Read to Learn

Main Idea **Light is a form of energy that travels in waves.**

What Is Light?

Everything around you seems to have color. What is color? Why do you see color? To answer these questions, you need to learn about light.

Light is a form of energy. Light travels to Earth from the Sun. Two other sources of light on Earth include fire and light bulbs. Often sources of light also give off heat.

Usually a source of light gives off white light. White light is actually made up of all colors. These colors range from red to violet.

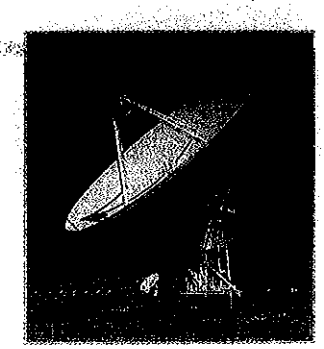
You can see the seven colors of light when white light from the Sun passes through tiny raindrops. The raindrops act like *prisms*. A prism is an object that separates white light into the colors that make it up. When raindrops separate light from the Sun, you observe a rainbow.

All light is made of waves. Light can be described using **wavelengths** (WAYV·lengkths). A wavelength is the distance from the top of one wave to the top of the next wave. Red light has the longest wavelength. Violet light has the shortest.

Scientists call the seven colors of light that make up white light the *visible spectrum*. A **spectrum** (SPEK·truhm) is a range of light

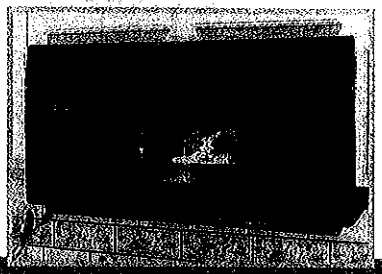
Electromagnetic Spectrum

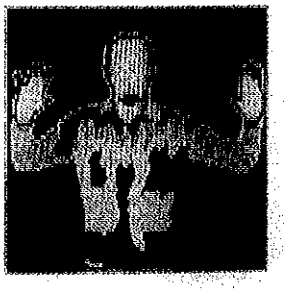
The electromagnetic spectrum contains a range of electromagnetic waves. These waves vary by their amount of energy.



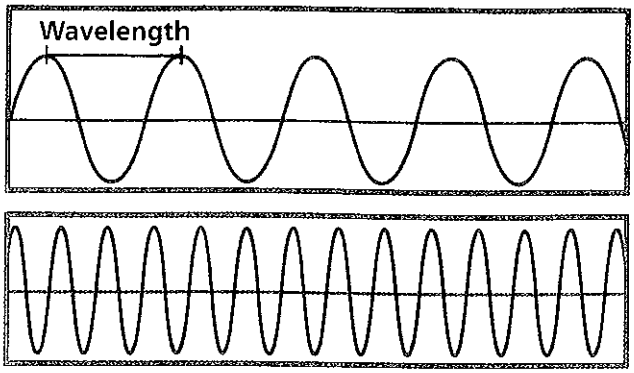
Radio waves are used to transmit radio and TV signals.

Microwaves can cook your food.





Infrared waves are felt as heat. Photos show the heat given off by objects. They can be taken



Low-energy waves have long wavelengths. As the energy of a wave increases, the wavelength decreases.

waves with different wavelengths and energies. The seven colors that make up white light are called the visible spectrum because they are light waves we can see.

As you read this book, light waves are traveling all around you.

The light waves you can see are in the visible spectrum. However, there are many waves you cannot see. The visible spectrum is only a small part of the *electromagnetic spectrum*.

The electromagnetic spectrum contains waves of many different wavelengths. Electromagnetic waves with the longest wavelengths are radio waves. They have the lowest energy. The electromagnetic waves with the shortest wavelengths are gamma waves. They have the highest energy. Look at the chart to see all of the waves that make up the electromagnetic spectrum.

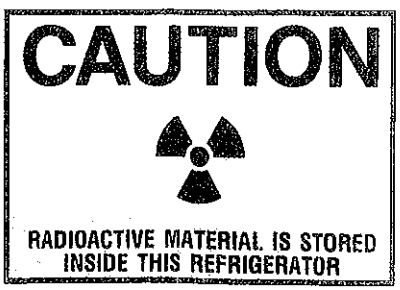
What is the electromagnetic spectrum?

Visible light allows you to see colors.

Ultraviolet light tans your skin but can also give you a sunburn.

X rays have many uses in medicine.

High-energy gamma waves are found in radioactive materials used in nuclear power plants.



Ultraviolet Waves | X-rays | Gamma Waves

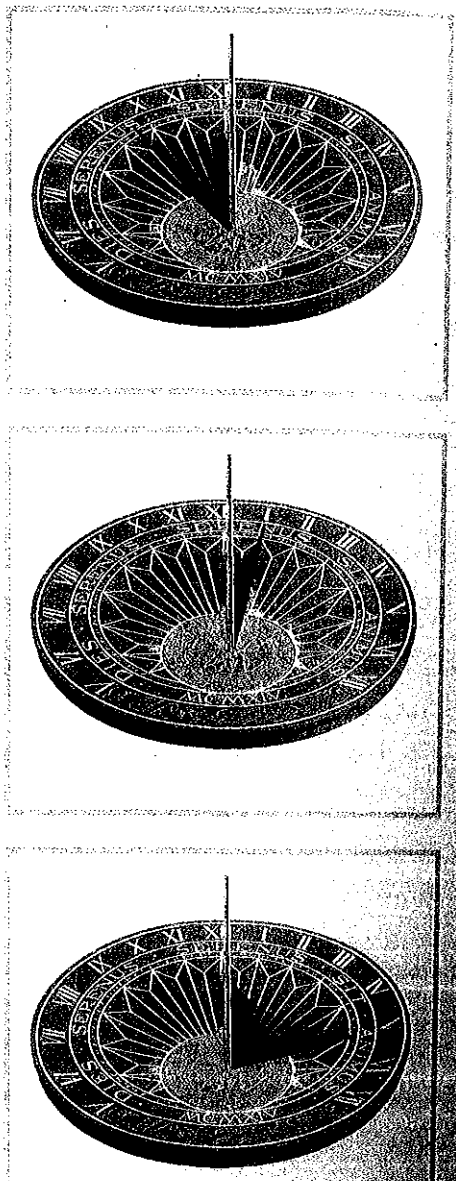
How Does Light Travel?

Have you ever made a shadow puppet? Shadows are places where light does not fall. A shadow forms when light is blocked. The light strikes an object but cannot pass through it. A shadow has the shape of whatever is blocking the light.

Shadows show that light travels in straight lines, or rays. Light spreads out from a source in all directions. However, light cannot bend and go around things. It cannot curve and "fill in" a shadow.

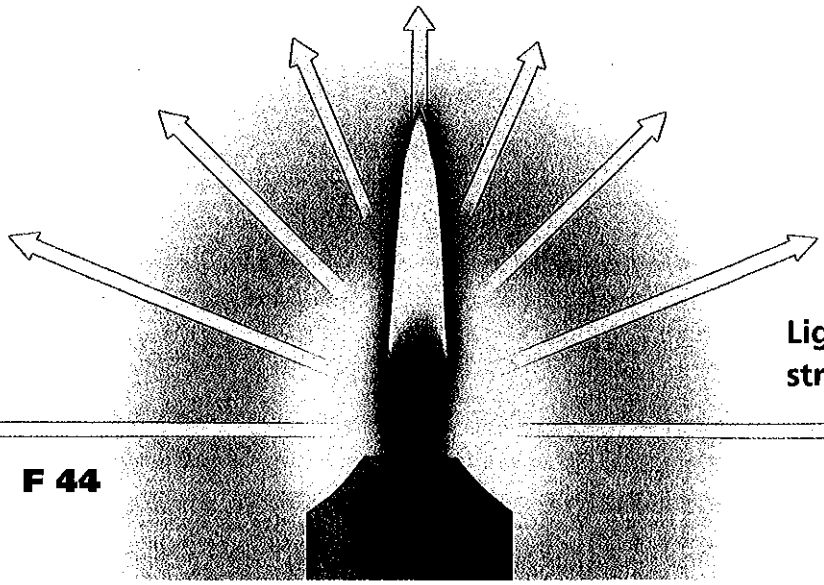
The size of a shadow depends on where the light source is. The closer an object is to a light source, the bigger the shadow. Light coming from above an object creates a shorter shadow. Light coming from the side of an object creates a longer shadow. A sundial tells time in this way.

A sundial tells time by using the position of the dial's shadow. As Earth rotates on its axis, the Sun moves across the sky. It casts its shortest shadow when it is directly overhead, at noon. It casts its longest shadow when it first appears and before it disappears.



Which sundial shows the time is 1:00? What time do the shadows on the other sundials read?

2 Why do shadows form?



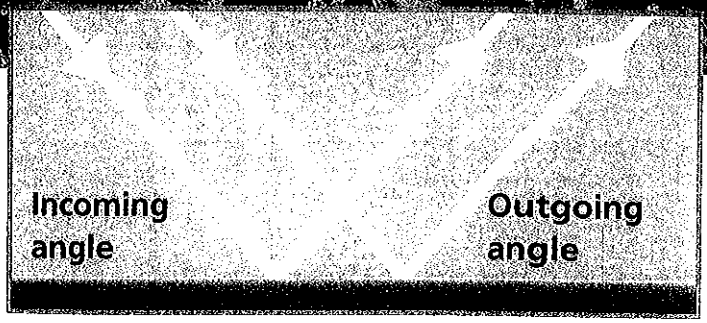
Light travels away from a source in straight lines and in all directions.

What Is Reflection?

Most of the light that reaches your eyes is reflected light. **Reflection** (ri·FLEK·shuhn) occurs when light strikes a surface and bounces off. When you throw a ball against a wall, it bounces off it. In a similar way, light bounces off, or is reflected, when it strikes a surface.

Most surfaces reflect at least some light. Smooth, shiny surfaces reflect almost all of the light falling on them. Very smooth, shiny objects reflect the most light and are used as mirrors.

What happens to light when it is reflected? Light changes direction when it is reflected off a surface. You can easily see this with a small mirror. Hold the mirror so it catches light rays coming from a flashlight. Move the mirror around, and see the spot of reflected light jump and jiggle. The rays bounce off the mirror and travel in a new direction.

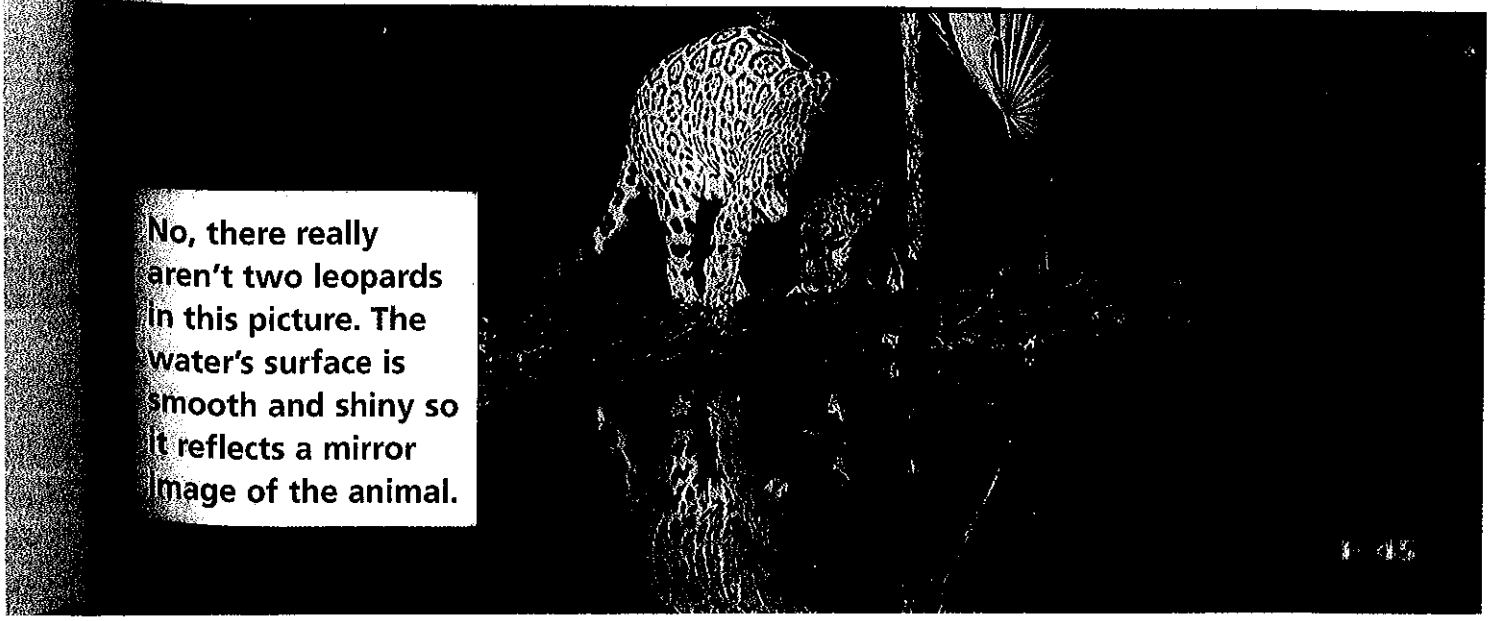


The law of reflection says that the incoming angle is equal to the outgoing angle.

The light rays from the flashlight are called the incoming rays. The reflected light rays are called the outgoing rays. Incoming rays strike the mirror at an angle called the *incoming angle*. Outgoing rays are reflected from the mirror at an angle called the *outgoing angle*.

Look at the diagram. What do you notice about the incoming angle and the outgoing angle? They are equal. With reflection the incoming angle is equal to the outgoing angle. This is called the *law of reflection*.

What happens to light when it strikes a surface?



No, there really aren't two leopards in this picture. The water's surface is smooth and shiny so it reflects a mirror image of the animal.

What Is Refraction?

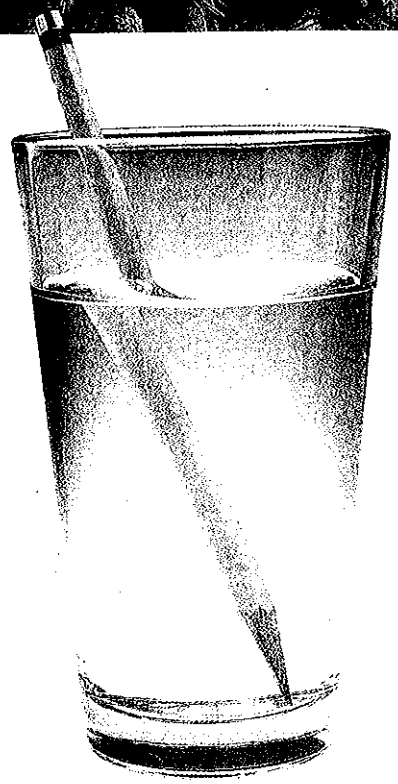
Look at the pencil in the picture. Is the pencil really cut in two pieces? No! It just appears to be. What do you think is happening?

The picture shows one example of **refraction** (ri·FRAK·shuhn). Refraction is the bending of light as it passes from one material into another.

Most materials reflect the light falling on them. However, some materials allow light to pass through. Refraction happens when light passes through glass, water, light plastic, and other transparent materials.

What do you think causes refraction? Light travels at different speeds in different materials. The more dense the material, the slower light travels through it. As light travels more slowly, it bends more. For example, water is more dense than air. It's harder for you to walk through water than air. It is also harder for light to move through water. Light slows and bends at the point where it passes from air to water.

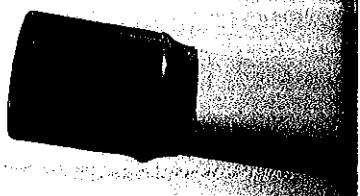
Earlier in the lesson, you learned that light travels in straight lines. This is still true during refraction. It is important to remember that a ray of light doesn't curve. During refraction the ray simply changes direction as it passes from one material to another.



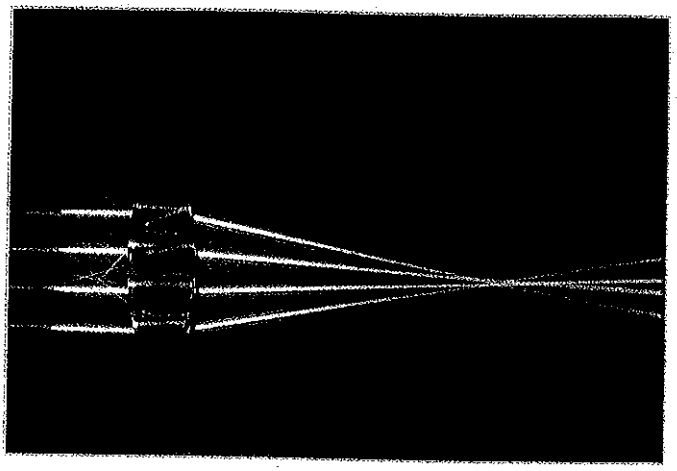
Refraction makes this pencil appear to be in two pieces!

Lenses are tools that refract light. They are used to gather light rays or spread them apart. When you wear glasses or use a camera, magnifying glass, or binoculars, you use one or more lenses.

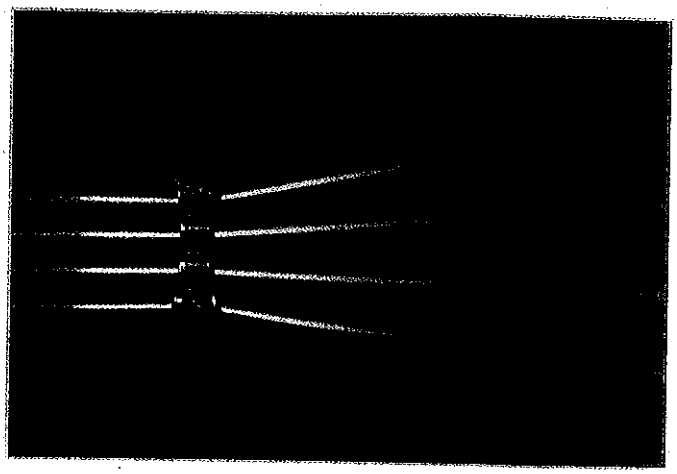
There are two kinds of lenses. One type, the *convex lens*, bulges in the middle. A convex lens brings



A telescope uses convex lenses to make distant objects appear larger and closer. Astronomers use telescopes to observe the stars and other planets.



The convex lens gathers light rays together.

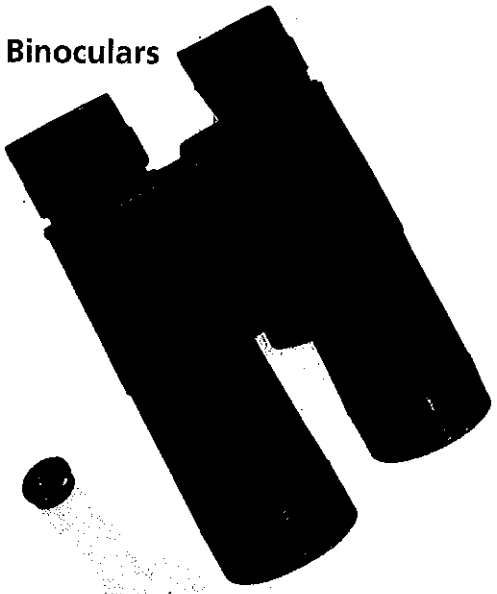


The concave lens spreads them apart.

rays of light together. Another type of lens, the *concave lens*, curves inward. A concave lens spreads light rays apart.

A magnifying glass is a convex lens. When you hold a magnifying glass near an object, light rays are reflected from the object to the lens of the magnifying glass. The lens then refracts the rays in such a way that the object looks bigger to you. Microscopes, telescopes, and cameras also use convex lenses.

When does refraction occur?



Binoculars

Microscope

How Do You See?

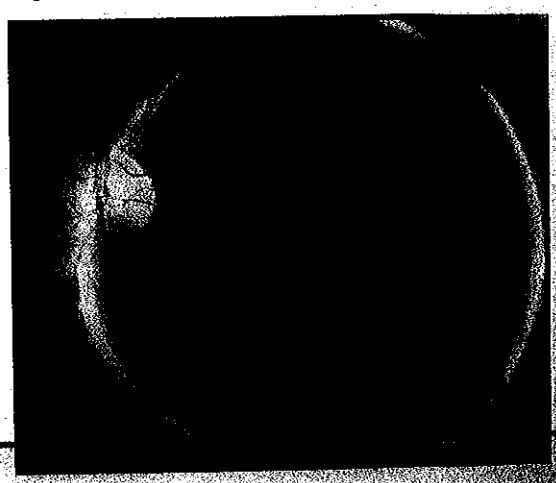
What happens to light when it reaches your eyes? First, it passes through a thin, clear tissue covering each eye called the *cornea* (KAWR·nee·uh). Then, light passes through an opening called the *pupil*. The pupil is the black spot in the center of each eye. After light passes through your pupils, it travels through your lenses. Each lens focuses light onto the back of your eye. A tissue called the *retina* (RET·uh·nuh) covers the back of your eyes.

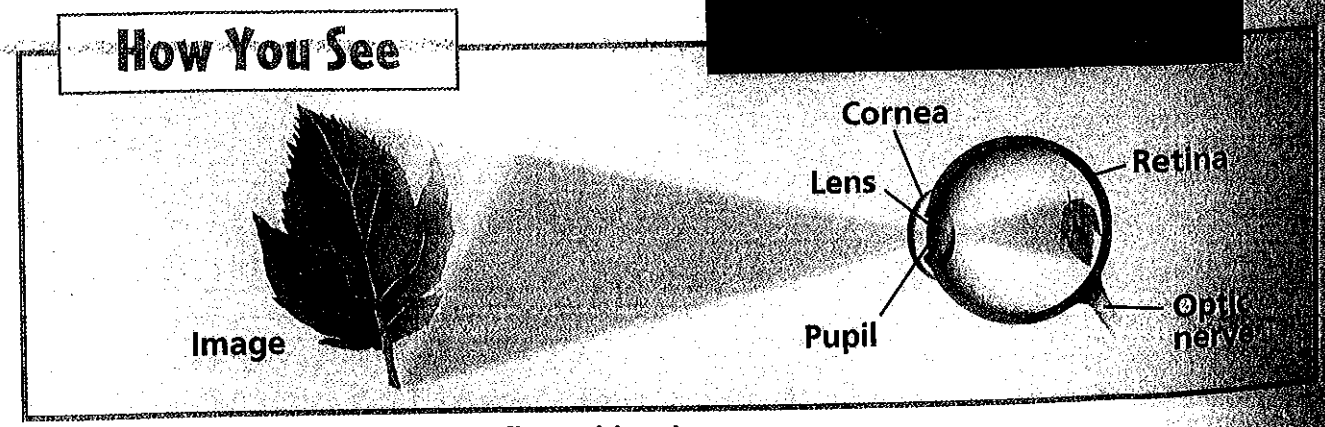
Did you know that the images focused on your retinas are actually upside down? Your retinas change the images into signals that travel along your optic nerves to your brain. Your brain sees the picture right-side up.

Why do you see green grass, red apples, and purple grapes? The answer has to do with the way that matter reflects and absorbs light.

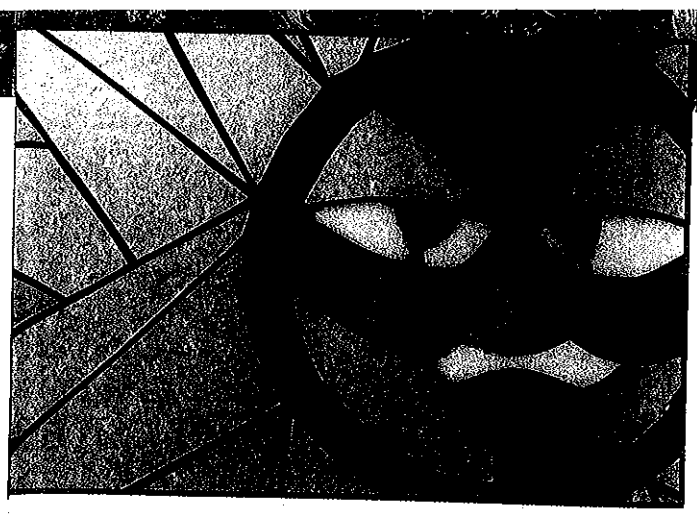
What if white light is shining on a green leaf? The leaf absorbs the entire visible spectrum of light energy except for light that has wavelengths for green light. These light waves are reflected off the leaf and into your eyes. The leaf appears green. The color of an object depends on the color of the visible spectrum it reflects.

This photo shows you how an image is formed upside down on the retina. After it travels to the brain, you see the image right side up.





You see objects because light reflected by them enters your eyes. A lens in the front of each eye bends the light and makes an image. Nerves bring this image to your brain.



White and black are not true colors. White things appear white because they reflect all wavelengths of light. White objects do not absorb any light energy. They tend to be cooler when placed in sunlight because of this. Black objects do just the opposite. Things appear black because they absorb all the wavelengths of the visible spectrum. Black objects tend to be warmer when placed in sunlight.

When light strikes different objects, it can be blocked or it can pass through. Many materials block light rather than let it pass through. Such materials are described as *opaque*. Wood, metal, and people are opaque objects.

Some materials are *transparent*. They let light pass through. Glass and water are transparent. You can see through them.

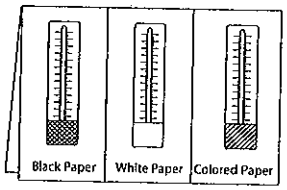
Translucent materials reflect some light and let the rest pass through. Cloudy looking plastics are translucent.

Why do objects appear to be a certain color?

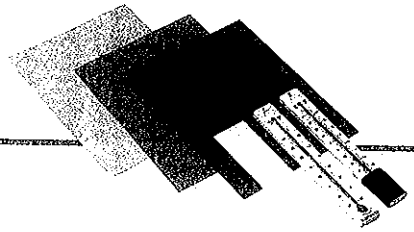
QUICK LAB

Absorbing Light

FOLDABLES Make a Three-Tab Book. (See p. R43.) Label the tabs as shown.



1. **Predict** Wrap a thermometer in black paper. Wrap a second thermometer in white paper. Put the two thermometers on a sunny windowsill or under a desk lamp. Predict which thermometer will heat faster.
2. **Measure** Read each thermometer after ten minutes. Record the temperatures on the front tabs of your Foldables book.
3. Under the tabs, write about what happened to each thermometer. Which warmed up faster?
4. **Infer** Why do you think this happened?
5. **Hypothesize** What do you think would happen if you tried different colors of paper? Test your hypothesis.

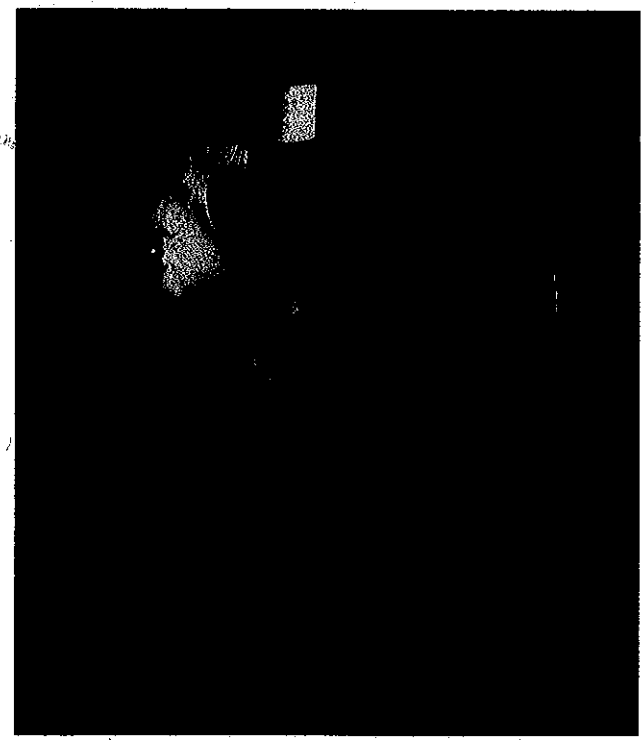


What New Technology Uses Light?

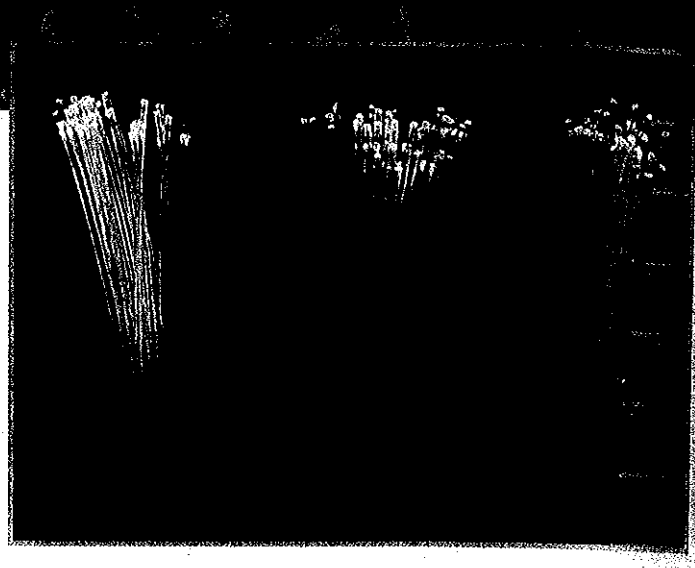
Have you ever seen a laser? Lasers read the bar codes at supermarket checkout counters. Lasers are used in many other ways, too.

Lasers are tubes of gas. They use electricity to produce thin beams that have one wavelength of light. All the rays of a laser travel in the same direction. This creates a very intense, high-energy beam. Lasers are so powerful that they can cut through steel! Doctors use lasers to do surgery because the beams are so narrow. Lasers are also used to make and interpret compact discs.

Another important technology that uses light is optical fibers. They are tubes made of glass or plastic.



Lasers are used to do delicate surgery.



Today most long-distance phone calls are carried along optical fibers.

Optical fibers keep the light energy inside the entire length of their fiber. They are also called *light pipes* because they carry light from place to place.

Scientists have found ways to code information in light. Optical fibers can carry large amounts of coded information from place to place. This information includes voices, images, and other data. The information can travel at nearly the speed of light. That's the fastest anything can possibly go! This means that optical fibers can bring you e-mail, colorful websites, music, and more over the Internet. Optical fibers deliver the Internet fast! What other light-based technologies might be next?

READING **Compare and Contrast**
How are lasers and optical fibers alike? Different?

Lesson Review

Why It Matters

Visible light, in all its colors, allows you to see. If you understand light's properties, you can explain shadows, color, refraction, and your reflection in a mirror. You can also understand the tools and technologies that use light.

Many new technologies that use light are still being developed.

e-Journal Visit our Web site www.science.nmhschool.com to do a research project on light technology.

Think and Write

1. Which has more energy—radio waves or X rays? Which waves have a longer wavelength?
2. How do we know that light travels in straight lines?
3. Why can you see your reflection when you look at a mirror and not at a book?
4. Does the light that passes through binoculars get refracted? Explain.
5. **Critical Thinking** Why does it feel cooler in the shadow of a big tree on a sunny day?

L·I·N·K·S

WRITING LINK

Explanatory Writing Traffic lights make transportation by foot, bicycle, and car safer. Explain how light is used to make other forms of transportation safer.

SOCIAL STUDIES LINK

Do research. Who were the first people to use lenses? Who were the first people to use telescopes? How were telescopes invented? Use the Internet or an encyclopedia to learn more about lenses and how they have developed. Write a report to tell what you have learned.

HEALTH LINK

Make a chart. Some light rays can be dangerous. Too much sunlight, for example, can be harmful to your skin. Make a list of radiation sources. Tell ways you can protect yourself from too much radiation. Organize your safety tips in a chart.

MATH LINK

Solve a problem. If the incoming angle of light is 45 degrees, how big is the outgoing angle? How do you know?

TECHNOLOGY LINK

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