

**CHAPTER 14** The Movement of Ocean Water

**SECTION 4** **Tides**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What causes tides?
- How do tides vary?

**National Science Education Standards**  
ES 3c

**What Are Tides?**

Remember that wind can move ocean water and produce waves. Other forces can also move ocean water in regular patterns, such as tides. **Tides** are daily changes in the level of the ocean water. Both the sun and the moon influence the level of tides.

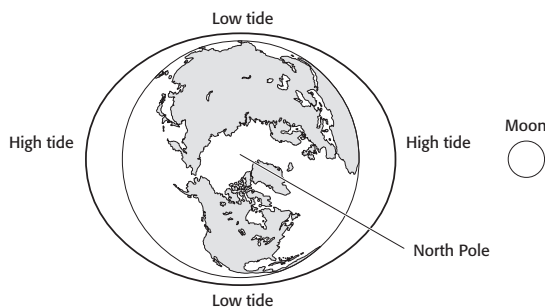


**Compare** As you read, make a chart describing the causes and features of high tides, low tides, spring tides, and neap tides.

**WHY TIDES HAPPEN**

The moon's gravity pulls on every particle on Earth. However, the moon's gravity doesn't pull on every particle with the same strength. The moon's gravitational pull on Earth decreases with distance from the moon. Therefore, the pull on some parts of Earth is stronger than on others.

The part of Earth that faces the moon is pulled toward the moon with the greatest force. Therefore, the water on the side of Earth that faces the moon bulges toward the moon. The water on Earth's opposite side is pulled toward the moon the least. Therefore, it bulges away from the moon. The figure below shows these bulges.



Water bulges toward the moon on the side of Earth that faces the moon. Water bulges away from the moon on Earth's far side. As a result, these two sides of Earth experience high tide. In this image, the sizes and locations of Earth, the oceans, and the moon are not drawn to scale.

**STANDARDS CHECK**

**ES 3c** Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth's surface and explains the phenomena of the tides.

**Word Help: phenomenon**  
any fact or event that can be sensed or described scientifically (plural, *phenomena*)

**1. Identify** What causes the tides?

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The difference in the moon's pull is more noticeable in liquids than in solids because liquids can move more easily. Therefore, the effects of the moon's pull on the oceans are more noticeable than on the land.

**SECTION 4** Tides *continued*

**HIGH TIDES AND LOW TIDES**

The bulges that form in the oceans because of the moon’s pull are called *high tides*. In high-tide areas, the water level is higher than average sea level. In areas between high tides, *low tides* form. In low-tide areas, the water level is lower than average sea level. This happens because the water is pulled toward high-tide areas.

Remember that Earth rotates on its axis. As a result, high tides happen in different places on Earth at different times of day. However, because Earth’s rotation is predictable, the tides are also predictable. Many places on Earth experience two high tides and two low tides every day. ✓

**READING CHECK**

**2. Describe** Why are the tides predictable?

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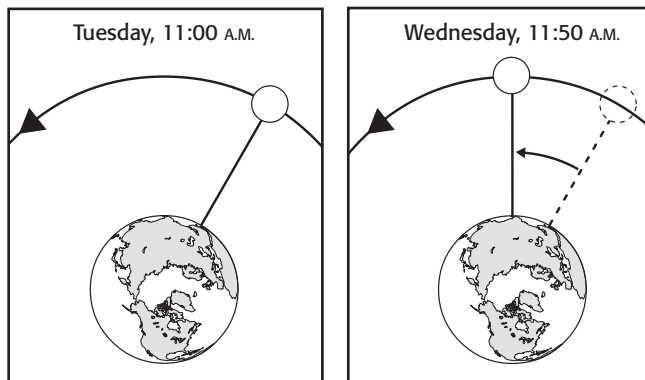
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**TIMING THE TIDES**

The moon revolves around Earth more slowly than Earth rotates. A place that is facing the moon takes 24 h and 50 min to rotate to face the moon again. Therefore, high and low tides at that place happen about 50 minutes later each day.



High and low tides happen about 50 minutes later each day at a given place. This happens because Earth rotates faster than the moon orbits Earth. If Earth rotated at the same speed as the moon orbits Earth, tides would not alternate between high and low.

**Math Focus**

**3. Calculate** An area experiences high tide at 9:30 A.M. on Monday. At about what time will it experience high tide on Thursday?

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**How Do Tides Vary?**

The sun and the moon affect the tides. Even though the sun is bigger than the moon, it is much farther away from Earth than the moon is. Therefore, the sun’s effect on tides is less than the moon’s. The combined forces of the sun and the moon on Earth produce different tidal ranges. A **tidal range** is the difference between levels of ocean water at high tide and low tide. ✓

**READING CHECK**

**4. Explain** Why does the sun affect the tides less than the moon does?

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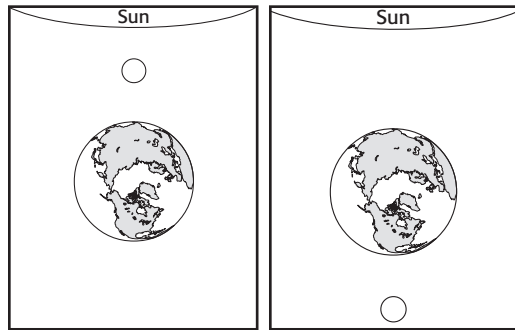
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**SECTION 4** Tides *continued*

**SPRING TIDES**

Tides that have the largest daily tidal range are **spring tides**. Spring tides happen when the sun, Earth, and the moon are aligned, as shown in the figures below. Spring tides happen during the new-moon and full-moon phases, or every 14 days. During these times, the pull of the sun and moon produces one pair of very large tidal bulges.

Spring tides happen when the sun, the moon, and Earth are aligned. This can happen in two ways. One way is when the moon is between Earth and the sun, as shown in the left-hand figure. The other way is when Earth is between the moon and the sun, as shown in the right-hand figure.



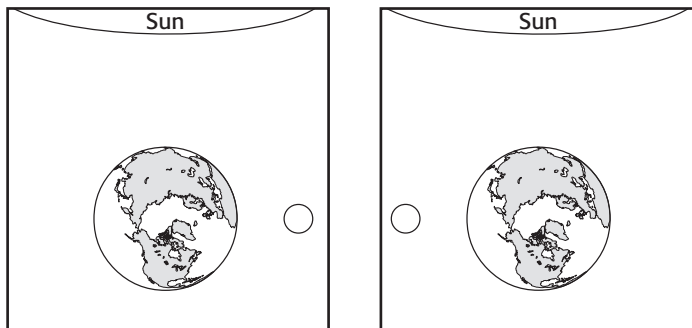
**TAKE A LOOK**

**5. Describe** Draw an oval around Earth in each picture to show where the tides are highest and where they are lowest during spring tides.

**NEAP TIDES**

Tides that have the smallest daily tidal range are called **neap tides**. Neap tides happen when the sun, Earth, and the moon form a 90° angle, as shown in the figures below. They happen halfway between the spring tides, during the first-quarter and third-quarter phases of the moon. During these times, the pull of the sun and moon produces smaller tidal bulges.

Neap tides happen when the sun, the moon, and Earth form a 90° angle.



*Critical Thinking*

**6. Apply Ideas** If you have a calendar that shows only the phases of the moon, can you predict when spring tides and neap tides will happen? Explain your answer.

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# Section 4 Review

## SECTION VOCABULARY

**neap tide** a tide of minimum range that occurs during the first and third quarters of the moon

**spring tide** a tide of increased range that occurs two times a month, at the new and full moons

**tidal range** the difference in levels of ocean water at high tide and low tide

**tide** the periodic rise and fall of the water level in the oceans and other large bodies of water

**1. Explain** How are high tides different from low tides?

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**2. Describe** Fill in the blank spaces in the table below.

| Tide        | Tidal range: small or large? | When it happens |
|-------------|------------------------------|-----------------|
| Neap tide   |                              |                 |
| Spring tide |                              |                 |

**3. Explain** Why do high tides happen in different places at different times of day?

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**4. Identify** What produces tidal ranges?

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**5. Explain** Why don't we notice changes in the elevation of the land due to the moon's pull?

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**6. Apply Concepts** How many days are there between a spring tide and a neap tide? Explain your answer.

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- Surface water temperatures can influence air temperatures.

## Review

- The South Pacific trade winds move less warm water to the western Pacific than usual.
- City A will probably have higher average temperatures than City B because City A is located closer to a warm surface current.
- Upwelling brings nutrient-rich water to the surface. These nutrients allow a wide variety of organisms to live in the ocean.

## SECTION 3 WAVES

- wind, earthquakes
- the distance between two successive troughs or crests
- They would drift closer and closer to shore over time.
- a circle
- $\text{wave period} = \text{wavelength} \div \text{wave speed}$   
 $50 \text{ m} \div 5 \text{ m/s} = 10 \text{ s}$
- the crest
- deep-water wave
- wave crests that crash onto the shore
- Swells last longer than whitecaps; swells have longer wavelengths than whitecaps.
- away
- Waves wash onto the beach in the same direction that they wash off the beach, so there is no sideways movement of water.
- Most probably form near plate boundaries because there are more earthquakes and volcanoes there.

## Review

- Waves form when energy is transferred from a source to the ocean water. Most waves form when wind blows across the water's surface, transferring energy to the water.
- Undertow currents pull objects away from shore, out to sea. Longshore currents move objects down the shore, parallel to the shoreline.
- $\text{wave speed} = 100 \text{ m} \div 20 \text{ s} = 5 \text{ m/s}$   
Wave speed decreases as wave period increases.
- underwater earthquakes, volcanic eruptions, landslides, underwater explosions, the impact of a meteorite or comet

- A storm surge is a local rise in sea level near shore caused by strong winds from a storm. Storm surges may disappear as quickly as they form, so they are difficult to study.

## SECTION 4 TIDES

- the moon's (and the sun's) gravitational pull on the Earth
- They are caused by the moon's pull and Earth's rotation, which are both predictable.
- about 12 noon
- The sun is much farther away from Earth than the moon is.
- Student should draw an oval showing high tides on the sides of Earth facing and opposite the moon.
- Yes, spring tides happen during the full moon and the new moon, and neap tides happen during the moon's first-quarter and third-quarter phases.

## Review

- High tides are caused by the moon's pulling the water toward it. The water forms a bulge at the place where it is closest to the moon and at the opposite side of the Earth. Low tides occur at the areas from which the water is drawn away.

| Tide        | Tidal range: small or large? |
|-------------|------------------------------|
| Neap tide   | small                        |
| Spring tide | large                        |

- Earth rotates on its axis.
- the combined gravitational pull of the sun and the moon
- The effects of the moon's gravity are more visible in liquids than in solids because liquids can move more easily.
- Seven days; spring tides occur during the full moon and the new moon, and neap tides occur during the first-quarter and third-quarter moons. The time between a full moon and a third-quarter moon is seven days.

# Chapter 15 The Atmosphere

## SECTION 1 CHARACTERISTICS OF THE ATMOSPHERE

- nitrogen and oxygen
- about 11/50
- water vapor, carbon dioxide