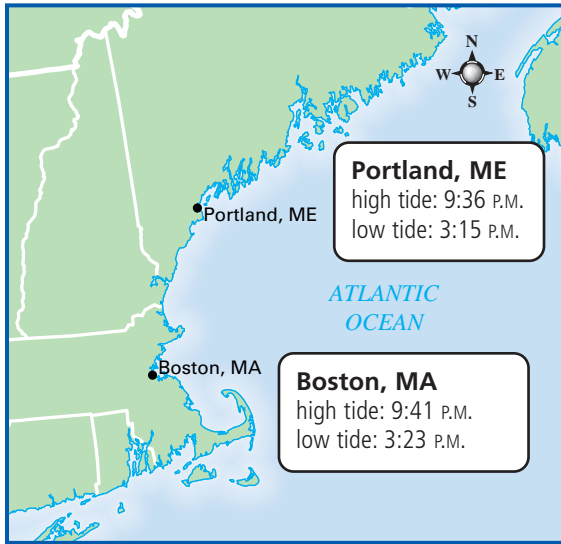
The diagram below shows the two bulges of ocean water: one on the side of Earth closest to the Moon, and the other on the opposite side of Earth. At these bulges, it is high tide. Between the two bulges are dips. At these dips, it is low tide. As Earth rotates, different parts of it pass through the bulges and the dips. As a result, most places experience two high tides and two low tides each day.



Watch daily tides in action.

Daily Tides





The timing of high and low tides at one location on a coast may differ from the timing at other locations along that coast. As you can see on the map of the coastline of New England, the tides occur later as you move west along the coastline. As Earth rotates, the easternmost points on a coastline will pass through the tidal bulge before places farther west on the same coastline.

A place farther east along a coastline experiences high and low tides earlier in the day, because it passes through the tidal bulge first. Times for high and low tides change daily.

The timing of high and low tides is not the only way that tides can differ along a coastline. Some places experience higher high tides and lower low tides than other places. The shape of the land above and below the water affects tidal ranges. A **tidal range** is the difference in height between a high tide and the next low tide. The tidal range is greater in a narrow bay than on a wide-open shore. For example, the narrow harbor of Lymptstone, England, shown in the photographs on page 448, has a very large tidal range. A coastline with a steeply sloped ocean floor has a larger tidal range than a coastline with a gradually dropping floor. For example, the coasts of Texas and western Florida have very small tidal ranges because of the gradual slope of the ocean floor there.



CHECK YOUR READING

In what two ways does the shape of the land affect the tidal range? What sentences tell you this?

INVESTIGATE Tides

How does the Moon make tides?

PROCEDURE

- 1 Cut the Tides datasheet in two, along the dotted line. Cut out the map of Earth on the bottom half of the sheet.
- 2 Use a paper fastener to connect the two pieces as shown in the photograph.
- 3 Now you are ready to model the tides. Rotate Earth one full turn in the direction of the arrow. One full turn is equal to one day.

WHAT DO YOU THINK?

- How does the model demonstrate the Moon's role in tides?
- How many times does each place in the ocean experience high tide and low tide each day?

CHALLENGE One full rotation of Earth takes place in a day, or 24 hours. About how much time passes between one high tide and the next high tide at any location on Earth?

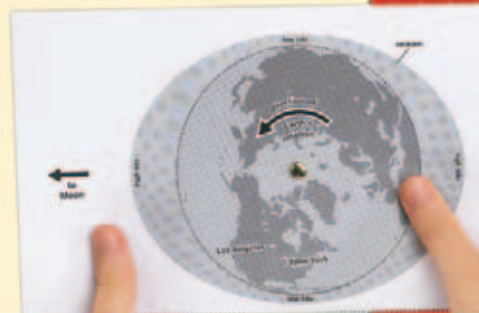
SKILL FOCUS
Making models

MATERIALS



- Tides datasheet
- scissors
- brass paper fastener

TIME
15 minutes



Monthly Tides

The Moon is the main cause of tides, but the Sun affects tides as well. The Moon takes about a month to move around Earth. Twice during this month-long journey—at the new moon and the full moon—the Moon, the Sun, and Earth line up. The gravity of the Sun and the gravity of the Moon combine to pull Earth's waters in the same directions. The result is an extra-high tidal bulge and an extra-low tidal dip, called a **spring tide**.

During first- and third-quarter moons, the Sun and the Moon are not lined up with Earth. The gravity of each pulls from a different direction. The result is a smaller tidal bulge and tidal dip, called a **neap tide**. During a neap tide, high and low tides are less extreme.

Changes in the timing and the height of tides occur in a regular cycle. The timing of tides may be important to people who live near a coast or use coasts for fishing or boating. In many coastal communities, tide tables printed in newspapers give the exact times and heights of the tides.



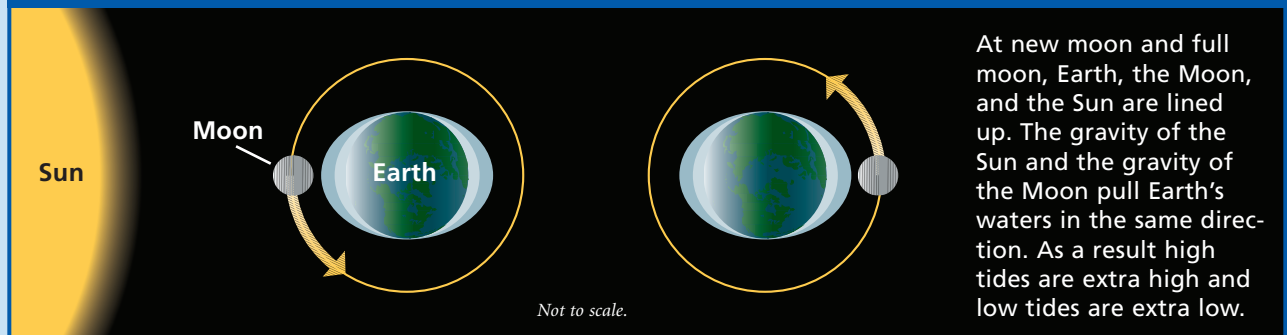
Find out more about ocean tides.

READING TIP

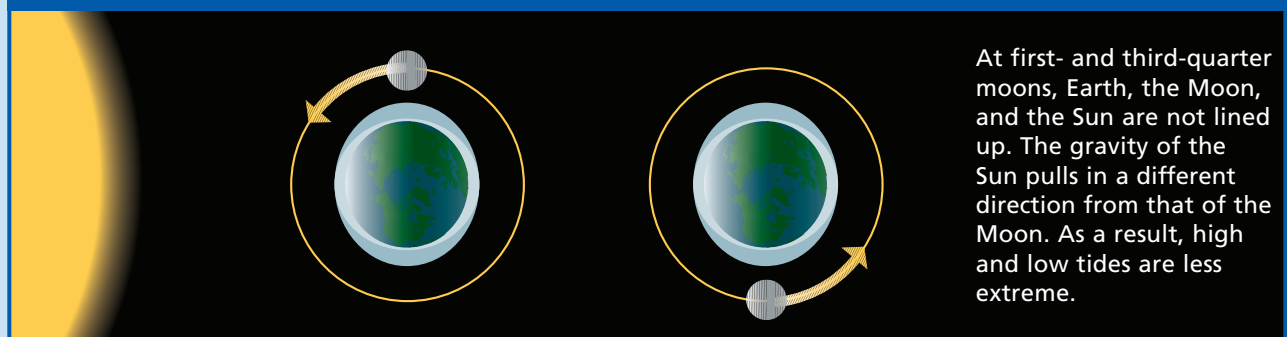
Spring tides occur twice a month all year long, not just in spring. This use of the word *spring* is related to its meaning "to jump."

Monthly Tides

Spring Tide



Neap Tide

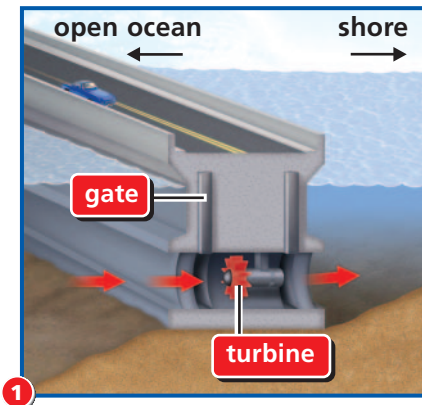


READING VISUALS

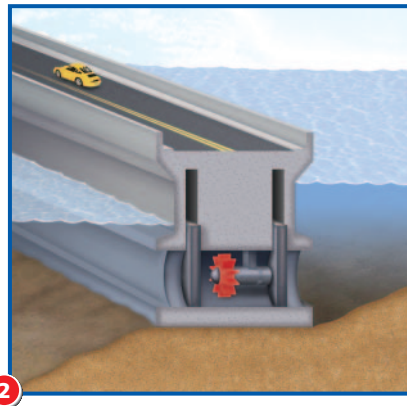
How are Earth, the Moon, and the Sun positioned during spring tides? How are they positioned during neap tides?

Tides can be used to generate electricity.

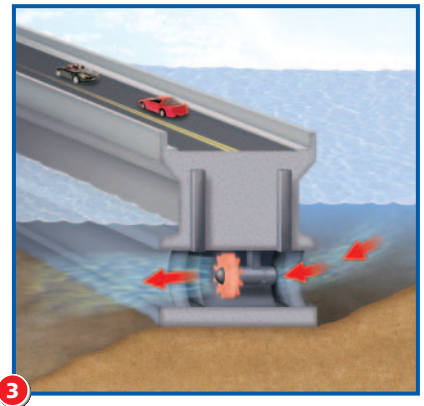
The energy of tides can be used to generate electricity. A tidal dam is built near a coast in the path of tidal waters. The water flows in during high tide and is trapped behind the gates of the dam. Then, when the tide is low, the gates open and the trapped water rushes out. As the water flows out, it spins turbines that power electric generators.



1 The dam's gates are open as the tide rises. Notice that the water level is the same on both sides.



2 When the tide begins to lower, the gates close, trapping water behind the dam.



3 At low tide, the gates open and the water rushes out, spinning turbines that generate electricity.

Tidal dams cause much less pollution than many other methods of generating electricity. Also, tides are a renewable source of energy; the tides are not used up in the process. However, tidal dams have some drawbacks. Few places in the world are actually suitable for such dams. Another problem is that the times of day when tidal dams generate electricity might not be the times of day when people most need electricity. Tidal dams also sometimes block the paths of migrating fish and might hurt marine life by altering the regular flow of water.



CHECK YOUR
READING

What are the benefits and drawbacks of tidal power plants?

13.4 Review

KEY CONCEPTS

1. Describe the appearance of tidal changes at a coastline.
2. Explain the difference between the Sun's role and the Moon's role in creating tides.
3. How are tides used to generate electricity?

CRITICAL THINKING

4. **Synthesize** Contrast the daily and monthly patterns of tides. What role does the Moon's orbit around Earth play in both?
5. **Compare** Tidal range is the daily difference in high and low water levels. Compare the tidal ranges of neap and spring tides.

CHALLENGE

6. **Draw Conclusions** How would the tides be different if the Moon revolved around Earth twice a month instead of once a month?