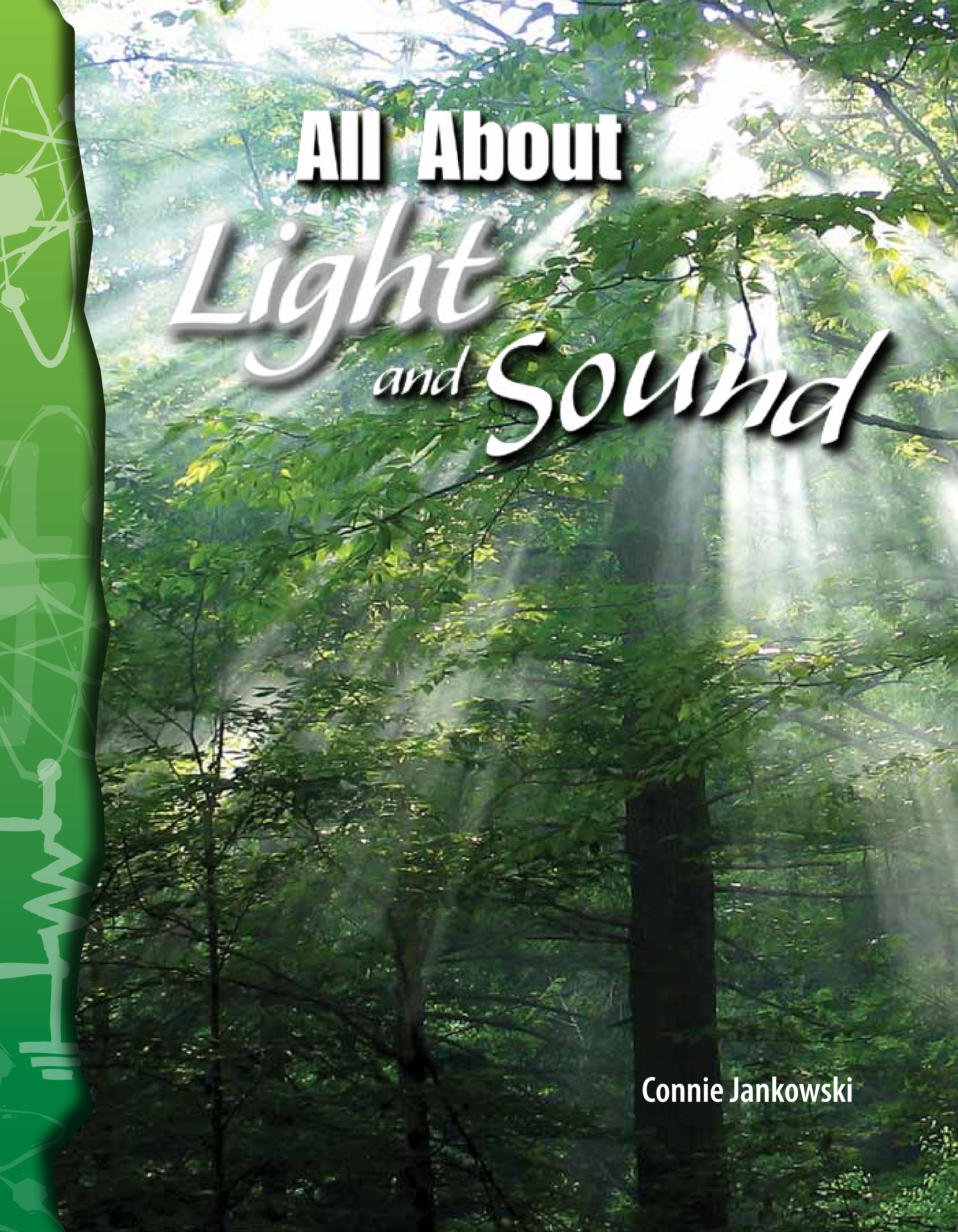
All About Light and Sound

Connie Jankowski



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The World of Light and Sound

Every day, we see beautiful, strange, and interesting things. Think about the many things you've seen today. Maybe you noticed the sky. Was there a bird in flight? Were there clouds covering the sun? Was the sky a bright blue or a dull gray?

The truth is that you were not actually seeing any of those things. You were only seeing light. Light comes from objects both near and far. That's what you see. In fact, that's what you're seeing now.

How about everything you hear? What do you hear now? Even in the quietest places and times, you can hear things. Maybe it is soft breathing. Maybe it is pages turning. Maybe someone is blowing her nose! When you hear those things, your ears are picking up sound **vibrations** (vie-BRAY-shunz).

For most people, light and sound are two of the most important ways to know the world. Through light, we see. Through sound, we hear.

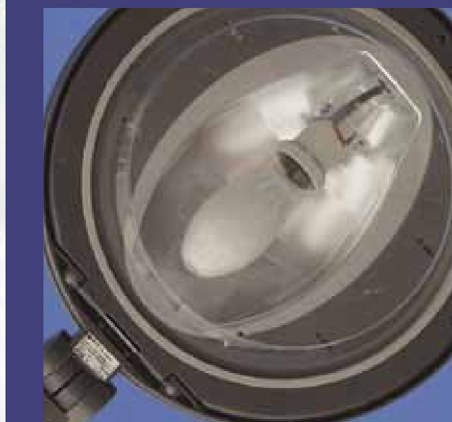
Drums create sound when the drum skin vibrates after being struck.

Importance of Light

Can you imagine life without light? Each morning, sunlight floods into your bedroom. Throughout the day, we use light to help with nearly everything we do. Light helps when we work and play. Without light, everything would be more difficult.

Before people knew how to use electricity, they planned their time around daylight hours. They used fire for light at night. Candles and stove fires lit the world. Later, oil and gas were found to be good fuels for making light.

Incandescent light bulb



Halogen light bulb

Fluorescent light bulb

Light On!

Not all light bulbs are the same. Incandescent light bulbs use a gas (usually argon or nitrogen) that is held in a glass case and heated. Inside the bulb is a **filament** that heats and gives off light. These light bulbs work for about 1,000 hours. Then the filament breaks.

Halogen (HAL-uh-juhn) bulbs use halogen gas and tungsten (TUNG-sten) filaments. When the filament heats up, tungsten atoms evaporate off. The halogen gas reacts with the atoms and returns them to the filament. The atoms are recycled! The filament lasts far longer. However, both incandescent and halogen bulbs waste energy by producing a lot of unwanted heat.

Fluorescent bulbs produce less extra heat, so they use less energy. They work in a different way. They use electrons flowing through a tube of mercury gas. The electrons bump into the mercury atoms, which then give off ultraviolet photons. The photons strike the coating of the tube and come out as visible light.

What Is Light?

Light is a form of energy. Energy is the ability of a system to do work. The power of light is obvious to the eye.

The energy of light is called **radiant energy**. To radiate means to send out rays or **waves**. Only a certain type of radiant energy can be seen with the human eye. We call this visible light. Visible means that we can see it.

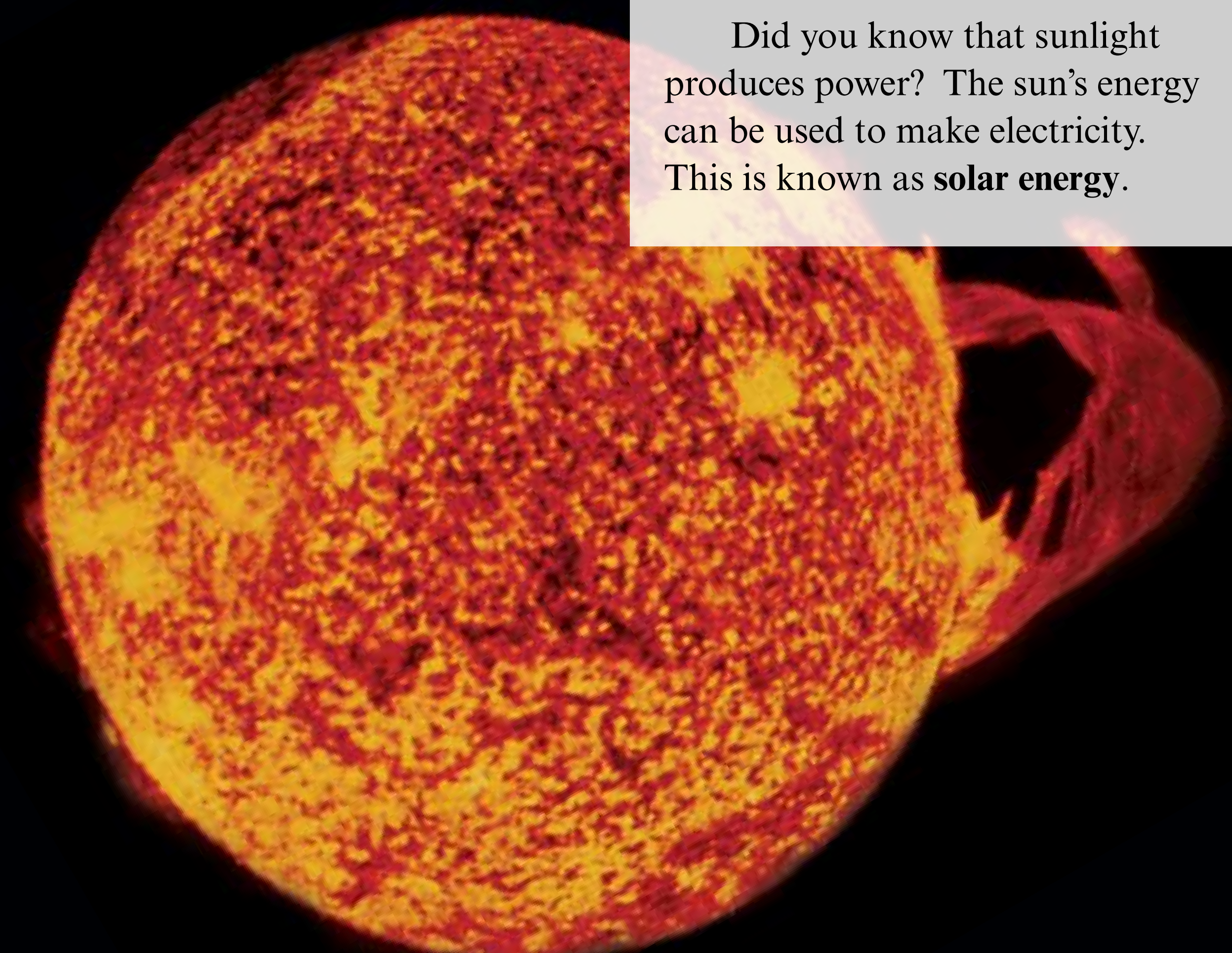
Natural light comes from natural sources like the sun and other stars. Other light sources are artificial. People make them. Lights in a home or the headlights of a car are sources of artificial light.

We can see because of light. Light bounces off objects and travels to our eyes. Our eyes and brain work together to translate that light into what we see.

The Sun

The sun is Earth's main source of energy and light. Without sunlight, there wouldn't be enough energy to heat Earth. We couldn't survive. Even if we burned all the fuel on Earth at once, it still would not keep the planet warm enough for life to exist.

Did you know that sunlight produces power? The sun's energy can be used to make electricity. This is known as **solar energy**.



How Light Is Made

Everything is made of very tiny particles (PAR-tuh-kuhls). They are called atoms. Whether something is big or small, solid or liquid, or light or heavy, atoms are its basic parts.

Light can come from excited atoms. Heat causes atoms to become excited. They move faster. Some excited atoms radiate light.

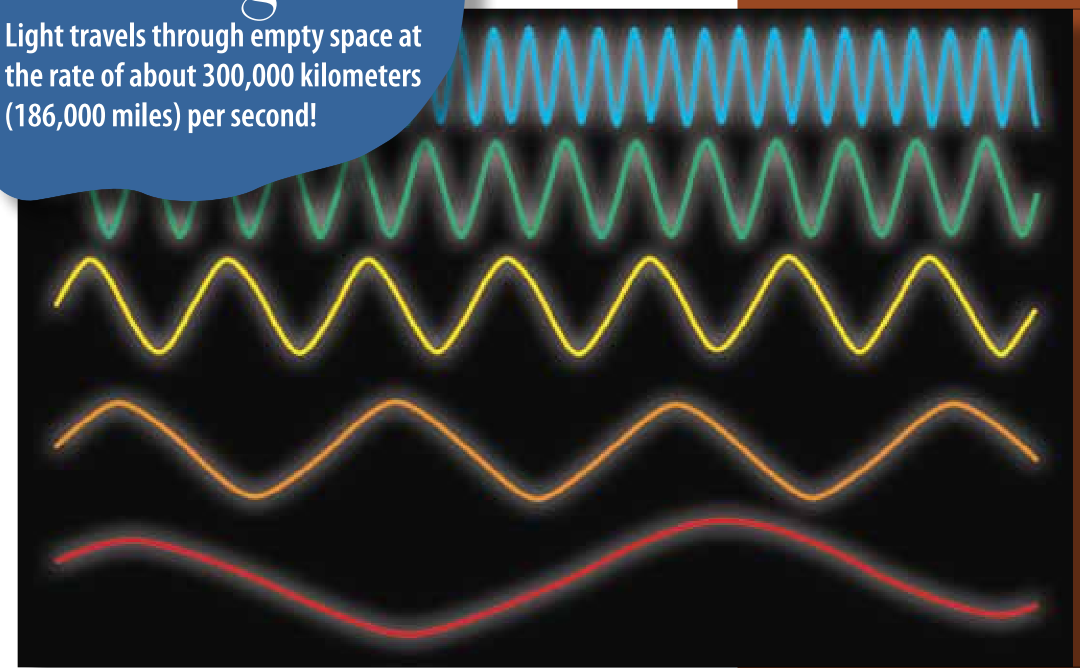
Have you ever seen the bottom of a pan that is heating on the stove? Did it look like the hot pan was turning colors? When heated, the atoms on the surface of the pan start to bump into each other. This causes them to give off extra energy. This radiant energy is what scientists call light.

Light travels in waves much like water moves in waves. The amount of energy that a wave carries determines the color of the light. Waves differ from each other in length, rate, and size. These are called **wavelength**, **frequency** (FREE-kwuhn-see), and **amplitude** (AM-pli-tood). Wavelength relates to the color of the light.

The Speed of Light

Light travels through empty space at the rate of about 300,000 kilometers (186,000 miles) per second!

Blue light has the shortest wavelength.



Red light has the longest wavelength.

White Light

The combination of all colors is white light.

What Do They Mean?

peak—the top of a wave

trough—the bottom of a wave

wavelength—distance from one peak of the wave to the next

frequency—number of times per second that peaks pass a checkpoint

amplitude—the height of the wave

Reflection, Refraction, and Absorption

What happens when a light wave hits the atoms that make up everything? Several things might happen.

- The light can change direction, or **refract**.
- Some of the light rays can **reflect** off of the surface.
- The light can be **absorbed** into the material.

Light rays bend as they travel through the surface of **transparent** (trans-PAIR-uhnt) material. Transparent means that light can be seen through it and move through it. This bend in the light is called refraction (ruh-FRAK-shuhn). It occurs when light travels through different materials at different speeds.

The return of a wave of energy after it strikes a surface is called reflection (ruh-FLEK-shuhn). Smooth and polished surfaces like mirrors reflect more light than surfaces that are rough or bumpy.

When light reflects from a smooth surface, all of the light rays reflect in the same direction. A mirror is smooth, so you can see your image in it. When light reflects from a rough surface, the rays reflect in many directions. It is impossible to see your reflection in paper, because the surface is rough.

As the light passes through the glass, it slows down. When the light passes through the water, you can see the straw appear to be cut in half.

Optics

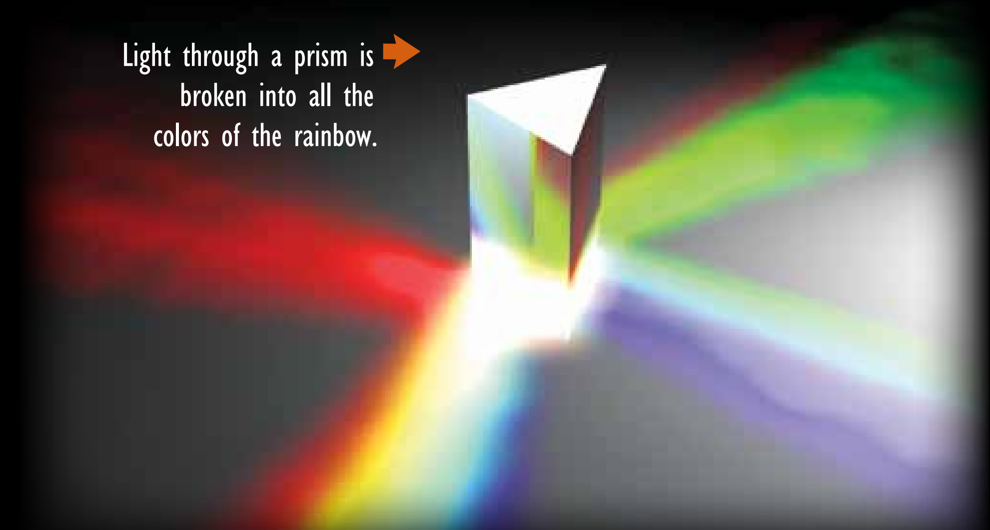
Optics is a branch of science that examines the behaviors and properties of light. Scientists have used their understanding of optics to invent many important devices. Microscopes allow us to study very small objects. Telescopes allow us to study objects far away. Optics allows doctors to prescribe lenses (glasses) to correct our vision. Binoculars, magnifying glasses, and cameras are examples of other optical devices that aid our vision. The science of optics plays an important part in our everyday lives.

When it comes to color, **absorption** (uhb-ZORP-shuhn) is the key. Look at the clothes you're wearing. What colors are they? The truth is, the colors are not in the clothing. The colors come from reflected and absorbed light. We see the colors because of the light that is reflected and sent to our eyes.

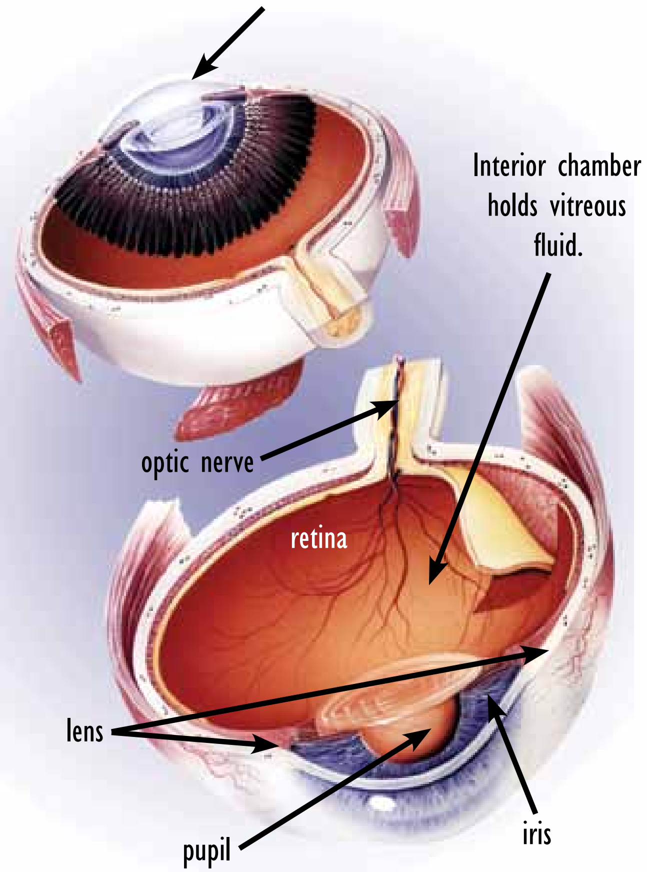
You know that light is made of waves. Each color has its own frequency. When visible light strikes an object, each frequency behaves differently. Some frequencies are absorbed. They are not seen. Some are reflected. The reflections are what appear as the color or colors of an object.

White light is made of all the colors of the rainbow. These colors are red, orange, yellow, green, blue, indigo, and violet. Some people know the colors as ROYGBIV. Now, look at something red. You can see just by looking at it that the object absorbs the frequencies for OYGBIV. But R, or red, is reflected. Your eyes pick up that reflection, and you see the object as red.

The important idea is that the color is not in the object. It is in the reflected light.



Light through a prism is broken into all the colors of the rainbow.



The Eye

The human eyeball is small. It measures only about 25 millimeters (one inch) wide. Even though it is small, it plays a big part in everything we do. It is the organ that gives us sight. We use our eyes to work, read, watch movies, play sports, and find a friend in a crowded schoolyard.

Really, the eye does not see objects. It sees light. Objects reflect light waves in all directions. The light rays enter the eye and change into signals. These signals are sent to the brain. The brain "sees" the objects as visual images.

Light and Bright!

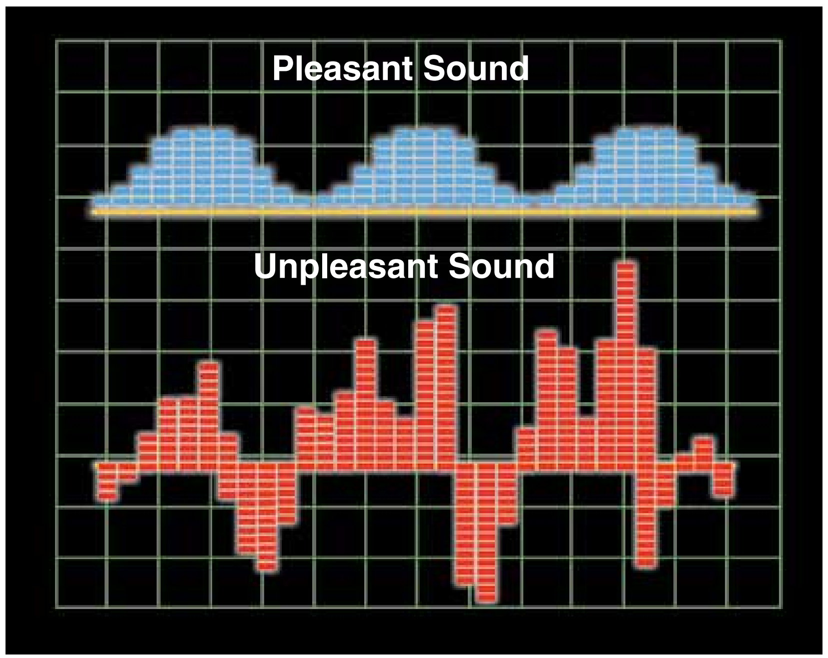
Let's "shed some light" on light and knowledge. People who are intelligent are sometimes called "bright." A light bulb often symbolizes a good idea. When someone teaches others about a subject, he or she "illuminates" them on the topic. Do you "see" what I mean?

Importance of Sound

Every day we're met with thousands of sounds. We are not aware of most of them. Stop for just a minute, close your eyes, and listen. How many sounds do you hear? Can you tell them apart? Listen carefully.

We go through our days bombarded with sounds. Some are pleasant to us and others are not. The pleasure has a lot to do with how sounds are made and the rhythm of their vibrations. To vibrate is to move back and forth.

Sound vibrations serve many purposes. Some sounds are simply for pleasure. For example, we enjoy listening to a radio, a concert, or a movie soundtrack. Other sounds serve as cautions and warnings. Thunder, wind, and crashing waves give messages about harsh weather. Engine vibrations tell about the working condition of a car or truck. A loud sound warns that danger may be near.



Like light, sound travels in waves. Different waves make different sounds. We can tell sounds apart by the vibrations they make.

Noise

Noise is all around us: car horns, barking dogs, crying babies, banging items, and more. Many noises are loud—and the louder they get, the more annoying they become.

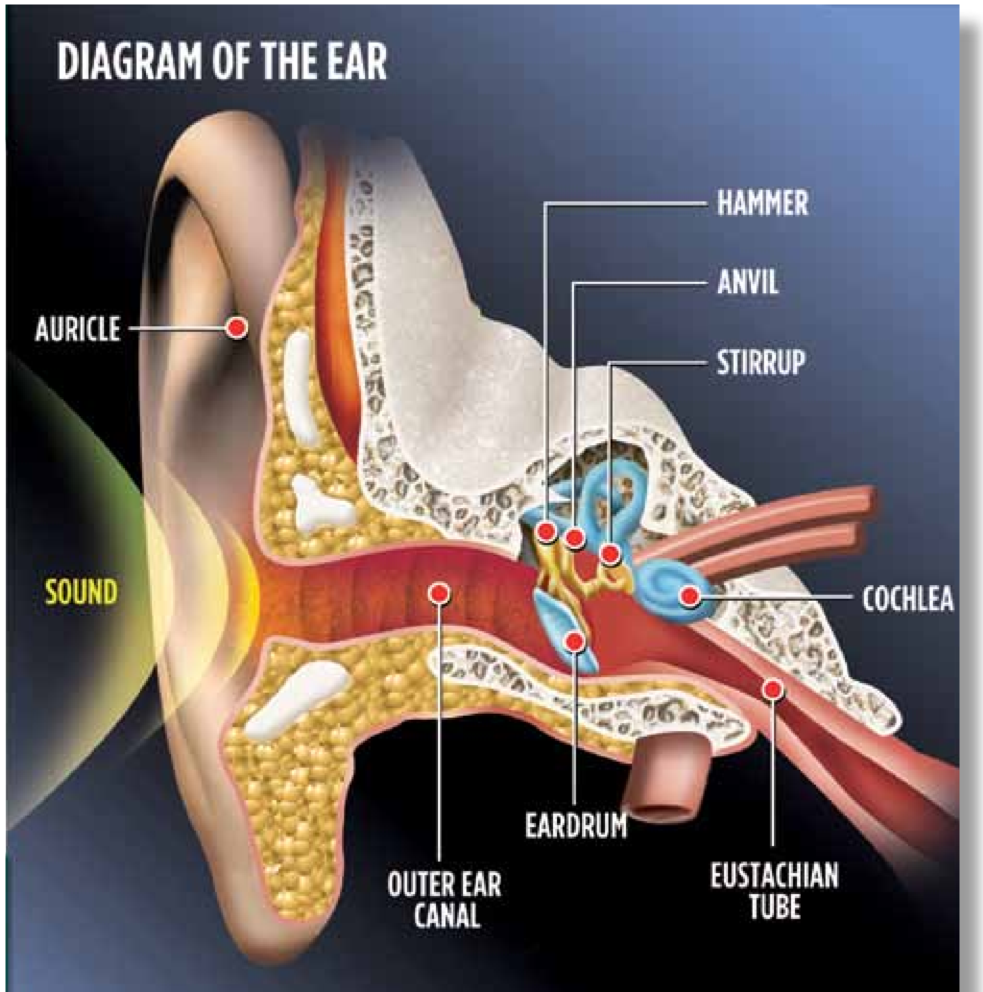
Any unpleasant sound is a noise. Is thunder a noise? Some people hate the sound of thunder. Others enjoy the mighty crashing sounds. Each person decides what he or she thinks is noise. That's why loud music, sirens, and traffic horns can be considered noise to many people. For others, they're music to their ears.

Loud sounds can damage one's ear drums and affect a person's hearing. People who work in places with loud sounds should wear headsets to protect their ears.

What Is Sound?

Our ears allow us to receive sound vibrations and translate them into meaningful messages. The ears control hearing. Nerves in the ear carry impulses to the brain. These impulses (IM-puhl-suhs) result in the messages we hear.

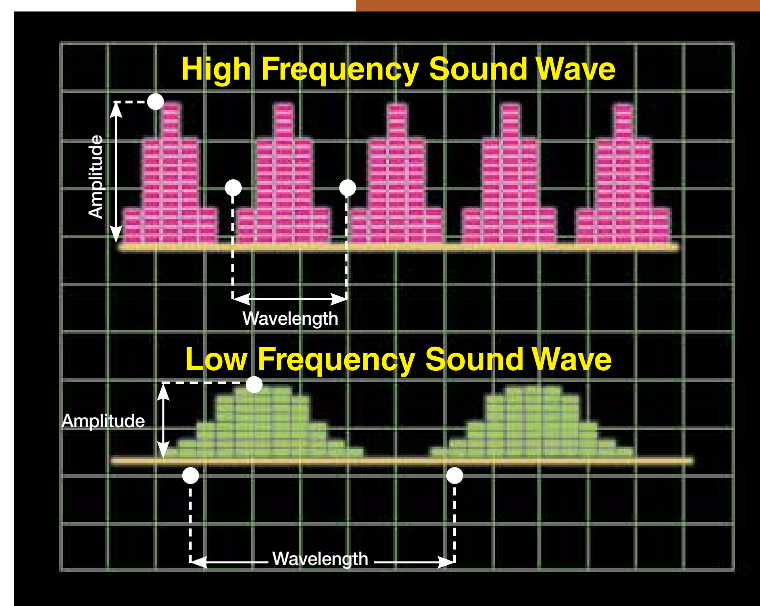
Sound comes from vibrations. Just like with light, atoms within substances move. Their movement creates **sound waves**. As the waves move through matter, they cause vibrations. The vibrations are picked up by the ear and sent as impulses to the brain. The brain translates them as the sounds we hear.



Sound Waves

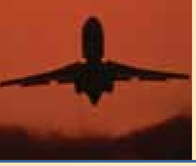
Not all sound waves are alike. The differences let us hear various sounds. Scientists have discovered that sounds and sound waves differ in the following ways:

- Wavelength is the distance between the troughs on either side of a single wave.
- Amplitude is measured in the height of the sound wave. It relates to loudness or softness of a sound. When a wave is high, the sound is loud and the amplitude is large. When a wave is low, the amplitude is small and the sound is soft.
- Frequency of sound relates to speed. The number of cycles per second that waves pass a given location is the frequency. The brain understands frequency as **pitch**. Fast vibrations cause high pitch. Slower vibrations make lower-pitched sounds. A tweeting bird makes a high-pitched sound. A roaring lion makes a low-pitched sound.



Did You Know?

Some animals can hear sounds at a higher frequency than humans can. If you have a pet such as a dog, you have probably seen it listening to something you cannot hear.

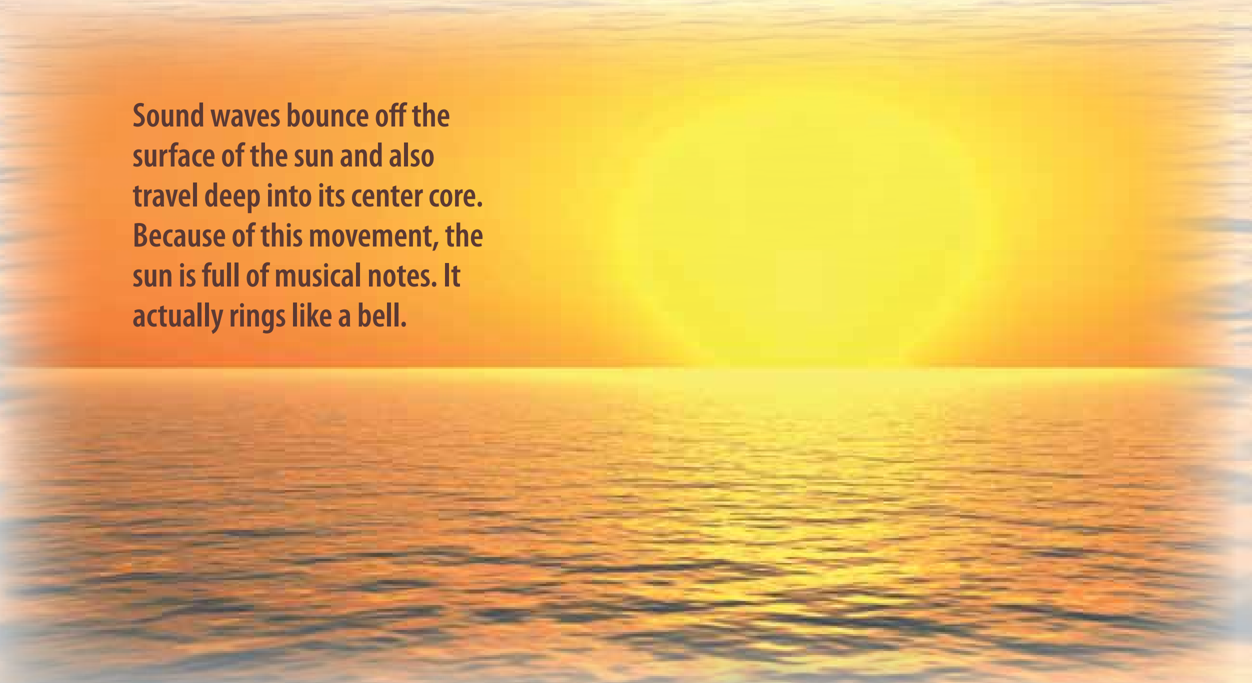


The Speed of Sound

Sound waves pass through all forms of matter. These include gas, liquid, and solid. The **speed of sound** changes as the waves pass these different states of matter. Sound waves move

- slowly through gases.
- more quickly through liquids.
- fastest through solids.

Temperature also affects the speed of moving sound waves. Higher temperatures cause sound to move faster. At normal room temperatures, sound travels about 343 meters (1,125 feet) per second. That is like traveling 1,217 kilometers (756 miles) per hour!



Sound waves bounce off the surface of the sun and also travel deep into its center core. Because of this movement, the sun is full of musical notes. It actually rings like a bell.

Chuck Yeager

A sonic boom cloud behind an F18 fighter jet

Boom!

Have you ever heard a big boom and couldn't figure out what made it? Objects—usually airplanes—cause **sonic booms** when they travel at supersonic speeds. Supersonic means speeds greater than the speed of sound waves through air.

A person on the ground might think the sonic boom is a crash of thunder. It is really a shock wave that was produced by the aircraft. When a plane nears the speed of sound, the air in front of the plane "piles up." It can't get around the plane fast enough. At the speed of sound, the air finally snaps around the plane. This creates a shockwave. The sudden change in air pressure goes BOOM!

Sonic booms can damage buildings, but they don't hurt people. On October 14, 1947, Captain Chuck Yeager of the U.S. Air Force was the first pilot to break the sound barrier.

Doppler Effect

As you've read, pitch is the highness or lowness of sound. The frequency of a sound determines its pitch. High-pitched sound has a higher frequency. Low-pitched sound has a lower frequency.

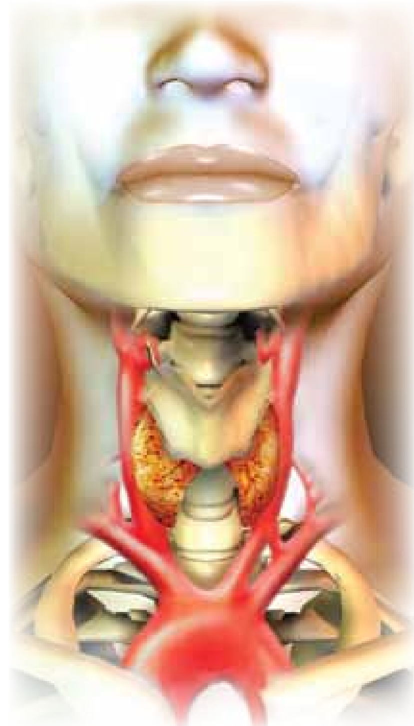
Have you ever noticed that the pitch of a fire truck's siren is high when it comes toward you? Then, it is lower as it passes and moves away. What causes this change?

As the fire truck approaches you, the waves reach you more frequently. The pitch is higher than if the fire truck were not moving.

This pitch change, which was caused by a moving object, is called the Doppler (DAHP-luhr) effect. The firefighters on the truck do not hear any change in pitch. Their distance from the source of the sound does not change. The Doppler effect only comes into play when the distance changes.

A sound's pitch changes as it approaches and passes you while you are standing in one place. This is called the Doppler effect.

Vibrations



Larynx

Living things and objects alike can make sounds. They do it differently, but they all rely on vibrations.

Humans

The larynx (LAR-ingks) produces sounds that become the human voice. The larynx is in the throat. Two small folded tissues stretch across the larynx. These tissues are called vocal cords. They have an opening that allows air to pass through. When people speak, muscles in the larynx relax and tighten. Air from the lungs passes the tightened vocal cords. The vocal cords vibrate and make sounds. Tight vocal cords vibrate fast and make high-pitched sounds. Relaxed vocal cords vibrate more slowly and make low-pitched sounds.

Animals

Almost all mammals have vocal cords or something similar. Many animals make sounds in other ways. A dolphin makes clicks and whistles in air-filled pouches connected to its blowhole. Bees buzz as they fly because their wings move rapidly. The wings make the air vibrate, producing sound. Other insects produce sounds by rubbing one body part against another. A cricket "sings" by scraping parts of its front wings together.

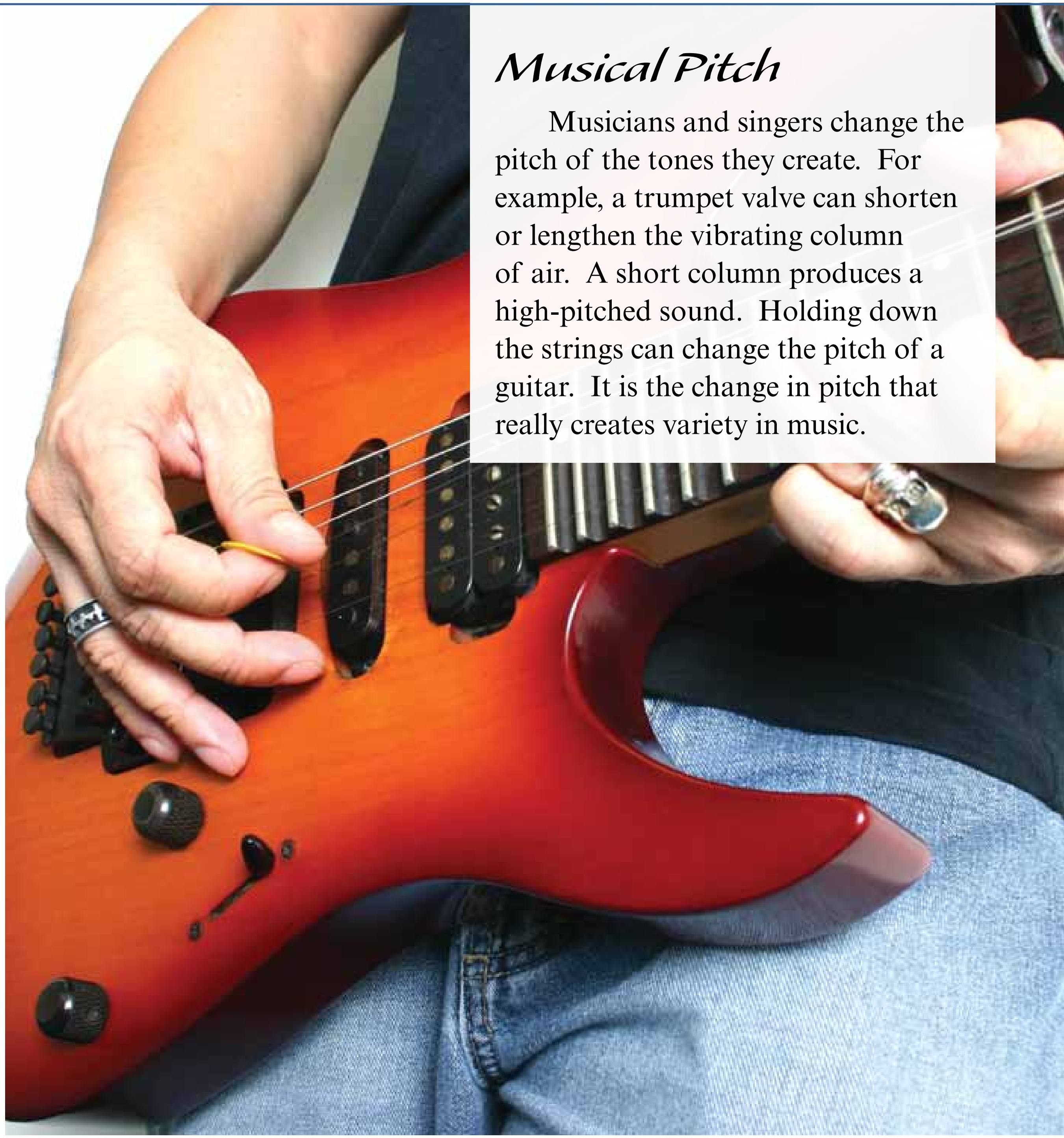
Frogs load their lungs with air and release it to produce croaking sounds.

The many sounds produced by instruments in a symphony blend to make one pleasing effect.

Instruments

Musical sounds are made in many ways, but they all rely on vibration. Percussion instruments make sounds when they are struck. When a drum is beaten, or a xylophone key is struck, vibrations result. String instruments, such as violins, harps, and guitars, make sound when the strings vibrate.

Woodwind instruments make sound when a player blows air through the mouthpiece. The air travels past a reed that vibrates. The vibration travels through the instrument and causes the air column to vibrate and produce sound. Brass instruments use the player's lips. A trumpet player's lips vibrate the air, which goes through the horn. The sound comes out louder and in different notes.



Musical Pitch

Musicians and singers change the pitch of the tones they create. For example, a trumpet valve can shorten or lengthen the vibrating column of air. A short column produces a high-pitched sound. Holding down the strings can change the pitch of a guitar. It is the change in pitch that really creates variety in music.

Ultrasound

Did you know that doctors use sound waves to take pictures of the inside of a body? A device known as an **ultrasound** uses sound to show what is happening inside. It turns the sound waves into pictures. Doctors can use the pictures made from the sound waves to treat patients. A pregnant woman may have an ultrasound to see the baby in her womb.

Can you tell what this ultrasound image shows?

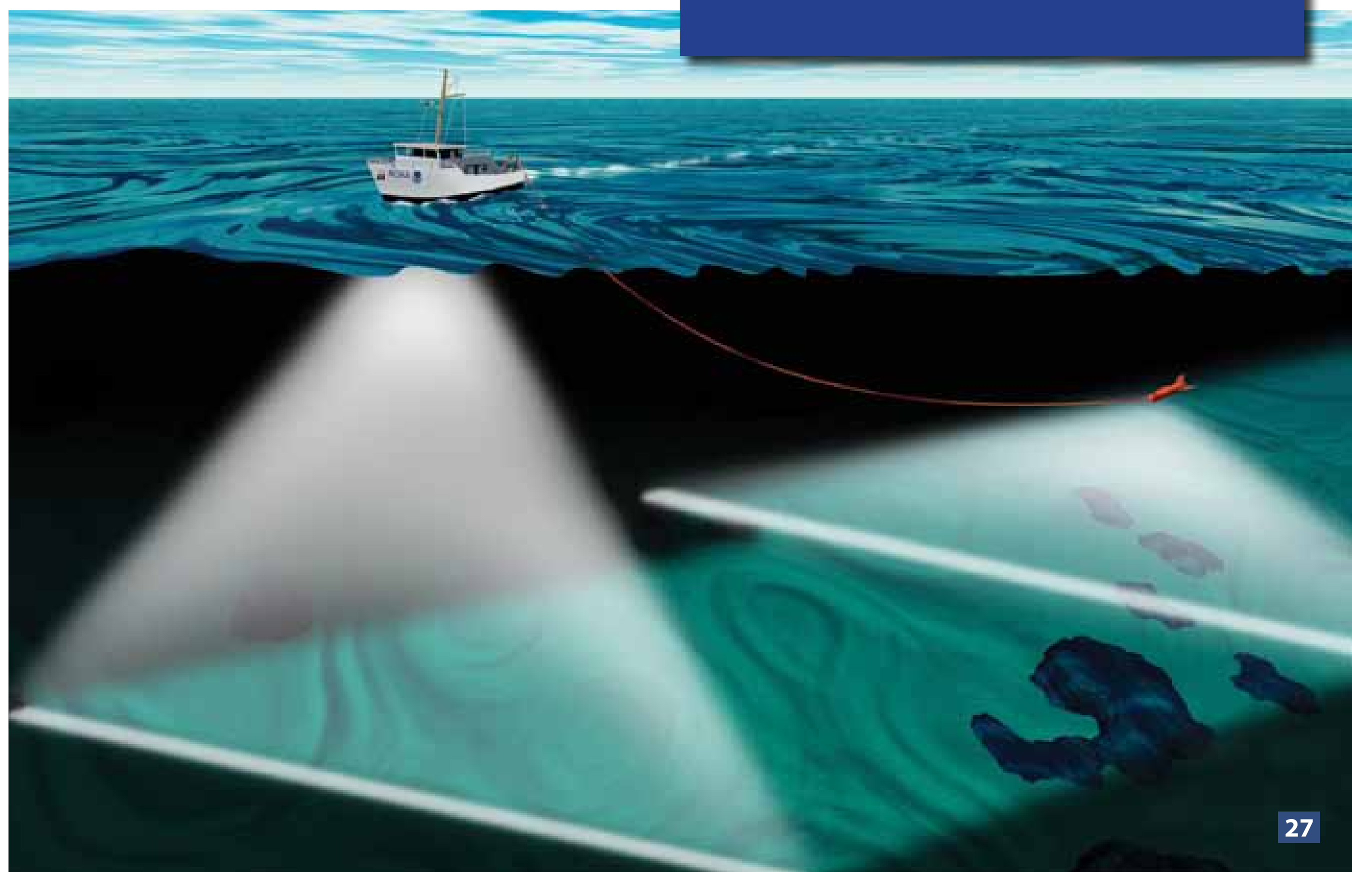
People cannot hear the waves of ultrasounds. The frequencies are too high for the human ear. Some animals use ultrasound to locate objects and other animals. For example, dolphins make a click sound to send out sound waves. The clicks can reach about the length of a football field. When the sound waves reach an object, more waves bounce back to the dolphin. Humans cannot hear the dolphins' clicks without special equipment.

Bats send out sound waves that bounce off insects and help them locate their dinner. This is called echolocation.

The object above is used to "read" sound waves as it is towed below the vessel. You can see it being towed below. This is one type of sonar device.

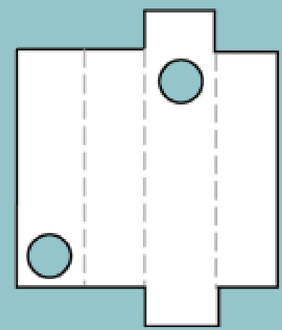
Sonar

Sonar stands for Sound Navigation Ranging. It is used in navigation and weather forecasting and for tracking moving objects. Airplanes, sea vessels, and missiles are commonly tracked with sonar. Sound waves bouncing off an object show its exact location. The waves are turned into images to create a picture of the object. Sonar is used to see images with sound.



Lab: *Make a Periscope*

Periscopes have been used for many years. Submarine sailors use them to see above water. Doctors use a type of periscope to look inside the body. Using the principles of light from this book, you can make your own periscope.



Materials

- 2 small mirrors
- stiff cardboard
- craft knife (only used with adult help)
- glue (strong enough to support a mirror)
- masking tape or wide clear tape

Procedure

1 Build the body of your periscope from cardboard. Follow the pattern shown on this page to create a hollow shaft to support your mirrors. Note the position of the tabs. Trace and cut the pattern from the cardboard. Take care when cutting the round holes.

2 Fold the cardboard along the dotted lines on the pattern. It may help to score the folds with a craft knife to make the bending easier.

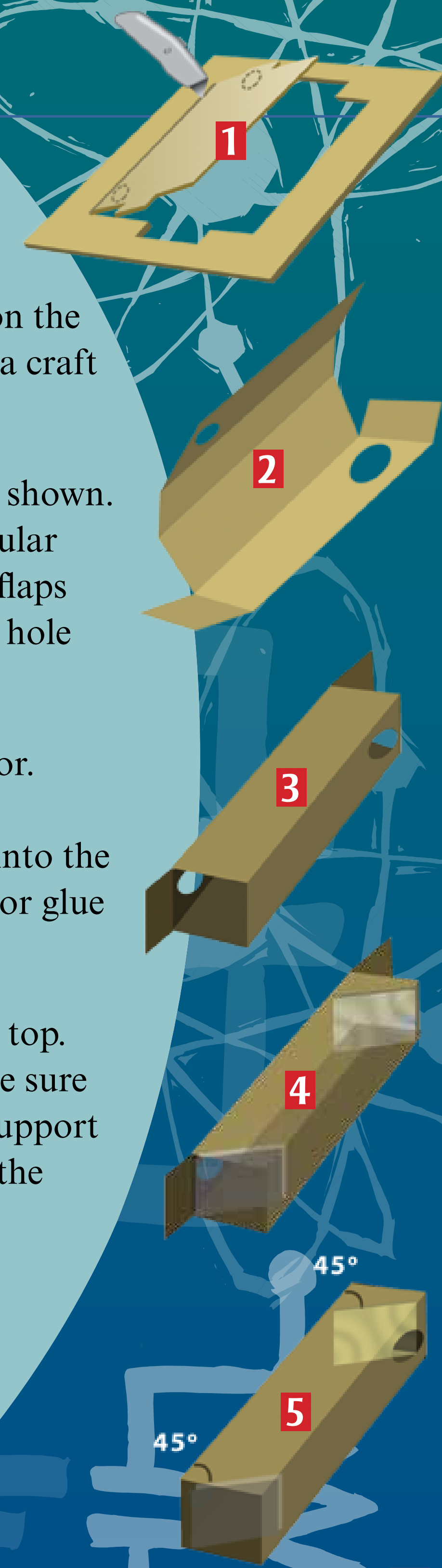
3 Assemble the shaft (box). Fold the sides as shown. Tape the long side closed to form a rectangular tube with flaps. Leave the top and bottom flaps open. Lay the box on its back with the top hole on your right side.

4 Attach a strip of tape to the edge of a mirror. Slide the mirror into the box end with the reflecting side up. (You should be looking into the mirror when you look into the hole.) Tape or glue the mirror in place.

5 Turn the box end up, with the mirror at the top. Push the mirror to angle it at 45 degrees. Be sure you can close the box lid over the mirror. Support the angle by taping reinforcements to hold the mirror in place.

6 Turn the box and repeat the procedure to install the second mirror.

7 Enjoy your periscope! Keep a notebook of the things you can observe.



Glossary

absorb—to take in radiant energy or sound waves

amplitude—the measure of a wave's magnitude or height

atom—the smallest particle of an element

filament—a thin thread or wire that is found inside a light bulb

frequency—number of times per second that crests of waves pass a checkpoint

optics—the science of light

pitch—the property of a sound determined by the frequency of the waves producing it

radiant energy—form of energy that can travel through space, e.g., visible light

reflect—return light or sound waves from a surface due to hitting the surface

refract—change direction of light or sound waves due to entering a new medium

solar energy—use of the sun's energy to produce electricity

sonar—system using sound waves to find objects or measure distances

sonic boom—sound waves that pile up into a shock wave when a source travels at or faster than the speed of sound

sound waves—form that sound takes when it passes through a substance

speed of light—the speed at which light travels through empty space

speed of sound—the speed at which sound travels in a medium under specified conditions

transparent—the state of a material in which light can pass through

ultrasound—a process using sound to show what is happening inside a body

vibration—repeating back-and-forth motion

wavelength—the distance along a straight line from one peak of the wave to the next

waves—any regularly recurring event that can be thought of as a disturbance moving through a medium

white light—a light mixture of wavelengths of various colors perceived as colorless, such as sunlight

Index

Sally Ride Science

Sally Ride Science™ is an innovative content company dedicated to fueling young people's interests in science. Our publications and programs provide opportunities for students and teachers to explore the captivating world of science—from astrobiology to zoology. We bring science to life and show young people that science is creative, collaborative, fascinating, and fun.

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All About Light and Sound

Light and sound are two of the most important ways to understand the world around us. The sun is Earth's main source of energy and light. Light bounces off objects and travels to our eyes. Our eyes and brain work together to translate that light into what we see, while our ears pick up sound vibrations and translate them into meaningful messages.

Physical Science

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