# Lesson 6
# How Do We See?

## Objectives

Students will

- identify the basic parts of the human eye
- describe the function of each part of the human eye
- identify and describe common eye conditions such as colorblindness, farsightedness, and near-sightedness
- identify several methods for correcting vision problems
- identify people in their community who work in scientific fields related to vision

## Vocabulary

*cone*—a cell in the retina that tells the brain about the color of an object

*cornea*—the clear, outer layer of the eye

*iris*—the colored part of the eye that controls the pupil

*pupil*—the opening in the center of the eye that controls how much light enters the eye

*retina*—the back layer of the eye that captures light and sends the images stored in the light to the brain

*rod*—a cell in the retina that helps the eye see in dim light

## Preparation/Materials

**Try This: Find Your Blind Spot**

√ white paper, one sheet per student
√ black pens or markers, one per student
√ metric rulers, one per student

**Try This: Observe Pupils**

√ metric rulers, one per student

**Let's Find Out: Are Two Eyes Better Than One?**

√ posterboard, half a sheet per team
√ black markers, one per team
√ metric rulers, one per team
√ markers of different colors (red, green, blue, orange, yellow, and brown), two markers of different colors per student. (No two colors should be the same within a team.)

**Activity: Why Do We Need Rods?**

√ water bottle caps, 10 per team
√ Coke bottle caps, 10 per team
√ Mountain Dew bottle caps, 10 per team
√ As an alternative to the above materials, you could also provide students with three sets of 10 very similar items, such as different colored pen caps or different colored candies, etc.
√ shoeboxes, one per team

**Drama: Acting Out the Eye**

√ Have students bring play props from home.

## Background

The human eye is an amazing structure. A person can see objects over a large angle even when looking straight ahead. The human eye can refocus from distant objects to objects only 20 cm away almost immediately. It can distinguish between 10 million different shades of color and can see over a range of light intensity of 10 billion to one—from brilliant sunlight to dark night. The cornea has an automatic scratch remover. If one eye is damaged, the remaining eye can meet most of a person's vision needs. The eye has a self-regulating pressure system to maintain its own internal pressure to keep its shape; if it is dented, the eye quickly rebounds back to its original shape. The eye and brain work together nearly simultaneously to constantly provide clear, sharp images of a person's surroundings. Although the image reaching the retina is upside down and backwards, the brain automatically inverts the picture right-side up. The brain also coordinates the images received by both eyes to provide depth perception and three-dimensional images.

How does the human eye accomplish the amazing feat of vision? Light enters the eye through the cornea, which is the outer, transparent layer of the eye. Next, the light passes through the pupil, which regulates the amount of light that enters the eye. The pupil enlarges in poor light to allow more light into the eye, and it contracts in bright light to limit the amount of light entering the eye. The iris is the colored portion of the eye, and it controls the movements of the pupil.

Once past the iris, the light strikes the lens of the eye, and the lens focuses the light onto the retina. The retina is the innermost layer of the eye; like film in a camera, the retina captures the images stored in the light waves. Before striking the retina, light waves pass through a colorless mass of gelatinous material behind the lens called the vitreous humor. When the image strikes the retina, it's upside down, backward, and two-dimensional. The retina contains rods and cones, which are light-sensitive cells. These cells connect the brain to the optic nerve, which relays messages about visual images to a part of the brain called the occipital lobe. The occipital lobe takes the backwards, upside-down, two-dimensional image and corrects it into the images we see.

Color vision is one the amazing design features of the human eye. Rods are sensitive to dim light and help with night vision. Cones distinguish between colors. There are three types of cones. Red cones absorb red and yellow light, green cones absorb mostly yellow and green light, and blue cones absorb blue and violet light. The color that we see depends on what combination of receptors is triggered.

Sometimes one or more types of cones in the eye don't work properly, leading to an inherited condition called colorblindness. Colorblindness isn't an inability to see color; it is an inability to distinguish between certain colors. The green cones are most commonly affected, resulting in the inability to distinguish between red and green. About 8 percent of males and 0.5 percent of females inherit colorblindness.

The cornea's curvature in a normal, healthy eye is matched to the distance from the eye's lens to the retina. If a person has normal vision, the image of an object focuses clearly on the retina. An image that focuses behind or in front of the retina, however, results in blurred vision. Artificial lenses are usu-

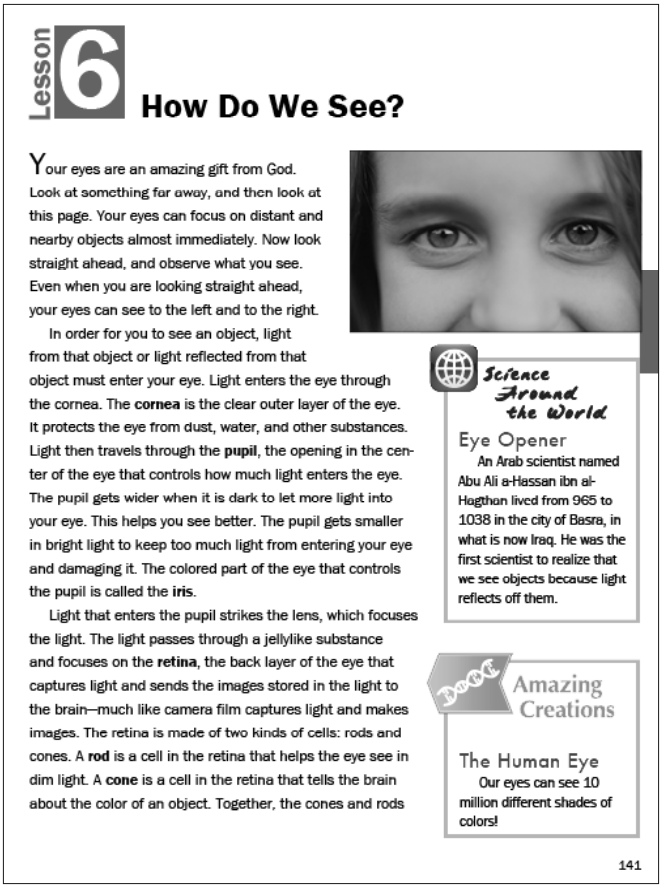
ally required to correct vision problems.

As a person ages, the muscles holding the eye's lens weaken, and eyeglasses are usually required to help focus on close-up objects such as the text of a book. This condition is called hyperopia, or farsightedness. The eye of a farsighted person has a cornea that isn't curved enough or an eyeball that is too short. Images focus behind the retina, causing them to be blurry when they strike the retina. A convex lens corrects farsightedness by causing light waves to bend sooner so that an image focuses on the retina.

If a person is nearsighted, his or her corneas are overly curved or their eyeballs are too long. Images of distant objects focus at a point in front of the retina and then spread apart again, blurring the images. A concave lens corrects nearsightedness by spreading out incoming light waves before they strike the lens so that the lens bends the waves to focus on the retina.

Poor vision usually is corrected with artificial lenses in the form of eyeglasses or contact lenses. Laser surgery is also used to correct vision problems. Lasers are used to reshape the cornea so that light refracts from the eye lens directly on the retina.

As you teach this lesson, be sensitive to students with vision disorders.



Lesson 6

## How Do We See?

Your eyes are an amazing gift from God. Look at something far away, and then look at this page. Your eyes can focus on distant and nearby objects almost immediately. Now look straight ahead, and observe what you see. Even when you are looking straight ahead, your eyes can see to the left and to the right.

In order for you to see an object, light from that object or light reflected from that object must enter your eye. Light enters the eye through the cornea. The **cornea** is the clear outer layer of the eye. It protects the eye from dust, water, and other substances. Light then travels through the **pupil**, the opening in the center of the eye that controls how much light enters the eye. The pupil gets wider when it is dark to let more light into your eye. This helps you see better. The pupil gets smaller in bright light to keep too much light from entering your eye and damaging it. The colored part of the eye that controls the pupil is called the **iris**.

Light that enters the pupil strikes the lens, which focuses the light. The light passes through a jellylike substance and focuses on the **retina**, the back layer of the eye that captures light and sends the images stored in the light to the brain—much like camera film captures light and makes images. The retina is made of two kinds of cells: rods and cones. A **rod** is a cell in the retina that helps the eye see in dim light. A **cone** is a cell in the retina that tells the brain about the color of an object. Together, the cones and rods

### Science Around the World

**Eye Opener**

An Arab scientist named Abu Ali a-Hassan ibn al-Hagthan lived from 965 to 1038 in the city of Basra, in what is now Iraq. He was the first scientist to realize that we see objects because light reflects off them.

### Amazing Creations

**The Human Eye**

Our eyes can see 10 million different shades of colors!

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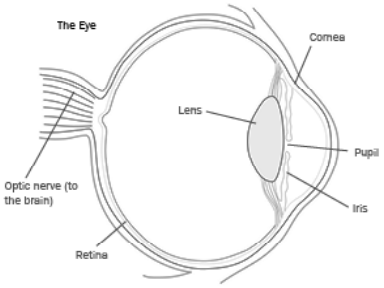
### Try This

**Observe Pupils**

Sit in a darkened room for a few minutes with your team members. Observe the size of a team member's pupils. Carefully use a ruler to estimate the diameter (width) of one pupil. (Be careful not to touch the person's eyes.) Turn on a bright light, and continue to watch your team member's pupils. (Don't shine the light into the person's eyes.) Observe what happens. Measure the diameter of the pupil again. Write two or three sentences in your science journal explaining why these changes happened.

capture the light and turn the images in the light waves into messages. These messages are sent from the eye to the brain through a nerve called the optic nerve. On the retina these images are upside down, backward, and two-dimensional. Your brain makes the images right-side up, forward, and three-dimensional.

Many people don't have perfect vision. If the cones don't work right, a person may be colorblind. Being colorblind




### Intersection with Life Science

**Achoo!**

Some people sneeze when they move suddenly from dim light into bright light. Does this happen to you? Why does this happen? Although scientists aren't sure exactly why this happens, they believe it is because the optic nerve is very close to the nerve that causes sneezing. When bright light surges suddenly through the optic nerve, it triggers the nearby "sneezing" nerve to sneeze!

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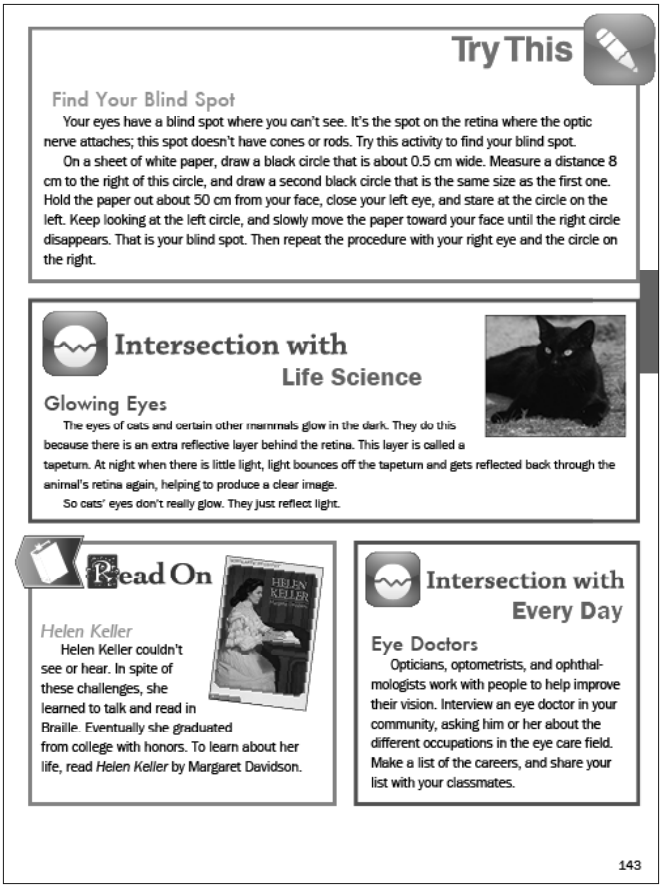
## Discover

1. Have students describe their results of **Try This: Find Your Blind Spot** (page 143) in the student text.

2. Have students complete **Try This: Observe Pupils** (page 142) in the student text. Explain to students that eye pupils become larger in dim light to allow more light to enter the eye. In bright light the eye pupils become smaller to protect the eyes. Too much light can damage the sensitive layer of the retina.

## Develop

1. Have students complete **Let's Find Out: Are Two Eyes Better Than One?** (page 144) in the student text. Students should be able to score much higher using two eyes instead of one eye. Two eyes are needed for depth perception, which is the ability to judge how far away or near objects are.
   1. *Compare the score you made using one eye to the score you made using both eyes. (Answers will vary, but the score for both eyes should be significantly higher than the score for one eye.)*
   2. *How did two eyes help you during this activity? (Two eyes provide depth perception, the ability to see how far or near an object is. Using only one eye to judge distances is much more difficult than using both eyes.)*



## Try This

### Find Your Blind Spot

Your eyes have a blind spot where you can't see. It's the spot on the retina where the optic nerve attaches; this spot doesn't have cones or rods. Try this activity to find your blind spot.

On a sheet of white paper, draw a black circle that is about 0.5 cm wide. Measure a distance 8 cm to the right of this circle, and draw a second black circle that is the same size as the first one. Hold the paper out about 50 cm from your face, close your left eye, and stare at the circle on the left. Keep looking at the left circle, and slowly move the paper toward your face until the right circle disappears. That is your blind spot. Then repeat the procedure with your right eye and the circle on the right.

## Intersection with Life Science

### Glowing Eyes

The eyes of cats and certain other mammals glow in the dark. They do this because there is an extra reflective layer behind the retina. This layer is called a tapetum. At night when there is little light, light bounces off the tapetum and gets reflected back through the animal's retina again, helping to produce a clear image.

So cats' eyes don't really glow. They just reflect light.

## Read On

*Helen Keller*

Helen Keller couldn't see or hear. In spite of these challenges, she learned to talk and read in Braille. Eventually she graduated from college with honors. To learn about her life, read *Helen Keller* by Margaret Davidson.

## Intersection with Every Day

### Eye Doctors

Opticians, optometrists, and ophthalmologists work with people to help improve their vision. Interview an eye doctor in your community, asking him or her about the different occupations in the eye care field. Make a list of the careers, and share your list with your classmates.

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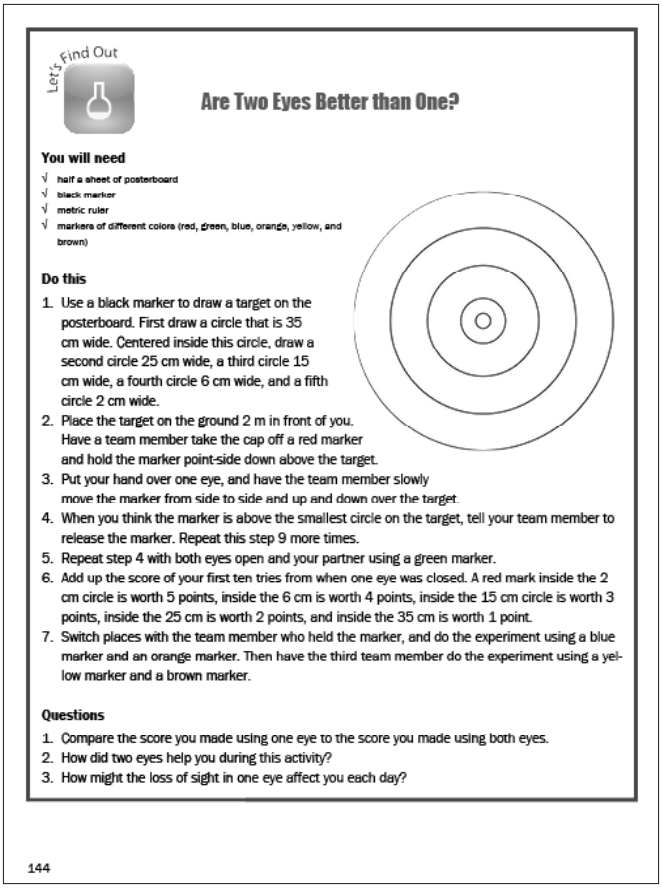

Let's Find Out

## Are Two Eyes Better than One?

**You will need**

- √ half a sheet of posterboard
- √ black marker
- √ metric ruler
- √ markers of different colors (red, green, blue, orange, yellow, and brown)

**Do this**

1. Use a black marker to draw a target on the posterboard. First draw a circle that is 35 cm wide. Centered inside this circle, draw a second circle 25 cm wide, a third circle 15 cm wide, a fourth circle 6 cm wide, and a fifth circle 2 cm wide.
2. Place the target on the ground 2 m in front of you. Have a team member take the cap off a red marker and hold the marker point-side down above the target.
3. Put your hand over one eye, and have the team member slowly move the marker from side to side and up and down over the target.
4. When you think the marker is above the smallest circle on the target, tell your team member to release the marker. Repeat this step 9 more times.
5. Repeat step 4 with both eyes open and your partner using a green marker.
6. Add up the score of your first ten tries from when one eye was closed. A red mark inside the 2 cm circle is worth 5 points, inside the 6 cm is worth 4 points, inside the 15 cm circle is worth 3 points, inside the 25 cm is worth 2 points, and inside the 35 cm is worth 1 point.
7. Switch places with the team member who held the marker, and do the experiment using a blue marker and an orange marker. Then have the third team member do the experiment using a yellow marker and a brown marker.

**Questions**

1. Compare the score you made using one eye to the score you made using both eyes.
2. How did two eyes help you during this activity?
3. How might the loss of sight in one eye affect you each day?

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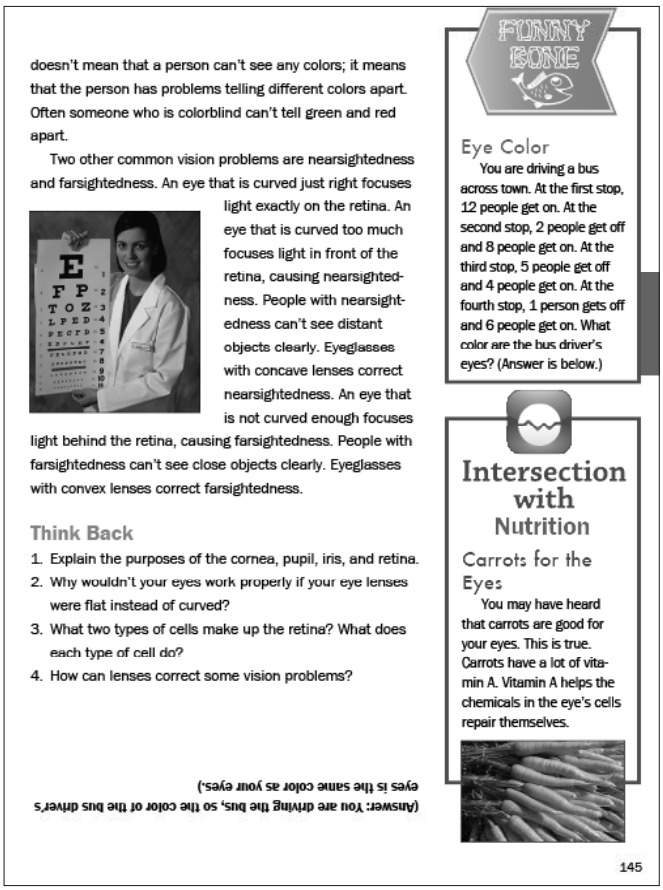
3. *How might the loss of sight in one eye affect you each day? (Answers will vary but may include having difficulty judging distances in sports such as shooting a soccer ball or basketball, difficulty picking up objects, and difficulty riding a skateboard, bike, or snowboard.)*

2. **Activity: Why Do We Need Rods?** Provide each team with 10 water bottle caps, 10 Coke bottle caps, and 10 Mountain Dew bottle caps. (You could use three sets of any 10 objects that are very similar.) All of the items should feel the same but look different.

   In a brightly lit room, have each team sort the items into three piles of identical items. Then have students place the items in a shoebox and shake the box. Darken the room as completely as possible. Have students take the caps out of the box and try to sort them again. Turn on the lights, and have students evaluate their efforts. They probably weren't as accurate as the first time. Have students place the items back in the shoebox and mix up the contents once again.

   Leaving the lights dimmed, discuss the role of rods and cones in human vision and in nocturnal animals. Explain that cells called rods in their eyes are responsible for seeing in dim light or darkness and the cones are responsible for seeing different colors. But what seems to be total darkness for a human may only be dim light for a nocturnal animal. Nocturnal animals have larger eyes than humans, and their pupils will open wider to allow more light into their eyes. Nocturnal animals also have highly specialized rods in their retinas. The eyes of many nocturnal animal have many more rods than human eyes, and some animals such as snakes, liz-



doesn't mean that a person can't see any colors; it means that the person has problems telling different colors apart. Often someone who is colorblind can't tell green and red apart.

Two other common vision problems are nearsightedness and farsightedness. An eye that is curved just right focuses light exactly on the retina. An eye that is curved too much focuses light in front of the retina, causing nearsightedness. People with nearsightedness can't see distant objects clearly. Eyeglasses with concave lenses correct nearsightedness. An eye that is not curved enough focuses light behind the retina, causing farsightedness. People with farsightedness can't see close objects clearly. Eyeglasses with convex lenses correct farsightedness.



**Think Back**

1. Explain the purposes of the cornea, pupil, iris, and retina.
2. Why wouldn't your eyes work properly if your eye lenses were flat instead of curved?
3. What two types of cells make up the retina? What does each type of cell do?
4. How can lenses correct some vision problems?

(Answer: You are driving the bus, so the color of the bus driver's eyes is the same color as your eyes.)

FUNNY BONE

Eye Color

You are driving a bus across town. At the first stop, 12 people get on. At the second stop, 2 people get off and 8 people get on. At the third stop, 5 people get off and 4 people get on. At the fourth stop, 1 person gets off and 6 people get on. What color are the bus driver's eyes? (Answer is below.)

Intersection with Nutrition

Carrots for the Eyes

You may have heard that carrots are good for your eyes. This is true. Carrots have a lot of vitamin A. Vitamin A helps the chemicals in the eye's cells repair themselves.

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ards, and many types of bats have all rods and no cones. Most nocturnal animals also have a tapetum on the retina of their eyes. A tapetum is a mirrorlike membrane that reflects light back on the retina a second time to give the light a second chance to be caught by the rods. The tapetum is what makes the eyes of nocturnal animals seem to glow at night. Different types of animals have different colored tapetums.

After they have been in dim light for 7–10 minutes, have students repeat the activity. Their eyes will have adjusted.

## Reinforce/Assess

1. Have students read **How Do We See?** (page 141) in the student text and answer the **Think Back** questions (page 145) as homework.
   1. *Explain the purposes of the cornea, pupil, iris, and retina. (The cornea protects the eye from dust, water, and other substances. The pupil controls how much light enters the eye. The iris controls the pupil. The retina captures light and sends the images to the brain.)*
   2. *Why wouldn't your eyes work properly if your eye lenses were flat instead of curved? (A curved lens focuses light onto the retina so an image can form, but a flat lens wouldn't focus light, so no image would form.)*
   3. *What two types of cells make up the retina? What does each type of cell do? (Rods help the eye see in dim light, and cones help the eye see color.)*

4. *How can lenses correct some vision problems? (Lenses can focus light to correct problems caused by an eye that isn't focusing light properly.)*

2. **Drama: Acting Out the Eye.** Have teams write and act out a play illustrating how the eye is able to see. The play should show how light waves enter the eye and are converted into images that are interpreted by the brain. Students should bring in any props they need from home.

## Extend

- To quickly demonstrate how two eyes provide the viewer with depth perception, have students hold two pencils out horizontally, one in each hand, at arm's length. Have students close one eye and try to touch the ends of the pencils together. Then have them touch the ends of the pencils with both eyes open.

- Show students some prints of optical illusions.

- Punch a 1-cm hole into the center of a 30-cm square of black posterboard. Have one student hold the black square in front of a large fish bowl full of water. Have a second student hold a 30-cm square of white posterboard on the opposite side of the fish bowl. Place a bare light bulb next to the hole in the black square (the side opposite the fishbowl). Darken the room, and turn on the lamp. A smaller, upside-down image will form on the white posterboard. (You may have to adjust the light bulb so that it shines straight through the hole and on the white square.) Explain that this is the type of image that forms on the retina of the eye; the brain turns the image right-side up.

- Have students complete the following activity to explore vision persistence. Give each student a piece of blank index card that has been cut in half lengthwise and two 30-cm pieces of string or strong thread. Have students draw a small fish on one side of the card and a larger fish bowl on the opposite side of the card in the same location as the fish. Have students punch a small hole in each corner of the card.

  Then have students thread a string through the two holes on each short side and knot the ends by the cards. Have students loop a finger through each string and twist the card as many times as possible. When the card is released and it spins, it will appear as if the fish is inside the bowl.

- People generally blink once every 2–10 seconds. Have students count the number of times a partner blinks in 10 seconds. Have students repeat their counts three or four times to determine the average number of blinks in 10 seconds. Have students use calculators to determine the number of blinks their partners would average in a minute, hour, day and week.

- Have student volunteers read aloud accounts of Jesus healing the blind in Mark 10:46–52 and John 9:1–7.

- Invite a person who knows how to read Braille to your class, and ask him or her to teach the class how to write in Braille. Have students try to write a Bible verse in Braille. Your guest

might also conduct one or more “vision impairment sensitivity” activities with students, such as matching socks while blindfolded or performing simple tasks while wearing eyeglasses with thick lenses.

- Have students write down observations about the eyes of their pet cats or dogs. Students should observe the size of the pet’s eyes and pupils, and they can observe the color of the animal’s tapetum in a dimly lit room.
- Have students make a list of animals that can see well in the dark, and then research which has best night vision and which has the worst.
- Have students experience blindness for short period of time. Using blindfolds to cover their eyes and ask the students complete some basic tasks. Have them share their experiences, especially noting the challenges they faced not seeing.

Lesson 6

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Light that enters the pupil strikes the lens, which focuses the light. The light passes through a jellylike substance and focuses on the **retina**, the back layer of the eye that captures light and sends the images stored in the light to the brain—much like camera film captures light and makes images. The retina is made of two kinds of cells: rods and cones. A **rod** is a cell in the retina that helps the eye see in dim light. A **cone** is a cell in the retina that tells the brain about the color of an object. Together, the cones and rods

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### Eye Opener

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## Amazing Creations

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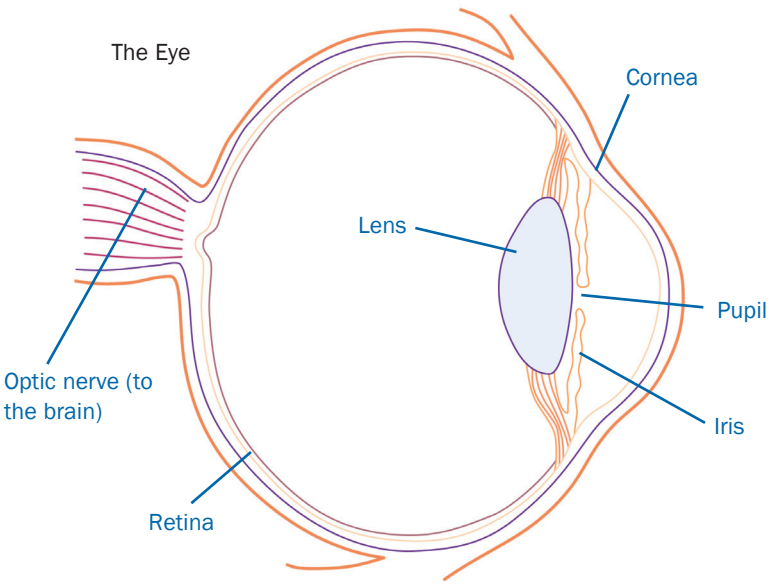
Many people don't have perfect vision. If the cones don't work right, a person may be colorblind. Being colorblind




## Intersection with Life Science

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# Try This

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Your eyes have a blind spot where you can't see. It's the spot on the retina where the optic nerve attaches; this spot doesn't have cones or rods. Try this activity to find your blind spot.

On a sheet of white paper, draw a black circle that is about 0.5 cm wide. Measure a distance 8 cm to the right of this circle, and draw a second black circle that is the same size as the first one. Hold the paper out about 50 cm from your face, close your left eye, and stare at the circle on the left. Keep looking at the left circle, and slowly move the paper toward your face until the right circle disappears. That is your blind spot. Then repeat the procedure with your right eye and the circle on the right.

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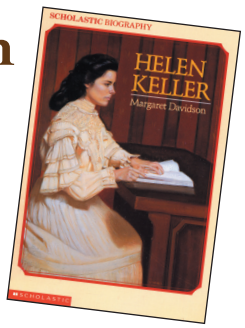


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Let's Find Out

# Are Two Eyes Better than One?

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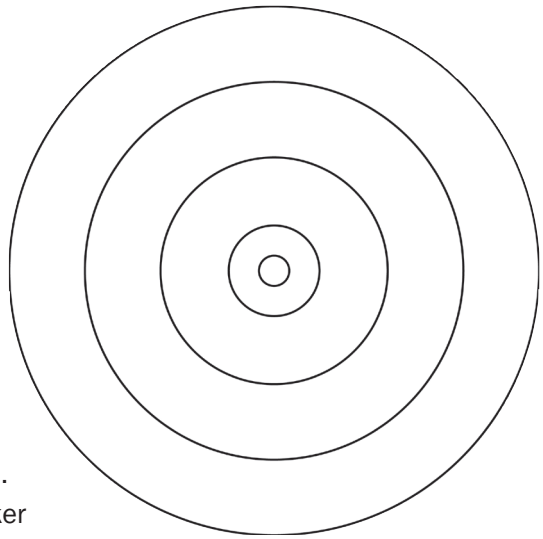

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7. Switch places with the team member who held the marker, and do the experiment using a blue marker and an orange marker. Then have the third team member do the experiment using a yellow marker and a brown marker.

## Questions

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3. How might the loss of sight in one eye affect you each day?

doesn't mean that a person can't see any colors; it means that the person has problems telling different colors apart. Often someone who is colorblind can't tell green and red apart.

Two other common vision problems are nearsightedness and farsightedness. An eye that is curved just right focuses light exactly on the retina. An eye that is curved too much focuses light in front of the retina, causing nearsightedness. People with nearsightedness can't see distant objects clearly. Eyeglasses with concave lenses correct nearsightedness. An eye that is not curved enough focuses light behind the retina, causing farsightedness. People with farsightedness can't see close objects clearly. Eyeglasses with convex lenses correct farsightedness.


## Think Back

1. Explain the purposes of the cornea, pupil, iris, and retina.
2. Why wouldn't your eyes work properly if your eye lenses were flat instead of curved?
3. What two types of cells make up the retina? What does each type of cell do?
4. How can lenses correct some vision problems?


### Eye Color

You are driving a bus across town. At the first stop, 12 people get on. At the second stop, 2 people get off and 8 people get on. At the third stop, 5 people get off and 4 people get on. At the fourth stop, 1 person gets off and 6 people get on. What color are the bus driver's eyes? (Answer is below.)

**(Answer: You are driving the bus, so the color of the bus driver's eyes is the same color as your eyes.)**

## Intersection with Nutrition

### Carrots for the Eyes

You may have heard that carrots are good for your eyes. This is true. Carrots have a lot of vitamin A. Vitamin A helps the chemicals in the eye's cells repair themselves.