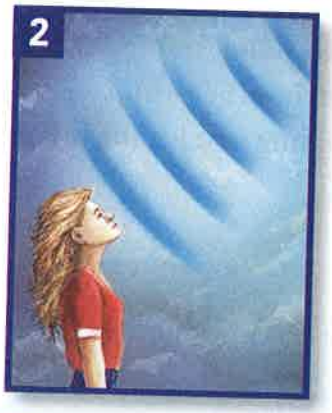
Sound moves even more slowly in gases. The particles in gases are far apart. They don't bump into each other often, so vibrations take longer to move through gases.

Sound travels through moving particles. If there are no particles, there can be no sound. We hear sounds mostly through air. In outer space there is no air for sound waves to travel through. If you were in a spacesuit outside the space shuttle, no one inside the shuttle could hear you shout. You could talk back and forth only by using a radio.

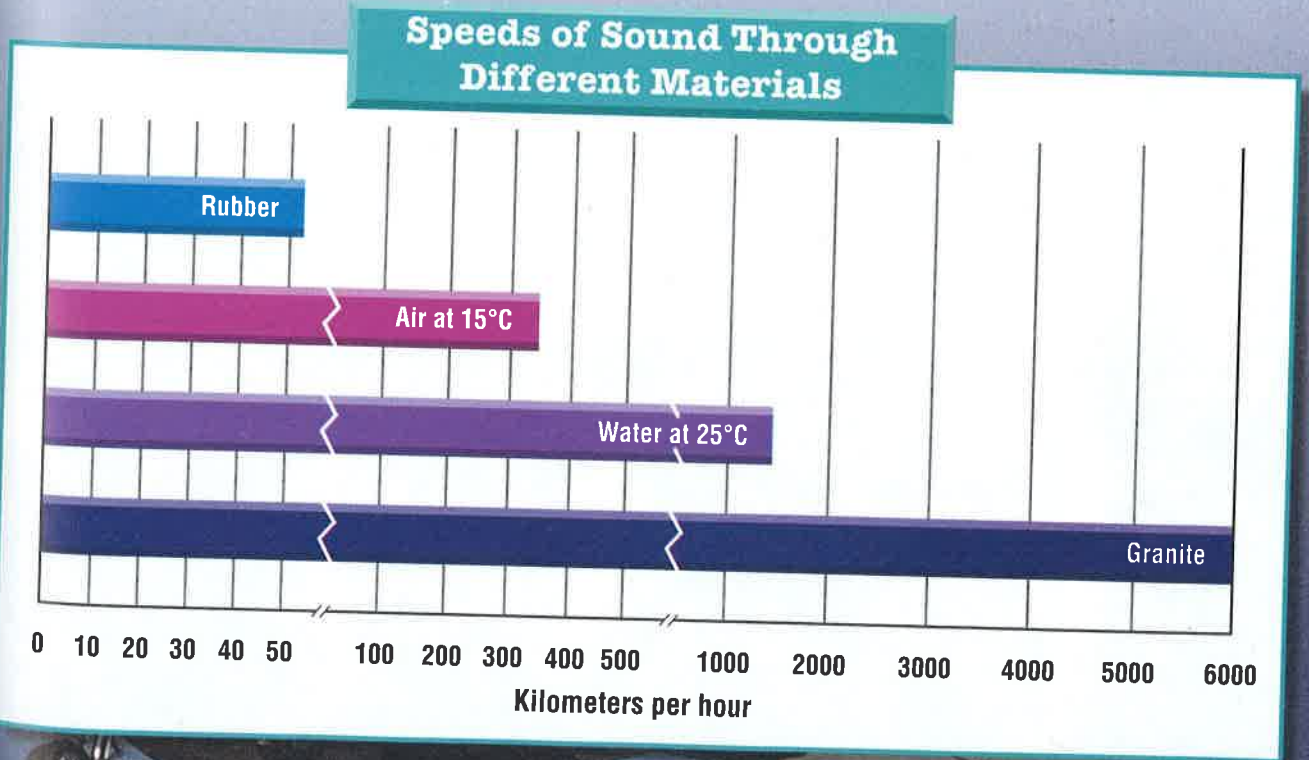
✓ **What does the speed of sound measure?**

1 In air, sound travels about 1 mile in 5 seconds. You can use this to find the distance to a thunderstorm. Light travels so fast that you see a lightning bolt almost as it happens. Start the stopwatch when you see the flash, and wait to hear the thunder.



2 When you hear the thunder, you stop the stopwatch. It reads 10 seconds.
10 sec ÷ 5 sec/1 mi = 2 mi
The storm is about 2 miles away.

Sound waves travel at different speeds in different materials. The arrangement of particles in materials affects how the waves move. ▼



Reflection

A mirror shows you a clear image. The light that bounces, or reflects, from the mirror looks like the light that hit the mirror. That's because a mirror has a very smooth surface.

Sound waves also reflect from surfaces. A sound reflection is called an **echo**. Sound waves reflected from smooth, hard surfaces sound like the original sound. In the investigation, you heard an echo when you faced the scoreboard or building and hit the pot with the spoon.

You can see your reflection in a smooth pond just as you see it in a mirror. But if the surface of the pond ripples, your reflection gets broken up. You can no longer see yourself clearly. The same thing happens when sound waves reflect off rough, uneven surfaces. Each sound wave hits a different part of the bumpy surface and is reflected in a different direction. A line of trees or a rough rock wall doesn't reflect clear echoes.

✔ What is an echo?

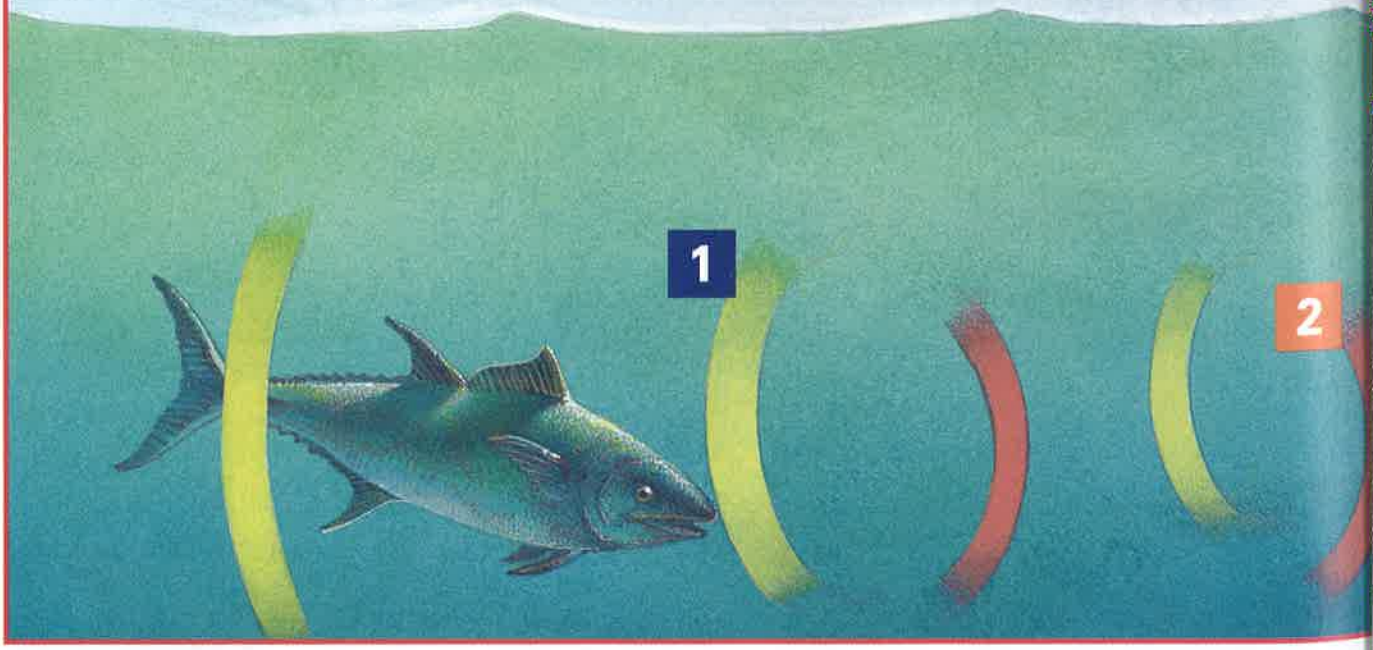
THE INSIDE STORY

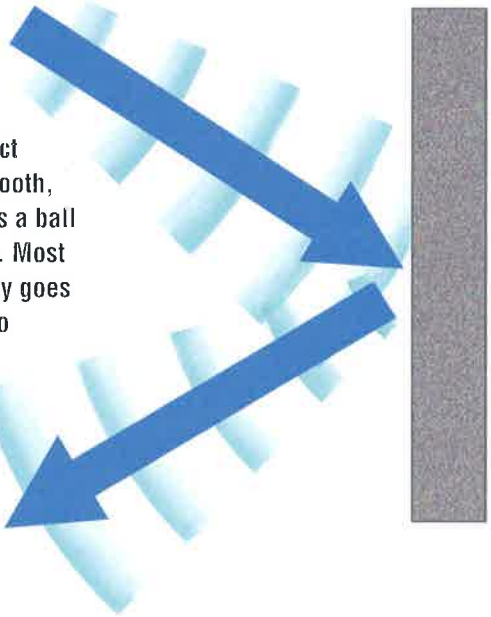
"Seeing" with Sound

Dolphins see with their eyes. They also "see" underwater by using echoes. Dolphins use sound to find their way around rocks and other things in their way. They also use sound to find food such as small fish and squid.

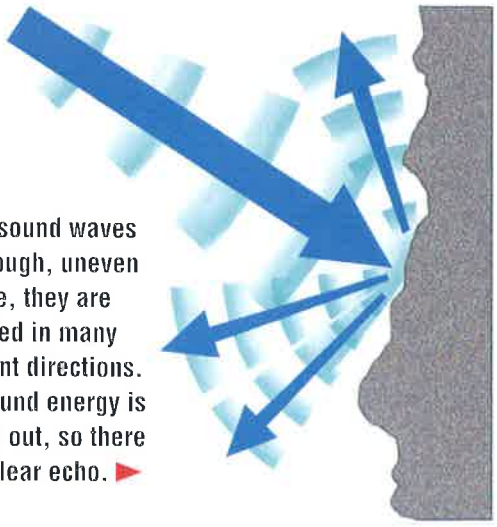
1 Dolphins make sounds that have high pitches. The sounds are called clicks. Scientists aren't sure how dolphins make the clicks. The click sound waves travel through the water.

2 The click sound waves reflect off the rocks and fish. Some echoes return to the dolphin.

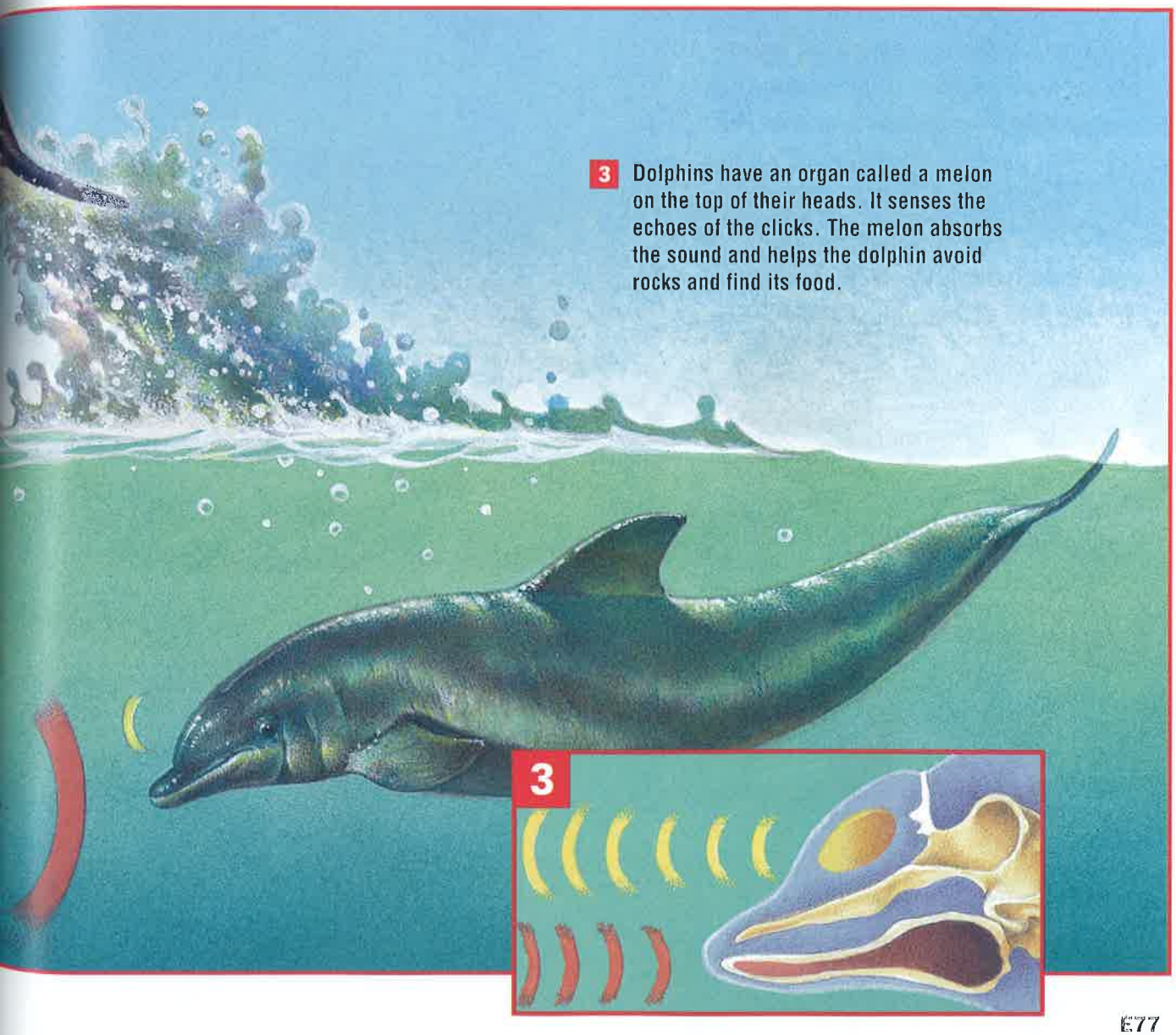




Sound waves reflect straight from a smooth, flat surface, just as a ball bounces off a wall. Most of the sound energy goes in one direction, so there is a clear echo. ►



When sound waves hit a rough, uneven surface, they are reflected in many different directions. The sound energy is spread out, so there is no clear echo. ►



3 Dolphins have an organ called a melon on the top of their heads. It senses the echoes of the clicks. The melon absorbs the sound and helps the dolphin avoid rocks and find its food.

Sonic Booms

Jet airplanes move fast. Some airplanes can fly faster than sound. Powerful jet engines produce loud sounds. What happens to these sounds when the plane is moving faster than they are?

An airplane traveling faster than sound makes sound waves that move away in all directions. But the airplane is moving faster than the sound waves moving away in front of it. When the plane catches up to these sound waves, they are squeezed closer together. All the energy of the sound waves becomes one strong wave. This strong wave is called a shock wave. You can hear this shock wave as a loud "boom-boom." People call the double boom a **sonic boom**. Any object moving faster than sound makes such a shock wave. You hear the "crack" of a rifle shot because the bullet is moving faster than sound.

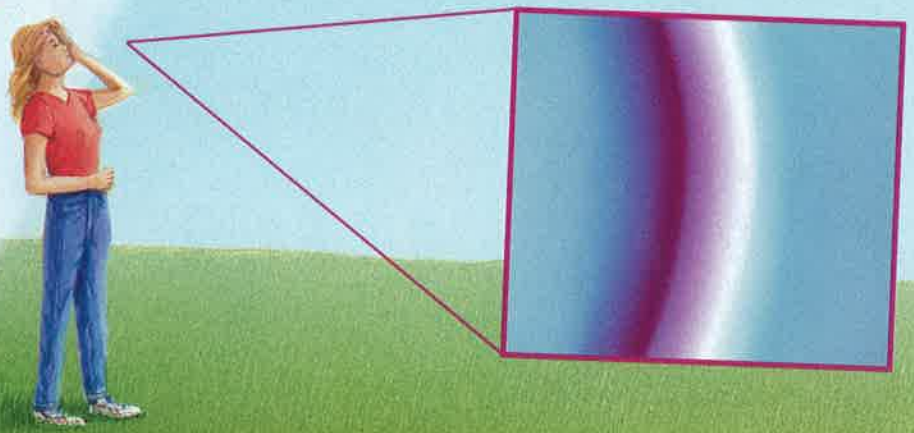
A plane is always making sound waves. So if it is flying faster than sound, its sonic boom travels with it, just as the plane's shadow does.

▲ The supersonic Concorde jet is allowed to fly faster than sound only over the ocean or deserts. Because of this, most of the time people don't hear its sonic booms.

Suppose you and 20 of your friends were to stand in a line down the length of a football field. You stand on a goal line. Each of your friends stands on a different yard line. Coming from the direction nearest you, an airplane flies down the field going faster than sound. You will be the first to hear its sonic boom. Then, one by one, each of your friends will hear it. Finally, the person standing on the far goal line will hear it.

✓ **What is a sonic boom?**

A sonic boom is a large, quick air pressure increase followed by a large quick decrease. Then the pressure returns to normal. ►



Summary

Sound waves travel at different speeds through different materials. They travel fastest through hard, solid materials. Sound waves reflect from smooth, hard surfaces. An echo is a sound reflection. Objects traveling faster than the speed of sound cause shock waves that we hear as sonic booms.

Review

1. What does the speed of sound measure?
2. Why is there no sound in outer space?
3. Where does the energy of a sonic boom come from?
4. **Critical Thinking** Why don't you hear echoes in a forest?
5. **Test Prep** In which material would sound waves probably travel the fastest?
   - **A** cotton
   - **B** milk
   - **C** iron
   - **D** oxygen

LINKS

MATH LINK

Sound Comparison The speed of sound in air is 340 meters per second. In water it is 1497 meters per second. About how many times as fast is the speed of sound in water as in air?

WRITING LINK

Informative Writing—Narration Suppose you are at home and a thunderstorm is going on outside. By watching the lightning and listening to the thunder, you track the storm. Write a story for a younger child telling what you see and hear, and where the storm is going.

HEALTH LINK

Ultrasound Doctors use ultrasound in medical tests. Find out what ultrasound is and how it works. Then find out about some of the tests it's used for. Make a poster or display to show what you learned.

TECHNOLOGY LINK

Learn more about sound wave differences by exploring *Waves of Music* on **Harcourt Science Explorations CD-ROM.**