Up!

What is sound?

When you beat a drum, the drum skin vibrates and causes the air to vibrate, as shown below. A *vibration* is the complete back-and-forth motion of an object. The vibrations in the air are interpreted as sounds by your brain. No matter how different they are, all sounds are created by vibrations.

What are sound waves?

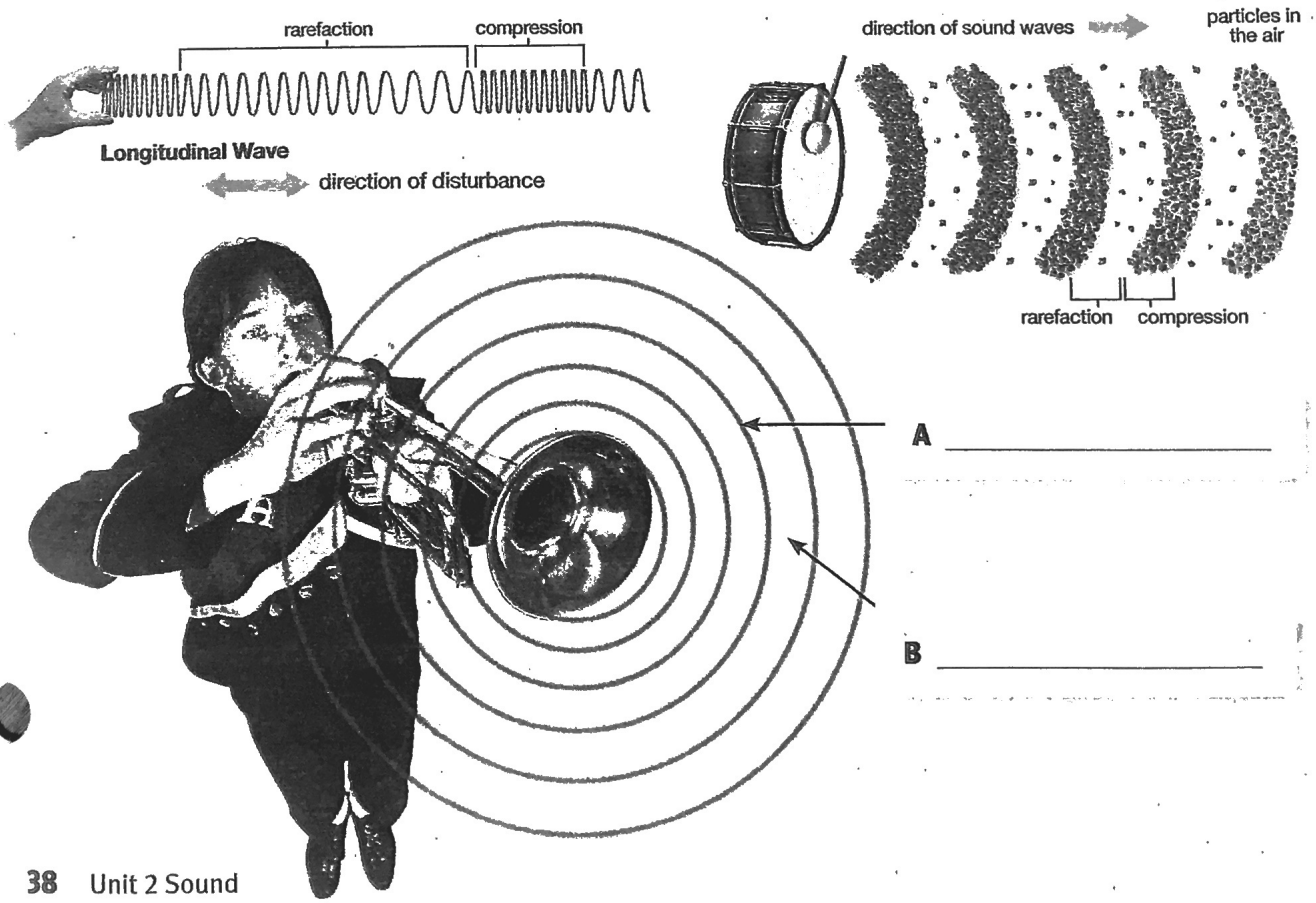
Active Reading

5 Identify As you read, underline the properties of longitudinal waves.

A **sound wave** is a longitudinal wave that is caused by vibrations and travels through a medium. In a **longitudinal wave** the particles of a medium vibrate in the same direction that the wave travels. Longitudinal waves, also called *compression waves,* are made of compressions and rarefactions (rair•uh•FAK•shuhns). A *compression* is the part of a longitudinal wave where particles are close together. A *rarefaction* is the part where particles are spread apart. As the wave passes through a medium, its particles are compressed together and then spread apart.

Visualize It!

6 Label Write labels for A and B on the sound wave in the diagram.



How do sound waves travel?

Sound waves travel in all directions away from their source, as shown in the photo of the student playing the trumpet. But this is only possible if there is a medium through which the sound waves can travel.

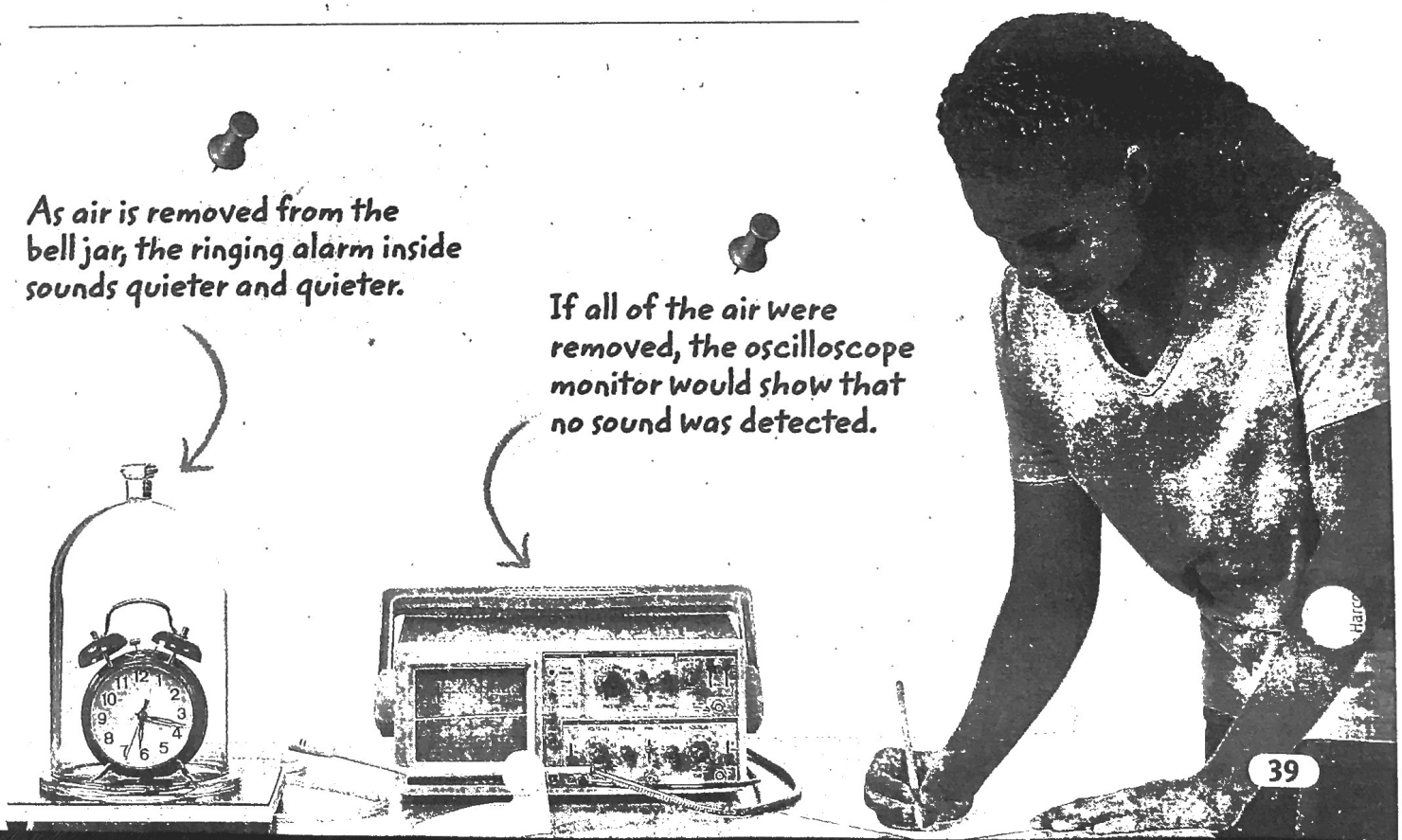
Through a Medium

All matter—solids, liquids, and gases—is composed of particles. Sound waves travel by disturbing the particles in matter, or a medium. The particles of the medium do not travel with the sound waves themselves. The particles of a medium only vibrate back and forth along the path that the sound wave travels.

Most of the sounds that you hear travel through air at least part of the time. Sound waves can also travel through other materials, such as water, glass, and metal. You have probably heard people talking or dogs barking on the other side of a window or door. When you swim underwater, you may hear the sounds of your swim buddies as they splash and call to each other above the surface.

In a vacuum, there are no particles to vibrate. Therefore, no sound can be made in a vacuum. This fact helps to explain the effect shown in the photograph below. Sound must travel through air or some other medium to reach your ears and be detected.

Active Reading **7 Explain** Why can't sound travel through a vacuum?

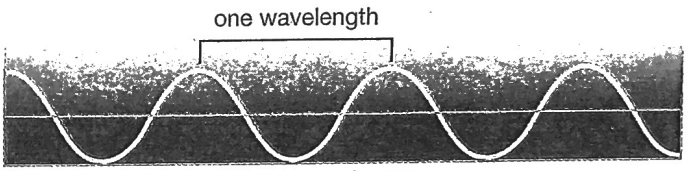


What determines pitch?

Pitch is how high or low you think a sound is. The pitch you hear depends on the ear's sensitivity to pitches over a wide range. Pitch depends on the frequency and wavelength of a sound wave.

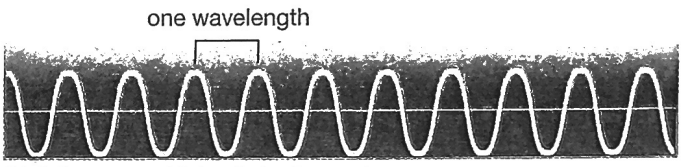
Frequency and Wavelength

Frequency is expressed in hertz (Hz). One hertz is one complete wavelength, or cycle, per second. In a given medium, the higher the frequency of a wave, the shorter its wavelength and the higher its pitch. High-frequency waves have shorter wavelengths and produce high-pitched sounds. A low-frequency wave has a longer wavelength and makes a low-pitched sound. The diagrams at right show how frequency, wavelength, and pitch are related.



low-frequency low-pitched sound wave

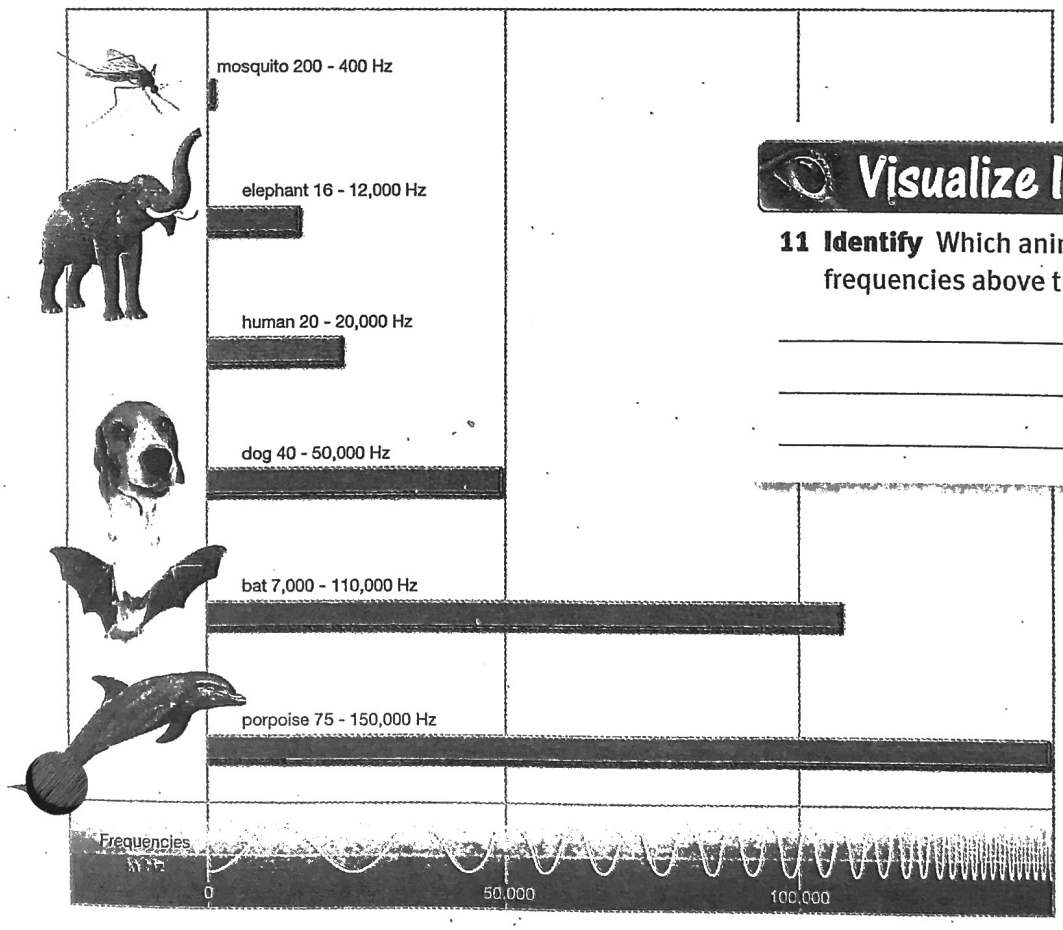
A low-pitched sound has sound waves with a low frequency and a longer wavelength.



high-frequency high-pitched sound wave

A high-pitched sound has sound waves with a high frequency and a shorter wavelength.

Approximate Sound Frequencies Heard by Animals



Visualize It!

11 Identify Which animals on this chart can hear frequencies above those that humans can hear?

What makes a sound loud?

If you gently tap a drum, you will hear a soft rumbling. But if you strike the drum much harder, with more force, you will hear a much louder sound. By changing the force you use to strike the drum, you change the loudness of the sound it makes. **Loudness** is a measure of how well a sound can be heard.

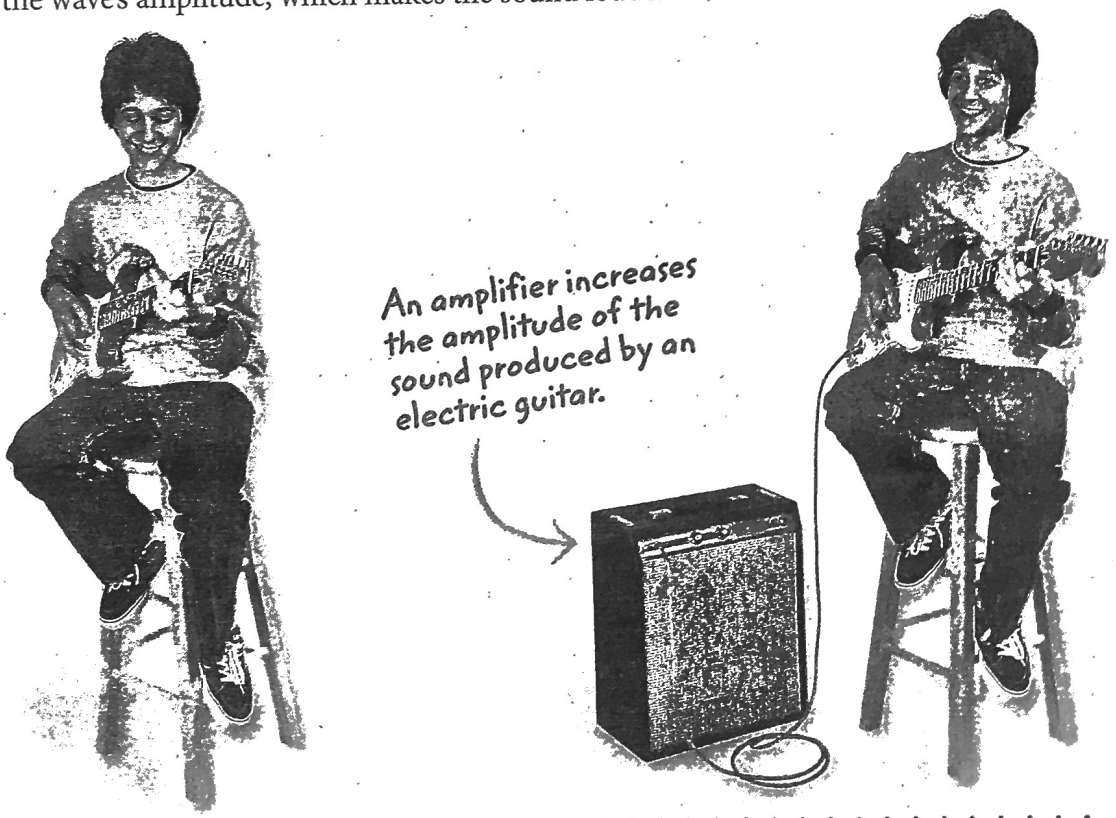
Amplitude

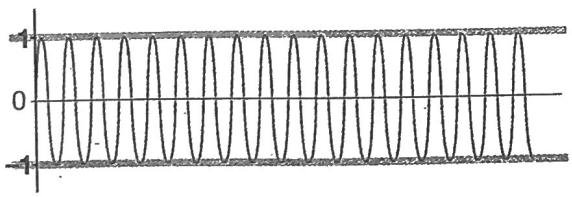
The measure of how much energy a sound wave carries is the wave's intensity, or amplitude. The *amplitude* of a sound wave is the maximum distance that the particles of a wave's medium vibrate from their rest position. When you strike a drum harder, you increase the amplitude of the sound waves. The greater the amplitude, the louder the sound; the smaller the amplitude, the softer the sound.

One way to increase loudness is with an amplifier, as shown below. An amplifier receives sound signals in the form of electric current. The amplifier increases the sound wave's energy by increasing the wave's amplitude, which makes the sound louder.

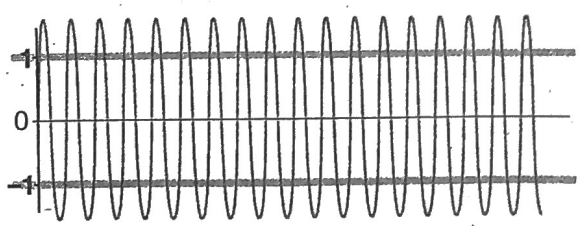
Active Reading

12 Explain What is the relationship between amplitude and the loudness of a sound?





Softer sounds have smaller amplitudes. Observe that the amplitude is 0 to 1, or 0 to −1.



Louder sounds have larger amplitudes. How did the amplitude change? Did the frequency change?