4.4 Read

How Does Sound Energy Travel?

Think of the ripples of water in a pond when you toss in a pebble. The ripples start at the point where the pebble hits the water. The ripples spread out from this point in all directions. The ripples are small waves, and they keep making larger and larger circles as they spread out. The waves can travel for quite a while after the pebble enters the water.

Now imagine people standing around the pond. Could they all hear the pebble when it goes into the water? No matter where you stand, you should hear the splash. Could the sound also be a kind of wave, like the ripples in the pond?

A pebble dropped into a pond will make concentric circles of waves.

Scientists often use models to help visualize things that cannot be seen. A model that shows sound traveling as waves can help you to understand many of the characteristics of sound. Sound travels from one place to another in the form of longitudinal waves, similar to the waves you made with the coiled spring. Recall that in longitudinal waves, the vibrations move in a direction parallel to the direction in which the wave travels.

Sound can travel through all forms of matter, but it travels better through most solids than liquids, and better through most liquids than gases. Most of the sounds you hear result from sound waves that travel to your ear through air, which is a mixture of gases.

Speed of Sound

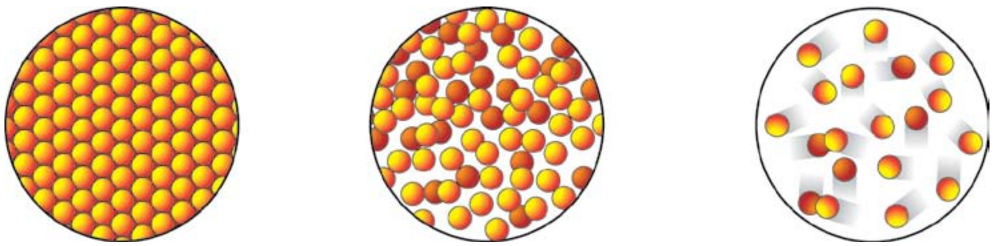
You already know that when a wave moves through a medium, it does not carry the matter in the medium with it. It is the same with sound waves. When a sound wave moves through a medium, it does not carry the medium along with it. Sound waves start with a vibration in matter. The waves travel when the kinetic energy of the vibration is transferred from particle to particle of the matter.

Think back to the Newton's cradle you explored in *Learning Set 2.* The balls in the middle hardly move at all, yet kinetic energy is transferred from one end to the other. In much the same way, a mechanical wave can carry energy through a medium without moving matter through the medium.

The speed of sound is 343 m/s (meters per second) in air at room temperature. You may have read about aircraft that go faster than the speed of sound. They are called *supersonic.* However, there is no single speed of sound. Sound travels more slowly in cold air and faster in hot air. Sound travels even faster through water, at 1443 m/s. The speed of sound is different in different materials.

pitch: how high or low a sound is.

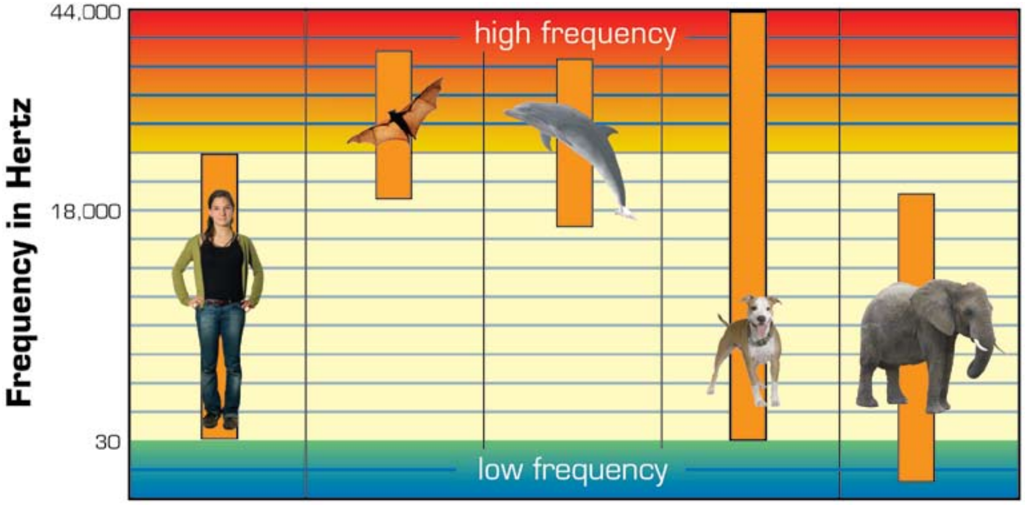
The speed of sound depends on the particles of the medium the sound wave is moving through. Because the particles in a solid are tightly packed together, sound waves can quickly transfer energy from particle to particle in a solid. The particles in liquids are less tightly packed, so the sound travels more slowly than in most solids. Gas particles are farther apart, so the speed of sound is slowest when it moves through gases.



The arrangement of particles in solids, liquids, and gases affects the speed of sound through the media. Sound travels slowest through gases and fastest through solids. This is because in solids, the particles are closest together, and in gases, they are farthest apart.

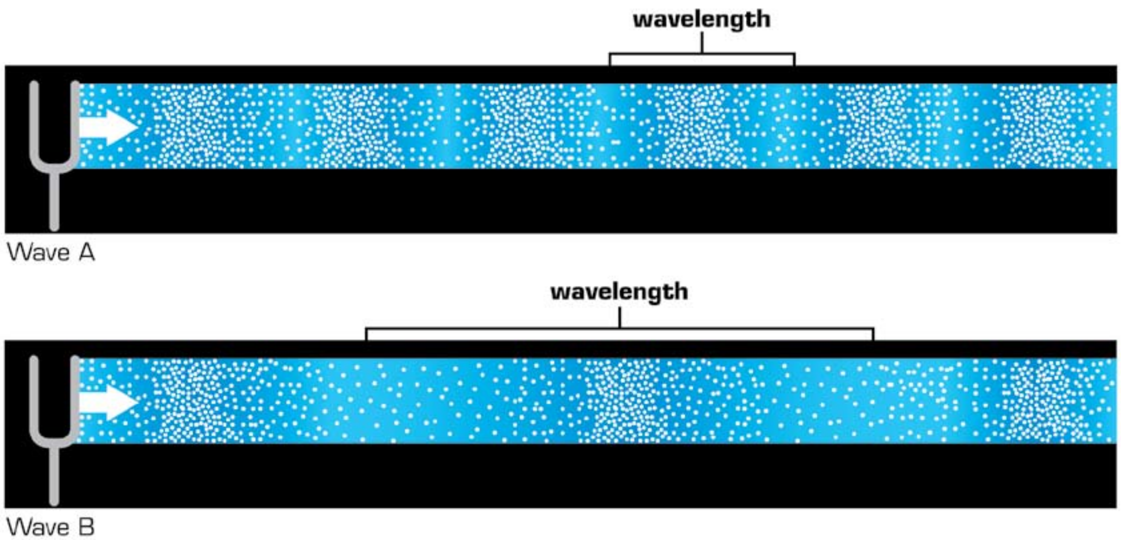
Relating Characteristics of Sound to Wave Characteristics

One characteristic of sound is its **pitch**. Pitch is how high or low a sound is. The pitch of a sound is related to the sound wave's frequency. When you hear a high-pitched sound, you are hearing sound waves with a high frequency. A low-pitched sound is from a wave that has a low frequency. The human ear can hear sounds from about 100 Hz (hertz) up to about 18,000 Hz. Other animals are able to hear lower- and higher-frequency sounds.



Different animals can hear a range of different frequencies of sound. Look at the graph to see which animal hears the greatest range of sound and which hears the smallest range.

As you observed in your mechanical-wave race in the previous section, the speed of a wave is not affected by the frequency of the wave. In air, high-frequency sound waves and low-frequency sound waves both travel at 343 m/s. How is this possible? The speed of any wave depends on both its frequency and wavelength. The longer the wavelength, the lower the frequency. The shorter the wavelength, the higher the frequency. With higher-frequency waves, more compressions pass by you each second, but the distance between compressions is smaller. You can see in the diagram that a higher frequency wave has a shorter wavelength than a lower frequency wave.



Which of the two longitudinal waves has the higher frequency? How do you know?

You read earlier that sound energy and intensity depend on how loud the source is. You compared intensity of different sounds using the decibel scale. The wave model can be used to explain the loudness of a sound. The louder the sound, the greater the energy. When you generated the waves in the rope, the more you moved the rope away from the rest position, the greater the amplitude of the wave you generated. It required more energy from you to move the rope the greater distance, so you transferred more energy to the rope. The amplitude of the wave was related to the energy transferred to the rope. The same is true for sound. The greater the amplitude of the sound wave, the greater the energy carried by the wave. Therefore, the louder the sound is.

Have you ever heard an echo? If you yell loudly in an empty gymnasium, you will hear the yell repeated shortly after. What you hear is the reflection of the sound off the hard walls of the gymnasium. Just as the wave you generated in the coiled spring or rope reflected from the fixed end, sound waves reflect off hard surfaces.

Stop and Think

1. Why does sound travel better through a solid than through air?
2. How is the pitch of a sound related to the frequency of a sound wave?
3. How is the loudness of a sound related to the amplitude of a sound wave?
4. Use the wave model of sound to describe what happens when you hear an echo.

Revise Your Explanation

With your group, revisit the explanations you wrote in *Section 4.2.* Use what you have learned about waves to revise or add to your claims about the factors that affect sound energy. Then use what you have read to revise the science knowledge and your explanation statement.

Conference

Share Your Explanations

When everyone is finished, share your claims and explanations with the class. As each group shares their revised claims and explanations, record the explanations. Revise the classroom poster that has the full set of claims and explanations.

Update the *Project Board*

Think about the results of your explorations in *Sections 4.2* and *4.3,* as well as what you have read about waves in this section. Record what you learned about sound waves in the *What are we learning?* column of the *Project Board.* Every time you add something to this column, remember to add supporting evidence in the *What is our evidence?* column.

Again, it is important to recognize any questions you may have. Well-developed questions can guide your learning. Any questions you have about sound energy should be recorded in the *What do we need to investigate?* column.

Design a Rube Goldberg machine to turn off a light				
What do we think we know?	**What do we need to investigate?**	**What are we learning?**	**What is our evidence?**	**What does it mean for the challenge or question?**

What's the Point?

Sound waves are longitudinal waves that can travel through many kinds of matter. Sound waves, like other mechanical waves, are described by the properties of wavelength, frequency, wave speed, and amplitude. Amplitude is a measure of the energy used to create the wave. The greater the amplitude, the greater the energy of the wave and the louder the sound. The pitch of a sound is related to frequency. When you hear a high-pitched sound, the frequency of the wave is greater than that of a low-pitched sound. The speed of sound is generally fastest in solids and slowest in gases. A wave model can account for reflection of sound waves and why the speed of sound in a medium is the same for waves with different frequencies.