Workshop 4:
Color, Cones, and Corneas

DESCRIPTION

Humans are able to see objects when light energy enters the eye. In this workshop we will investigate human vision, and interview students to find out their understanding of 'how we see.' Using models, we will study the function of the major parts of the human eye, and revisit refraction by following the path of light through various lenses. We will also visit an optometrist for a vision check-up, discuss the perception of color, and actually see inside a human eye.

LEARNING OBJECTIVES

Participants will be able to:

- Explain that the only thing we see is light that enters the eye.
- Explain the function of the most important structures in the human eye.
- Explain how light photons of differing energy are detected by the eye leading to the perception of color.

Workshop 4 timeline

GETTING READY

30 minutes

F.A.C.T.S.

In Workshop 4 you will hear students describing their ideas about light and vision. One boy will tell us his vision F.A.C.T.S. (Five Actual Causes To Seeing)

1. All the colors you can see come from three colors: red, blue and yellow.
2. Light is different colors.
3. When light is separated you can see the projection it sends.
4. You see from light.
5. Light makes color.

Using what you learned in Workshop 3 about color and also your own prior knowledge, discuss these vision F.A.C.T.S. with your peers. The questions below may help you to focus your discussion.

- Do you need light to see? What evidence do children have for this?
- What in the natural surroundings allows children to make the statement that light is different colors?
- Are there three colors of light: red, blue and yellow?
- What do you think the child means by his fact #3
- How might the child be distinguishing between his fact #2 and his fact #5?

Broadway Red

As a group, firm up your ideas about colored light by discussing the answers to these questions:

Imagine that you are wearing a red sweater.

1. Which color of light is reflected back to your eyes to allow you to see the color red?
2. What happens to the other colors of light that are not reflected by your red sweater?
3. You've landed a prime role in a Broadway play. If you now go 'on stage' wearing your red sweater and stand under a blue spot-light, what color will your sweater appear to be? Explain your answer.
4. What color spotlights could you stand under so that your sweater look red?

Workshop 4 timeline

GOING FURTHER

30 minutes

Peripheral Vision

In Workshop 4 we visited Franklin Park Zoo in Massachusetts and saw that some animals have eyes on the sides (rather than the front) of their heads. This improves their peripheral vision. Let's investigate how accurate a human's peripheral vision is.

All you need for this activity is a partner and a few small objects (colored pencils or crayons are best).

- One partner sits down and faces forward.
- The other partner stands behind the sitting partner.
- The standing partner chooses an object to use but does not show his/her partner.
- The standing partner slowly moves the chosen object from the back of the partner's head, around the side passing the ear, and on toward the eye. Keep the object about 12 cm (about five inches) away from the head.
- As soon as the sitting partner 'sees' the object, he/she should say so. The person may know what the object is, but when can he/she tell you its color?

Repeat the activity using objects of different colors.

1. Are there any differences where you can see different colors?
2. Using the information from Workshop 4 and what you already know about the eye, explain how light from the object you used entered and was detected by the eye.
3. In this activity, people often find that they can see the shape of the object before they can tell what color it is. What might explain this observation? (Think about where the color detectors (cones) are found in the eye?)

Workshop 4 timeline

Detector Detective

In Workshops 1-4 you met several types of photon detectors.

Fill in the columns in the table below as a means of keeping track of these detectors. (Keep in mind there are several possible answers). The first row across is completed for you.

Type of photon	Energy level (greater than visible light or less than visible light)	Detected by:
X-ray	Greater	Chandra Telescope
		Human Skin – sunburn
Visible light	-----	Give at least 3 different detectors of visible light.
Infrared		Garage door opening system

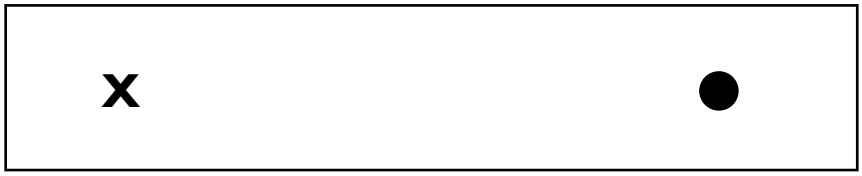
For next time

HOMEWORK ASSIGNMENT

Blind Spot

In Workshop 4, you saw that the eye has a blind spot where the optic nerve leaves the eye. Why do we fail to see objects if light from them hits the blind spot?

1. Copy the image below onto an index card.



2. Close your left eye and stare at the X with your right eye.
3. Slowly move the card away from you (keep looking at the X).
4. At what distance do you lose sight of the dot? (You may have to try this several times. Move the card slowly. Do not stare at the dot -only view it out of the corner of your eye as you look at the X)
   - Measure the distance from your eyes to the card.
   - Try this with family, colleagues and students. Collect the blind-spot position measurements and tabulate the data.

Group Discussion

1. What might you infer from any differences you find in the 'blind spot' position measurements?
2. The light detectors making up the retina are known as rods and cones. Why are you more likely to detect the color of an object when it is in front of you, than when it is to your side? (To help you with this question – remember the pre-workshop activity that you performed ((Peripheral Vision)) and what you have heard about the position and function of rods and cones in the retina).
3. Draw the path of light from the dot into your eye showing clearly why you are unable to see it at the 'blind spot' position.

EXTRA CREDIT—In this series we have said that visible light photons do not have color, they merely have differing amounts of energy to which detectors on our eyes respond.

Use your knowledge of photons of differing energy as well as your knowledge of the structure of the retina to explain why we see red when lower energy photons enter our eyes.

- In this series we have called the eyes detectors of light. How is light detection different from seeing?

Standards

National Science Education Standards

K-4 standards: http://bob.nap.edu/html/nses/html/6c.html#ps

Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object.
Content Standards: K-4: Physical Science: Light, Heat, Electricity, and Magnetism

5-8 Standards: http://bob.nap.edu/html/nses/html/6d.html#ps

Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object--emitted by or scattered from it--must enter the eye.
Content Standards: 5-8: Physical Science: Transfer of Energy

American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks

http://project2061.aaas.org/tools/benchol/bolframe.html

By the end of the 2nd grade, students should be able to:

Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.
Habits of the Mind: 12A Values and Attitudes: K-2

By the end of the 2nd grade, students should know that:

Tools such as thermometers, magnifiers, rulers or balances often give more information about things than can be obtained by just observing things without their help.
Nature of Science: 1B Scientific Inquiry: K-2

By the end of the 5th grade, students should be able to:

Offer reasons for their findings and consider reasons suggested by others.
Habits of the Mind: 12A Values and Attitudes: 3-5

By the end of the 8th grade, students should know that:

Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors.
The Physical Setting: 4F Motion: 6-8

Related Sources

David Lindberg. 1976. Theories of Vision from Al-kindi to Kepler. The University of Chicago Press.

David Falk, Dieter Brill, David Stork. 1986. Seeing the Light: Optics in Nature, Photography, Color, Vision and Holography. Wiley.

Rossotti, Hazel. 1983. Colour: Why the World Isn't Gray. Princeton University Press.