

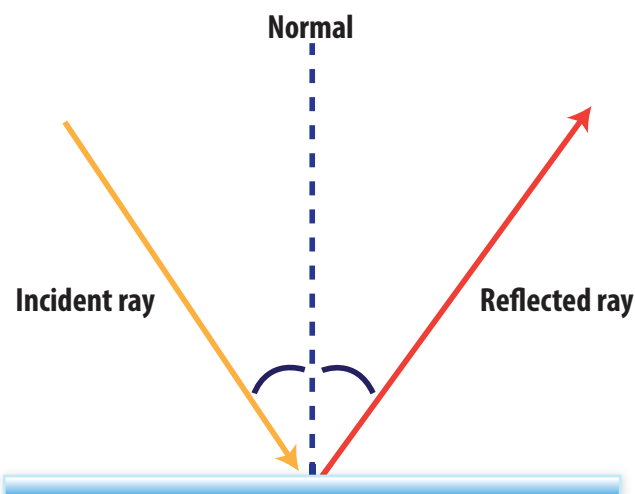
## Essential Question

# How Do Lenses and Mirrors Affect Light?

What reflective surfaces do you see in your classroom? What are the different properties of these surfaces that make some reflections better than others? **Mirrors** are very smooth surfaces usually made of polished metal or silver-coated glass. People have used mirrors for thousands of years. When the Israelites were constructing the tabernacle, the bronze basin and stand were made from the bronze mirrors donated by the women. What is another use of mirrors in history?

### Mirrors **Explain**

Mirrors come in a variety of types. Some mirrors have a flat surface while others have a curved surface. Where might you find flat mirrors in your home? Where have you seen curved mirrors used? Why were they used there? Whether a mirror is flat or curved, the **law of reflection** states that light reflects off the mirror in straight lines at the same angle as the light hits the mirror. This means the incoming angle, called the *angle of incidence*, equals the angle at which the reflected ray leaves, called the *angle of reflection*.



A line drawn perpendicular to the surface of the mirror called the *normal*, labeled Normal in this diagram, divides the angle formed between the incident ray and the reflected ray into two equal angles.

**?** Use a protractor. What is the angle of incidence in the picture?

### Objectives

- Compare how plane, convex, and concave mirrors reflect light.
- State the law of reflection.
- Compare refraction by concave and convex lenses.
- Compare how optical devices are used.

### Vocabulary

mirror  
law of reflection  
virtual image  
concave  
focus  
real image  
focal length  
convex

## Lesson Activity

Locate different everyday objects with flat or curved reflective surfaces, like spoons. Examine how each object acts as a mirror. Experiment with reflecting light off each object, using sunlight, a penlight flashlight, or other light sources.

 **How did the different reflective surfaces affect the object's image? Were they distorted or changed in some way? Explain.**

### Plane Mirrors

Plane mirrors are flat mirrors that reflect light. In Bible times, they were made of polished metal. Today, they are more commonly made of glass or plastic coated with a thin film of metal. The image produced by a plane mirror that appears “behind” it is called a virtual image. A **virtual image** is one that forms where light cannot actually reach. The image appears to be as far behind the mirror as the object is in front of the mirror.

What does an image look like in a plane mirror? How is the image different from the actual object? Use a plane mirror to look at this line of text. What does the text look like in the mirror?




### Scripture Spotlight

Probably the most famous verse in the Bible that mentions a mirror is **1 Corinthians 13:12**. What type of mirror do you think is being referred to in this verse—plane, convex, or concave?

## Explore-a-Lab

### Structured Inquiry

 **How does the image of your face appear in different mirrors?**

Work with a partner. Observe the image of your face in a plane mirror, a concave mirror, and a convex mirror. Hold each mirror about 25 cm (10 in.) from your face. Have your partner move the mirror. Then switch places. Use a table, like the one below, to record the data.

Type of mirror	Image right side up or upside down?	Larger, smaller, or the same size?	Effect of moving mirror closer?	Effect of moving mirror farther away?
Plane				
Concave				
Convex				



## Structured Inquiry

### Discover

Record your work for this inquiry. Your teacher may also assign the related Guided Inquiry.



# Looking at Lenses

## How do lenses affect light as it passes through them?

### Procedure

1. Open a book to a page that has both text and pictures. Stand the book upright at least 1.5 m (about 60 in.) from your eyes. Hold a convex lens at arm's length and observe the page through the lens. Note the size (larger or smaller) and position (upright or upside down). **Record** your observations.
2. **Observe** any changes to the image as you move the lens to the following distances from the book: 100 cm (39 in.), 75 cm (30 in.), 50 cm (20 in.), 25 cm (10 in.), 10 cm (4 in.), and 5 cm (2 in.) closer to the book. **Record the data** in the table. Repeat Steps 1–2 with the other three lenses.
3. Hold a convex lens up to a window. Have a partner hold half a sheet of poster board behind the lens. Your partner should move the poster board toward or away from the lens until a clear image of the scene outside the window forms on the poster board. **Observe** the appearance of the scene. Sketch the image that you see.
4. With the meterstick, **measure** the distance between the lens and the screen when a clear image forms. This is the focal length of the lens. **Record the data. Measure** the height and width of the image. Repeat Steps 3–4 with the other three lenses.

### Materials

- 2 convex lenses (labeled A and B)
- 2 concave lenses (labeled C and D)
- white poster board
- meterstick
- book with text and one or more pictures

### Analyze Results

Use a table to **compare** the four different lenses you used.

### Create Explanations

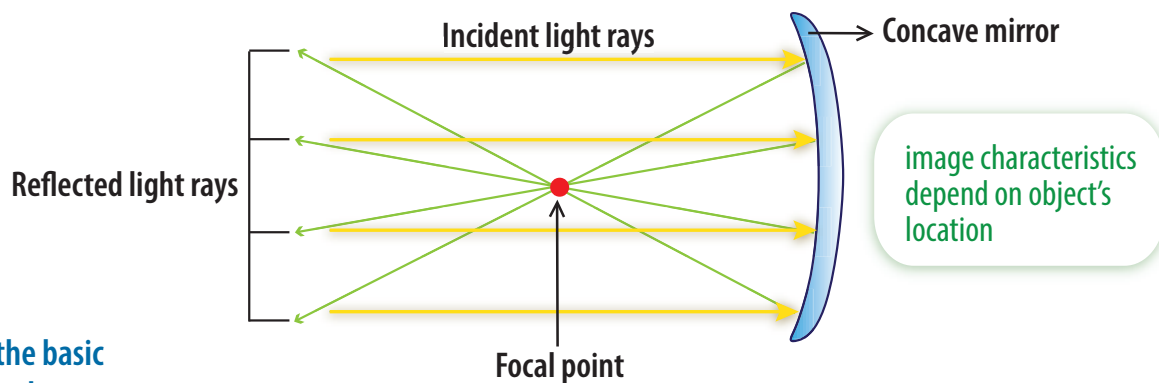
1. How do lenses affect light as it passes through them?
2. Did all the lenses form an image on the poster board? Why or why not? How do they compare in size with the object?
3. How did the thickness of the convex lenses affect the focal length? Why?


## Concave Mirrors

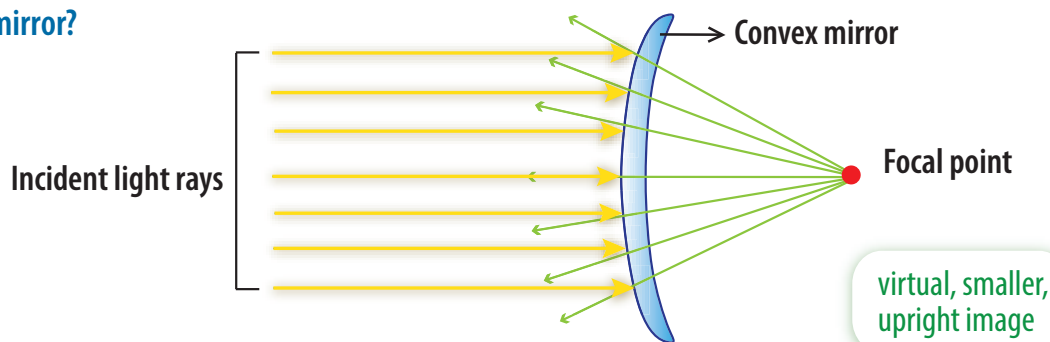
A **concave** mirror is curved like the inside of the bowl or a spoon. The edges of the mirror curve toward you. What other objects in your everyday life are concave? What does an image in a concave mirror look like?

Concave mirrors reflect light rays to a point in space called the **focus**. The focus is in front of the mirror. If you put a piece of paper there, you could see the image on it. The image formed by a concave mirror is called a **real image** because it would appear on a piece of paper. The distance from the center of the mirror to the focus is the **focal length**. What happens if the object being reflected is located between the focus and the mirror?

Concave mirrors have many uses. Since they tend to make an object appear larger, they are used in science equipment, such as microscopes, and in dental equipment. Make-up mirrors are concave mirrors. The satellite dishes you see on people's roofs are shaped like concave mirrors for other electromagnetic waves. What are other potential uses for a concave mirror?



 What is the basic difference between a concave and a convex mirror?



## Convex Mirrors

A **convex** mirror is curved like the back of a spoon. The edges of the mirror curve away from you. A convex mirror makes reflected light rays spread out. The green lines in the convex mirror diagram are where the reflected rays are traced backwards. They seem to come to a point behind the mirror, forming a smaller, virtual image.

Convex mirrors are used on vehicles as the side-view mirrors to help drivers have a wider view of surrounding cars to the side and at the back of the vehicle. What are other uses for a convex mirror?



### Scripture Spotlight

Read **James 1:23**. What does James say someone is like who listens to God's word but does not do what it says? What is he trying to tell us?



### Check for Understanding

Compare and contrast the three types of mirrors.



Fun house or carnival mirrors combine concave and convex mirror shapes to distort images in amusing ways.

? What kind of image distortions are produced by convex or concave shapes in a fun house mirror?

## Lenses **Explain**

Lenses offer a way to refract light waves for many different uses. Lenses are smooth, curved pieces of transparent glass or plastic. They are made to cause light rays to form certain kinds of images. What are some objects that use lenses? What are the lenses being used for in these objects?

Why do lenses work the way they do? Recall what you learned about light in Lesson 1.

- Light always travels in straight lines.
- Light travels more slowly through glass or plastic than air.
- Light bends when it moves from one substance to another.

The amount of bending depends on how the lens is curved and the type of material that the lens is made from. Lenses can have one or two curved surfaces, like mirrors. Lenses are grouped by shape into two kinds—convex and concave.

### Convex Lenses

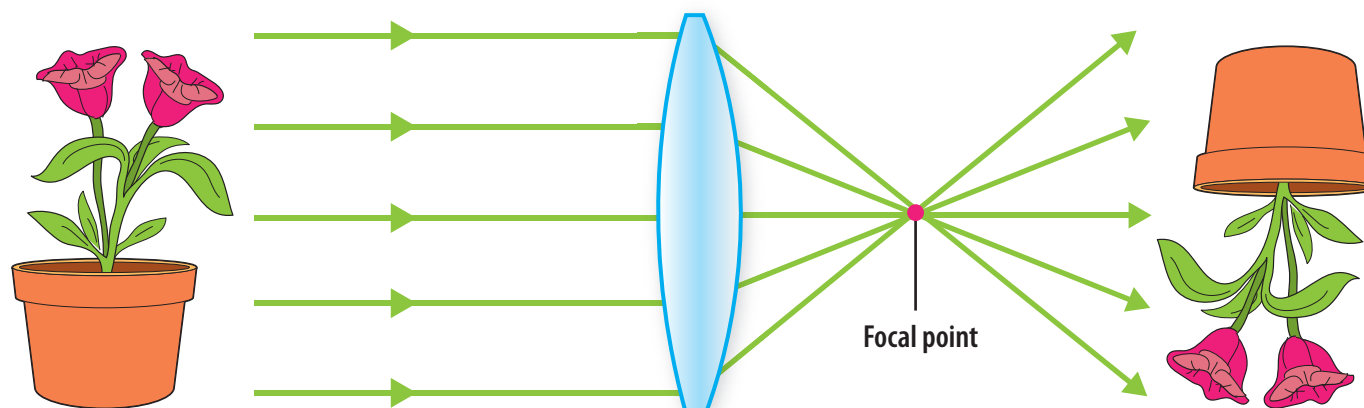
Look at the illustration on the next page. You will see that convex lenses are thicker in the middle than at the edges. A thicker convex lens will bend light more than a thinner, less curved lens. The diagram shows how a convex lens refracts light rays. The rays are bent so they come together at a point behind the lens—the focus. A convex lens that is thicker and more curved has a shorter focal length than one that is thinner and less curved. How might a convex lens be useful?

### Concave Lenses

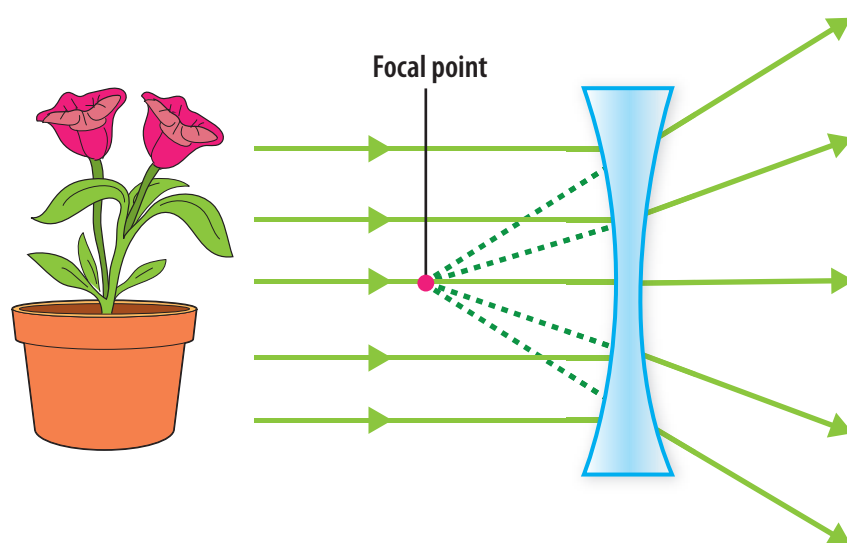
Concave lenses are thinner in the middle than at the edges. The diagram shows how a concave lens refracts light rays. Notice that the light rays do not come together at a focus. Instead, the rays are bent and spread apart as they pass through the lens. How might a concave lens be useful?

There is an easy way to remember how light rays travel through lenses. Light rays passing through a lens always bend toward the thickest part of the lens. Light waves bend toward the thick center in a convex lens. They bend out toward the thick edge in a concave lens.

## Refraction of light through a convex lens



## Refraction of light through a concave lens



### Check for Understanding

Think about the images you observed in the *Structured Inquiry*. How do you explain the images that appeared upside down?

Because it can focus light, a convex lens can form a real image. A concave lens cannot form a real image because it cannot focus light.

❓ What type of lens would work best to help a person who has trouble seeing small words in a newspaper?



Check out your *Science Journal* for a Guided Inquiry that explores a use of lenses to make an optical device.

**Extend**

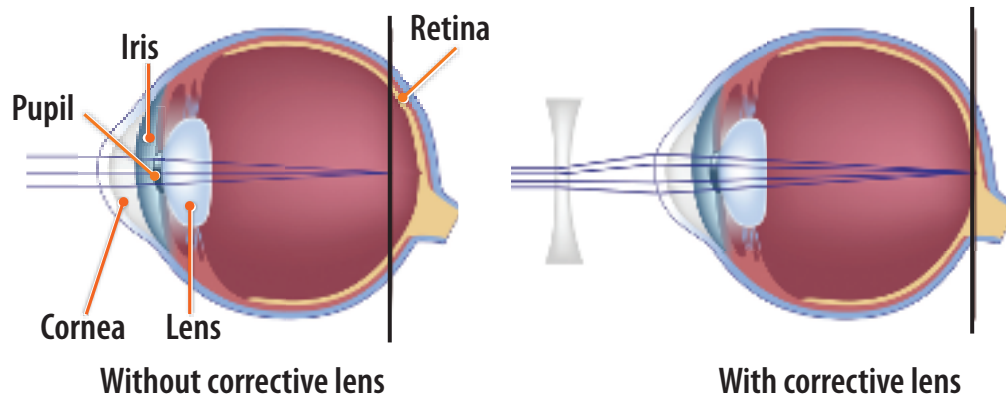
## Use of Lenses

Most optical devices that control light have one or more lenses in them. Devices that magnify often use convex lenses. What other devices use these lenses?

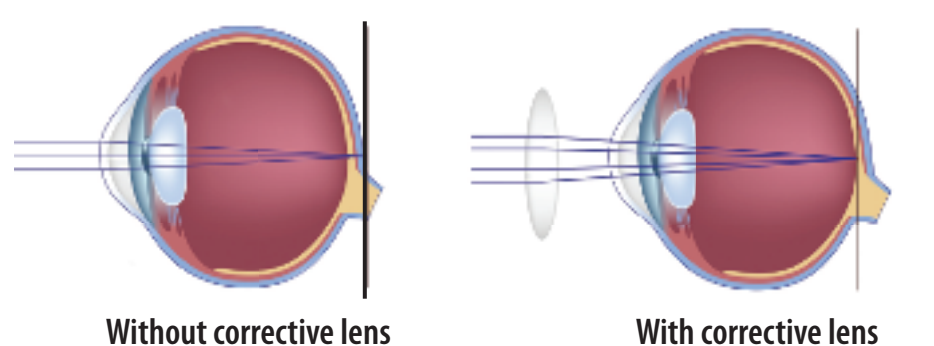
God created the eye especially to focus light so that we could see the world around us. A clear layer called the cornea covers the outer eye. The cornea actually does most of the refraction of light in the eye. Behind the cornea is the iris, the colored part of the eye. The pupil in the center of the iris is an opening that lets reflected light enter the eye. A convex lens lies behind the iris and pupil. The lens does the fine-tuning that helps us see clearly. This lens is able to change shape in order to focus an image on the retina at the back of the eye. The lens becomes thicker when a person looks at a close object. It becomes thinner when a person views a distant object. Farsightedness occurs naturally with age. Usually the eye muscles become weak and cannot pull the lens into the thicker shape needed for focusing on close objects.

Your eye contains a convex lens. This lens changes its shape to focus an image on the retina at the back of your eye. People use lenses in glasses to help correct certain vision problems.

### Concave nearsightedness (myopia)



### Convex farsightedness (hyperopia)





## Explore-a-Lab

## Guided Inquiry

### How do reflections of multiple mirrors interact?

Work in small groups. Make a kaleidoscope by taping three mirrors (forming a hinge) together to make a triangle. Put the shiny, mirrored sides on the inside. Place plastic beads, sequins, or confetti in the center of the triangle.

Observe the reflections in the mirrors. What do you notice when you look at the reflected images?

Humans have developed mirrors and lenses of different shapes to manipulate electromagnetic waves. We use them in simple to complex devices to make our lives easier and explore our world. Engineers combine convex and concave lenses and mirrors to make more complex devices that work better. Optics has a long history when it comes to astronomy and microscope studies. Concave lenses are often used as eyepieces in more complex optical devices. Imagine how different your life would be without mirrors or lenses.



## Concept Check **Assess/Reflect**

**Summary: How do lenses and mirrors affect light?** Plane mirrors and convex mirrors produce virtual images. Concave mirrors produce real images. Lenses can also be convex or concave. Convex lenses bring light rays together at a point called the focus so they form real images. Concave lenses spread light rays apart so they form virtual images.

1. What is the point at which light rays come together after passing through a lens?
2. How is the way light rays reflect from a flat mirror and a curved mirror similar?
3. Explain how people use mirrors and lenses to make complex optical devices.
4. If you look at yourself in a convex mirror and move the mirror closer to your face, what happens to the image?