Section 1

What Are Waves?

Reading Preview

Key Concepts

- What causes mechanical waves?
- What are two types of waves and how are they classified?

Key Terms

- wave • energy • medium
- mechanical wave • vibration
- transverse wave • crest
- trough • longitudinal wave
- compression • rarefaction

Target Reading Skill

Using Prior Knowledge Before you read, look at the section headings and visuals to see what this section is about. Then write what you know about waves and energy in a graphic organizer like the one below. As you read, continue to write in what you learn.

What You Know
1. Waves are high and low. 2.

What You Learned
1. 2.

Lab zone Discover Activity

How Do Waves Travel?

1. Fill a shallow pan with about 3 cm of water.
2. With a pencil, touch the surface of the water at one end of the pan twice each second for about a minute.
3. Describe the pattern the waves make. Sketch a rough diagram of what you see.
4. Float a cork in the center of the pan. Repeat Step 2 and observe how the cork moves. Draw a diagram of what you see.

Think It Over

Observing How did the cork move in Step 4? How is its movement similar to the wave's movement? How is it different?

It was a long swim, but now you're resting on the swimming raft in the lake. You hear the water lapping gently against the raft as the sun warms your skin. Suddenly a motorboat zooms by. A few seconds later you're bobbing wildly up and down as the boat's waves hit the raft. Although the speedboat didn't touch the raft, its energy caused waves in the water. Then the waves moved the raft—and you!

You can see and feel the water waves when you're on a swimming raft. But did you know that many kinds of waves affect you every day? Sound is a wave. Sunlight is a different kind of wave. Light, sound, and water waves may seem very different, but they all are waves. What is a wave?

▼ **A motorboat making waves**

Waves and Energy

A **wave** is a disturbance that transfers energy from place to place. In science, **energy** is defined as the ability to do work. To understand waves, think about the swimming raft. A wave that disturbs the surface of the water also will disturb the raft. The wave's energy lifts the heavy raft as the wave passes under it. But the disturbance caused by the wave is temporary. After the wave passes, the water is calm again and the raft stops bobbing.

What Carries Waves? Most kinds of waves need something to travel through. Sound waves travel through air. Water waves travel along the surface of the water. A wave can even travel along a rope. The material through which a wave travels is called a **medium.** Gases (such as air), liquids (such as water), and solids (such as rope) all act as mediums. Waves that require a medium through which to travel are called **mechanical waves.**

But not all waves require a medium to travel through. Light from the sun, for example, can carry energy through empty space. If light could not travel through empty space, you could not even see the sun! Waves that can travel without a medium are called electromagnetic waves. You will learn more about electromagnetic waves in a later chapter.

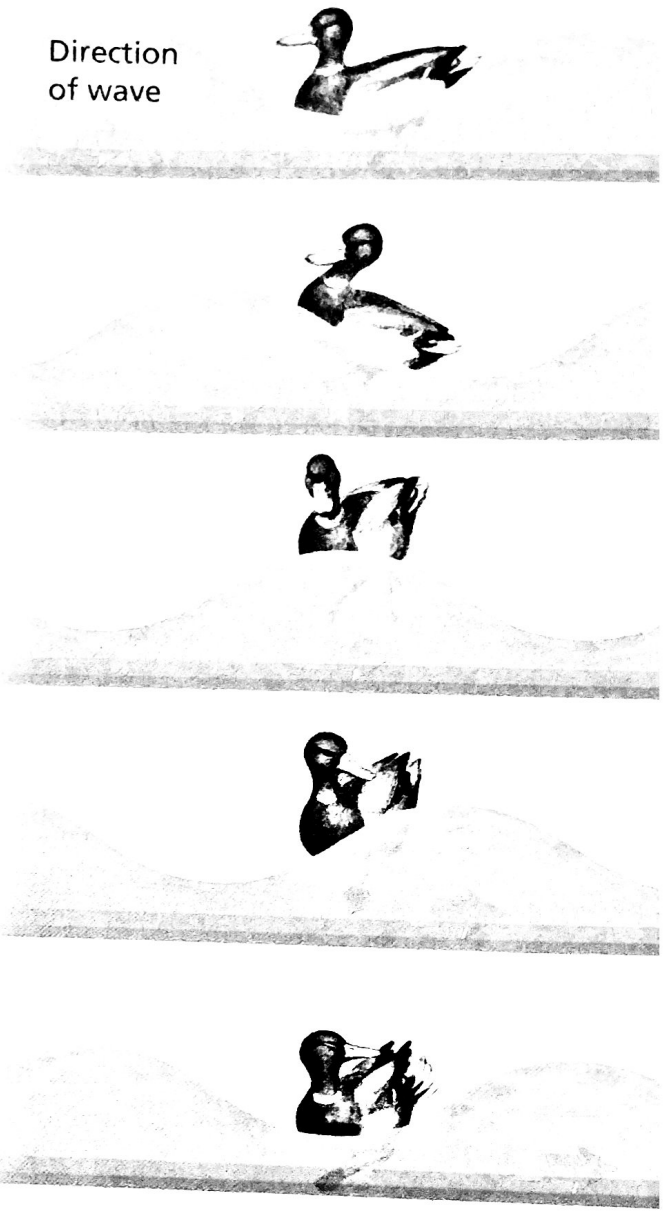


FIGURE 1
Motion of a Medium
Waves travel through water, but they do not carry the water (or the duck) with them. **Predicting** *If you add a sixth stage to the diagram, which earlier stage should it most resemble?*

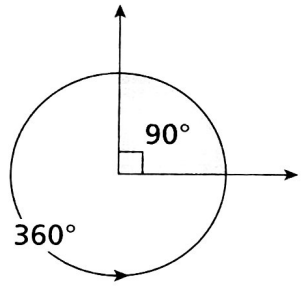
How Do Waves Transfer Energy? Although mechanical waves travel through a medium, they do not carry the medium with them. Look at the duck in Figure 1. When a wave travels under the duck, the duck moves up and down. But the duck does not travel with the wave. After the wave passes, the duck and the water return to where they started.

Why doesn't the medium travel along with the wave? All mediums are made of tiny particles. When a wave enters a medium, it transfers energy to the medium's particles. The particles bump into each other, passing the wave's energy along. To understand this, think about how food is passed at a table. You hand the food to the next person, who passes it to the next person, and so on. The food is transferred, but the people don't move. The food is like the wave's energy, and the people are like particles in a medium.

Math Skills

Angles

An angle is formed when two lines meet at a point. Angles are measured in degrees, indicated by the symbol °. A circle has 360 degrees. A right angle is an angle that contains 90 degrees. Two lines that meet at a point to form a 90° angle are said to be perpendicular to each other.



Practice Problems

1. Draw a circle on a piece of paper. How many right angles can you fit in the circle?
2. How many degrees do two right angles contain?

What Causes Waves? Energy always is required to make a wave. **Mechanical waves are produced when a source of energy causes a medium to vibrate.** A **vibration** is a repeated back-and-forth or up-and-down motion. When a vibration moves through a medium, a wave results.

Moving objects have energy. A moving object can transfer energy to a medium, producing waves. For example, you can make waves by dipping your finger in water. Your finger has energy because it is moving. When your finger touches the water, it transfers energy to the water and makes waves. In the same way, a motorboat slicing through calm water transfers energy to the water and makes waves.

Reading Checkpoint **What is a vibration?**

Types of Waves

Waves move through mediums in different ways. **Mechanical waves are classified by how they move. There are two types of mechanical waves: transverse waves and longitudinal waves.**

Transverse Waves When you make a wave on a rope, the wave moves from one end of the rope to the other. But the rope itself moves up and down or from side to side, at right angles to the direction in which the wave travels. Waves that move the medium at right angles to the direction in which the waves travel are called **transverse waves.** Transverse means "across." As a transverse wave moves, the particles of the medium move across, or at a right angle to, the direction of the wave.

In Figure 2, you can see that the red ribbon on the rope is first at a low point of the wave. Then it is at a high point. The high part of a transverse wave is called a **crest,** and the low part is called a **trough** (trawf).

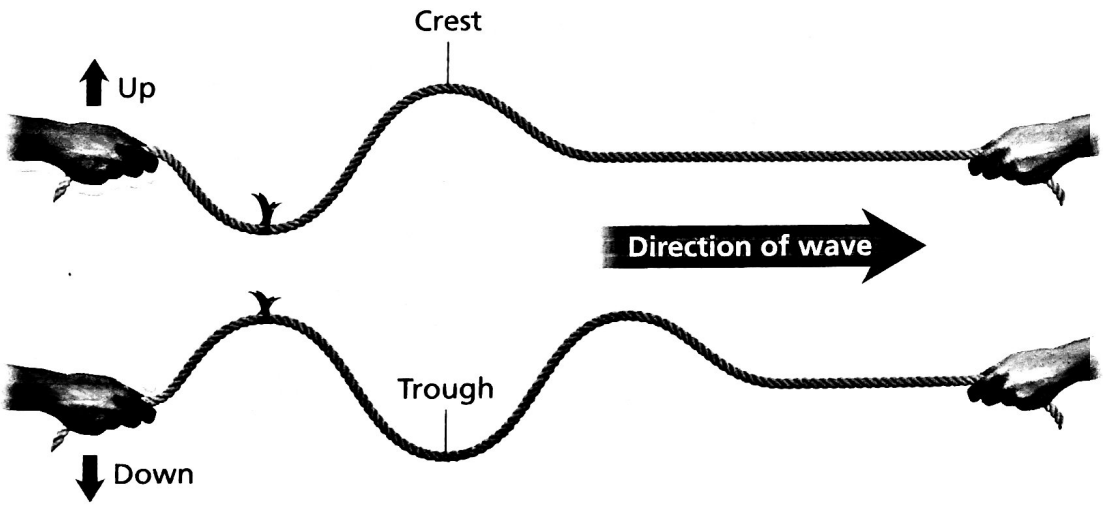


FIGURE 2
Transverse Waves
A transverse wave moves the rope up and down in a direction perpendicular to the direction in which the wave travels.

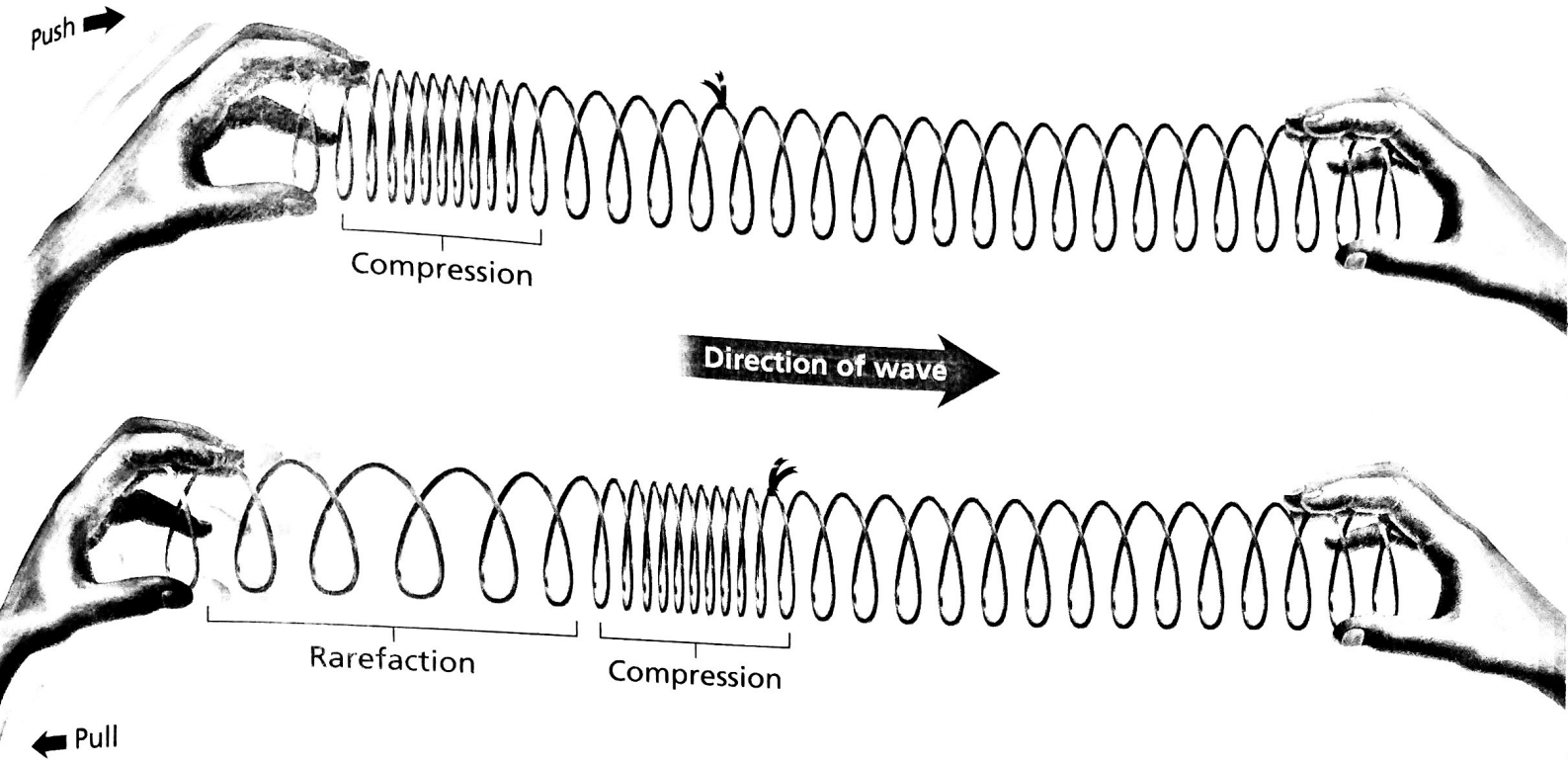


FIGURE 3
Longitudinal Waves
A longitudinal wave moves the coils of a spring toy back and forth in a direction parallel to the direction the wave travels. **Comparing and Contrasting** *How do the coils in a compression compare to the coils in a rarefaction?*

Longitudinal Waves Figure 3 shows a different kind of wave. If you stretch out a spring toy and push and pull one end, you can produce a longitudinal wave. **Longitudinal waves** (lawn juh TOO duh nul) move the medium parallel to the direction in which the waves travel. The coils in the spring move back and forth parallel to the wave motion.

Notice in Figure 3 that in some parts of the spring, the coils are close together. In other parts of the spring, the coils are more spread out. The parts where the coils are close together are called **compressions** (kum PRESH unz). The parts where the coils are spread out, or rarified, are called **rarefactions** (rair uh FAK shunz).

As compressions and rarefactions travel along the spring toy, each coil moves forward and then back. The energy travels from one end of the spring to the other, creating a wave. After the wave passes, each coil returns to the position where it started.

Sound is also a longitudinal wave. In air, sound waves cause air particles to move back and forth. In areas where the particles are pushed together, compressions form. In between the compressions, particles are spread out. These are rarefactions.

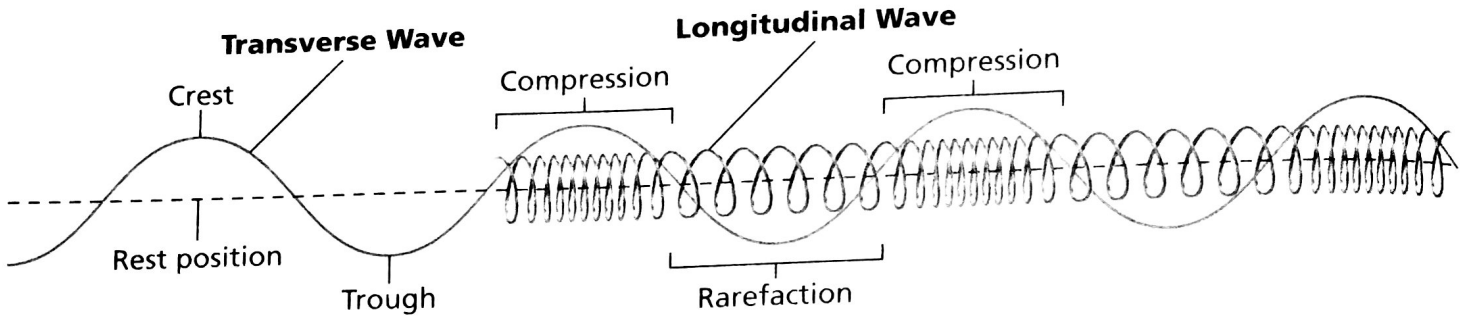


FIGURE 4
Representing Waves
The compressions of a longitudinal wave correspond to the crests of a transverse wave. The troughs correspond to rarefactions.

Representing Types of Waves You can use diagrams to represent transverse and longitudinal waves. Transverse waves like those on a rope are easy to draw. You can draw a transverse wave as shown in Figure 4. Think of the horizontal line as the position of the rope before it is disturbed. This position is called the rest position. As the wave passes, the rope moves above or below the rest position. Remember that the crests are the highest points of the wave and the troughs are the lowest points of the wave.

To draw longitudinal waves, think of the compressions in the spring toy as being similar to the crests of a transverse wave. The rarefactions in the spring toy are like the troughs of a transverse wave. By treating compressions as crests and rarefactions as troughs, you can draw longitudinal waves in the same way as transverse waves.

Reading Checkpoint **How do you draw the rest position of a transverse wave?**

Section 1 Assessment

Target Reading Skill Using Prior Knowledge Revise your graphic organizer about waves based on what you just learned in the section.

Reviewing Key Concepts

1. **a. Defining** What is a mechanical wave?
   b. Explaining How are mechanical waves produced?
   c. Inferring A wave moves a floating dock up and down several times, but then the dock stops moving. What happened to the wave?
2. **a. Identifying** What are the two types of mechanical waves?
   b. Describing Use a wave diagram to represent the crests and troughs of a wave. Then describe a crest and trough in your own words.
   c. Comparing and Contrasting How does a transverse wave move a medium? How does a longitudinal wave move a medium?

Writing in Science

Firsthand Account Suppose you are a particle of water in a lake. Describe what happens to you when a motorboat passes by. Be sure to use words like *vibration* and *crest* in your description.