Advanced Level

Physical Science

Matter and Energy

Light Is Energy

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- Core Curriculum Covered
- Student Book
- Assessments and Reading Activities

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Light Is Energy

What are some ways that energy can be changed from one form to another?

CORE CURRICULUM STATEMENTS

Energy exists in many forms, and when these forms change energy is conserved.

Energy exists in various forms: heat, electric, sound, chemical, mechanical, light.

Energy can be transferred from one place to another.

Some materials transfer energy better than others (heat and electricity).

Energy and matter interact: water is evaporated by the Sun's heat; a bulb is lighted by means of electrical current; a musical instrument is played to produce sound; dark colors may absorb light, light colors may reflect light.

Interactions with forms of energy can be either helpful or harmful.

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FOCUS ON SCIENCE

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AL

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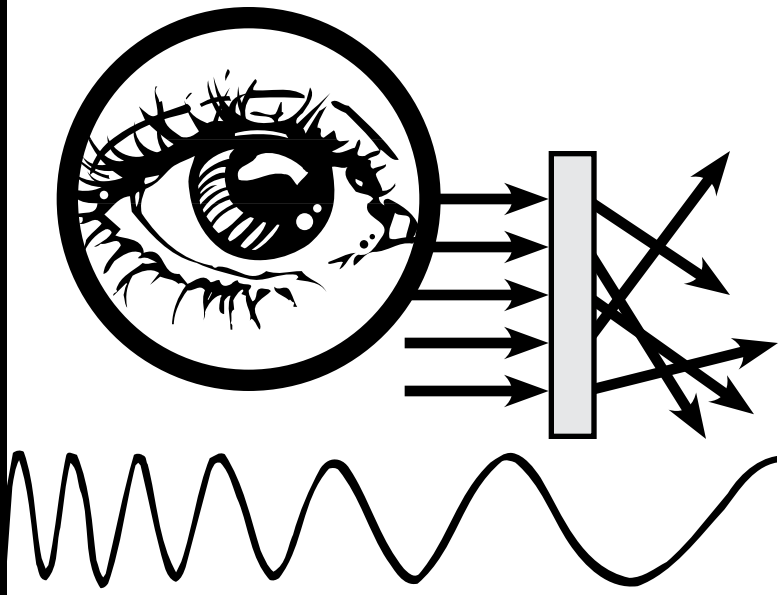
FOCUS ON SCIENCE

Physical Science

Matter and Energy

Light Is Energy

by
Charles Pederson



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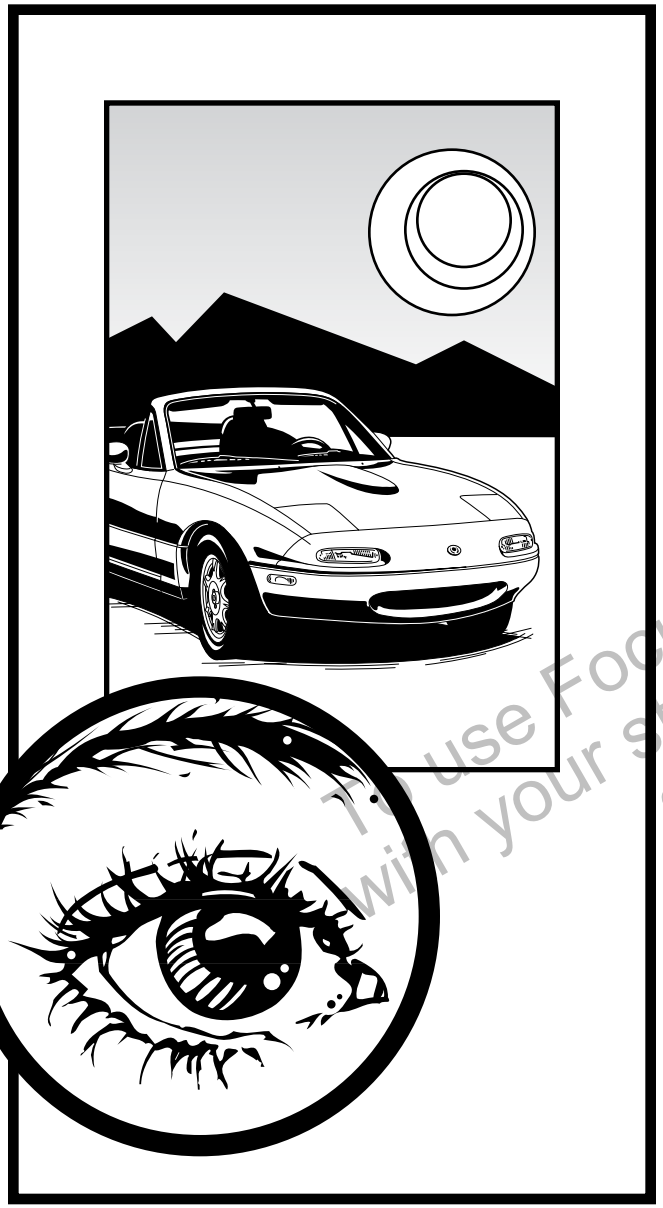
Curriculum materials for **your** content standards

Table of Contents

– Predict –
What do you think you will learn from this book?



Our eyes can see things because of light.

Light Lets Us See

You open your eyes in the morning and look around. There is a fly sleeping upside down on the ceiling. Outside the window are colorful cars on the street. You look at your clothing for the day. What colors go together?

Did you ever wonder how you can see these things? Light is the reason. When we see objects, our eyes sense the light bouncing off the objects.

This book is all about light. You will read about what it is. You will learn what it does. You will read about some scientists and their investigations about light. When you are done with this book, you will know more about light. You'll be able to tell your friends something new!

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CHAPTER 1

What Is Light?

Many scientists have wondered what light is. The ancient Greeks believed light was a stream of particles. They thought these particles flowed like water.

Christian Huygens lived in the 1600s. He was a scientist from the Netherlands in Europe. He developed a **theory** that light was like waves in water. He thought the waves moved in straight lines and had tops and bottoms. He believed these waves of light could be long or short.

Other scientists wondered, too. They designed experiments that showed the ancient Greeks and Huygens were right. One of these scientists was Thomas Young. In the early 1800s, he shined light through a narrow slit in a piece of paper. The light spread out on the other side. If he used two slits, the light spread out from both slits. The two beams of light interfered with each other. Light behaved just like two waves of water crashing into each other.

theory: an explanation that is based on evidence and reason and can be confirmed

Today, we know light is a form of energy that does indeed travel in waves. Light comes from two sources—natural and **artificial**.

Natural light sources are beyond human control. They include such things as lightning, the sun, and other stars. Artificial light sources are created by humans. They include such things as candles and electric light bulbs.

The type of light our eyes can see is visible light energy. This light is part of the visible spectrum. The **visible spectrum** is made up of light of many colors. When our eyes sense light with all the visible light, we see white light or light without color. Later in this book, you will learn how a scientist proved this to be true.

artificial: made by people, not made by nature
visible spectrum: the light humans can see

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CHAPTER 2

Properties of Light

What causes light? Light is caused by the release of energy from tiny particles of **matter**.

Particles in matter can gain and lose energy. When they gain energy they become "excited." One way to excite particles is to heat them. For example, when particles in metal are heated, the excited particles give off energy. That makes the metal turn red. In a red-hot object, the particles are getting enough energy to begin producing light that we can see.

When the metal gets even hotter, it turns white. Its particles are very excited and are giving off lots of energy. All of the colors of light are being generated. The colors mix together and look white.

matter: what all things are made of; anything that takes up space

This is how a light bulb works. A thin piece of metal in the bulb is heated. This excites the particles in the metal wire. The particles then give off energy in the form of white light. When the electricity is turned off, the particles become de-excited. They no longer move around creating heat and light.

Both natural and artificial light can make objects hot and glowing. The sun and many light bulbs **emit** this **incandescent** light. You can actually feel the heat produced when some of the light energy is absorbed by your skin.

Natural and artificial light can also be cool, as with **fluorescent** lamps, or with fireflies and other objects that glow in the dark.

– Brainstorm –
What are other examples of incandescent and fluorescent light?

emit: to send out
incandescent: light produced from a hot object
fluorescent: light produced from a relatively cool object

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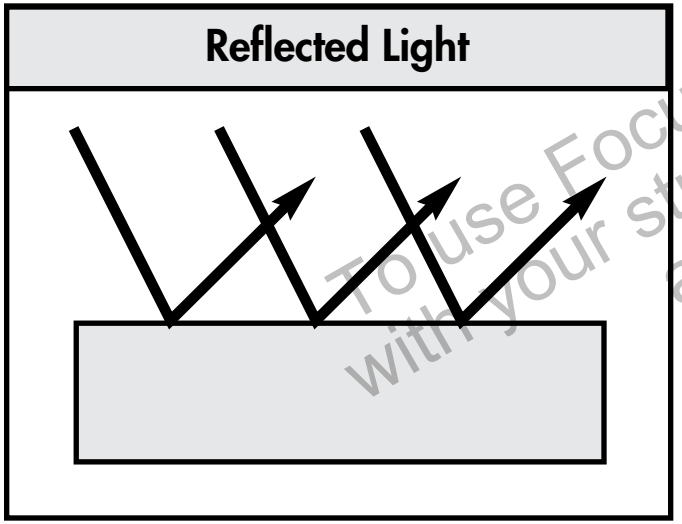
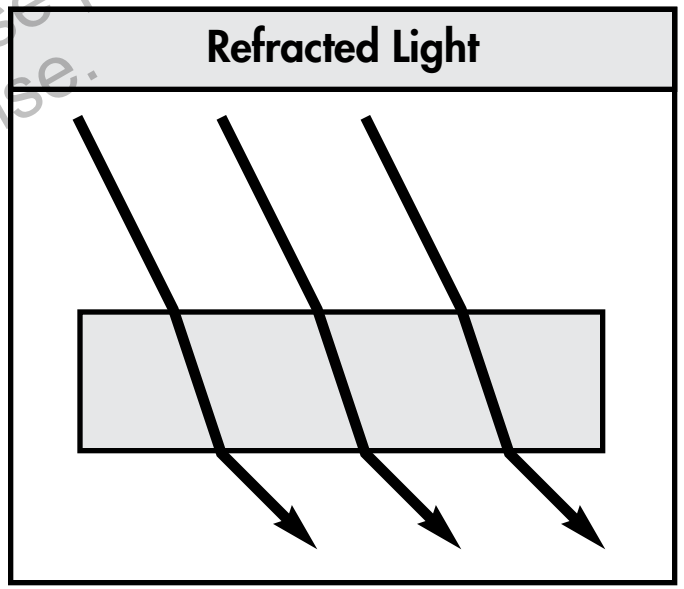
Behavior of Light

Light travels in a straight line until it hits an object. It may pass through it. It may also bounce off the object. Light that bounces is called **reflected** light. Smooth surfaces reflect light waves in one direction. Rough surfaces reflect light but **scatter** it in many directions. This is why we can see ourselves in a mirror but not in a wool sweater.



reflected: bounced or thrown back
scatter: to reflect in many directions

Refracted light is not absorbed by an object but rather passes through it. The light refracts, or bends. The amount of bending depends on the material. For example, when light passes through water, the particles in water slow the light down and bend it. This causes a pencil to appear to be bent when placed in a glassful of water. Try it. Some materials slow down and refract light more than others.



refracted: bent

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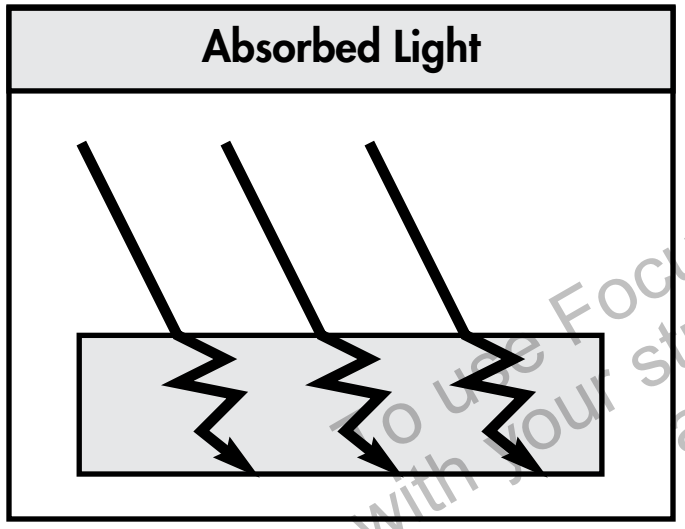
Absorbed light enters an object without bouncing off or passing through it. The particles that make up some materials absorb certain colors of the visible spectrum. The remaining color or colors reflect from the material. Our eyes can then sense the color or colors reflected.



– Describe –
What are some examples of reflected, refracted, and absorbed light?

absorbed: taken in and not reflected or thrown back

Materials that Affect Light

Three types of materials affect how we see light. **Transparent** materials allow light to pass through them without mixing or bouncing the light. We can clearly see an object on the other side of transparent materials. Clear glass or plastic are examples of transparent materials.

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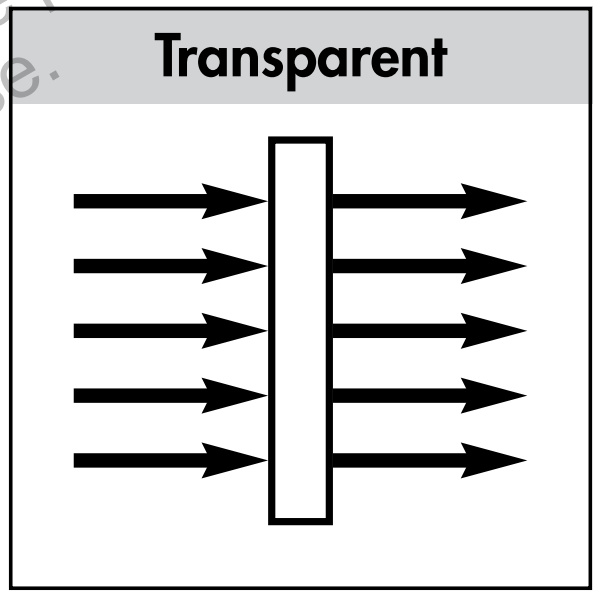
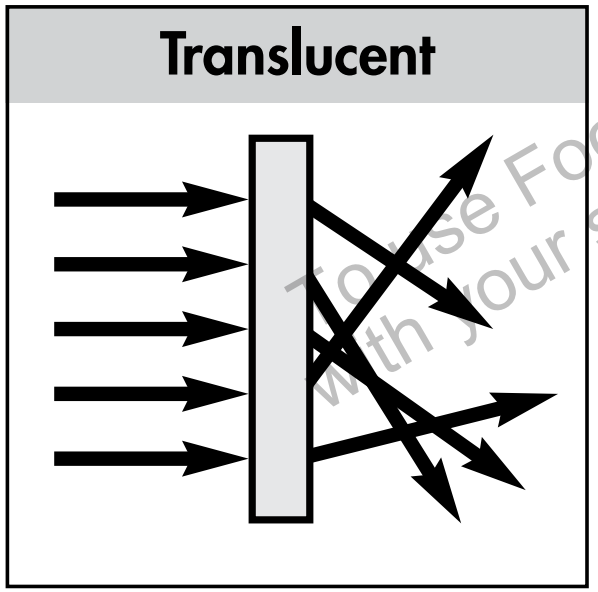


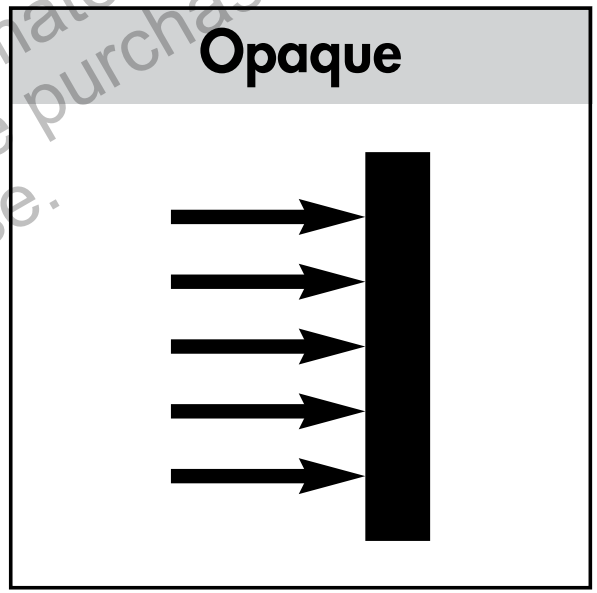
transparent: allowing light to pass through without mixing

Translucent materials let some light pass through. The light does not pass directly through the materials. It changes direction many times and is scattered as it passes through. Therefore, we cannot see clearly through them. Objects on the other side of a translucent object appear fuzzy and unclear. Frosted glass is an example of a translucent material.



translucent: allowing light to pass through with mixing

Opaque materials block or reflect all light and keep it from passing through the material. We cannot see anything on the other side of opaque materials. Opaque materials include such things as wood, stone, and steel.



– Transfer –
Name several materials that are transparent, translucent, and opaque.

opaque: blocking or reflecting all light

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CHAPTER 3

Optics
The Study of Light

The ancient Greeks believed that light and color were not directly related. They thought color came from white light being changed by an object's color. Besides, if you take red, orange, yellow, and all the other rainbow colors of paint and mix them up, you just get a murky brown-black, not white.

Isaac Newton asked himself if white light really was white. Or was there more to it than that? Newton was a leader in the study and uses of light in the 1600s and 1700s. He wrote a book called Opticks. It dealt with measuring and using light. Today, we still use Newton's word optics for this area of science.

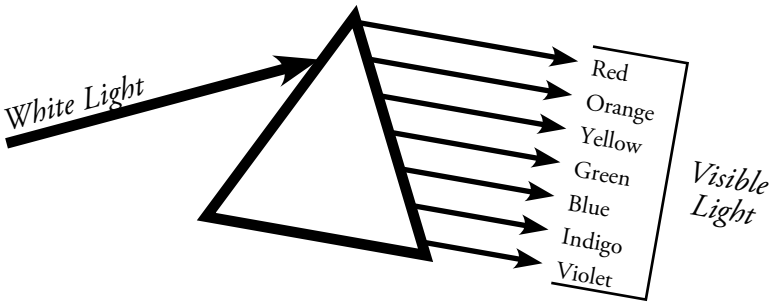
To find the answer to his question, Newton shaded a window. The shade had a hole in it. One beam of sunlight entered the room through the hole. Newton placed a prism in the sunlight. A prism is a wedge-shaped piece of polished glass.

Newton discovered that white light passing through a prism bends or refracts. The prism split the invisible white light into visible colored light.

Newton repeated the experiment many times to be sure it was accurate. The experiment helped Newton decide that white light is not the absence of colors. It is instead the presence of all visible colors.

The colors of light that make up the visible spectrum are the colors in a rainbow. You can easily remember them by using the acronym ROY G. BIV, which stands for Red, Orange, Yellow, Green, Blue, Indigo, and Violet. These are the colors of the visible spectrum in the correct order of their wavelength.

You can make white light from colored light. Shine beams of light through a red, yellow, and blue filter. When the three colors of light combine, the light becomes white.



A prism splits white light into visible light.

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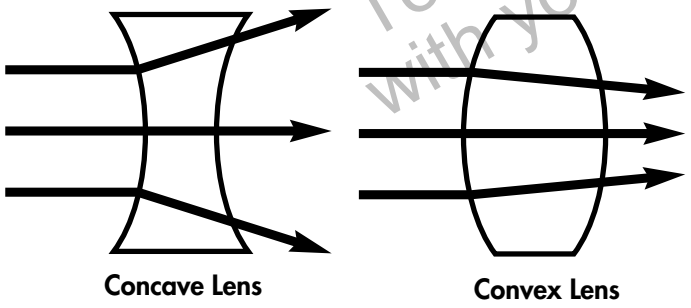
Instruments to Study Light

Scientists have created many different instruments to study light and its behavior. Specially shaped pieces of glass or plastic called lenses are one of the primary instruments. A prism is one type of lens.

Concave lenses curve inward. They have a narrow center and thicker outer edge. Light rays passing through a concave lens refract away from each other. This causes things seen through the lens to look smaller.

The middle of a convex lens, such as a magnifying glass, curves outward. This causes light rays to refract toward each other, making objects look larger.



Light refracts when it passes through lenses. Concave lenses make things look smaller. Convex lenses make them look larger.

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Another early optical scientist was Galileo Galilei in the 1500s and 1600s. He used a telescope to study planets and stars. A telescope has a convex shaped piece of glass. It bends light so users can see faraway objects. Galileo's telescope changed the way people thought about space.

Microscopes are another optical instrument. A microscope uses one or more convex lenses to make extremely small objects visible.

Lasers give off thin beams of very powerful light. Lasers have different strengths. Some are delicate enough to perform eye surgery. Others are strong enough to cut through steel.

Mirrors are important instruments, too. They reflect light smoothly. This allows us to see objects clearly.

CHAPTER 4

Light Phenomena

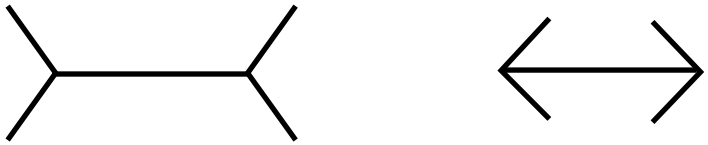
We can see rainbows, optical illusions, and shadows because of light. You may not have thought of these as being related to light, but they are.

Rainbows

You probably have seen rainbows on rainy days. Rainbows occur when light passes through the raindrops. Each raindrop acts as a tiny prism. It refracts the sun's white light into its rainbow colors.

Optical Illusions

Optical illusions are another light event. They trick the eye. They show the difference between what your brain expects and what your eye sees. Look at the two horizontal lines below. Is one line longer than the other?



Optical illusions trick the brain and eyes. If you take a ruler and mark the ends of the lines, you'll see the two lines above are the same length.

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Shadows

Shadows are interesting, too. They are caused by the absence of light. Shadows occur because light travels in a straight line. When the light strikes an opaque object, the object blocks the light on the other side. This is where the shadow is.

Shadows have two parts. The umbra is the darkest part of a shadow. In the umbra, no light falls. But light acts like waves. The waves leak around the sides of the opaque object. They cause the shadow's edges to be less dark. This slightly lighter edge is called the penumbra.

Did you know nighttime is a giant shadow? The opaque Earth blocks the sunlight and casts a giant shadow. The parts of Earth turned away from the sun lie in this shadow.

Glossary

absorbed—taken in and not reflected or thrown back

artificial—made by people, not made by nature

emit—to send out

fluorescent—light produced from a relatively cool object

incandescent—light produced from a hot object

matter—what all things are made of; anything that takes up space

opaque—blocking or reflecting all light

reflected—bounced or thrown back

refracted—bent

scatter—to reflect in many directions

theory—an explanation that is based on evidence and reason and can be confirmed

translucent—allowing light to pass through with mixing

transparent—allowing light to pass through without mixing

visible spectrum—the light humans can see

To Find Out More . . .

Want to learn more about light?

Try these books

Light by Darlene R. Stille. Child's World, 2005.

Light: From Sun to Bulbs by Christopher Cooper. Heinemann, 2003.

Access these Web sites

See the Light
http://library.thinkquest.org/13405/index.html

Optical Research Associates
Optics for Kids: The Science and Engineering Behind It
http://www.opticalres.com/kidoptx_f.html

Write for more information

The Exploratorium
3601 Lyon Street
San Francisco, CA 94123
415-397-5673

Museum of Science and Industry
57th Street and Lake Shore Drive
Chicago, IL 60637-2093
773-684-1414

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Advanced Level

Physical Science

Matter and Energy

Assessments

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Light Is Energy

Print pages 20–22 of this PDF for the assessments.

Light Is Energy

Check Understanding

Write your answer on the lines provided.

1. Sometimes when light hits an object, some of the light is absorbed and some is reflected. Explain how we sense the absorbed light.

_____

_____

_____

_____

_____

Explain how we sense the reflected light.

_____

_____

_____

_____

_____

2. Identify **one** example of an instrument that uses light.

_____

Explain how that instrument works.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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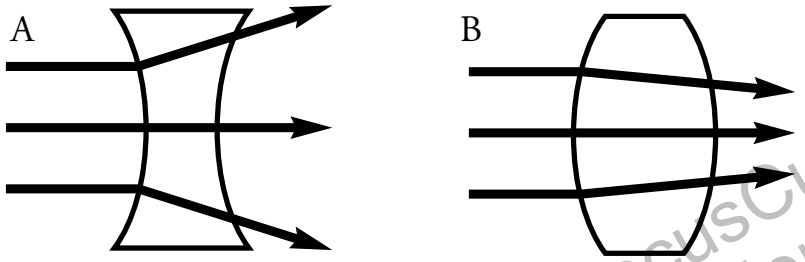
Check Understanding

Write your answer on the lines provided.

3. The illustration below shows light passing through two different lenses.



Identify each type of lens.

A _____

B _____

Explain how lens **A** affects light.

_____

_____

_____

_____

_____

_____

_____

Explain how lens **B** affects light.

_____

_____

_____

_____

_____

_____

_____

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Assessment Scoring Guidelines

1. We do not see light that is absorbed.

The color of the light that is reflected is the color we see.

2. Examples of instruments and how they work include:

Telescope
A telescope has a convex lens. This allows users to see faraway objects.

Microscope
A microscope has a convex lens. It allows people to see very small objects.

Laser
A laser gives off thin beams of light. If the beam of light is strong enough, it can cut through a solid object.

3. A. concave lens
B. convex lens

Concave lenses curve inward. They have a narrow center and thicker outer edge. Light rays passing through a concave lens refract away from each other. This causes things seen through the lens to look smaller.

The middle of a convex lens curves outward. This causes light rays to refract toward each other, making objects look larger.

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Physical Science

Matter and Energy

Advanced Level

English Language Arts Activities

Light Is Energy

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Print pages 24–28 of this PDF for the reading activities.

Summarize

Summarizing means retelling what you have read. Summaries are often shorter than the text you read. Summarizing helps you understand what you read**.**

Read this paragraph from *Light Is Energy* and try to summarize it.

> Transparent materials allow light to pass through them without mixing or bouncing the light. We can clearly see an object on the other side of transparent materials. Clear glass or plastic are examples of transparent materials.

Is the following a good summary?

Transparent materials are made of glass.

No! This statement is too specific and does not summarize the main idea. How about the one below? Is it a good summary?

Transparent materials allow light to pass through them.

Yes! This is the main idea of the paragraph.

TRY THE SKILL

Read the paragraphs from *Light Is Energy*. Shade the circle next to the best summary.

1. Scientists have created many different instruments to study light and its behavior. Specially shaped pieces of glass or plastic called lenses are one of the primary instruments. A prism is a type of lens.

Concave lenses curve inward. They have a narrow center and thicker outer edge. Light rays passing through a concave lens refract away from the others. This causes things seen through the lens to look smaller.

Ⓐ Concave lenses make objects look smaller.

Ⓑ Convex lenses curve outward.

Ⓒ Lenses are useful for studying light.

2. Light comes from two sources—natural and artificial. Natural sources are beyond human control. They include such things as the sun and stars. Artificial light sources are created by humans. They include such things as candles and electric light bulbs.

Ⓐ Light sources can be natural or created by people.

Ⓑ Humans cannot control natural light sources.

Ⓒ Candles and lamps are two artificial light sources.

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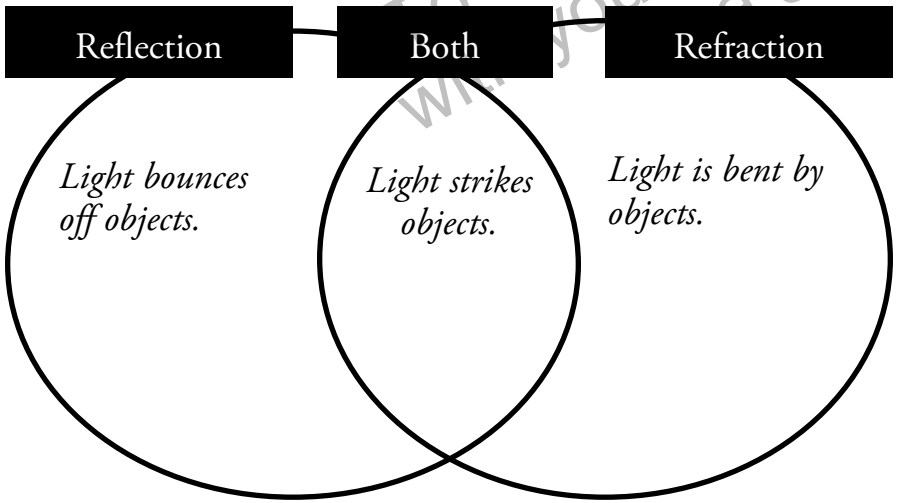
Compare and Contrast

Comparing and contrasting can help you understand what you read. Comparing tells how things are alike. Contrasting tells how things are different.

Read the following paragraphs. Then read the Venn diagram that compares and contrasts.

Reflection: Light does several things when it hits an object. It may pass through it. It may also bounce off the object. This light is reflected.

Refraction: Some objects bend light. It is refracted. The amount of bending depends on the material. Water, for example, slows down light. This causes a pencil to look bent when placed in a glassful of water.

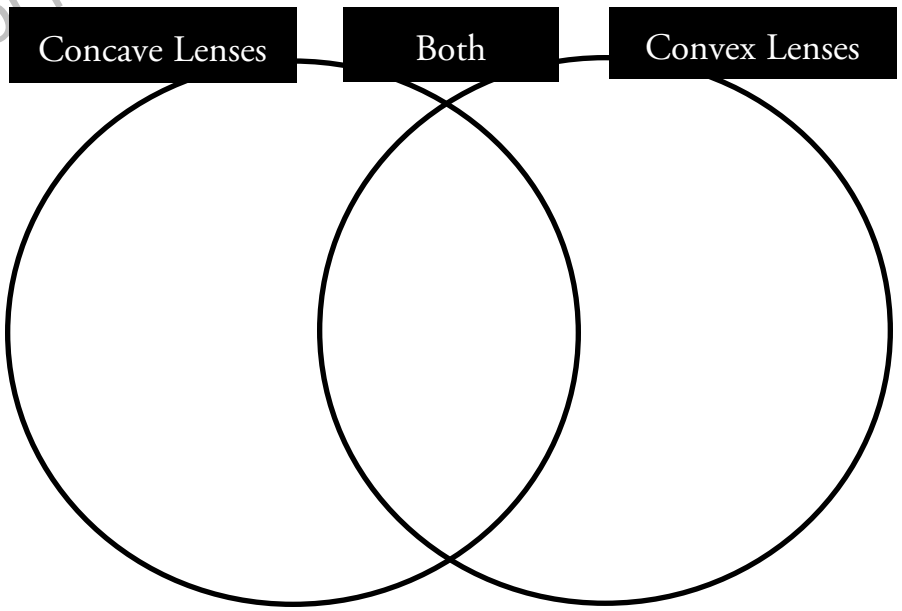


TRY THE SKILL

Read the paragraphs below. Think about comparing and contrasting. Then fill in the Venn diagram.

Concave lenses curve inward. They have a narrow center and thicker outer edge. Light rays passing through a concave lens refract away from the others. This causes things seen through the lens to look smaller.

The middle of a convex lens, such as a magnifying glass, curves outward. This causes light rays to refract toward each other, making objects look larger.



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Interpret Graphic Information

TRY THE SKILL

Graphic information is presented in picture or chart form. It contains information that you must think about.

Look at the following chart. Then look at the questions and answers.

Rain Amounts in Minnesota and Iowa

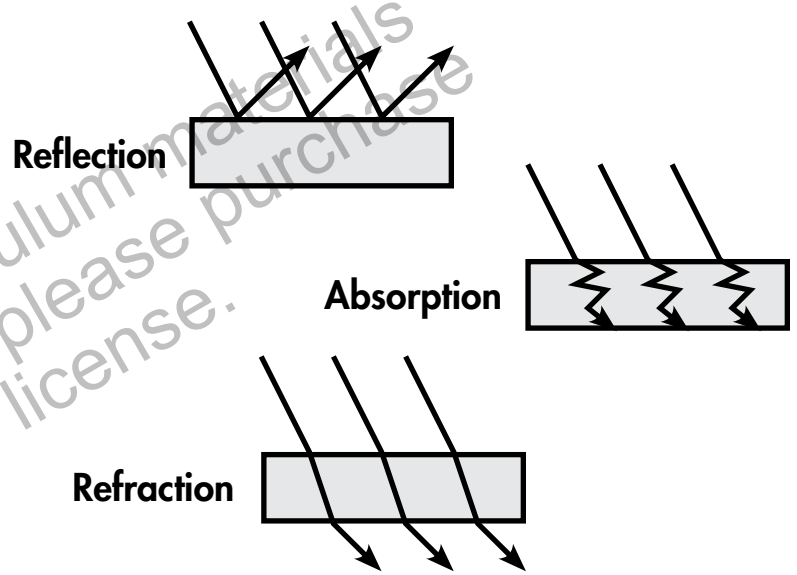
	June	July	August
Minnesota	20 inches	8 inches	9 inches
Iowa	19 inches	6 inches	12 inches

1. In which month does Minnesota receive the least rain?
July

2. Does Minnesota or Iowa receive more rain in August? How much more?
Io*wa receives 3 more inches of rain than Minnesota.*

3. Which month is best for farmers in these states if farmers like lots of rain?
June

Look at this graphic showing what happens when light hits different objects.



What does this graphic show you about light?

_____

_____

_____

_____

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Antonyms

Antonyms are words that have opposite meanings from each other. Some examples of antonyms are:

night and *day*
up and *down*
inside and *outside*
left and *right*

Read the following paragraph from *Light Is Energy*. Look for the antonyms.

Concave lenses curve inward. They have a narrow center and thicker outer edge. Light rays passing through a concave lens refract away from the others. This causes things seen through the lens to look smaller.

The middle of a convex lens, such as a magnifying glass, curves outward. This causes light rays to refract toward each other, making them look larger.

Inward and *outward* are antonyms. So are *smaller* and *larger*.

TRY THE SKILL

Read the following paragraph from *Light Is Energy*. Circle the antonyms.

This is how a light bulb works. A thin piece of metal in the bulb is heated. This excites the particles in the metal wire. The particles then give off energy in the form of white light. When the electricity is turned off, the particles become de-excited. They no longer move around creating heat and light.

Both natural and artificial light can make objects hot and glowing. The sun and many light bulbs emit this incandescent light. You can actually feel the heat produced when some of the light energy is absorbed by your skin.

Natural and artificial light can also be cool, as with fluorescent lamps, or with fireflies and other objects that glow in the dark.

Find as many antonyms as you can that have to do with light. Write them on the lines below.

_____

_____

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Answer Key

Summarize

1. C

2. A

Compare and Contrast

Concave Lenses: lens curves inward; narrow center and thicker edge; light refracts away; objects look smaller

Both: specially shaped glass; called lenses

Convex Lenses: lens curves outward; light rays refract toward each other; objects look larger

Interpret Graphic Information

- Light can reflect or bounce off an object.
- Light can be absorbed and not pass through an object.
- Light can refract, or bend, when passing through an object.

Antonyms

excites–de-excites

natural–artificial

hot–cool

incandescent–fluorescent

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