

section 2 Lenses

What You'll Learn

- what convex and concave lenses look like
- how convex and concave lenses form images
- how lenses can help people see better

Study Coach

Make a Chart Make a two-column chart. As you read, list the main ideas in the left column. In the right column, list the details that support each main idea.

Picture This

1. **Predict** A light ray travels along the optical axis to a convex lens. Draw a line on the figure to show what will happen to the ray as it passes through the lens.

Before You Read

Tools used to look at objects contain at least one lens. On the lines below, make a list of tools that have lenses in them.

Read to Learn

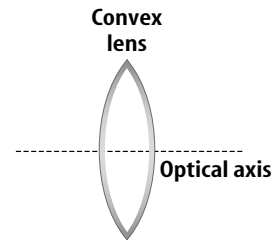
What is a lens?

What do your eyes have in common with cameras, eyeglasses, and microscopes? They all contain at least one lens. A lens is made of transparent material. Remember, transparent means that almost all the light rays that hit the material pass through it. A lens has at least one curved surface. The curved surface makes light rays refract, or bend, as they pass through the lens.

Like mirrors, lenses produce images. What an image looks like depends on the shape of the lens. A lens can be convex or concave.

Convex Lenses

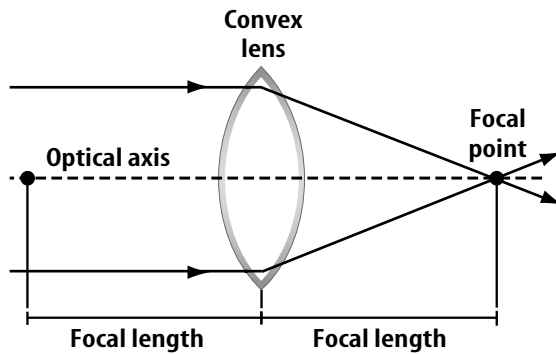
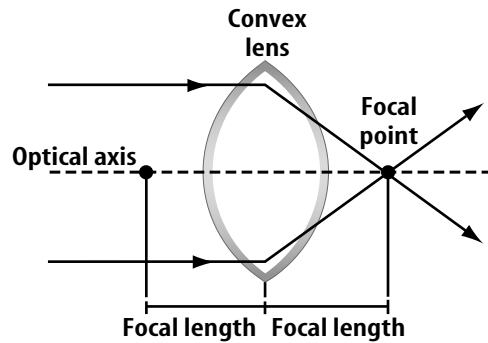
A **convex lens** is thicker in the middle than at the edges. The optical axis of a convex lens is an imaginary line perpendicular to the thickest point on the lens. The figure shows a convex lens.



How does a convex lens work?

Some light rays travel parallel to the optical axis on their way to a convex lens. The lens refracts these light rays in a special way. The refracted rays all cross each other at the same point, called the focal point. The focal length of the lens is the distance from the center of the lens to the focal point.

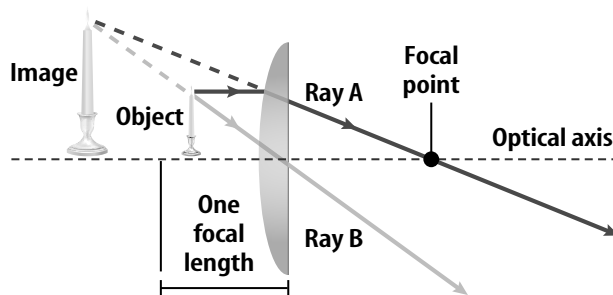
The focal length of a convex lens depends on the shape of the lens. Look at the figures below. If the curved sides of the lens are very rounded, the light rays bend sharply. The focal point is close to the lens. So, the focal length is short. If the sides of the lens are flatter, the light rays bend less. The focal point is farther from the lens. So, the focal length is longer.



What does an image from a convex lens look like?

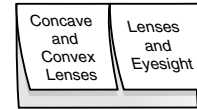
The image of an object from a convex lens does not always look the same. It depends on how close the object is to the lens.

Suppose you put an object less than one focal length from a convex lens. The lens will produce a virtual image of the object. The image is right side up. But, the image is larger than the object, but magnified. Have you ever used a magnifying glass? This tool is a convex lens.



FOLDABLES™

B Organize Take notes about lenses in a 2-tab Foldable such as the one shown below.



Picture This

- 2. Compare** Extend the top horizontal line in each figure. Compare the angles formed by these lines and the bent rays. Which angle is greater, the one in the figure of more curved lens or the one on the figure with the flatter lens?

Picture This

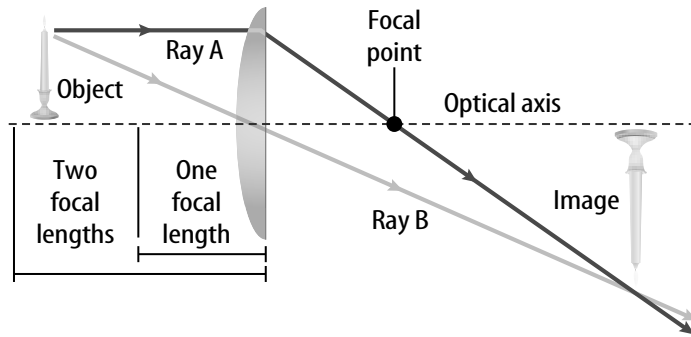
- 3. Apply** Rob has a convex lens with a focal length of 5 in. He wants to produce a larger, right-side-up image of a pencil. Which figure shows where Rob should put the pencil? Circle your answer.

- inside one focal length
- between one and two focal lengths
- outside two focal lengths

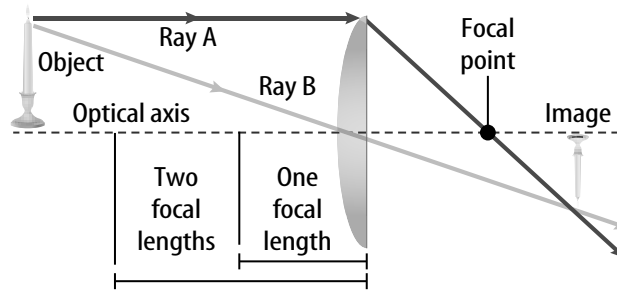
Picture This

4. **Describe** Suppose you need to create an upside down image of an object. You have a convex lens. Where should you put the object?

What would happen if you put the object between one and two focal lengths from the lens? This time the lens will produce a real image. The image is larger than the object. And, the image is upside down.



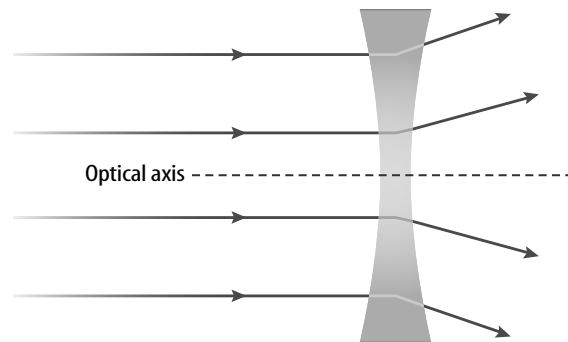
If the distance between the object and the lens is more than two focal lengths, you get another kind of image. The lens produces a real image. The image is upside down. However, the image is smaller than the object.



Concave Lenses

A **concave lens** is thinner in the middle and thicker at the edges, as shown below. The optical axis of a concave lens is an imaginary line perpendicular to the thinnest point on the lens.

When a concave lens refracts light rays, it bends the rays outward, away from the optical axis. The rays spread out and never meet at a focal point.



Concave lenses are used in some eyeglasses and some telescopes. Often they are used in combination with other lenses.

A concave lens creates a virtual image. The image is right side up. But, the image is smaller than the object.

Think it Over

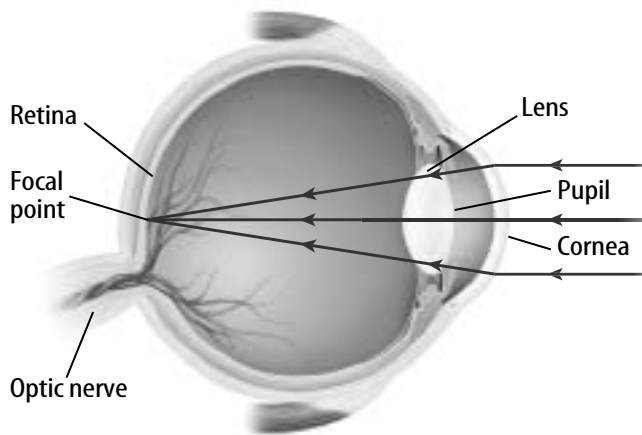
5. **Classify** Is a concave lens most like a concave mirror or a convex mirror? Explain your choice.

Lenses and Eyesight

What determines how well you can see the words on this page? If you do not need eyeglasses, it is because the parts of your eyes work together to let you see clearly.

How do your eyes work?

Light enters your eye through the cornea. The **cornea** (KOR nee uh) is a transparent covering over your eyeball. The cornea bends light rays to bring them together. Then the light goes through an opening in your eye called the pupil. Behind the pupil is a convex lens. The lens also brings the light rays together. Then the rays form an image on your retina. The **retina** is the inner lining of your eye. It has cells that can change the image into electrical signals. The optic nerve sends the signals to your brain. ✓



How do you clearly see both near and far objects?

You can see the watch on your wrist clearly. Then you can look at a clock across the room and see it clearly, too. How is this possible? For you to see an object clearly, its image must form on your retina. If the image forms in front of the retina or behind the retina, the object will look blurry.

Remember that the location of an image from a convex lens depends on the focal length and the location of the object. For an image to be formed on the retina, the focal length of the lens must change as the object's distance changes.

✓ Reading Check

6. **Explain** On what part of the eye does the image form?

Picture This

7. **Find** Highlight the two parts of the eye that bring light rays together. What are these two parts?

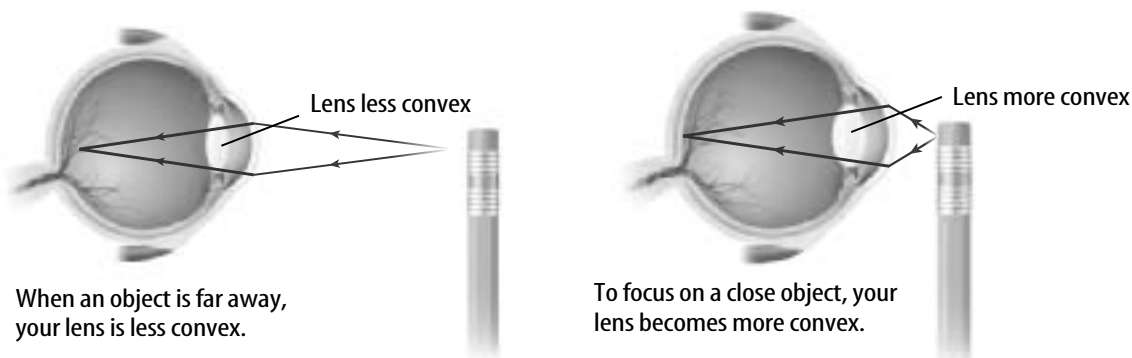
Picture This

8. **Identify** Circle the figure that shows what your retina does to let you clearly see a nearby object.

How does a lens change shape?

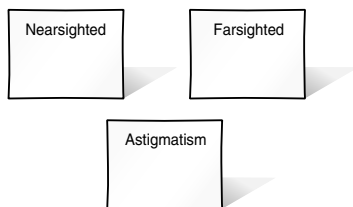
Fortunately, the lens is made of material that can change shape. Muscles are attached to the lens of an eye. They can pull the lens into rounder or flatter shapes. This changes the lens' focal length.

If the object is far away, the muscles make the lens flatter. This increases the focal length to keep the image on the retina. If the object moves closer to you, muscles make the lens rounder. This shortens the focal length to keep the image on the retina.



FOLDABLES™

- Compare** Make three note cards out of quarter sheets of paper to take notes and compare different vision problems.



Vision Problems

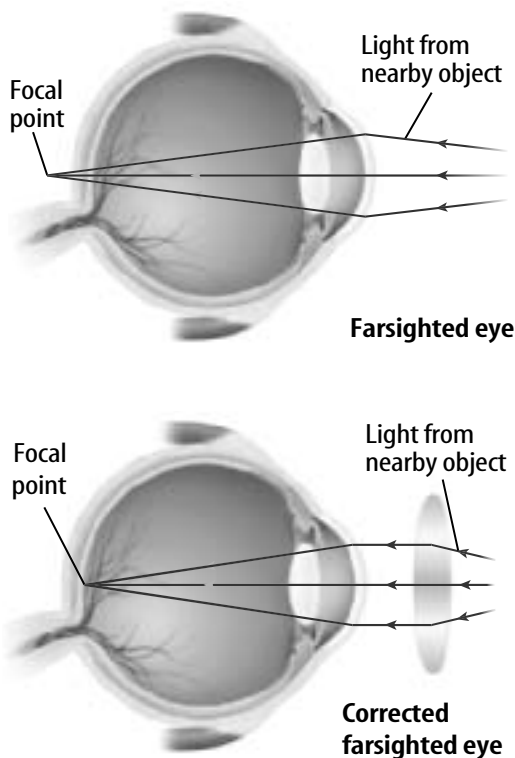
If you have healthy vision, you should be able to see objects clearly when they are 25 cm or farther away from your eyes. However, many people have trouble seeing objects at certain distances. Images can be blurry or in the wrong place. One cause of these problems is the length of the eyeball or the fact that the lenses may not be able to change shape properly. Diseases of the retina can cause vision problems. But, eyeglasses, contact lenses, and surgery often can correct vision problems and help people see more clearly.

What does it mean to be nearsighted?

If you have nearsighted friends, you know that they can see clearly only when objects are nearby. Their eyeballs may be too long which means their lenses may not be able to flatten enough. This means that they cannot make the focal length of their lenses long enough to form an image on the retina. Instead, the image forms in front of the retina. Eyeglasses with concave lenses can help increase the focal length. Nearsighted people see objects that are near better than objects that are far away.

What does it mean to be farsighted?

Some people can see objects clearly that are far away. But, nearby objects look blurry to them. These people are farsighted. Their eyeballs may be too short which means their lenses may not be able to curve enough. This means that they cannot make the focal length of their lenses short enough to form an image on the retina. To correct this problem, they may wear glasses with convex lenses. As you can see in the figure, the convex lenses help shorten the focal length. Farsighted people see objects that are far away better than objects that are near.



Farsightedness is common as people get older. The lenses in the eyes of older people often become less flexible. The muscles cannot make the lens curve enough to form an image on the retina. ✓

What is astigmatism?

Another vision problem, called astigmatism (uh STIHG muh tih zum), occurs when the surface of the cornea is curved unevenly. When people have astigmatism, their corneas are more oval than round in shape. Astigmatism causes blurry vision at all distances. Eyeglasses with unevenly curved lenses can help people with this condition. The lenses cancel out the effects of the uneven cornea.

Think it Over

9. Compare and Contrast

What are the differences between farsightedness and nearsightedness?

Picture This

10. **Measure** Use a metric ruler to measure the distance from the outer edge of the cornea to the focal point in each figure. By how much did this length change?

Reading Check

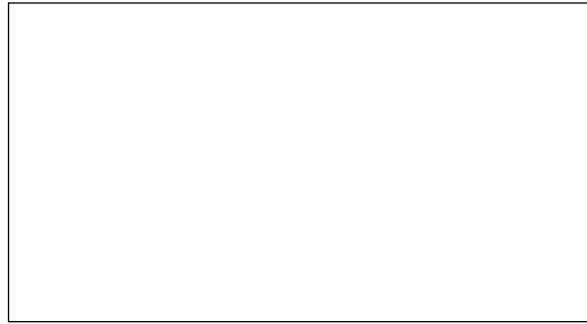
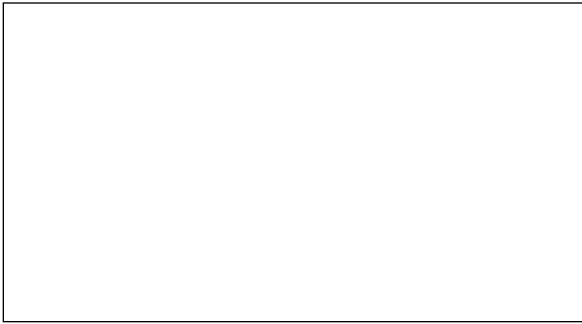
11. **List** What are the causes of farsightedness?

● After You Read

Mini Glossary

concave lens: a lens that is thinner in the middle than at the edges : **cornea:** the transparent covering over the eyeball
convex lens: a lens that is thicker in the middle than at the edges : **retina:** the inner lining of the eye

- Review the terms and their definitions in the Mini Glossary. In the first box, sketch a convex lens. In the second box, sketch a concave lens. Add light rays to show how the lenses affect them.



- Complete the chart below to organize the information from this section.

Kind of Lens	Position of Object	Is image right side up or upside down?	Is image larger, smaller, or the same size as the object?
Convex			
Convex			
Convex			
Concave	X		

