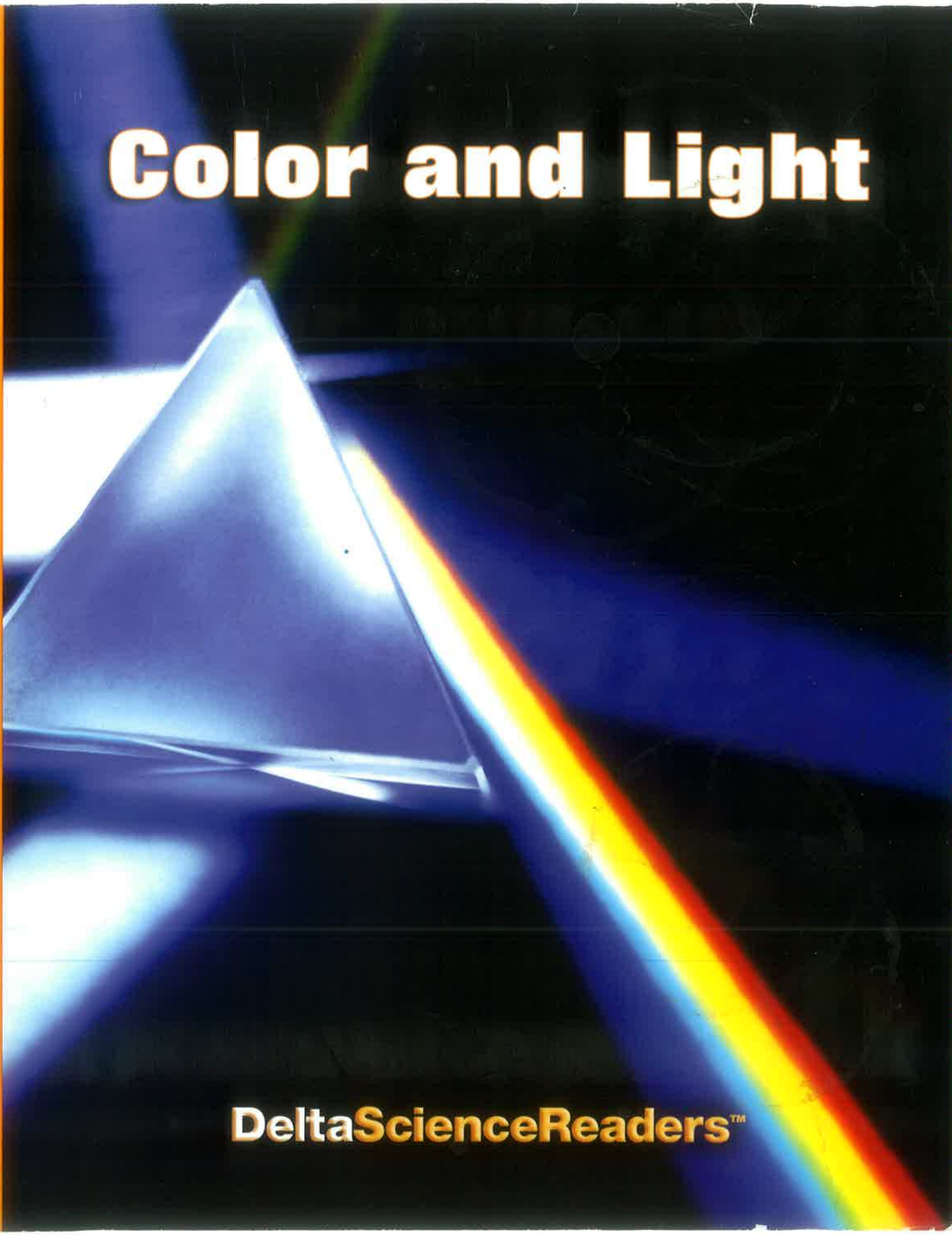
Color and Light



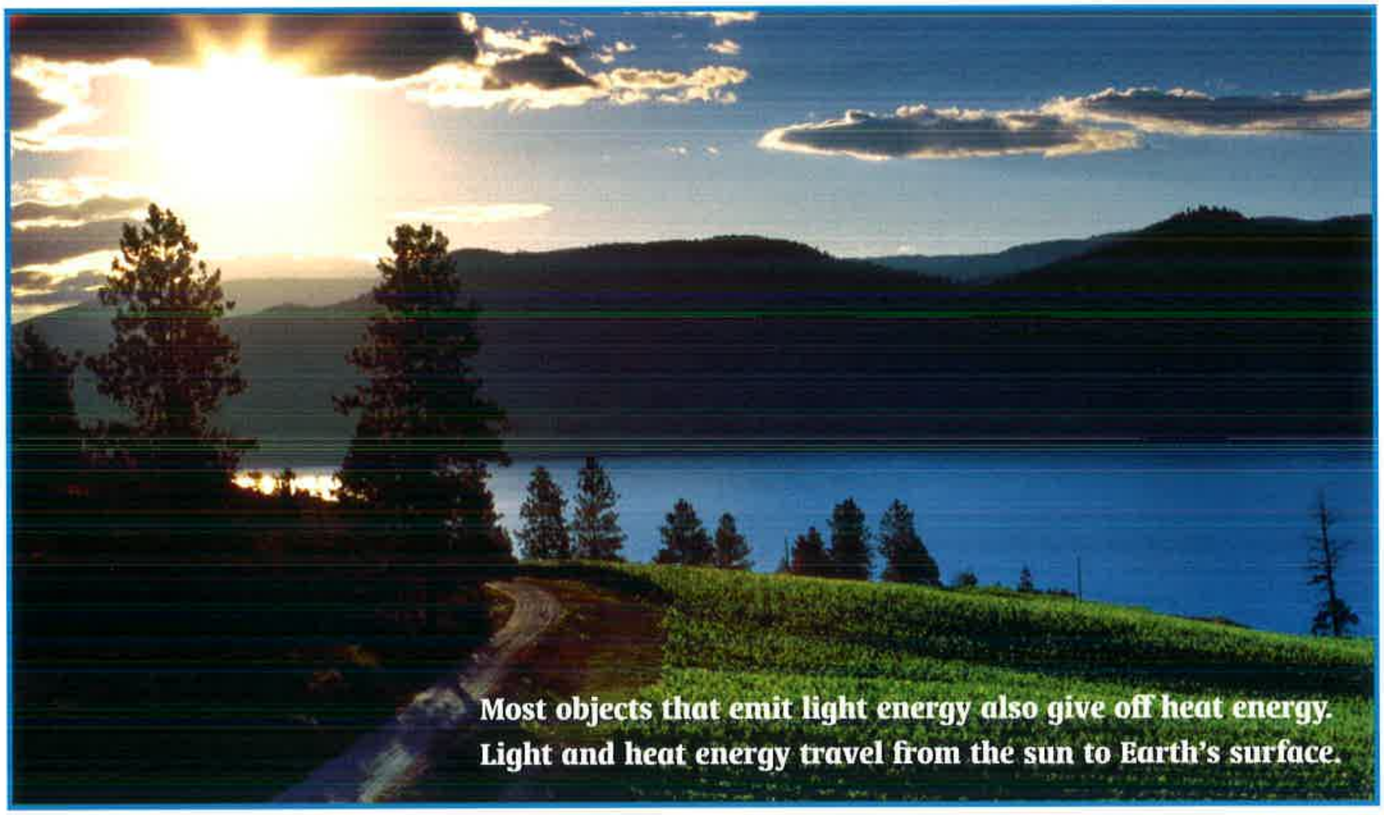
DeltaScienceReaders™

Delta Science Readers™

Color and Light

CONTENTS

Think About . . .



Most objects that emit light energy also give off heat energy. Light and heat energy travel from the sun to Earth's surface.

What Is Light?

Light is a form of energy. **Energy** is the ability to cause change. Electricity, sound, mechanical motion, and heat are also forms of energy. The sound energy of an explosion can cause windows to rattle or even break. The heat energy of an oven can bake a cake. The light energy that comes from the sun to Earth can cause skin to become sunburned.

Like water waves in a lake, light travels in waves. A **wave** is a rhythmic pattern that carries energy. Light waves are **electromagnetic waves.** These waves are made of vibrating electric and magnetic fields.

Light bulbs give off, or emit, light waves by changing electrical energy into light energy. Other sources of light are the sun, fire, lasers, and even some animals such as fireflies and certain deep-sea fish.

People can see objects that are sources of light. People also can see objects when a light source shines on them. We need light to see. We cannot see in complete darkness.

Light travels in a straight line until it strikes an object. Light **rays** do not curve around corners. We can hear the sound of a barking dog around the corner of a building, but we cannot see the dog.

Light waves travel much faster than water waves. Light waves travel nearly 300,000 kilometers (186,300 miles) per second. Light from the sun takes only eight minutes to reach Earth.

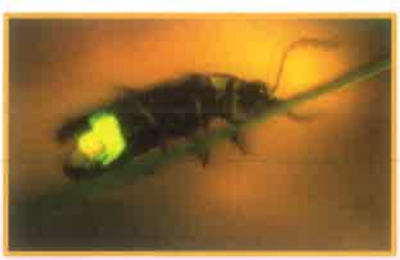
Light from the sun reaches Earth because light waves can travel through empty space. Other waves such as sound waves cannot do that. Sound waves need air or some other material to travel through.

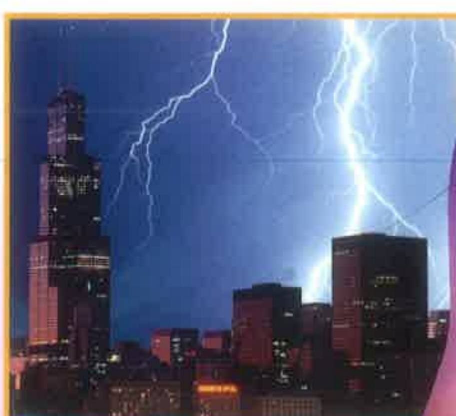
Sources of Light


fire


flashlight


laser


firefly


lightning

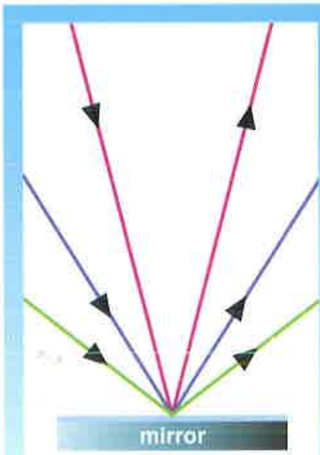

light bulb

Reflection of Light

Light striking some surfaces bounces back, or **reflects,** from the surface. Light reflects best from smooth, shiny surfaces. An **image** is formed when light reflects off a smooth, shiny surface such as a mirror. You can see an image or reflection of yourself if you look at a piece of smooth, shiny aluminum foil.

Mirrors are very smooth surfaces made of polished metal or silver-coated glass. A ray of light reflects off a flat mirror the same way a ball bounces off the floor. If a ball drops straight down to the floor, it bounces straight back up. A light ray shining straight at a mirror reflects straight back out. If a ball hits the floor at an angle, it bounces off at an angle. A light ray hitting a mirror at an angle will reflect off the mirror at the same angle it strikes the mirror.

Rough, shiny surfaces also reflect light, but complete images do not form. That is because rough surfaces such as wrinkled foil cause the light rays to scatter. That means the rays reflect in many different directions.



Light reflects off a mirror in straight lines at the same angle that the light hits the mirror.

When water is calm and smooth, light reflects off the water's surface to form images.

Absorption of Light

Light that shines on objects is not always reflected. Sometimes light is taken in, or **absorbed,** by the object. Some of the light that is absorbed by objects is changed into heat energy. Dark-colored objects absorb more of the light that strikes them than light-colored objects do. So when the sun shines on them, dark objects get warmer than light objects do. That is one reason that people often wear light-colored clothing on a hot, sunny day.

Refraction of Light

A straw in a glass of water may appear to be broken at the water line. This strange sight is caused by the way light travels. Light travels at different speeds through different materials. For example, light travels faster through air than it does through water. When light changes speed going from one material to another, it often bends, or changes direction.

When a light wave hits a new material at an angle, the part of the wave that hits the material first is slowed. The rest of the wave keeps moving at the same speed until it hits the material. This causes the light wave to bend. This bending of light is called **refraction.**

The refraction of light can make some objects look very odd. The turtle's head looks as though it is in two sections.

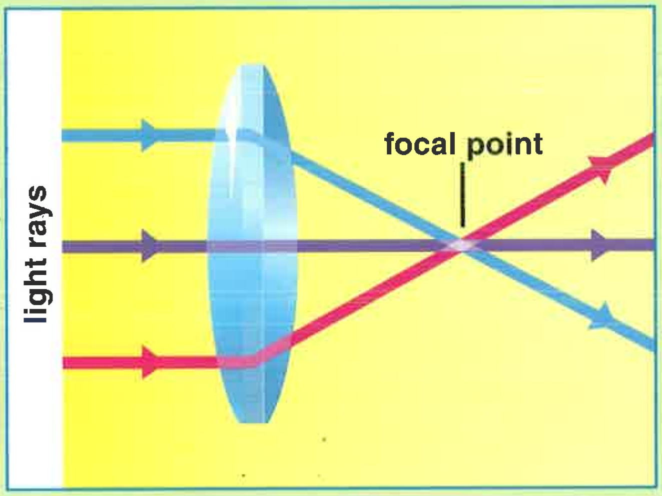
The "water" on the road is not really there. Light bends as it travels from cold air to warm air and creates a mirage.

Suppose you are riding in a car. You see something that looks like a puddle of water on the road ahead. But as you get closer, the puddle disappears. The puddle that was not really there was a mirage.

A **mirage** is produced when light bends as it passes through air of different temperatures. The dark road heats up from sunlight hitting it. The road heats the air just above it. Higher up, the air is cooler. Light from the sky reaches the hot air above the road and bends up toward your eyes. As a result, the blue "water" you see on the road is actually an image of the blue sky caused by refracted light.

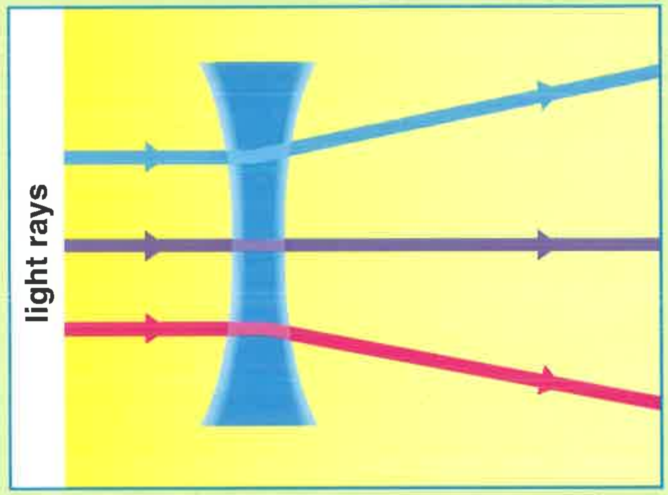
convex lens

Light rays bend toward each other.



concave lens

Light rays bend away from each other.



Lenses Light is also refracted when it passes from air into clear glass or plastic. Because of this property, we use glass and plastic to make lenses. A **lens** is a smoothly curved piece of glass or plastic. Lenses refract light in special ways.

Lenses are grouped into two types based on their shapes. **Convex lenses** are thicker in the middle than at the edges. These lenses bulge in the middle like a football. **Concave lenses** are thinner in the middle than at the edges.

When light rays pass through a convex lens, the rays are refracted so that they come together at a point behind the lens. This point is called the **focal point.** A camera uses a convex lens to focus light rays. Microscopes and telescopes also have convex lenses in them. A magnifying glass is a convex lens. People who do not see nearby things well may wear eyeglasses with convex lenses. If you look through a convex lens at a close object, it looks bigger.

When light rays pass through a concave lens, the rays do not come together at a focal point. Instead, they are bent and spread apart as they pass through the lens. People who do not see distant things clearly may wear glasses with concave lenses.

What Happens When Light Hits Different Materials?

A flashlight, a candle, and a light bulb are sources of light because they give off their own light. Objects that give off their own light are called **luminous** objects. The sun is a luminous object that is the source of light for Earth and the rest of our solar system.

When light from a luminous object strikes another object, the light may be reflected. An object that reflects light is called an **illuminated** object. A book may be illuminated by light from a light bulb. The moon is illuminated because it reflects sunlight that strikes its surface. The moon does not give off its own light.

When light shines on an object, one of three things can happen. An object may block the light and cast a **shadow.** An object that blocks light is called an **opaque** object. If you put a book in front of a flashlight, you will see a dark shadow opposite the light because the book is opaque.

Another object may transmit light, or let almost all the light pass through it easily. This kind of object is called **transparent.** A window of clear glass is transparent because it allows most light to pass through. Transparent objects usually form only faint shadows.

A third object may let only some of the light pass through. This kind of object is called **translucent.** A frosted glass window is translucent because it will allow some light to pass through, but not as much as a clear glass window would allow. The frosted glass used for some light bulbs is also translucent. A translucent object may cast a partial shadow.

opaque

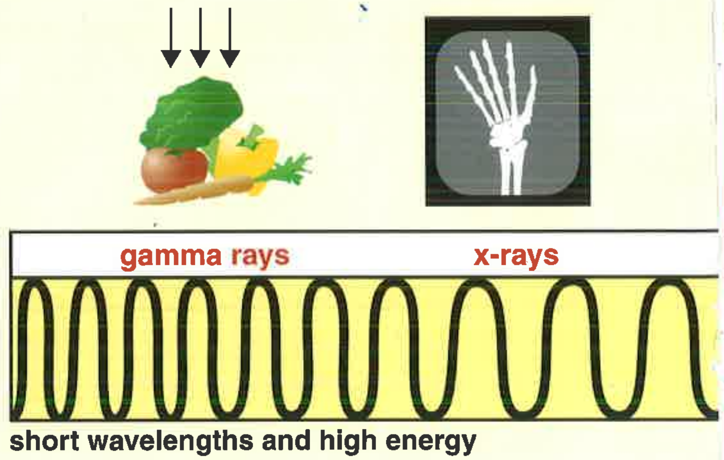
transparent

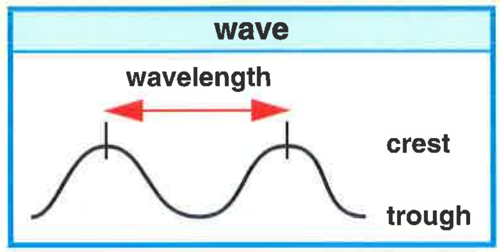
translucent

Electromagnetic Spectrum

Light from a light source such as the sun, a flashlight, or a light bulb is called **white light.** But white light is really made of all colors. These colors can be seen in a rainbow or when white light passes through a prism. A **prism** is a solid, transparent object that refracts light that passes through it. Prisms separate the colors in white light.

Light travels in waves. Some parts of light have shorter wavelengths than others. **Wavelength** is the distance from one wave crest to the next. Different wavelengths produce different colors of light.

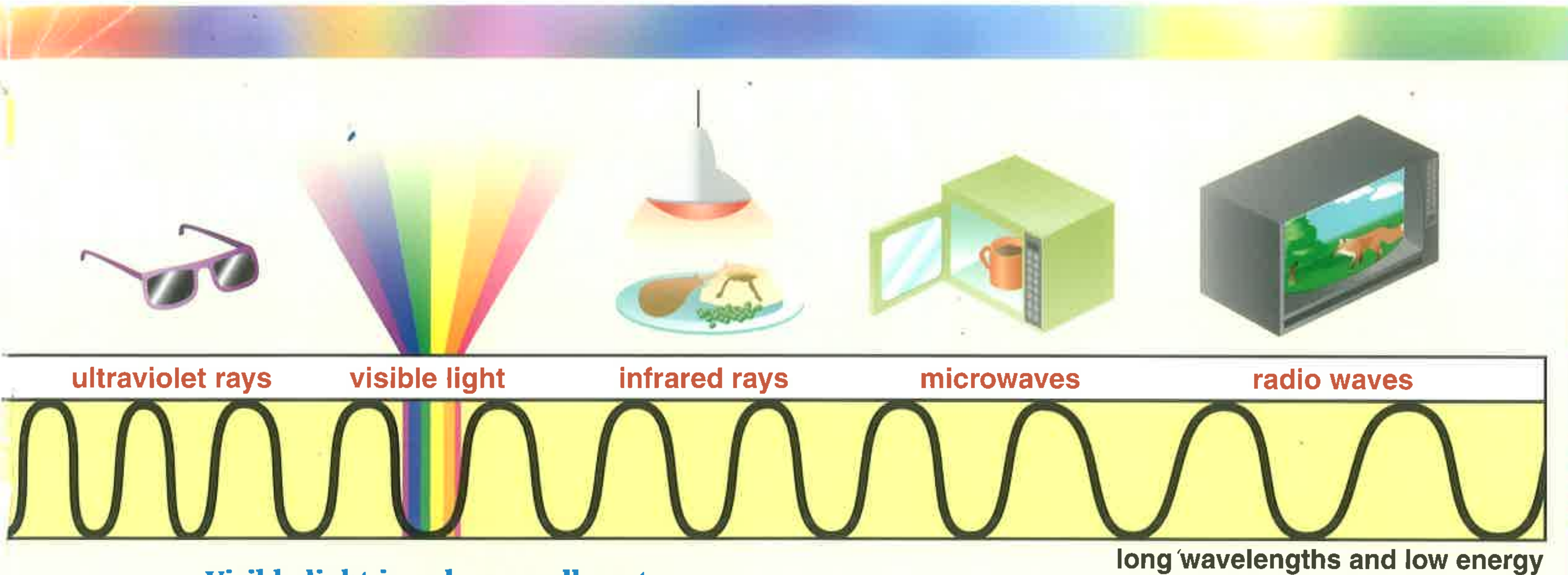




The visible spectrum has a gradual change from one color to another. Sometimes it is difficult to see the individual colors.

When white light passes through a prism, the light is refracted. The refraction separates the colors that make up white light into a band of colors called the **visible spectrum.** The colors in the visible spectrum are red, orange, yellow, green, blue, indigo, and violet. A way to remember the colors is to think of the name ROY G BIV.

Each color of the visible spectrum is refracted a different amount. Violet light has the shortest wavelength. It is refracted the most. Red light has the longest wavelength and is refracted the least.



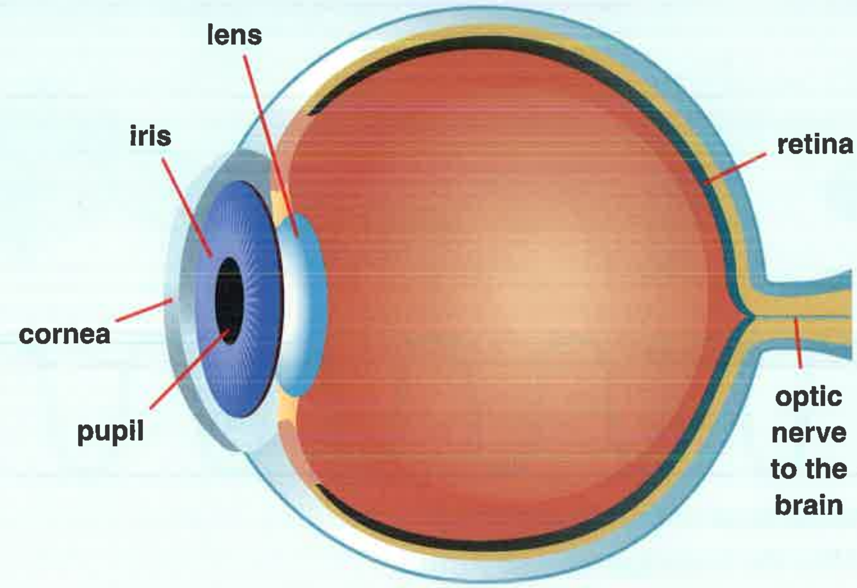
Visible light is only a small part of the electromagnetic spectrum.

The **electromagnetic spectrum** includes the visible spectrum as well as other wavelengths that people cannot see. Waves with the shortest wavelengths are on one end of the electromagnetic spectrum. They have shorter wavelengths than violet light. Waves with the longest wavelengths are on the other end of the electromagnetic spectrum. They have longer wavelengths than red light. Some animals can see parts of the electromagnetic spectrum that people cannot see.

Three kinds of electromagnetic waves have shorter wavelengths than the visible spectrum. These waves carry a lot of energy. People can use these high-energy waves, but they must be careful doing so because the waves can be dangerous.

Gamma rays can be used to kill harmful bacteria in foods. **X-rays** are used to find tooth decay or to check for broken bones and other problems inside the body. Doctors also use gamma rays and x-rays to kill cancer cells. **Ultraviolet rays** can cause sunburn and skin cancer. They also can harm eyes. But they are helpful when they are used in hospitals to kill harmful bacteria.

Three kinds of electromagnetic waves have longer wavelengths than visible light. These waves have low energy. Hospitals use **infrared rays** to treat some skin problems or sore muscles. Infrared lamps are also used to keep food warm. Night-vision goggles work by sensing infrared rays. **Microwaves** are used to cook or heat foods. **Radio waves** bring television and radio programs into our homes.



We see objects because light reflects off them and enters our eyes. The parts of the eye work together to take in light and send signals to the brain.

How Do We See Objects?

We see an object when light from the object enters our eyes. The light that enters our eyes can be from a luminous object or from an illuminated object. We see most things because light is reflected from them to our eyes. Our eyes receive the light and send a message to our brain.

Light enters the front of the eye through a clear layer called the **cornea.** The cornea covers the pupil and the iris. The **pupil** looks like a black circle in the center of the **iris.** The iris is the colored part of the eye. The pupil is the opening through which light enters the eye.

The iris is made of tiny, ring-shaped muscles. The iris expands and contracts to control the amount of light entering the eye through the pupil. In dim light, the pupil becomes larger to allow more light into the eye. In bright light, the pupil becomes smaller. This protects the eye by keeping too much light from entering it.

A convex lens lies just behind the iris and pupil. This lens focuses light just as a glass lens does. The lens can change its shape slightly to become thicker or thinner. The lens becomes thicker when we look at a close object. The lens becomes thinner when we look at something far away.

The lens turns the image of what we see upside down. The upside-down image forms on the **retina** at the back of the eye. Special cells in the retina send signals about the image along the **optic nerve** to the brain. The brain turns the image right side up so we see things the right way.

How Do We See Colors?

White light contains all the colors of the visible spectrum. When white light shines on many objects, we see colors. The colors that we see depend on the wavelengths of light that are reflected and absorbed by an object.

What happens when we see a rose with red petals and green leaves? We see the flower because it reflects light to our eyes. But most of the light that hits the rose is absorbed and not reflected. Red petals absorb wavelengths of all the colors of white light except red. The petals look red because they reflect only wavelengths of red light to our eyes. The green leaves absorb wavelengths of all colors except green. The leaves look green because they reflect only wavelengths of green light to our eyes.

What makes some objects look black, white, or gray? These objects absorb or reflect all wavelengths of light equally. The more light an object absorbs, the darker it will be. A black object absorbs all the light that hits it and reflects none. A white object reflects all the light that hits it and absorbs none. A gray object absorbs some light and reflects some light.

Black and white are not colors. The white in a zebra's coat is due to the reflection of all colors of light. The black in a zebra's coat is due to the absorption of all colors of light.

Colored light can change the way objects look. Theaters often use spotlights to light objects on a stage. **Color filters** are used on these lights. Color filters allow only certain colors of light to pass through them. The filters absorb all the rest of the colors. When white light shines through a blue filter, only blue light passes through. All the other colors of the spectrum are absorbed by the filter.

Suppose light shines on a rose through a green filter. The filter absorbs all the colors but green, so only green light shines on the rose. The green leaves will reflect the green light and still look green. But the red petals can reflect only red light. The green light striking them is absorbed, and no light is reflected. Objects that absorb all the light that shines on them look black. So the rose petals will look black.

The top picture shows a rose with white light shining on it. The bottom picture shows the same rose with green light shining on it.

What Are the Primary Colors of Light?

Red light, green light, and blue light are the **primary colors of light**. These colors can be mixed together to make the other colors found in white light. Suppose beams of red, green, and blue light shine on white paper. Where the colored beams overlap, other colors are produced.

Where red and green light overlap, yellow light is produced. Where red and blue light overlap, a reddish-blue color called magenta is produced. Where blue and green light overlap, a greenish-blue color called cyan is produced.

Where all three colors of light overlap, white light is produced. This is because white light is made up of all the colors of the visible spectrum. When beams of colored light are mixed, each color adds its light to the mixture. So a mixture of all the colors of light looks white.

All colors of the visible spectrum can be made by using various amounts of red, green, and blue light. Combining different colors of light to make new colors is called additive color mixing.

Most televisions work by combining the three primary colors of light. The picture is actually made of tiny dots of red, green, and blue light. Our eyes blend the dots together to make all the colors we see on the screen. For example, we see red dots next to blue dots as magenta. We see red dots next to green dots as yellow, and we see blue dots next to green dots as cyan. When we see all three colors of dots next to each other, we see white.

Since cyan light is a mixture of blue and green light, mixing cyan and red light will make white light.

People in Science

Annie Jump Cannon (1863–1941)

Annie Jump Cannon was an astronomer, a scientist who studies objects in space. She was born in Dover, Delaware. When Annie was a child, her mother taught her about the constellations, the patterns of stars in the night sky. Annie continued to study stars for the rest of her life.

The sun is one of many stars in the universe. A star gives off light that has a spectrum of color. By looking at a star's spectrum, we can learn important information about the star, including its temperature. Hotter stars are blue-white. Cooler stars are orange and red.

Annie Jump Cannon attended Wellesley College. There she learned to measure the spectra of stars. She became very skilled at this work.

In 1896 Cannon was hired for a special project at the Harvard College Observatory. First, the astronomers recorded the spectra of as many stars as possible. Then they developed a system for grouping, or classifying, the spectra. Annie Jump Cannon

created a system that is still used today. It contains seven main types of stars: O, B, A, F, G, K, and M. These range from the highest temperature (O) to the lowest (M).

Annie Jump Cannon worked at Harvard until 1940. During that time she received many awards. She was the first woman to receive an honorary doctorate from Oxford University. She was the first woman to become an officer of the American Astronomical Society.

Annie Jump Cannon classified more than a quarter of a million stars during her lifetime. She also discovered 300 new stars.

Did You Know?

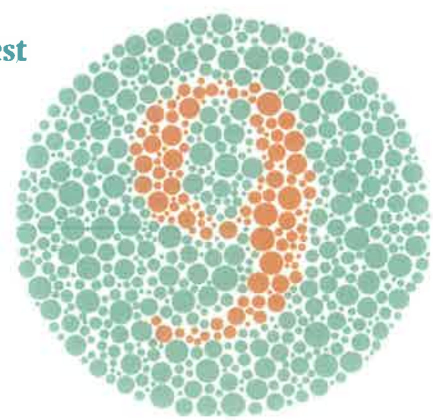
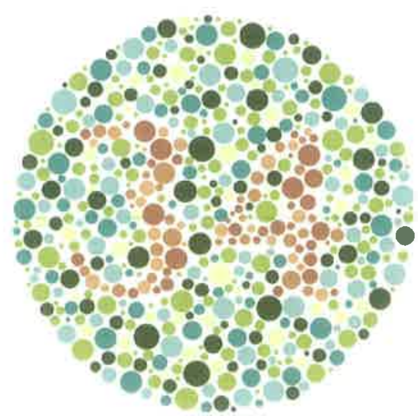
About Color Blindness

People, as well as monkeys, fish, butterflies, and a few other animals, see the world in color. In the retina of the eye, special cells called cones help us tell the difference between colors. One type of cone absorbs blue-violet wavelengths of light. A second type absorbs green wavelengths. A third type absorbs yellow and red wavelengths.

Some people have color blindness. This means that they see colors differently than most people. The cones in their eyes may not pick up all the color signals. Or the cones may not send these signals to the brain. About 8 percent of men and less than 1 percent of women are color blind.

Most people with color blindness have trouble telling the difference between red and green. A few people with color blindness have trouble with yellow and blue. A very small number of people cannot see color at all! They see only various shades of gray.

Color is used for important signs and signals. For example, a traffic light uses green to signal “go” and red to signal “stop.” Drivers with color blindness have to use other information to understand the signal. They must remember that the “stop” light is on the top and the “go” light is on the bottom.

Pictures like these are used to test for color blindness. Most people can see the number 9 in the left picture. People with red-green color blindness may not be able to see the number 34 in the picture on the right.

Glossary

absorb to take in

color filter substance that allows only certain colors of light to pass through it

concave lens lens that is thinner in the center and thicker at the edges

convex lens lens that is thicker in the center and thinner at the edges

cornea clear covering over the iris and the pupil in the eye

electromagnetic spectrum all the types of electromagnetic waves, listed in order of wavelength

electromagnetic wave wave made of vibrating electric and magnetic fields; part of the electromagnetic spectrum

energy ability to cause change

focal point point at which rays of light meet after refracting from a convex lens

gamma rays electromagnetic waves with the shortest wavelengths and highest energy

illuminated reflecting light that strikes it

image likeness or copy

infrared rays electromagnetic waves with long wavelengths and low energy

iris colored part of the eye around the pupil

lens piece of glass or plastic with curved surfaces that refracts light; part of the eye that focuses light rays on the retina

light form of energy that travels in waves that the human eye sees as visible light

luminous giving off its own light

microwaves electromagnetic waves with long wavelengths and low energy, used in microwave ovens

mirage illusion caused by the refraction of light rays

opaque blocking light

optic nerve nerve that carries messages from the eye to the brain

primary colors of light red, green, and blue light

prism solid, transparent object that refracts light that passes through it, separating the light into the colors of the visible spectrum

pupil opening in the center of the iris in the eye

radio waves electromagnetic waves with the longest wavelengths and lowest energy

ray narrow beam of light that travels in a straight line from a light source

reflect to bounce off a surface

refraction bending of light as it moves from one material into another

retina layer at the back of the eye that receives images

shadow dark area made when an object blocks light

translucent letting some, but not all, light through

transparent letting light pass through easily

ultraviolet rays electromagnetic waves that can cause sunburn and skin cancer

visible spectrum range of wavelengths in the electromagnetic spectrum that humans can see

wave rhythmic pattern that carries energy

wavelength distance from one wave crest to the next or from one wave trough to the next

white light light from a light source such as the sun, a flashlight, or a light bulb

x-rays electromagnetic waves used to take pictures of teeth and bones

DSM

THIRD EDITION

DeltaScienceModules™

FAST FACTS

- A prism separates light into the colors of the visible spectrum: red, orange, yellow, green, blue, indigo, and violet. We see a rainbow in the sky when water droplets in the air act like tiny prisms.
- Nothing travels faster than light. Light waves move through air at about 300,000 kilometers (186,300 miles) per second.
- Benjamin Franklin invented the first bifocal eyeglasses in 1784. The lenses in these glasses help people see both near and faraway objects better.
- The word *lens* comes from the Latin word for "lentil." A lentil is a bean that is shaped like a convex lens.
- A glass of water can be used as a magnifier. If you look at a ruler through a glass of water, the numbers on the ruler will look bigger.

Delta Science Readers are 16-page nonfiction books for students. Developed for **Delta Science Modules, Third Edition,** these books provide key information about a science topic and support the experiences of hands-on activities. Check **www.deltaeducation.com** for availability of titles.

ISBN-10: 1-59242-366-3
ISBN-13: 978-1-59242-366-8

Published and Distributed by
Delta Education
because children learn by doing

A member of School Specialty Science

538-6098 Color and Light