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What Gives Your Vision Precision?

Exploring Vision With a Model Eye

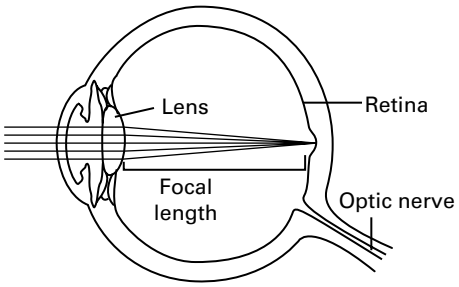
Questions How does the eye produce an image the brain can interpret? What physical differences exist in the eyes of people who are nearsighted or farsighted?

Lab Overview In this investigation, you will create a model eye using a glass lens and a shoe box. You will use your model eye to discover how the shape of the eye is related to common vision problems.

Introduction To start your investigation, you will read about eye structure and vision to prepare to construct and experiment with a model eye. Then you will do an activity that reveals the "blind spot" in your vision.

Background

The lens The eye contains a lens that focuses images on the retina at the back of the eye. The distance from the lens to the point where the image is focused is called the focal length. The image projected on the retina is upside down. Photoreceptors lining the retina detect light and send signals along the optic nerve to the brain. The brain integrates these signals and forms the right-side-up image you see.



Cross section of eye

Blind spots The area of the retina where the optic nerve pokes through is not lined with photoreceptors. If an image hits this portion of your retina, no signals are sent to your brain. This "hole" in your vision is called the blind spot. Usually, you do not notice your blind spot because your brain uses information from the surrounding environment to fill in the missing information. In the Prelab Activity you will locate your blind spot.

Prelab Activity Close your left eye and stare at the + with your right eye. Focus only on the +. Now move your head slowly closer to the page and notice what happens to the spot on the right as you move your head forward. Write your observations below.

Observations

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Prelab Questions

1. What causes the blind spot in the field of vision?

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2. What information does the brain use to fill in the blind spot?

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3. Each of your eyes has a blind spot in a slightly different area of the retina. How do you think this helps your brain "fill in" the missing parts of the visual field?

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Materials

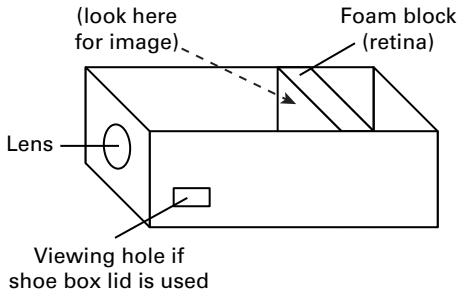
- shoe box
- lens
- sheet of white cardboard or plastic foam block, cut to the width of the shoe box
- markers
- safety knife or scissors
- pencil
- 10-cm piece of yarn
- marker
- construction paper (various colors)
- black construction paper
- penlight or mini-flashlight
- red glitter glue or red marker
- black marker

Procedure

Part A: Constructing a Model Eye

1. With the safety knife or scissors, cut a hole in one end of the shoe box. The diameter of the hole should be about 1 cm smaller than the diameter of the lens. **CAUTION:** *Be careful when handling sharp instruments.*
2. Tape the edges of the lens to the inside of the box so that the lens covers the hole. The outward-curving side of the lens should face the outside of the box. **CAUTION:** *Handle glass carefully to avoid breakage.*
3. Move the box around and look for an image to form at the inside end of the box opposite the lens. If the image is blurry, place the cardboard or plastic foam in the box and slide it back and forth until the image is in focus. The distance between the lens and this "retina" is the focal length for your model eye. (**NOTE:** *If you are using your model eye outdoors, you will need to block out more light. Cover the shoe box and cut a second small hole in one side of the box near the lens. Look in the hole toward the "retina" to see the image of the outside world.*)

Shoe box eye model



Part B: Modeling Vision Problems

1. To demonstrate how a nearsighted eye differs from an eye with normal vision, move the cardboard or plastic foam retina back from the focal length (away from the lens) or remove it. What happens to the image?

The shape of a nearsighted eye is too long for the image to focus properly on the retina. The image is focused in the middle of the eye, which leads to the image being interpreted as blurred. People who are nearsighted can clearly see objects close to them because of the ability of the lens to change shape so that the image is focused on the retina. The shape of the lens cannot change enough to focus objects that are far away.

2. To demonstrate how a farsighted eye is different from an eye with normal vision, move the retina closer to the lens. What happens to the image?

The shape of a farsighted eye is too short for the image to focus properly. People who are farsighted can clearly see objects far from them because the shape of the lens changes so that the image is focused on the retina. Images from nearby objects are focused so far behind the retina, however, that the lens cannot change shape enough to focus objects that are nearby.

Part C: Adding Features to the Model Eye

1. Follow the directions to observe the blood vessels crossing the lens side of your retina.
   - **a.** With one hand, hold a sheet of black construction paper at arms length in front of your face.
   - **b.** Close your left eye and shine the penlight (or have a partner do this for you) through the side of your right eye. The beam of the light should pass through the outside border of your iris.
   - **c.** Jiggle the light slightly. You should be able to see the shadow of the blood vessels that lie on top of your retina projected on the black background.

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2. Using the materials listed below, add the following features to your model eye: blind spot, optic nerve, blood vessels crossing the retina, iris, and pupil.

   Materials: red marker or red glitter glue, colored construction paper, pencil, black construction paper, yarn

3. Use a black marker to label the lens, blind spot, optic nerve, retina, iris, pupil, and sclera.

Analysis and Conclusions

1. How is the model eye like a real eye? List as many similarities as you can.

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2. How is the model eye unlike a real eye? List as many differences in structure and function as you can.

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3. Nearsighted and farsighted people can wear glasses or contact lenses to correct their vision. How do you think these lenses help?

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Extension

There are two types of photoreceptors in the retina—rods and cones. Rods allow you to see in dim light, although only in shades of gray. Cones, which require bright light to function, allow you to see colors. To test the action of cones, tape a bright piece of construction paper to a white or light-colored wall. Step back and stare directly at the paper for 30 seconds. Then, look at a blank space on the wall. What do you see? This image is called an *afterimage*. Research the function of cones and write a report describing the cause of the afterimage phenomenon.