Lesson 3

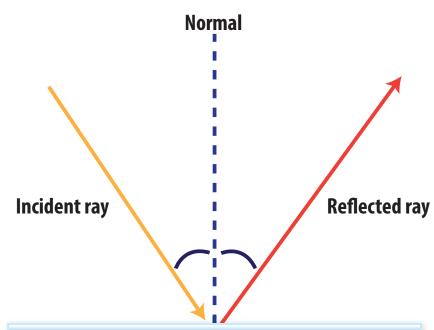
Essential Question

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 3

Essential Question

How Do Lenses and Mirrors Affect Light?

Preview Lesson Content

Read the objectives with students and help them pronounce each term in the vocabulary list. Then, ask students to name different ways they have used mirrors and lenses.

Explain

Mirrors

Objectives

- Compare how plane, convex, and concave mirrors reflect light.
- State the law of reflection.

Set Goals

As they study this lesson, ask students to summarize what they have learned in their own words.

Develop Key Vocabulary

mirror Explain to students that mirrors reflect images.

law of reflection When discussing the law of reflection, the incoming ray is called the incident ray. The returning ray is called the reflected ray.

Understand Visuals

Walk students through the diagram of light reflecting off of a plane mirror. Ensure students are clear that a plane mirror is the flat kind of mirror they are most familiar with. **Which of the pictured angles does the law of reflection describe?** the angles formed between the normal and the light rays

Use a protractor. What is the angle of incidence in the picture? The ray is bisecting a right angle, so the angle of incidence is 45 degrees.

Science Background

Concave Mirrors in Telescopes Every satellite dish you see on people's roofs is a concave mirror for electromagnetic waves. Concave mirrors can focus electromagnetic waves other than light. A radio telescope uses a concave mirror made of wire mesh to focus incoming parallel radio waves to a point. The mirror telescope focuses radio waves onto a receiver suspended at the focus. The telescope detects faint radio waves from distant objects in the universe. The giant radio telescope at Arecibo, Puerto Rico, is the largest in the world. Its concave mirror is 305 m (1000-ft) across. China has started construction on an even larger 500-m (1640-ft) radio telescope. Its construction is expected to be completed in 2016.

Explain (cont.)

Lesson Activity

How did the different reflective surfaces affect the object's image? Were they distorted or changed in some way? Explain. Sample answer: Pretty much any polished surface will reflect light. My reflection was upside down when I looked at the inside of a spoon, because it is curved and bowl-shaped. As I got closer, I could even flip the reflection. Sometimes the image was bigger, sometimes smaller. In other round objects, such as a doorknob, the reflection was bent.

Develop Key Vocabulary

virtual image Point out the kinship between the first part of this compound word and the term *virtual reality.* It means something that "does not physically exist, but is made to appear as if it does." Explain that a *virtual image* is one that forms where light rays cannot actually go.

Scripture Spotlight

1 Corinthians 13:12. What type of mirror do you think is being referred to in this verse—plane, convex, or concave? Sample answer: probably a plane mirror

Explore-a-Lab — Structured Inquiry

Make sure a set of concave and convex mirrors is provided for each student group. If you do not have curved mirrors available, shiny metal soup or serving spoons could be substituted. However, students may not be able to get a clear, larger, right-side-up image to form when they move the concave side closer to themselves.

How does the image of your face appear in different mirrors? Plane mirror: right side up, same size, but reversed right to left, image gets bigger, image gets smaller; concave mirror: upside down, smaller, image gets larger and right side up, image is upside down and smaller; convex mirror: right side up, smaller, image gets larger, image gets smaller.

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				

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Science and Technology

Mirrors and Photography The single lens reflex (SLR) camera is popular with amateur photographers. This type of camera has a mirror behind the lens. The mirror allows the photographer to see the same image that will be recorded on film or digitally. When you depress the shutter release, the mirror flips out of the way and the shutter opens, exposing film to the light or digitally recording the image on a memory card.

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Structured Inquiry

Discover

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

Science Journal

Looking at Lenses

How do lenses affect light as it passes through them?

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

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.

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?

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Inquiry Extension

Extend

Water Drop Lens

Guided Inquiry

How can you make your own lens?

Extend the Structured Inquiry and challenge students to use the materials provided to make a lens and examine text on a sheet of newspaper.

Teaching Tip Provide bulb pipettes, waxed paper, and newspaper. Provide water and other liquids, such as mineral oil, alcohol, or corn syrup.

Students may record their work in their ***Science Journals.*** A scoring rubric can be found as an ***Online Teacher Resource.***

Discover

Use the inquiry activities as an opportunity for students to perform hands-on investigations and think like a scientist.

Structured Inquiry

Looking at Lenses

How do lenses affect light as it passes through them?

Preparation and Tips

Plastic lenses are preferable to glass lenses. Label two convex and two concave lenses of different thicknesses for each group, and place the lenses in a plastic container. Have students work in pairs and have two pairs share one tub of lenses.

Predict **How does lens shape affect the appearance of an image?**

Science Journal

Have students use their ***Science Journals*** to record their work for this inquiry.

Expected Results

Step 1: A & B: image is smaller, upside down; C & D: image is smaller, right side up.

Step 2: A & B: image gets larger, then turns right side up; C & D: image gets larger; as you move closer to the object it gets larger. A & B: image gets smaller until it's the same size as the object; C & D: image gets larger.

Step 3: A & B: image is smaller, upside down.

Step 4: A & B: focal length measurements will depend on the lenses used.

Create Explanations

1. See Expected Results.
2. No—only convex lenses formed an image because the light rays come to a focus behind the lens. Images were enlarged, reduced, or the same size depending on an object's position. (See Expected results)
3. A thicker convex lens will have a shorter focal length than a thinner lens. Thus, a thicker lens can focus light closer to the lens than a thin lens of the same refractive index.

Explain *(cont.)*

Develop Key Vocabulary

concave Point out that *concave* means curving inward, like a cave in a hillside.

focus Tell students that *focus* is used as a noun on this page, but can also be used as a verb, as in *Focus your camera or the picture will be fuzzy.*

real image Explain that this term refers to an image formed when actual rays of light come to a focus.

focal length Photographers use focal length to take crisp pictures. Longer focal lengths require shorter exposure times and minimize blurring caused by shaky hands.

Teach Science Concepts

Have students place a light-colored sheet of paper on the floor with one long edge against the wall. Students will roll a small rubber ball toward the wall of the classroom and draw the angles of incidence and reflection of the ball. **How is the path the ball follows like the path of a reflected light ray?** The angle at which the ball is reflected equals the angle at which the ball hit the wall. **What scientific law does this illustrate?** the law of reflection

What happens if the object being reflected is between the focus and the mirror? It forms a virtual, enlarged image located on the other side of the mirror.

Understand Visuals

Where would an image form with each type of curved mirror? What kind of image would it be? The image would form at the focus. A concave mirror would form a real image in front of the mirror and a convex mirror would form a virtual image that appeared to be behind the mirror.

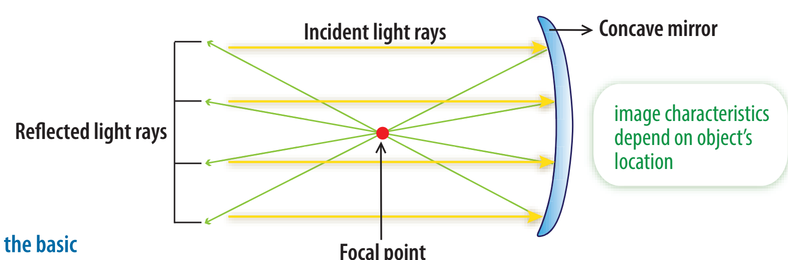
What is the basic difference between a concave and a convex mirror? Both are spherical mirrors. The concave mirror reflects light inward and the convex mirror reflects light outward.

Concave Mirrors

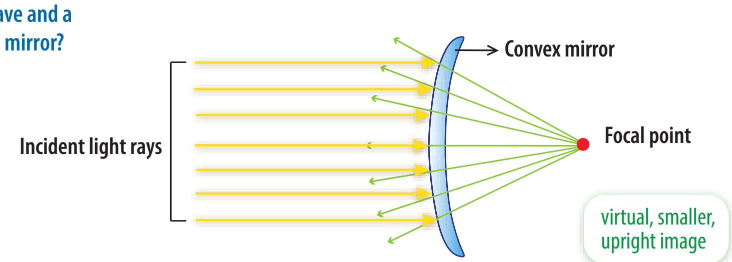
A **concave** mirror is curved like the inside of the bowl or a spoon. The edges of the mirror curve toward you. What other objects in your everyday life are concave? What does an image in a concave mirror look like?

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?



English Language Learners

Assist with Comprehension Draw the shapes of a plane mirror, a concave mirror, and a convex mirror on the board. Label each one. Have students use a sheet of paper to model the shapes of each kind of mirror as they repeat the terms after you. Tell students the curved mirror side should point toward themselves. Repeat several times. Then erase the board and ask them to make the mirror shapes as you call them out. Visually check to see if all students are making the correct shapes.

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?

Develop Key Vocabulary

convex Explain that a convex mirror is shaped the opposite of a concave mirror. It bulges outward like the outside of a ball.

Check for Understanding

Plane mirrors are flat mirrors that reflect light. Concave and convex mirrors are spherical mirrors that have the reflective coating on the inside or outside of the surface of the ball.

Scripture Spotlight

James compared someone who listens to God's word, but does not do what it says to a man who looks at himself in a mirror and immediately forgets what he looks like.

Understand Visuals

Have students explain to classmates who are unfamiliar what fun house or carnival mirrors look like and how they distort images.

What kind of image distortions are produced by convex or concave shapes in a fun house mirror? Sample answer: The angle of the fun house mirror determines exactly what kind of distortion is created. When the mirror bulges outward (convex), the result makes one look short and fat. When the mirror curves inward (concave), it makes one look elongated and thinner.

Science Background

Using Curved Mirrors A convex mirror is a spherical reflecting surface in which its bulging side faces the source of light. Since convex mirrors have wider fields of view than other reflective surfaces, such as plane mirrors or concave mirrors, they are commonly used in automobile side mirrors. A convex mirror is also a good security device. Store owners, for instance, install a number of them inside their stores and orient them in such a way that security personnel can see large portions of the store even while monitoring from a single location. They are the large disk-like reflective surfaces that you see near the ceilings of grocery stores or convenience shops. Spherical mirrors are used in fun houses to distort images: Concave mirrors stretch out an image, while convex mirrors squash an image. We also use curved mirrors to concentrate light in solar cookers and telescopes.

Pull Me Down!

Encourage students to complete the analysis of the data gathered in the Open Inquiry activity. Remind them that they should think like scientists and use the scientific process when creating explanations.

Reminder

Explain (cont.)

Lenses

Objectives

- Compare refraction by concave and convex lenses.
- Compare how optical devices are used.

Teach Science Concepts

Explain that a lens is a transparent curved piece of glass or plastic that works or produces an image by refracting light so that the light rays that pass through it bend or change direction. The rays come to a focus at a point that is closer or further away from the place where they actually originate.

As with mirrors, there are two main types of lenses: concave (diverging) and convex (converging). The convex lens makes parallel rays of light bend inward, or converge, at the focus. Convex lenses are mainly used in devices like telescopes and microscopes that magnify. A concave lens makes parallel rays of light curve outward or diverge. Concave lenses are used in devices like projectors to spread out the light.

Have students study the paragraphs that describe the two types of lenses under the heading "Lenses." Explain that the extra inquiry activity in their ***Science Journals*** will encourage them to experiment with and explore the basic principles behind optical devices that utilize these lenses.

Incorporate Inquiry Skills

Skill: Compare Ask students to look at the lens diagram. **How do the shapes of the two kinds of lenses compare?** Answer: Convex lenses are thicker in the middle than at the edges and concave lenses are thinner in the middle than at the edges.

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.

Scaffolded Questions

Help students understand how lenses can be used to produce images.

Approaching Level **Why do some people wear glasses or contact lenses?** The glasses or lenses help them see better.

On Level **How does the way convex and concave lenses bend light compare?** Convex lenses bend light rays so they come together at the focus. Concave lenses spread light rays apart so they do not come together at a focus.

Above Level **Why do concave lenses always produce virtual images?** Sample answer: Concave lenses will always create a virtual image because when you extend their light rays, they diverge or spread apart and never end up intersecting at the focus point.

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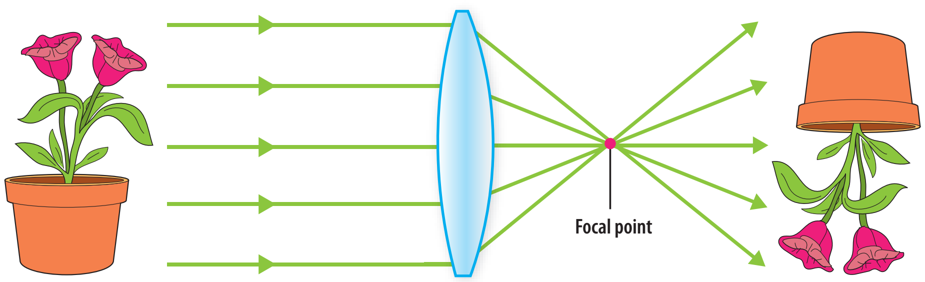
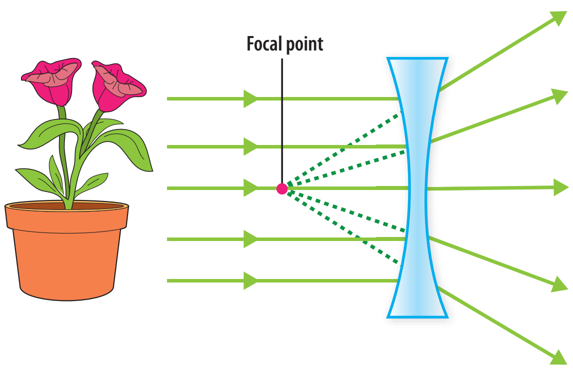
Refraction of light through a convex lens



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?

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Health Link

Myopia and Hyperopia Myopia is a condition commonly called nearsightedness. It occurs because the eyeball is too long or the cornea has too great of a curvature. As a result, the rays entering the eye do not converge at the retina. Instead, the rays converge in front of the retina, so images at a distance appear blurry. Hyperopia is a condition commonly called farsightedness. It occurs because the eyeball is too short or the cornea is curved too little. As a result, the light rays converge behind the retina, so close that images appear blurry.

Ask for volunteers who wear glasses or contact lenses to describe how corrective lenses help them see.

Teach Science Concepts

Use the images on this page to clarify how the two different types of lenses focus light rays. Point out that concave lenses generally make images smaller, so they are not as common in devices as convex lenses are. Both types are used in eyeglasses however, to improve vision.

Check for Understanding

Refer back to the Structured Inquiry. Have student discuss the inverted images they observed and the focal point of the lenses. Sample answer: Light rays coming in parallel to the lens are bent as they pass through the lens. This causes them to all pass through a single point called the focal point on the opposite side of the lens. When the light rays cross at this focal point, the resulting image is turned upside-down.

Understand Visuals

Draw students' attention to the lens diagrams and have them study the caption. **How do the images formed by convex and concave lenses differ?** Convex lenses form real images and concave lenses form virtual images. **What are three ways that convex and concave lenses differ?** They differ in shape. They differ in how they bend light rays. They differ in the kind of image they form. **What optical device can you think of that uses a single convex lens to observe a small object?** hand lens **How do these lenses relate to a common magnifying lens?** Most magnifiers are double-sided two-convex lenses; single-sided convex lenses are used in many optical instruments.

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

Explain (cont.)

Teach Science Concepts

Point out that lenses have many uses in a variety of optical devices. Often they are combined with mirrors in more complex devices. Ask students to identify some ways in which different kinds of lenses are used. One of the most obvious uses is in people's glasses. Have students look at the pictures on this page and identify which kind of lens is used to help people who are nearsighted (where light focuses in front of the retina), a convex lens, and which is used to help people who are farsighted (where the light focuses behind the retina), a concave lens.

Which lenses are used in devices to magnify? convex lenses

Point out that while concave lenses often make images appear smaller, they are useful in producing clearer images, which is why they are often used as eyepieces.

Understand Visuals

Direct student attention to the cross-sectional drawing of the human eye. You might share some of the information from the Health Link on human vision. **What kind of lens does the human eye contain?** The human eye contains a convex lens. The lens focuses light to the back of the eye. Tell students that they can think of the eye like a camera. The cornea acts like a lens cover and the retina acts like the camera film. Explain that behind the retina is the optic nerve, which changes the image produced on the retina to an electrical signal the brain can interpret.

What type of lenses does a person who is farsighted use? What type of lenses does a person who is nearsighted use? Explain. Sample answer: Someone who is farsighted uses convex corrective lenses because the distance between the lens and the retina is too short and the image comes to a focal point behind the retina. Someone who is nearsighted uses concave corrective lenses because the image comes to a focus before the retina. This lengthens the focal length so the image forms on the retina.

Science Journal

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

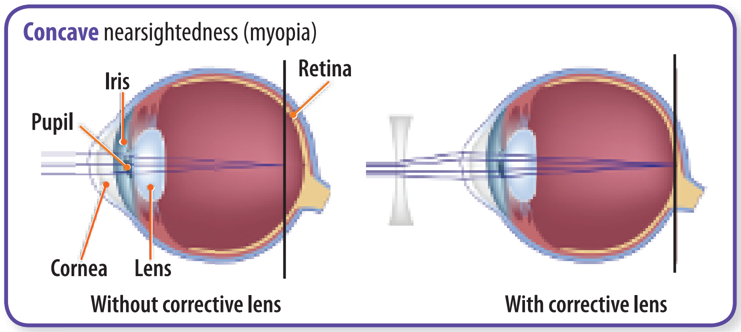
Extend

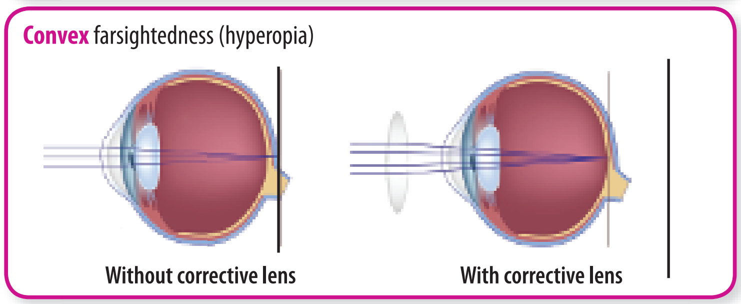
Use of Lenses

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 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.





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Inquiry Extension

Extend

Simple Optics

Guided Inquiry

What combination of lenses will make a model optical device?

Extend the lesson content by challenging students to use two lenses, a flashlight, an index card, and clay to make a model microscope or telescope.

Teaching Tip Encourage students to shine the flashlight through different combinations of lenses and draw pictures of what they see through the lenses. Can they make the lenses magnify smaller objects, or make distant objects appear closer? Students might work near an outside window.

Students may record their work in their ***Science Journals.*** A scoring rubric can be found as an ***Online Teacher Resource.***

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?

Science Background

Trilobite Eyes The trilobite is an extinct arthropod. It had unique compound eyes. The eyes consisted of many lenses of perfectly aligned and crafted six-sided crystals of pure calcium carbonate. The lens configuration allowed the eye to focus on objects up close and at a distance. In other words, the trilobite was able to focus on objects like food in the foreground, while simultaneously focusing on potential predators at a distance. The different eye forms are differentiated by the unique arrangement and number of lenses in the eye structure. Trilobite visual systems came in three forms: holochroal (many hexagonal compound eyes in one corneal layer), schizochroal (thick lenses each covered by a single cornea), and abathochroal (a few small lenses separated from each other).

Explore-a-Lab Guided Inquiry

Practice: Observe This activity allows students to observe how kaleidoscopes produce multiple internal reflections. Have students observe the reflections by holding the mirrors above the colorful objects. Another option is to make a portable version of this optical toy using paper towel rolls, acrylic mirrors, or mylar film (or foil glued to cards), and duct tape.

How do reflections of multiple mirrors interact? Sample answer: The patterns inside a kaleidoscope are made by light bouncing between the mirrors inside. You look through one end and the light enters from the other. Moving the mirrors produces different colors and patterns.

Assess/Reflect

Read the essential question and lesson summary with students. You may work through the concept check as a class, or use it as a formal assessment.

Concept Check

1. focus
2. Whether the mirror is flat or curved, light rays always reflect off a mirror at the same angle as the light rays hit the mirror.
3. Sample answer: People combine mirrors and lenses in complex optical devices to take advantage of their properties that reflect and refract light rays in different ways.
4. The image is larger than normal. As you bring the mirror closer, the image gets even larger.