A wave is a disturbance.

You experience the effects of waves every day. Every sound you hear depends on sound waves. Every sight you see depends on light waves. A tiny wave can travel across the water in a glass, and a huge wave can travel across the ocean. Sound waves, light waves, and water waves seem very different from one another. So what, exactly, is a wave?

A wave is a disturbance that transfers energy from one place to another. Waves can transfer energy over distance without moving matter the entire distance. For example, an ocean wave can travel many kilometers without the water itself moving many kilometers. The water moves up and down—a motion known as a disturbance. It is the disturbance that travels in a wave, transferring energy.

How does an ocean wave transfer energy across the ocean?
Forces and Waves

You know that a force is required to change the motion of an object. Forces can also start a disturbance, sending a wave through a material. The following examples describe how forces cause waves.

Example 1 Rope Wave  Think of a rope that is tied to a doorknob. You apply one force to the rope by flicking it upward and an opposite force when you snap it back down. This sends a wave through the rope. Both forces—the one that moves the rope up and the one that moves the rope down—are required to start a wave.

Example 2 Water Wave  Forces are also required to start a wave in water. Think of a calm pool of water. What happens if you apply a force to the water by dipping your finger into it? The water rushes back after you remove your finger. The force of your finger and the force of the water rushing back send waves across the pool.

Example 3 Earthquake Wave  An earthquake is a sudden release of energy that has built up in rock as a result of the surrounding rock pushing and pulling on it. When these two forces cause the rock to suddenly break away and move, the energy is transferred as a wave through the ground.
Materials and Waves

A rope tied to a doorknob, water, and the ground all have something in common. They are all materials through which waves move. A **medium** is any substance that a wave moves through. Water is the medium for an ocean wave; the ground is the medium for an earthquake wave; the rope is the medium for the rope wave. In the next chapter, you will learn that sound waves can move through many mediums, including air.

Waves that transfer energy through matter are known as **mechanical waves**. All of the waves you have read about so far, even sound waves, are mechanical waves. Water, the ground, a rope, and the air are all made up of matter. Later, you will learn about waves that can transfer energy through empty space. Light is an example of a wave that transfers energy through empty space.

**Check Your Reading** How are all mechanical waves similar?

Energy and Waves

The waves caused by an earthquake are good examples of energy transfer. The disturbed ground shakes from side to side and up and down as the waves move through it. Such waves can travel kilometers away from their source. The ground does not travel kilometers away from where it began; it is the energy that travels in a wave. In the case of an earthquake, it is kinetic energy, or the energy of motion, that is transferred.

This photograph was taken after a 1995 earthquake in Japan. A seismic wave transferred enough energy through the ground to bend the railroad tracks, leaving them in the shape of a wave.
Look at the illustration of people modeling a wave in a stadium. In this model, the crowd of people represents a wave medium. The people moving up and down represent the disturbance. The transfer of the disturbance around the stadium represents a wave. Each person only moves up and down, while the disturbance can move all the way around the stadium.

Ocean waves are another good example of energy transfer. Ocean waves travel to the shore, one after another. Instead of piling up all the ocean water on the shore, however, the waves transfer energy. A big ocean wave transfers enough kinetic energy to knock someone down.

How does the stadium wave differ from a real ocean wave?

**Waves can be classified by how they move.**

As you have seen, one way to classify waves is according to the medium through which they travel. Another way to classify waves is by how they move. You have read that some waves transfer an up-and-down or a side-to-side motion. Other waves transfer a forward-and-backward motion.
Transverse Waves

Think again about snapping the rope with your hand. The action of your hand causes a vertical, or up-and-down, disturbance in the rope. However, the wave it sets off is horizontal, or forward. This type of wave is known as a transverse wave. In a transverse wave, the direction in which the wave travels is perpendicular, or at right angles, to the direction of the disturbance. *Transverse* means “across” or “crosswise.” The wave itself moves crosswise as compared with the vertical motion of the medium.

Water waves are also transverse. The up-and-down motion of the water is the disturbance. The wave travels in a direction that is perpendicular to the direction of the disturbance. The medium is the water, and energy is transferred outward in all directions from the source.

**CHECK YOUR READING** What is a transverse wave? Find two examples in the paragraphs above.

**INVESTIGATE Wave Types**

*How do waves compare?*

**PROCEDURE**

1. Place the spring toy on the floor on its side. Stretch out the spring. To start a disturbance in the spring, take one end and move it from side to side. Observe the movement in the spring. Remember that a transverse wave travels at right angles to the disturbance.

2. Put the spring toy on the floor in the same position as before. Think about how you could make a different kind of disturbance to produce a different kind of wave. *(Hint: Suppose you push the spring in the direction of the wave you expect to make.)* Observe the movement in the spring.

**WHAT DO YOU THINK?**

- Compare the waves you made. How are they alike? How are they different?
- What kind of wave did you produce by moving the spring from side to side?

**CHALLENGE** Can you think of a third way to make a wave travel through a spring?
Longitudinal Waves

Another type of wave is a longitudinal wave. In a longitudinal wave (lah-nij-tood-uhl), the wave travels in the same direction as the disturbance. A longitudinal wave can be started in a spring by moving it forward and backward. The coils of the spring move forward and bunch up and then move backward and spread out. This forward and backward motion is the disturbance. Longitudinal waves are sometimes called compressional waves because the bunched-up area is known as a compression. How is a longitudinal wave similar to a transverse wave? How is it different?

Longitudinal Wave

Sound waves are examples of longitudinal waves. Imagine a bell ringing. The clapper inside the bell strikes the side and makes it vibrate, or move back and forth rapidly. The vibrating bell pushes and pulls on nearby air molecules, causing them to move forward and backward. These air molecules, in turn, set more air molecules into motion. A sound wave pushes forward. In sound waves, the vibrations of the air molecules are in the same direction as the movement of the wave.

15.1 Review

KEY CONCEPTS
1. Describe how forces start waves.
2. Explain how a wave can travel through a medium and yet the medium stays in place. Use the term energy in your answer.
3. Describe two ways in which waves travel, and give an example of each.
4. Analyze Does water moving through a hose qualify as a wave? Explain why or why not.
5. Classify Suppose you drop a cookie crumb in your milk. At once, you see ripples spreading across the surface of the milk. What type of waves are these? What is the disturbance?
6. Predict Suppose you had a rope long enough to extend several blocks down the street. If you were to start a wave in the rope, do you think it would continue all the way to the other end of the street? Explain why or why not.

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