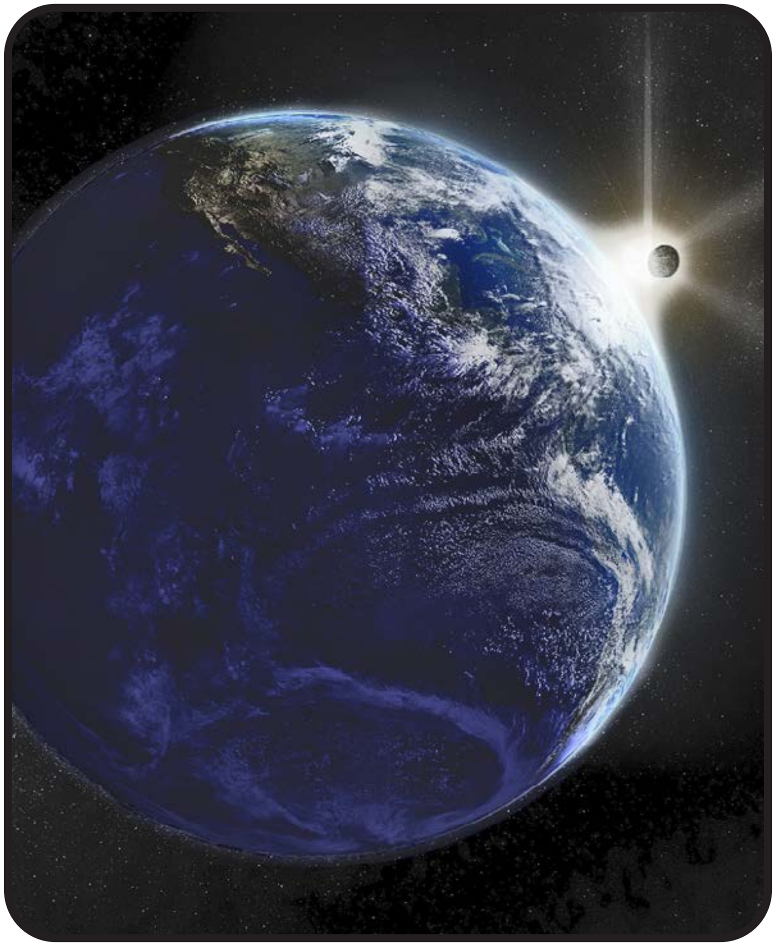
LIGHT

A Science A–Z Physical Series
Word Count: 1,922



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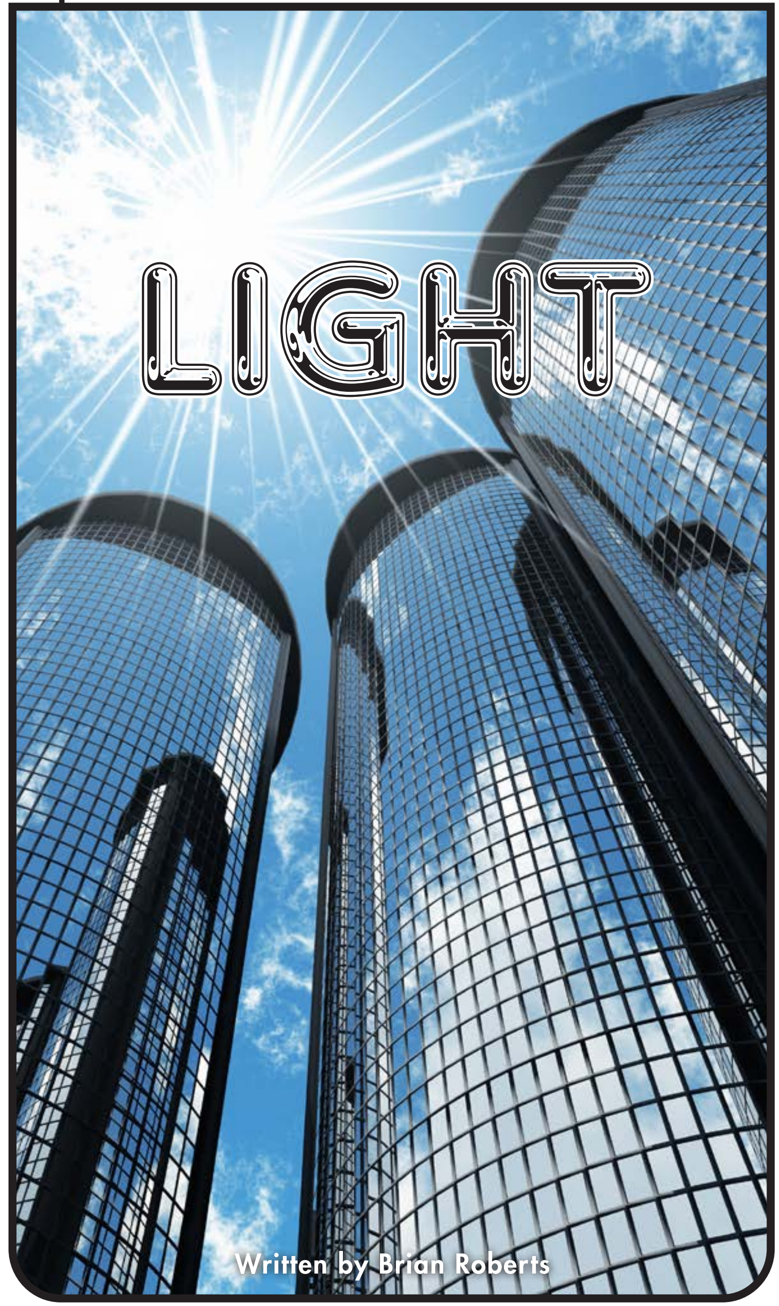

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Written by Brian Roberts

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KEY ELEMENTS USED IN THIS BOOK
The Big Idea: Many aspects of our lives are affected by or dependent upon light. In addition to learning about light, students may gain an appreciation for the extensive roles that light plays in their lives.
Key words: absorb, color, concave, convex, Earth, eclipse, electricity, energy, eye, filament, fluorescent, frequency, gamma waves, incandescent, invisible, iris, laser, lens, light, light-year, medium, Moon, opaque, photon, pigments, prism, pupil, radiant, radio waves, rainbow, reflection, refraction, retina, shadow, spectrum, Sun, translucent, transparent, visible, wavelength, white light **Key comprehension skill:** Interpret charts, graphs, and diagrams *Other suitable comprehension skills:* Main idea and details; compare and contrast; summarize information; identify facts; elements of a genre; classify information **Key reading strategy:** Ask and answer questions *Other suitable reading strategies:* Connect to prior knowledge; summarize; visualize; make, revise, and confirm predictions

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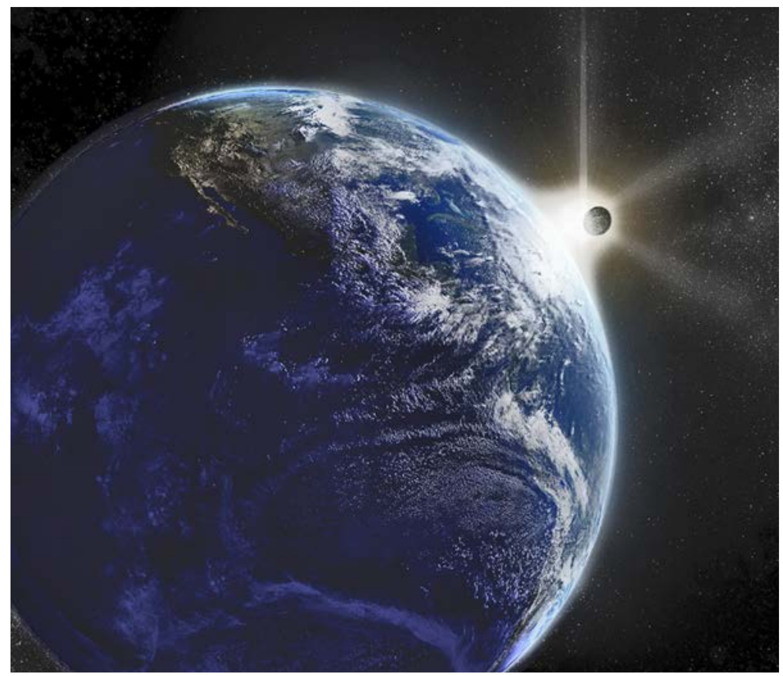
Introduction

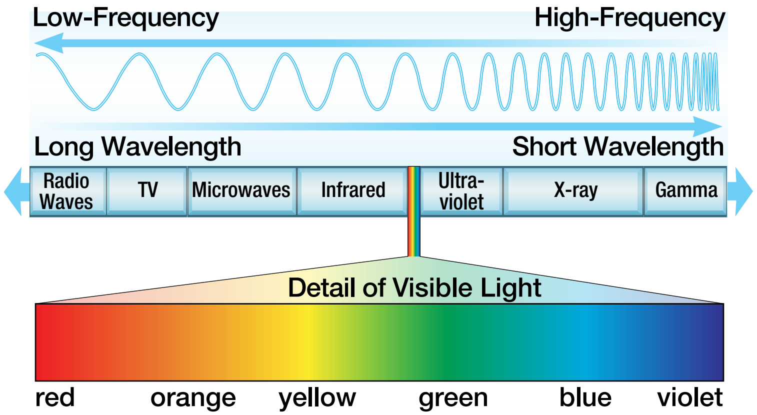
If you've ever walked into a closet and closed the door, you've experienced a world without light. Without light, we can't see a thing. But allowing us to see things is only one important aspect of light, especially sunlight.

This book will reveal many of the fascinating facts that scientists have discovered about light. These facts include what it is, where it comes from, how it moves, and what happens when light strikes different surfaces. There is much more to light than meets the eye.



Seen from space, light from the Sun reflects off Earth's oceans.

KINDS OF RADIANT ENERGY



Light is just one of many kinds of radiant energy.

What Is Light?

Light is a kind of energy called *radiant energy.* But the light you can see is only one kind and a very small part of radiant energy. There are many kinds of radiant energy, and scientists usually describe the whole range as a **spectrum**—a series of energy bands. The diagram above shows the major bands of radiant energy. Visible light is only a small part of the spectrum, in the middle. On each side of visible light is invisible radiant energy. The bands on the left of the diagram have less energy than the bands on the right. For example, radio waves are much less powerful than gamma waves.

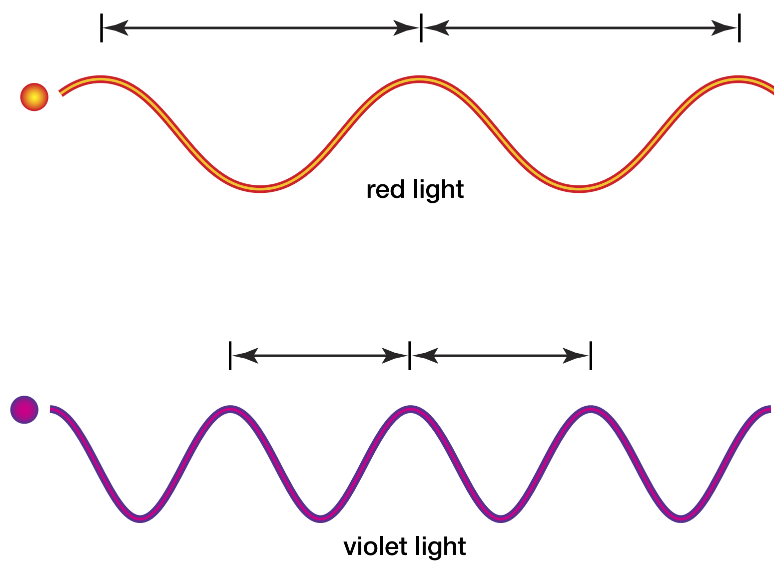
You can see bands of color in a rainbow. Each of these bands is made by radiant energy with a different amount of energy than the band next to it.

How Light Moves

Scientists describe light and how it moves in two ways. The first way is as tiny, invisible packets of energy called **photons**. Photons are particles of energy. They don't weigh anything, even when billions get together!

Not all photons are equal. High-powered gamma rays have photons with more energy than photons of visible light. Even in visible light, there is a difference in energy from one color to another. For example, violet light photons carry more energy than red light photons.

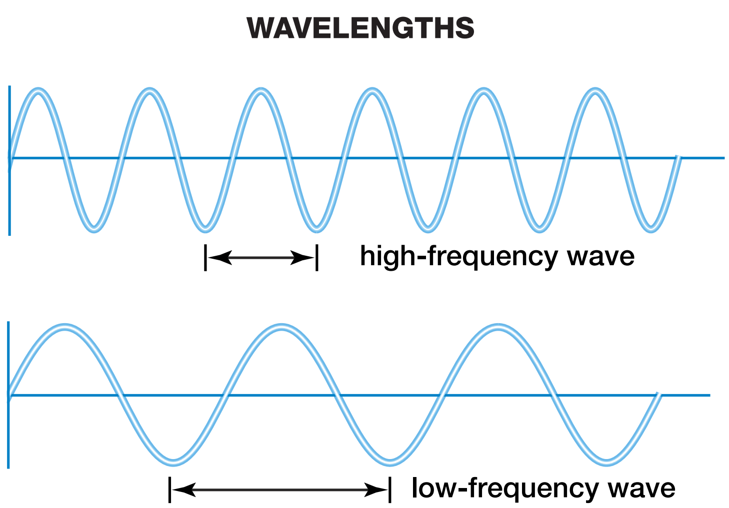
COMPARING COLORS OF LIGHT



Violet light photons have shorter wavelengths and more energy than red light photons.

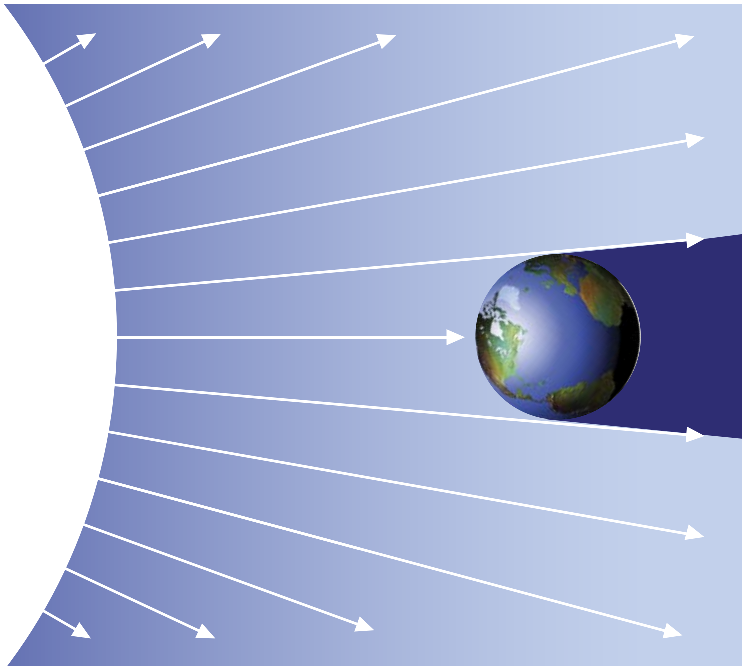
Light is also described as moving in waves. These waves are measured by their **frequency**, or how closely together they travel. High-frequency waves travel more closely than low-frequency waves, which are more spread out. More high-frequency waves pass a given point in a period of time than low-frequency waves. Scientists measure frequency by a wave's **wavelength**. Wavelength is the distance between the peak of one wave and peak of the wave next to it.

Look at the diagram of a high-frequency wave and a low-frequency wave. The low-frequency wave is more spread out. It has a longer wavelength. The longer the wavelength, the lower the wave's energy.



There are several more things to know about how light moves. One is that it travels in straight lines. Another is that beams, or rays, of light can change direction. We will read more about this in the section on how light behaves.

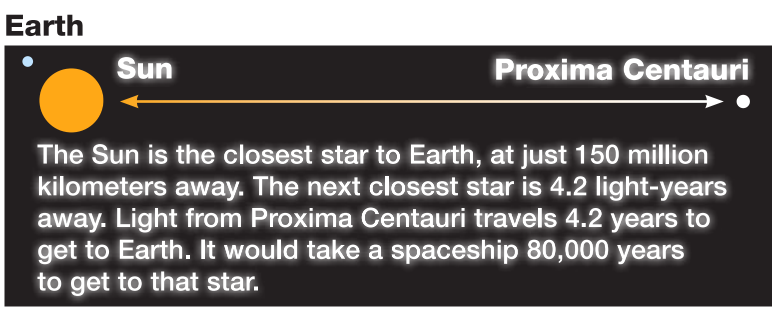
A third important thing to know about how light moves is that—unlike sound—it does not need a **medium** such as air, water, or wood to travel through. This makes radiant energy special—it can travel through the emptiness of space. If radiant energy could not do this, sunlight would never reach Earth.



Light rays travel in a straight line through space from the Sun to Earth.

One of the most impressive things about light is its speed. Nothing travels faster. In fact, light travels 300,000 km (186,000 mi.) through space in a single second. This is much faster than sound travels. This explains why you see a distant lightning bolt instantly, but you hear its thunder several seconds later.

Because light travels so fast and far in space, scientists have created a special unit called a **light-year**. It is the distance light travels in one year—about 9.5 trillion kilometers (5.9 trillion mi.)!



Math Moment

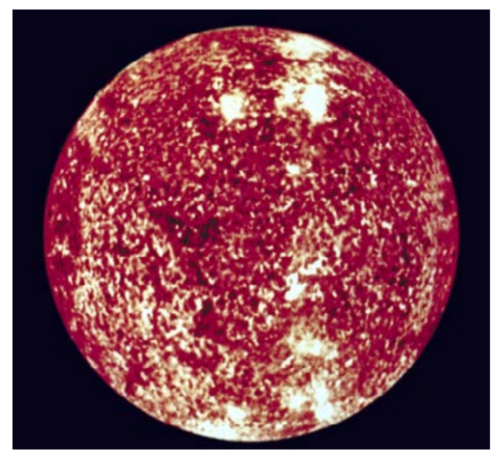
The distance from Earth to the Sun is about 150 million kilometers. Light moves at about 300,000 kilometers per second. About how long does it take light to reach Earth from the Sun?

Where Does Light Come From?

Now that you know what light is and how it moves, let's look at where it comes from. Sources of light can be put in two categories—natural and human-made.

The most important natural source of light is the Sun. The radiant energy it sends to Earth is responsible for the food we eat, our weather, most of our electricity and fuel, and the warmth of our atmosphere. But don't be misled into thinking the Sun sends its heat to Earth. The Sun is much too far from Earth for its heat to get here. Instead, the radiant energy from the Sun is absorbed by Earth's surface. Then the light changes to heat energy.

The Sun is just one of billions of stars that give off radiant energy. Because the Sun is much closer to Earth than any other star, we get large amounts of energy from it.

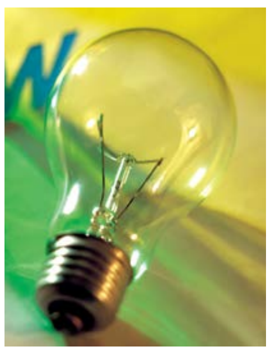


The Sun is a giant ball of energy and gases. It sends light in every direction.

Lava and fireflies are two natural sources of light.

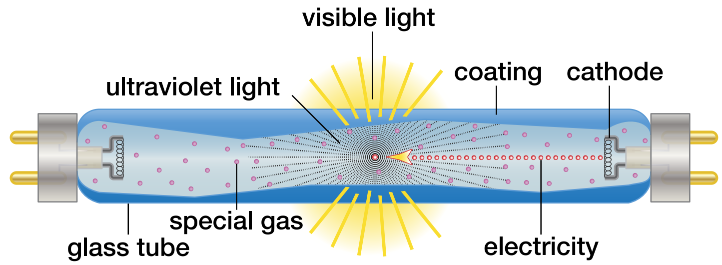
Other sources of natural light exist as well. One source is lightning. It is made of highly charged particles of air that get so hot, they create light energy. Some volcanoes produce lava that glows. And animals like fireflies and glowworms make light.

But people wanted light when there was no natural light. So they invented ways to create light. At first, they used campfires and oil lamps that burned with a flame. Then Thomas Edison developed the modern lightbulb. He put an electric current through a thin wire—a filament. The filament heated up and glowed. This type of lightbulb is called an **incandescent bulb**.



an incandescent bulb

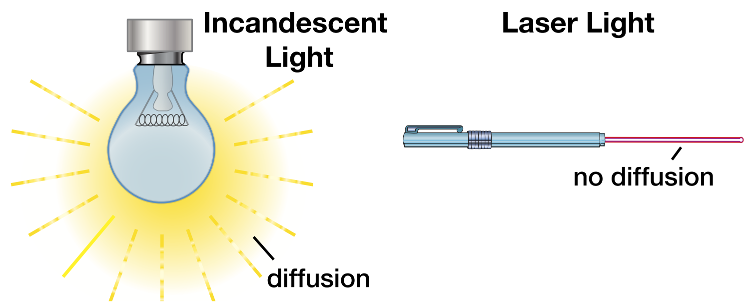
FLUORESCENT BULB



Later, inventors found another way to make a lightbulb. This new bulb passes electricity through a long glass tube filled with a special gas. The particles of gas give off invisible photons. The photons hit the inside of the glass tube, which is covered with a special chemical. The chemical gives off visible light when the invisible photons hit it. We call this a **fluorescent bulb**.

Do You Know?

Neon lights are like fluorescent lights. But neon lights use different gases that produce different-colored light when an electric current passes through the gas.



Laser light does not diffuse, or weaken, as fast as other light.

Another type of human-made light that people often use is laser light. We know that light is a useful source of energy. When this energy is focused, it can be quite powerful. Laser light is highly focused light. Unlike light from a lightbulb, which spreads out and weakens, laser light stays focused and strong.

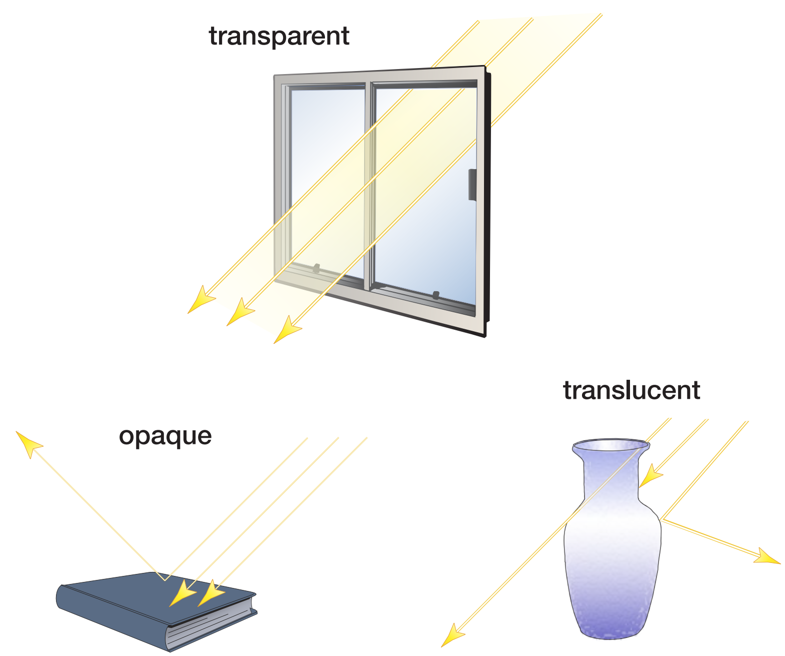
A laser device makes a very narrow, concentrated beam of light. The light is all about the same wavelength. Lasers are used to cut metal, to make incisions during surgery, to read images in scanners and printers, and to read CD and DVDs.

Word Wise

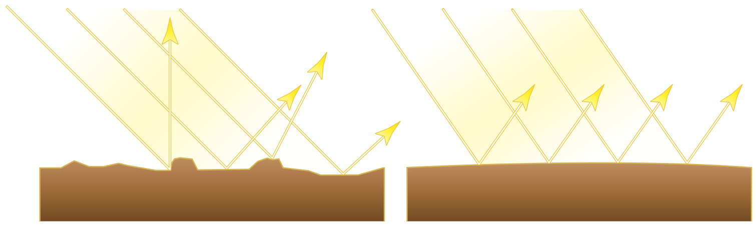
The word *laser* is an acronym. It stands for the first letters of the words that describe how it is made: Light Amplification by Stimulated Emission of Radiation.

How Light Interacts with Objects

Light does different things when it hits different materials and surfaces. Light passes through clear materials such as glass or water. They only absorb and reflect a small amount of light. These materials are **transparent**. Only some light passes through things such as frosted glass and wax paper. These materials are **translucent**. Still other materials block all light. These materials are **opaque**. A brick wall and a book are both opaque materials. Opaque materials absorb or reflect the light that strikes them.



Transparent objects let almost all light through, and opaque objects block all light. Translucent objects let some light through, but absorb or reflect the rest.



A rough surface has many angles that scatter light in different directions, while a smooth surface reflects light in a regular pattern.

Reflection

We see most things because light bounces, or reflects, off of them. Light reflecting from a smooth surface bounces off of it at the same angle at which it strikes the surface. If the surface is very smooth, like a mirror, light reflects in a regular pattern. The **reflection** looks normal. That is why a smooth, flat mirror allows you to see a perfect image of yourself.

If a surface is uneven, on the other hand, light scatters in many directions. That's why sunlight sparkles off water waves. The waves create many angles on the water's surface. These angles reflect and scatter light in many directions.

Do You Know?

The Moon does not produce its own light. Instead, its surface reflects light from the Sun.

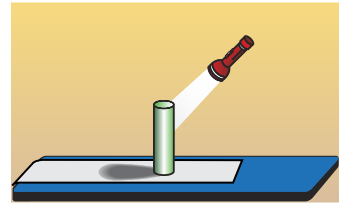


Illustration A

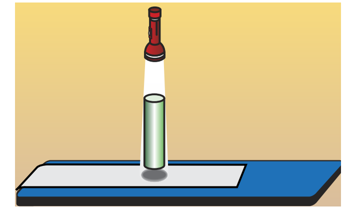


Illustration B

Because opaque objects reflect and absorb light, they cast shadows. A shadow occurs behind an opaque object because light cannot get through the object to the area behind it. The farther an object is from the surface the shadow falls on, the larger its shadow will be. The size of the shadow also depends on the angle and distance of the light. If a light source is far from or directly above an object (Illustration B), the object will cast a small shadow. But if the light is close to or beside the object (Illustration A), its shadow will be bigger. That's why you cast a bigger shadow when the Sun is lower in the sky.

Top: lunar eclipse
Bottom: solar eclipse

Do You Know?

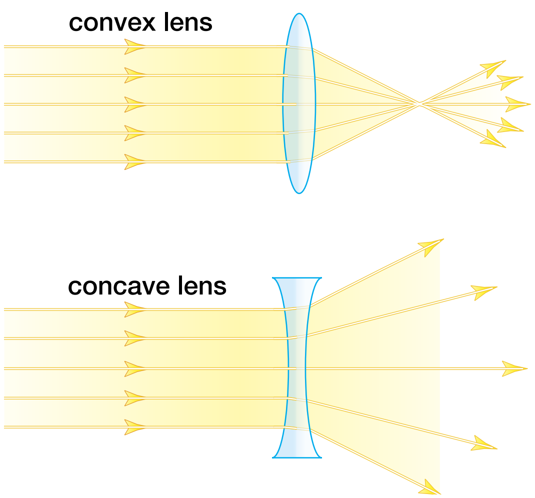
A *solar eclipse* occurs when the Moon passes between Earth and the Sun. The Moon, which is opaque, casts a shadow on Earth. People on Earth see the Moon slowly block out the Sun. A *lunar eclipse* occurs when the Moon moves through Earth's shadow.

Refraction

When light moves from one transparent material to another—such as from air to water—it changes speed and bends. When light bends, the process is called **refraction**. Some materials cause more refraction than others. For example, water slows the speed of light more than air does. Look at the photo of the spoon in a glass of water. Because the light changes speed as it moves from water to air, the spoon looks bent.

Light also refracts when it goes through transparent lenses. The diagrams show what happens when light passes through a **convex lens** or a **concave lens**.

LENSES

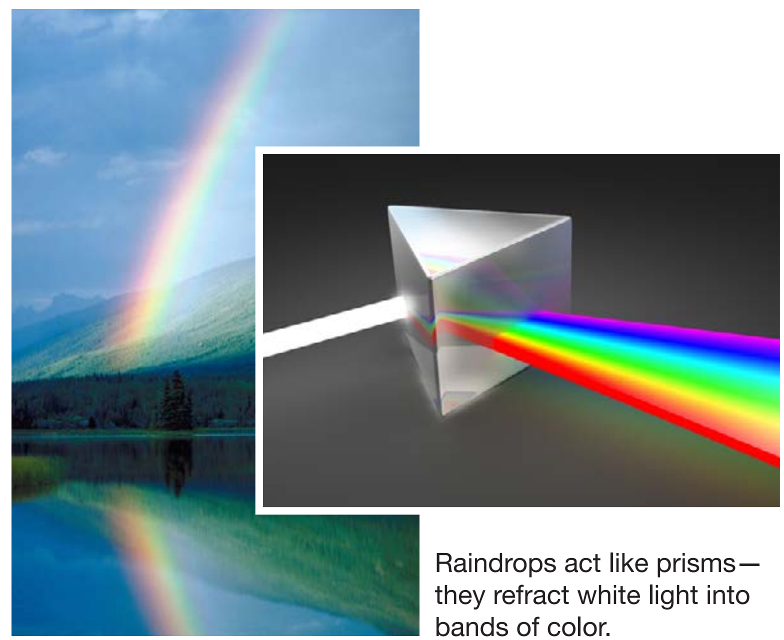


Convex lenses focus light, and concave lenses spread light out.

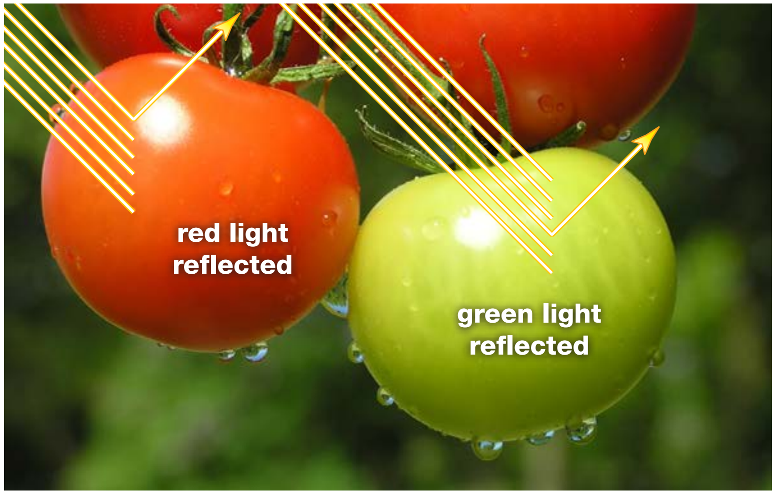
The different speeds of light through water and air make the spoon look bent.

All About Color

Visible light is made of many colors of light. When all these colors are combined, they create what we call **white light**. You can't see the colors of light until they are reflected or refracted to your eyes. Sunlight and light from lightbulbs have all the colors of light. You can separate the colors of light by sending white light through a prism. The prism refracts the light and separates the colors into a rainbow. Each color of light bends slightly differently from the others. When sunlight goes through raindrops, the drops act like prisms. They refract the light into bands of color that you see as a rainbow.



Raindrops act like prisms—they refract white light into bands of color.



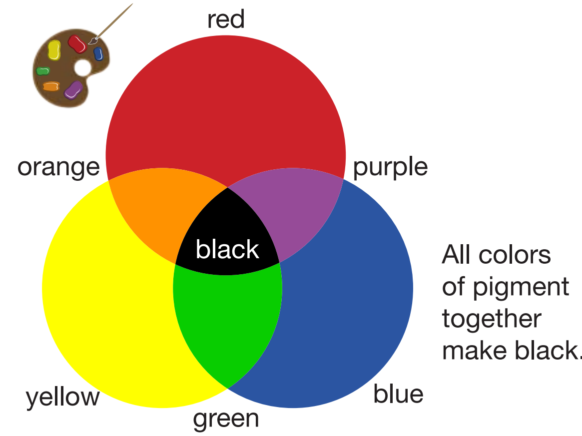
The red tomato absorbs all but red light, and the green tomato absorbs all but green light.

So what causes something to be a certain color? Pigments are substances that absorb some colors of light and reflect others.

When white light hits an object, our eyes detect only the colors of light that reflect. Imagine a ripe tomato. It looks red because its surface contains red pigment. This pigment absorbs all the colors except red. The reflected red light enters your eyes and a signal goes to your brain telling you that the tomato is red. If the tomato weren't ripe, it would have green pigment rather than red. Therefore, it would absorb the red color along with the other colors and only reflect green.

Paints are pigments that are used to coat objects. Mixtures of pigments can create a variety of colors.

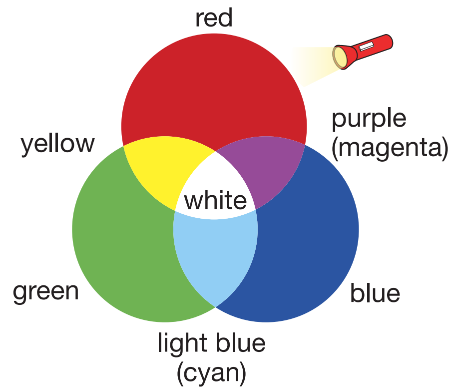
MIXING PIGMENTS



The three primary pigments are red, blue, and yellow. They can be combined to make any other color.

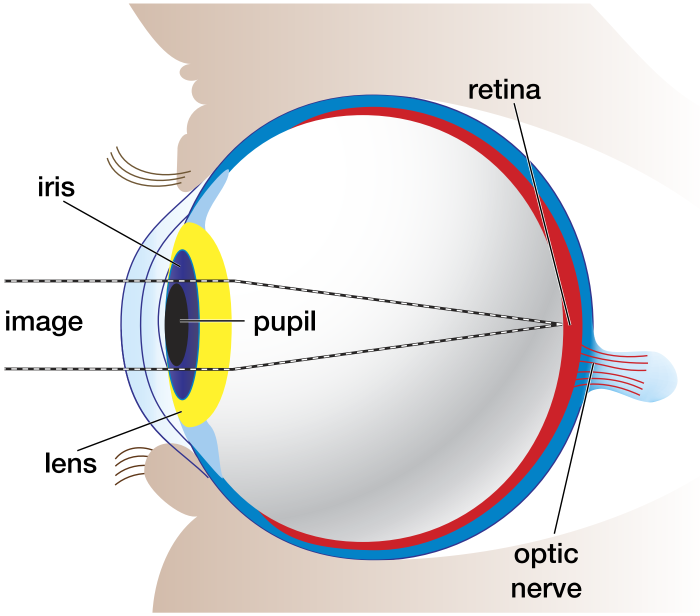
Black pigment is created when all colors of light are absorbed and no color reflects from a surface. White pigment reflects all colors and absorbs none. Since black surfaces absorb all light and its energy, black surfaces exposed to light get much warmer than white ones.

MIXING LIGHT



All colors of light together make white.

Just as pigments can be mixed to create different colors, colored light can also be mixed to create other colors of light. However, unlike pigment, when you blend all the colors of light, you get white, not black.



The lens of the eye focuses light on the retina, which sends a signal to the brain.

Human Eye

Your eyes are like cameras. They collect light and make images. Each eye, like a camera, has a small opening that light goes through. This is called the *pupil*. Your eyes also have a colored circle, called the *iris*, that controls the amount of light entering the pupil. Light that enters the pupil goes through a clear, convex lens. The lens focuses the light on a light-sensitive tissue at the back of the eye. This tissue is called the **retina**. It changes the light to a signal and sends it to a nerve to the brain. Your brain turns the signal into an image.

Conclusion

You've learned that light is energy. It can travel on its own, even through the emptiness of space. Light does some amazing things, including bending, refracting, reflecting, and being absorbed. And it does these things incredibly quickly. Because it can do all these things, we see the world the way we do.

What are some of the fascinating things you've learned about light?

Light helps our food grow, powers our homes, and does many more amazing things. What can you do with light?

Glossary

concave lens a lens that is wider at the edges than in the middle and that refracts light rays so they bend outward (p. 17)

convex lens a lens that is wider in the middle than it is at the edges and that refracts light rays so they come together (p. 17)

fluorescent bulb a lightbulb in which electricity passes through a gas that reacts with a coating inside the bulb to produce light (p. 12)

frequency the number of waves that pass a point in a specific length of time (p. 7)

incandescent bulb a lightbulb in which electricity passes through a wire, which heats up and produces light (p. 11)

light-year a unit that is the distance light travels in one year (p. 9)

medium a substance through which something is carried or transmitted (p. 8)

opaque blocking all light from passing; not see-through (p. 14)

photon the smallest particle of light energy (p. 6)

reflection the return of light as it bounces off something (p. 15)

refraction the bending of light waves when they pass from one kind of matter to another (p. 17)

retina a layer of light-sensitive cells at the back of the eye (p. 21)

spectrum the range of radiant energy, arranged in order of energy or wavelength (p. 5)

translucent allowing some light through; images are distorted (p. 14)

transparent allowing all light through; images are not distorted (p. 14)

wavelength the distance between two consecutive peaks or troughs of a wave (p. 7)

white light all the colors of light mixed together (p. 18)

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