chapter 10

Sound

section 1 The Nature of Sound

What You'll Learn

- how sound travels
- what changes the speed of sound
- how your ears allow you to hear

Before You Read

Place your hand on your throat and hum a tune. How is the movement that you feel related to the sound you made?

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Mark the Text

Identify the Main Point
Highlight the main idea of each paragraph. Then review what you highlighted after you finish reading the section.

Read to Learn

What causes sound?

An amusement park is a noisy place. Music is playing, videogames are beeping, and people on rides are screaming. It can be hard to hear your friends talking. These sounds are all different, but they all have something in common. Each sound is made by an object that vibrates.

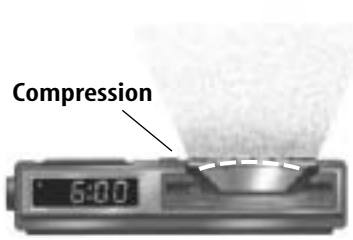
Remember that vibration is a quick, rhythmic back-and-forth movement. The sounds of your friends' voices and people screaming are made by the vibrations of their vocal cords. Music and noises from videogames are made by vibrating speakers. All sounds are made by something that vibrates.

Sound Waves

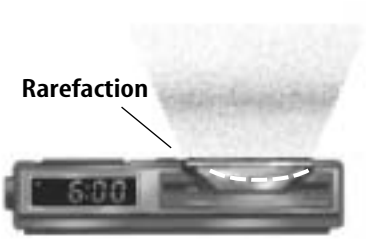
Think of a radio speaker. When the speaker vibrates, it bumps into nearby molecules in the air. Some of the speaker's energy is transferred to air molecules. These air molecules bump into other air molecules. They pass the energy on to the new molecules. The energy that came from the vibrating speaker keeps moving from one molecule to another. The collisions and the energy they transmit make a sound wave.

Sound waves are longitudinal waves. Recall that there are two areas in longitudinal waves. One area is the compression where the molecules of the medium are very close together. The other area is the rarefaction where the molecules of the medium are more spread out. A longitudinal wave has alternating areas of compressions and rarefactions.

In each figure, the radio speaker is vibrating. In the first figure, the speaker is vibrating outward. When this happens, molecules in the air are pushed together to form a compression. The second figure shows the speaker moving inward. Air molecules have room to spread out. A rarefaction forms. The back-and-forth vibrations form compressions and rarefactions.



When the speaker vibrates outward, molecules in the air next to it are pushed together to form a compression.



When the speaker vibrates inward, the molecules spread apart to form a rarefaction.

How does a sound wave travel?

The air molecules around the speaker bump into other molecules. The speaker keeps vibrating, so a series of compressions and rarefactions forms a sound wave. This sound wave travels out from the speaker for your ear to hear.

Moving Through Materials

Did you ever swim underwater and hear sounds? Most sounds that you hear travel through air. Sound can also travel through solids, liquids, and other gases. Sound waves travel in any material, or medium. But sound waves cannot travel through empty space. There are no molecules to transmit a sound wave.

How does the speed of sound change in different materials?

How quickly a sound wave moves through a material depends on the material and whether it is solid, liquid, or gas. The table shows that sound travels slowest through gases and fastest through solids. Molecules in liquids and solids are closer than molecules in gases. When molecules are close, they transmit energy more quickly. Loud and soft sounds travel through a material at the same speed.

Speed of Sound in Different Mediums

Materials	Speed of Sound (m/s)
Air	347
Cork	500
Water	1,498
Brick	3,650
Aluminum	4,877

Picture This

1. **Communicate** Look at the figures to the left. Describe how the particles in a compression are different from the particles in a rarefaction.

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Applying Math

2. **Use a Table** Suppose lightning strikes two kilometers away from you. Find how long it would take the sound of the thunder to reach your ears by dividing the distance by the speed of sound through air. Round your answer to the nearest tenth of a second.

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Why do close molecules transmit sound more quickly?

Imagine a large group of people standing in a line. They are passing a bucket of water from person to person. If everyone stands far apart, each person has to take the time to walk the bucket to the next person. But if everyone stands close together, each person quickly can hand the bucket to the next person.

The molecules in solids and liquids are like the people standing close together in the line. The particles in gases are farther apart, like the people standing far apart in line. The closer the molecules are to each other, the faster they can transfer energy.

Reading Check

3. **Explain** Why does sound travel faster in solids and liquids than it does in gases?

How does temperature affect the speed of sound?

The speed of sound waves also depends on the temperature of a medium. As temperature increases, molecules move faster. It is easier for molecules to bump into each other if they are moving quickly. If the particles in a medium are bumping into each other more often, more energy can be transferred faster. So the higher the temperature, the faster sound waves move. For example, when the air temperature is 0°C, sound travels through the air at 331 m/s. But at a temperature of 20°C, sound travels at 343 m/s.

Human Hearing

Our vocal cords and mouths produce many different kinds of longitudinal waves. But how does your brain make sense of sound waves? Your ears and your brain work together. They turn longitudinal waves into something that you can understand. Making sense of sound waves involves four steps. First, your ears gather the longitudinal waves. Next, your ears amplify the waves, or make them stronger. The amplified waves are changed to nerve impulses that travel to the brain. Finally, the brain makes sense of the nerve impulses.

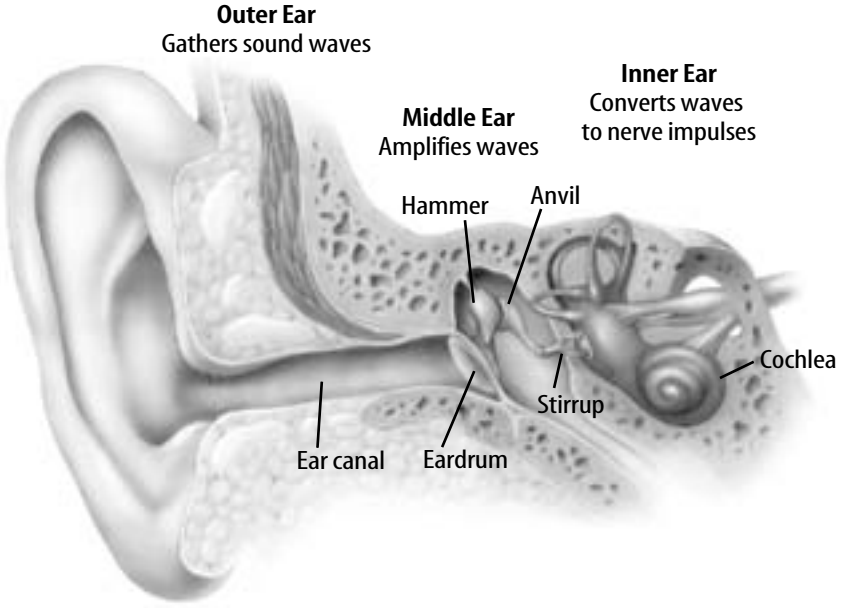
How does the outer ear gather sound waves?

When you think of your ear, you probably picture the part that is on the outside. But the human ear has three parts: the outer ear, the middle ear, and the inner ear. Look at the figure on the next page. It shows the three parts of the human ear. The outside part of the ear together with the ear canal and the eardrum make up the outer ear. The outer ear is where sound waves are gathered. Like a funnel, it helps catch the sound waves, then sends them into the ear canal.

Think it Over

4. **Explain** Hearing aids are placed in a person's outer ear. This makes it easy for the person to put them in and take them out. What do hearing aids do when they are placed in a person's outer ear?

The sound waves travel along the ear canal to the eardrum. The **eardrum** is a tough membrane, or tissue, about 0.1 mm thick. The eardrum is stretched over the end of the ear canal. When sound waves reach the eardrum, they transfer their energy to the eardrum and it vibrates.



What does the middle ear do?

When the eardrum vibrates, it transfers the vibrations into the middle ear. There are three tiny bones in the middle ear that amplify the vibrations. The bones are called the hammer, anvil, and stirrup. They are a lever system that makes the force and pressure of the sound waves stronger. The stirrup is connected to a membrane in the oval window. When the stirrup vibrates, the membrane vibrates too.

What does the inner ear do?

When the membrane in the oval window vibrates, the sound vibrations are sent into the inner ear. The inner ear contains the cochlea. The **cochlea** (KOH klee uh) is a spiral-shaped structure that is filled with liquid. It also contains tiny hair cells. When the hair cells in the cochlea begin to vibrate, nerve impulses are sent to the brain. When the nerve impulses reach the brain, they are interpreted as sounds. It is the cochlea that changes sound waves to nerve impulses.

If the hair cells in the cochlea are damaged or destroyed, a person can lose some hearing ability. This damage can happen when someone is exposed to loud sounds. Scientists are finding that the hair cells may be able to repair themselves.

Picture This

5. Use a Scientific Illustration Using a highlighter, draw a circle around the structures that make up the outer ear. Then use two different colors of highlighters to draw circles around the structures of the middle ear and of the inner ear.

FOLDABLES™

A Drawing and Identifying On the inside of a 3-tab book Foldable, draw a human ear. Identify the three sections of the ear and label all the parts found in each section.

Think it Over

6. Think Critically Write two things you can do to help protect your hearing.

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After You Read

Mini Glossary

cochlea: a spiral-shaped structure in the inner ear that turns vibrations into nerve impulses

eardrum: a tough membrane, or tissue, at the end of the ear canal that transmits vibrations to the middle ear

1. Review the terms and their definitions in the Mini Glossary. Choose one term and use it in a sentence that demonstrates your understanding of how it makes hearing possible.

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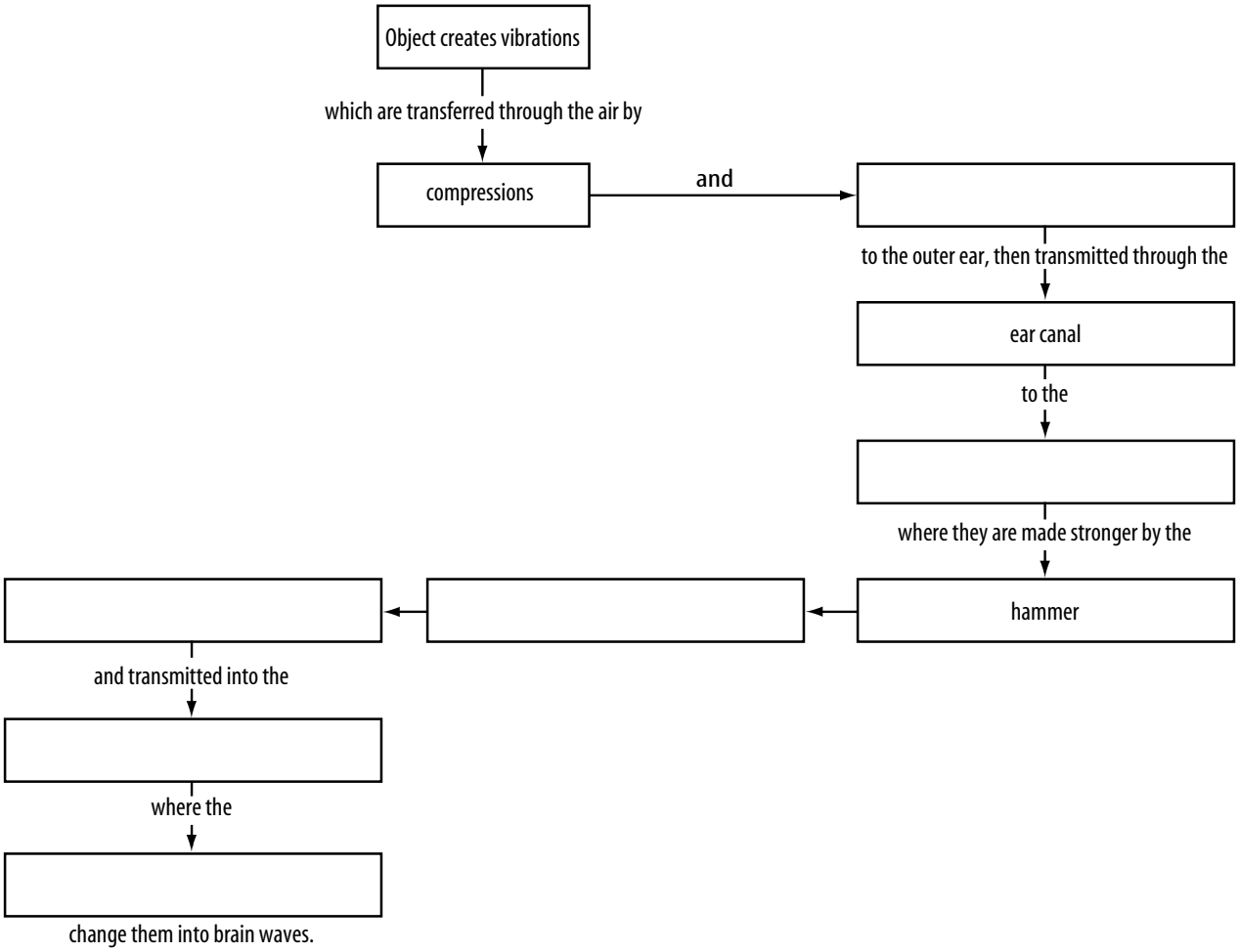
2. Complete this graphic organizer to outline how vibrations travel through the air to be interpreted as sounds by the brain.



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