Lesson 3 Sound

Skim *Lesson 3 in your book. Read the headings and look at the photos and illustrations. Identify three things you want to learn more about as you read the lesson. Record your ideas in your Science Journal.*

Main Idea

Details

What are sound waves?

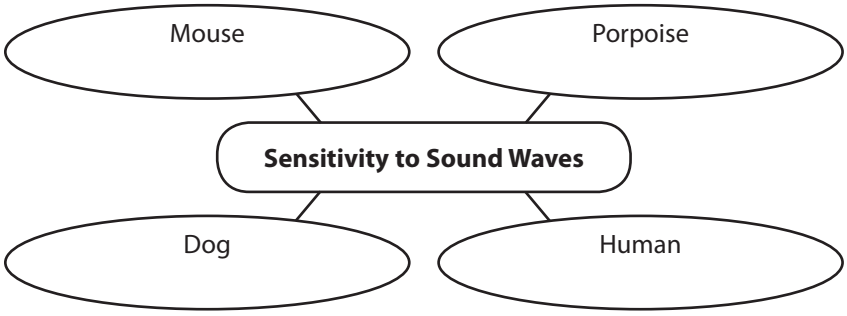
I found this on page _____.

Identify *three ways in which light waves and sound waves are different from each other.*

1. Light waves are electromagnetic; sound waves are _____.
2. We perceive light waves by seeing; we perceive sound waves by _____.
3. Light waves are transverse; sound waves are _____.

I found this on page _____.

Detail *sensitivity to sound waves. Write the range in Hz, and circle the animal with the most sensitive hearing.*



I found this on page _____.

Differentiate *regions of a longitudinal wave.*

Compression	Rarefaction

Properties of Sound Waves

I found this on page _____.

Relate *frequency and* pitch.

The higher the frequency of the waves, _____.

The lower the frequency of the waves, _____.

Waves, Light, and Sound

Sound

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	5. Sound travels faster through solid materials than through air.	
	6. The more energy used to produce a sound, the louder the sound.	

Read to Learn

What are sound waves?

Just as light is a type of wave that can be seen, sounds are a type of wave that can be heard. Sound waves are longitudinal, mechanical waves. Unlike light waves, sound waves must travel through a medium.

Audible Vibrations

What would you hear if you struck two metal pans together? Now suppose you strike two pillows together. How would the two sounds differ? Sound waves are audible vibrations—vibrations the ear can detect. You hear a loud sound when you hit the pans together because they vibrate so much. You barely hear a sound when you hit the pillows together because they vibrate so little. Healthy young humans can hear sound waves produced by vibrations with frequencies between about 20 Hz and 20,000 Hz. As people age, their ability to hear the higher and the lower frequencies of sound decreases. The human ear is most sensitive to frequencies between 1,000 Hz and 4,000 Hz.

Animals have ranges of hearing that help them live in their environment. For example, elephants hear sounds as low as 15 Hz. Chickens hear sounds between 125 Hz and 2,000 Hz. Porpoises can hear sounds between 75 Hz and 150,000 Hz.

Key Concepts

- What are some properties of sound waves?
- How do ears enable people to hear sounds?

Study Coach

Create a Quiz about sound. Exchange quizzes with a partner. After taking the quizzes, discuss your answers. Read more about the topics you don't understand.

Reading Check

1. Explain Why would you hear a louder sound if you dropped a book onto a wooden floor than if you dropped it onto a pillow?

Compressions and Rarefactions

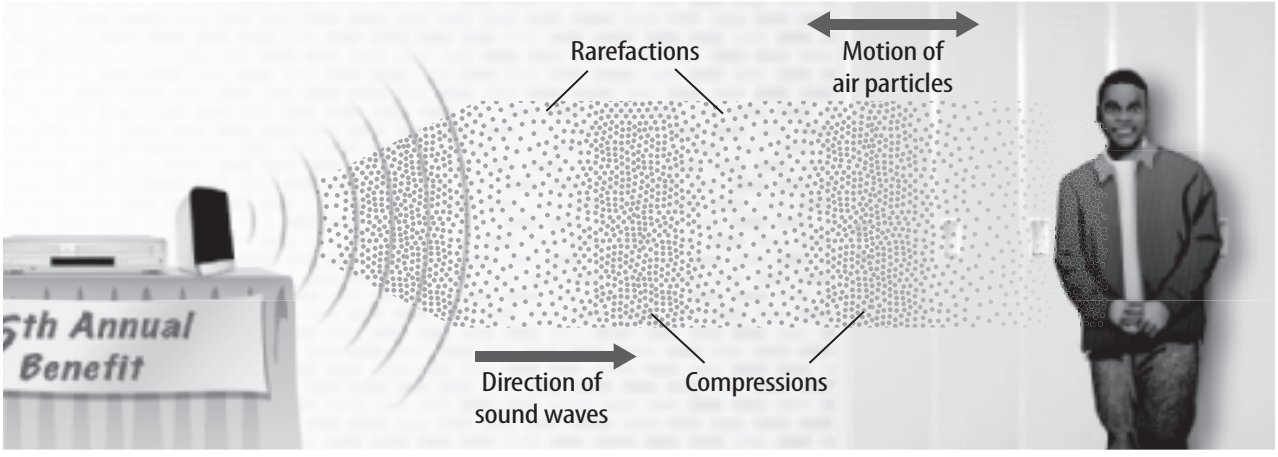
Sound waves usually travel to your ears through air. Air particles are in constant motion. As the particles bounce off objects, they exert a force, or pressure. The figure below shows how sound waves moving through air change air pressure by causing air particles to move toward and then away from each other.

Reading Check

2. Distinguish How do compressions and rarefactions differ?

Suppose you pluck a guitar string. As the string springs back, it pushes air particles forward, forcing them closer together. This increases the air pressure near the string. *The region of a longitudinal wave where the particles of the medium are closest together is a* **compression.** As the string vibrates, it moves in the other direction. This leaves behind a region with lower pressure. *A* **rarefaction** *is the region of a longitudinal wave where the particles are farthest apart.*

Sound Waves



Visual Check

3. Recognize Why is pressure lower in rarefactions than in compressions?

Properties of Sound Waves

A sound wave is described by its wavelength, frequency, amplitude, and speed. These properties of sound waves depend on the compressions and rarefactions of the sound waves.

Wavelength, Frequency, and Pitch

Recall that the wavelength of a wave gets shorter as the wave's frequency increases. How does the frequency of a sound wave affect what is heard?

The perception of how high or low a sound seems is called **pitch.** The higher the frequency, the higher the pitch of the sound. For example, a female voice generally produces higher-pitched sounds than a male voice. This is because the female voice has a higher range of frequencies.

Amplitude and Energy

You use more energy to shout than to whisper. The more energy you put into your voice, the farther the particles of air move as they vibrate. The distance a vibrating particle moves from its rest position is the amplitude. The more energy used to produce the sound wave, the greater the amplitude.

Speed

Sound waves travel much slower than electromagnetic waves. With sound, the transmitted energy must pass from particle to particle. Two factors that affect the speed of sound are the type of medium and the temperature.

Type of Medium In a gas, the particles are far apart. They collide less often than particles in a liquid or a solid. Therefore, a gas takes longer to transfer sound energy from one particle to another, as shown in the table to the right.

The Speed of Sound

Material	Speed (m/s)
Air (0°C)	331
Air (20°C)	343
Water (20°C)	1,481
Water (0°C)	1,500
Seawater (25°C)	1,533
Ice (0°C)	3,500
Iron	5,130
Glass	5,640

Temperature The temperature of the medium also affects the speed of sound. As the temperature of a gas increases, the particles move faster and collide more often. This increase in the number of collisions transfers more energy in less time.

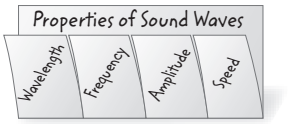
Temperature has the opposite effect on liquids and solids. As liquids and solids cool, the molecules move closer together. They collide more often and transfer energy faster.

Intensity and Loudness

You might think that the greater the amplitude of a sound wave is, the louder it will sound. That is true if you stay at the same distance from the source. However, as you move away, the wave's amplitude decreases and the sound seems quieter. This is because as a sound wave moves farther from its source, more and more particles collide, and the energy from the wave spreads out among more particles. Therefore, as you move farther from the source of the sound waves, less of the waves' energy is present in the same area of space. Recall that the amount of energy that passes through a square meter of space in one second is the intensity of a wave. Loudness is your ear's perception of intensity.

FOLDABLES®

Make a horizontal four-tab book to review properties of sound waves.



Interpreting Tables

4. Interpret At 20°C, which transmits sound faster: air or water? Why?

Key Concept Check

5. Identify What are some properties of sound waves?

Reading Check

6. Recognize Why does a sound seem quieter as you move farther from the source of the sound?

Math Skills

Because sound energy travels out in all directions from the source, the intensity of the sound decreases as you move away. You can calculate the fraction by which the sound intensity changes. The fraction is $\left(\frac{r_1}{r_2}\right)^2$, where r_1 is the starting distance and r_2 is the ending distance from the source. For example, by what fraction does sound intensity decrease when you move 3 m to 6 m from a source?

a. Replace the variables with given values.

$$\text{fraction} = \left(\frac{3}{6}\right)^2$$

b. Solve the problem.

$\left(\frac{3}{6}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$, so the intensity decreases to $\frac{1}{4}$ of its original value.

7. Use a Fraction You stand 2 m from a sound source. How does the sound intensity change if you move to a distance of 6 m?

_____

Visual Check

8. Identify What is the highest decibel level to which you can listen without risking permanent hearing loss?

_____

Key Concept Check

9. Identify How do your ears enable you to hear sounds?

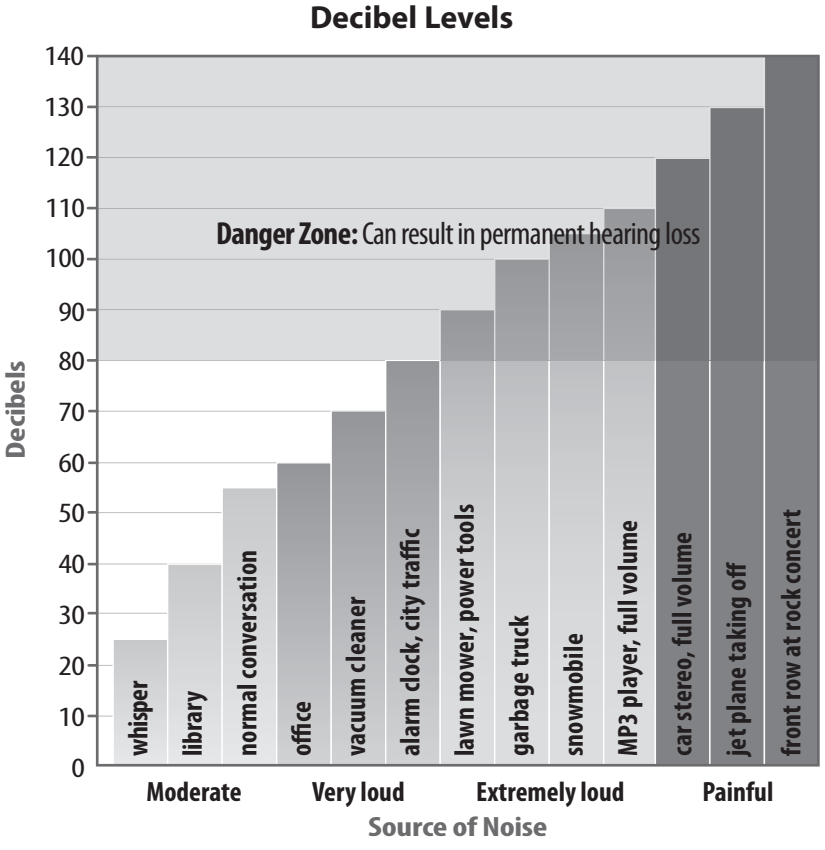
_____

_____

_____

The Decibel Scale

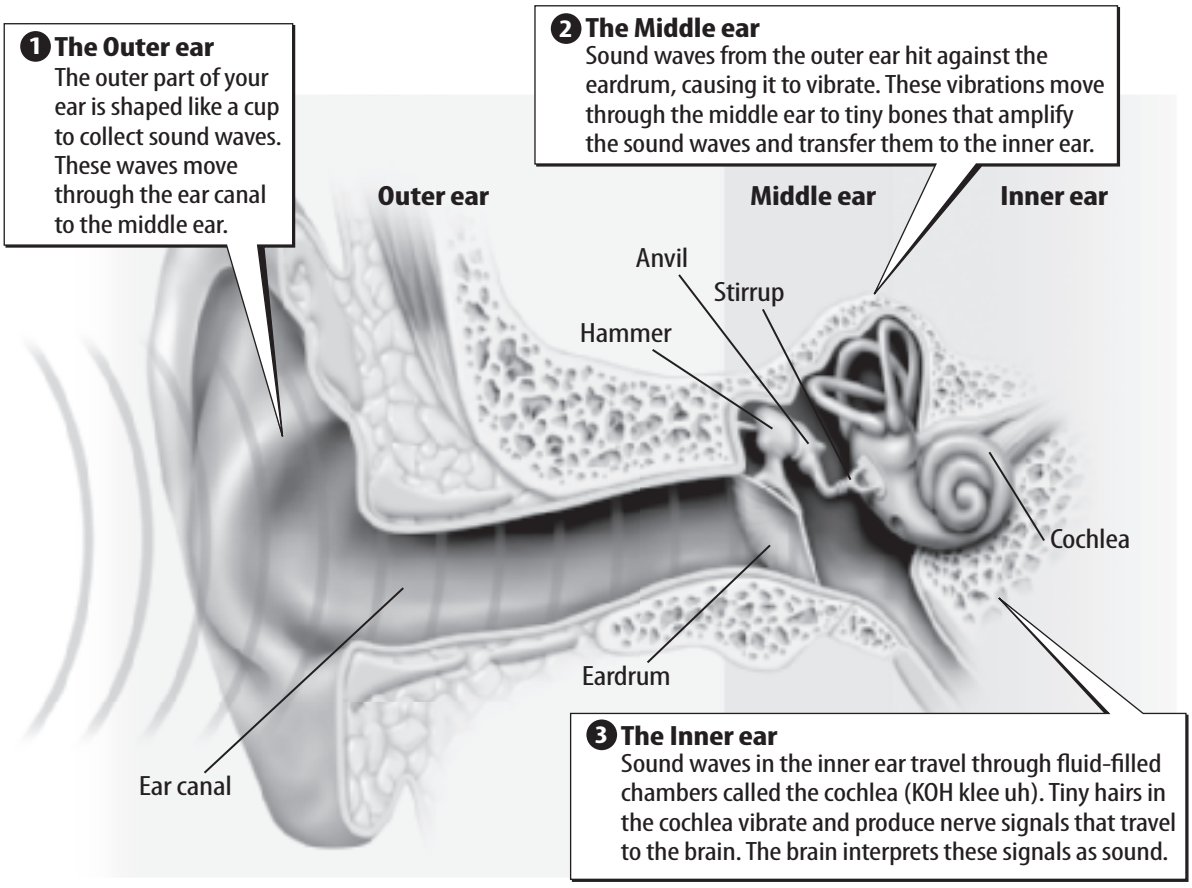
The unit used to measure sound intensity, or loudness, is the **decibel (dB).** The decibel levels of common sounds are shown in the figure below. Each increase of 10 dB results in a sound about twice as loud. As the decibel level goes up, the amount of time you can listen to the sound without risking hearing loss gets shorter and shorter. People who work around loud sounds wear protective hearing devices to prevent hearing loss.



Hearing and the Ear

Typically, objects are seen when light waves enter the eyes. Similarly, sound waves enter the ears with information about the environment. The human ear has three main parts, as shown in the figure on the next page. The external outer ear, which includes the part that you can see, collects sound waves. The middle ear amplifies, or intensifies, the sound waves. The middle ear includes the eardrum and three tiny bones—the hammer, the anvil, and the stirrup. The inner ear contains the cochlea (KOH klee uh). The cochlea changes the sound waves to nerve signals. The brain then can process these signals to create the perception of sound.

Parts of the Human Ear



Visual Check

10. Name Which part of the ear has a spiral shape?

Mini Glossary

compression: the region of a longitudinal wave where the particles of the medium are closest together

decibel (dB): the unit used to measure sound intensity, or loudness

pitch: the perception of how high or low a sound seems

rarefaction: the region of a longitudinal wave where the particles are farthest apart

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that describes how an increase in decibel level affects sound intensity.

_____

_____

2. Write *increases* or *decreases* in the blanks below to describe the relationships among the properties of sound.

If this property increases,	then…	does this property increase or decrease?
wavelength increases	→	frequency _____
frequency increases	→	pitch _____
energy used to produce the sound increases	→	amplitude _____
temperature of a gas increases	→	the speed of sound through the gas _____
temperature of a liquid or solid increases	→	the speed of sound through the liquid or solid _____
distance from the sound source increases	→	intensity _____

3. Record a question from your partner's quiz that was difficult for you. Then answer it.

_____

_____

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

ConnectED

Log on to ConnectED.mcgraw-hill.com and access your textbook to find this lesson's resources.

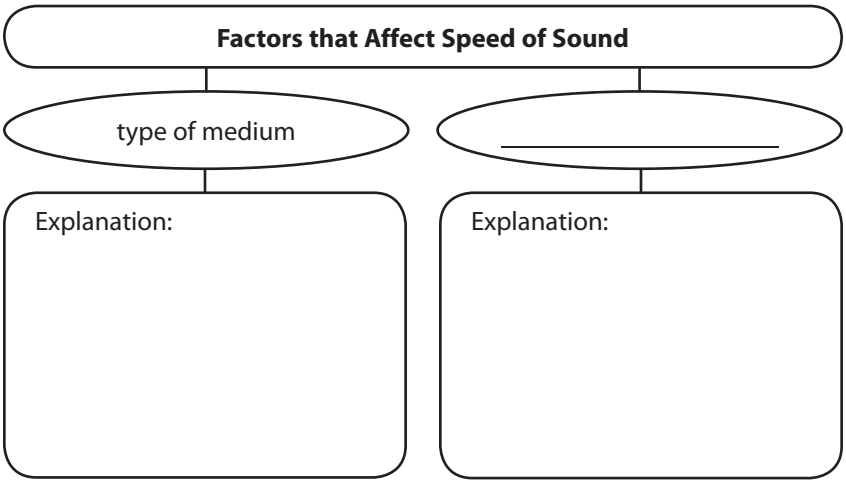
END OF LESSON

Main Idea

I found this on page _____.

Details

Identify *two factors that affect the speed of sound.*



I found this on page _____.

Explain *the change in* decibel *level of a sound as you move farther away from the source.*

Hearing and the Ear

I found this on page _____.

Describe *how structures contribute to hearing.*

Structures for Hearing Sound		
Outer Ear	Middle Ear	Inner Ear

Synthesize It Suppose your dog is barking at the door as if he hears something there, but you hear nothing. Hypothesize what is happening in your outer and middle ears at that time.