January 2017

Dumpster Optics

SEEING COLOR – EYES AND ART

AN ELEMENTARY INTRODUCTION TO VISION AND HOW YOUR EYES CAN BE FOOLED, PLUS ONE ARTIST'S EXPERIMENTS IN COLOR

This STEAM lesson has includes both science and art activities. To complete both takes about 2 hours.

MATERIALS:

Activity 1, Make an Image
- Magnifying glass or similar positive lens (for example, from reading glasses)

Activity 2, Blind Spot
- Drawing for Activity 2 from Observation Sheet;

Activity 3, Rods or Cones?
- A few colored crayons or markers (different colors)

Activity 4, Do My Shoes Match?
- Pieces of felt or other fabric or colored paper of dark, similar shades, for example, black, brown, navy
- Box to hold samples (if the room cannot be darkened)

Activity 5, What Color?
- Bright primary colored small candies like Skittles® or M&Ms®. Choose 2 or 3 colors
- Source of colored light (LEDs or flashlight with a thin balloon as a color filter)

Activity 6, Presto Change-o
- Red 3 inch circle with a black dot at the center
- One black background and 1 white background (paper squares)

Remaining activities
- Squares of colored paper of different sizes and colors including one large white square to use as the background

VOCABULARY:
- Retina
- Rod
- Cone
- Optic nerve
- Cornea
- Iris
- Lens

TEACHER NOTES:

Some of these activities are done in a darkened room, others require bright lighting. For color discrimination and comparison, daylight is best if possible. If the room can't be darkened sufficiently, place items in the bottom of a large carton so they are in a shadow. Depending on the type of lighting in the room (fluorescent, LED, halogen) results of the activities may vary.

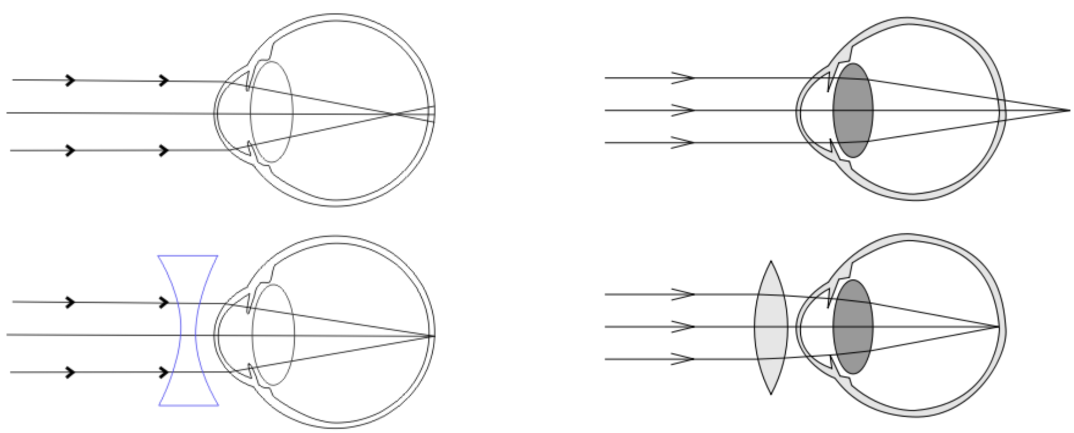
BASICS OF THE EYE:

The eye can be compared to a camera:

- The *pupil* is the opening that lets in light, it changes size depending on the amount of light available. A fun activity is to have pairs of students look at each other's eyes with the lights off, then note the change in pupil size when the lights come on.
- The *cornea* and *lens* focus the light and create an image on the retina. Most of the focusing is by the cornea. The lens "fine tunes" by changing its shape for seeing close objects like a printed page.
- The cells of the *retina* convert light signals to electrical signals to be transmitted to the brain via the *optic nerve*.

Students may be interested to know that nearsightedness (*myopia*, or the inability to see distant objects clearly) occurs when the clearest image falls in front of the retina – by just millimeters or so. Vision can be improved by wearing concave (negative) lenses that spread light before it reaches the eye, allowing the image to form on the retina. Farsightedness (*hyperopia*, or the inability to focus on nearby objects) is the reverse; the image forms (or is headed toward forming) behind the retina. In this case, convex (positive) lenses help the eye's focusing system project a clear image on the retina. These conditions are due to the structure of the eye and may occur at any age.

The inability to focus on nearby objects that occurs to most people around age 40 is called *presbyopia*. With age, the eye's lens stiffens and it becomes more difficult for the muscles to change the lens shape to focus on nearby objects. As with hyperopia, convex lenses are used to help the eye to focus.



(Left) The nearsighted eye focuses in front of the retina. Concave (or diverging) lenses spread light and move the image back onto the retina. (Right) The farsighted eye doesn't have enough focusing ability and is assisted by a convex (or converging) lens. (via WikiMedia Commons, user CryptWizard)

ACTIVITY 1 – MAKE AN IMAGE

For this activity, you need a convex (converging, or positive) lens. A magnifying glass or the lens from a pair of reading glasses will work. As long as the lens is thicker in the middle than on the edges (the cross section shown in the diagram on the slide) it will work for this experiment. You only need one lens so a pair of glasses will serve two students. Note that the lenses worn to correct for nearsightedness will not form an image.

The best images are of something bright – a lamp or the world outdoors in the daytime. To image the outdoors, stand in a darkened room (turning the lights out is sufficient) and partially close the shades or blinds. The remaining light coming through the window can be imaged onto the opposite wall. Move the lens closer to and farther from the wall until the image forms. For my reading glasses, the best distance is about half a meter.

A light bulb can be used instead of the light from outdoors. Or use a flashlight with an opaque (paper) triangle taped over the front. The triangle provides a sense of “up and down” so the image orientation can be compared to the object. Don't hold it too close to the flashlight; start with the lens about a meter from the flashlight and move it back and forth slowly to find the image.

The image will be upside down. It should be clear but depending on the lens used it may be blurry around the edges when the center of the image is sharp.

ACTIVITY 2 – BLIND SPOT

There are no light sensors where the optic nerve enters the back of the eye. This is called the blind spot. Use the figure on the Observation Sheet (the dot and plus sign) or copy them onto a piece of paper and follow the instructions on the slide. When the light from the printed dot falls on the blind spot it can’t be seen. It takes some practice but it's quite startling when the dot disappears from sight. If you keep moving the paper toward your face it will reappear after a short distance.

To find the blind spot of the right eye, close the *left* eye and stare at the dot. The plus sign will disappear at some distance from the eye. (For me, the paper is about 30 cm from my face.) A question for students: Why aren't there blind spots in your vision with both eyes open?

SEEING IN COLOR:

Cones are concentrated at the back of the eye in part of the retina called the *macula.* They are used for detailed vision and for color vision. The cones are not really the three colors shown (red, green blue), they are just colored that way in the diagram. The cones are named for the color they are sensitive to. The reason you need to move your eyes when you read to keep the words imaged on the part of the eye with the most cones (detailed vision).

There are many more rods than cones and they are distributed mostly outside the area used for central vision. They are not able to distinguish color but can respond to much lower light levels than cones. This explains why color discrimination is difficult in poor light. Also, peripheral vision (to the side) is accomplished mostly with rods. Light that falls on the retina outside of the central viewing area excites rods, which are not color sensitive. Peripheral vision is very sensitive to dim light, but it doesn’t register color.

ACTIVITY 3 – RODS OR CONES?

Some children have difficulty with this activity because they don't want to be wrong when guessing the color. For best success, make sure the student is not color-blind (boys are more likely to be color blind than girls). Don't tell the student you'll be asking for the crayon color and remind them to stare straight ahead. Stop as soon as they say they sense motion. A trick to be sure the student is seeing the crayon but not the color: Show the student one color crayon, but use a second color in the demonstration.

For more interesting facts about rods and cones see
https://faculty.washington.edu/chudler/retina.html (Neuroscience for Kids)
http://hyperphysics.phy-astr.gsu.edu/hbase/vision/rodcone.html (More advanced)

ACTIVITY 4 – DO MY SHOES MATCH?

This activity is inspired by real life – several loose socks in a drawer, identical except for color or navy and black pants of the same style in a dark closet.

If the room can be made dark enough (like the inside of a closet on a dark winter morning!) a box may not be necessary. A deep box helps exclude room light. Be sure the color samples inside are dark – black, brown, and navy are good choices.

Mr. Jones needs to check his socks and shoes under a bright light before leaving home! The color sensitive cones need bright light to work.

ACTIVITY 5 – WHAT COLOR?

This activity follows well after the reflection lesson where students learn that they see objects when light is reflected from them. A red candy, for example, only looks red when there are red wavelengths in the illuminating light. Under white light and red light, it looks red because the red light is reflecting back to your eye. Under blue light, it will look purplish and under green light black or brownish depending on whether some room light also illuminates it. That is, the color you see depends on the colors the surface reflects and the colors present in the illuminating light.

This activity was originally named “What color is a tomato?” because it was performed with a tomato and a blue LED light. Candies are easier to transport and store but if you try this with a tomato use a small one (cherry or plum type) and hold it in your hand so only a small portion of the surface is visible. Use a blue LED and it looks like a purple plum!

ACTIVITY 6 – PRESTO CHANGE-O

Afterimages are due to photoreceptors in the eye becoming overstimulated or “fatigued”. The white background reflects all colors but the “fatigued” sensors do not respond so the afterimage appears blue-green when the original object was red. Experiment with other color pairs by, for example, drawing a blue flower and seeing the color of the afterimage (yellow). The flag afterimage makes use of the color pairs yellow-blue, green – red and black- white.
A quick explanation of afterimages can be found here:

https://www.youtube.com/watch?v=FhZrU6g9seg&feature=youtu.be
Additional afterimage experiments (as well as other illusions) can be found here https://faculty.washington.edu/chudler/chvision.html (Neuroscience for Kids)

COLOR IN ART – JOSEF ALBERS

Josef Albers (1888-1976) was a German-born American artist and art professor at Yale University. He is best remembered for his work as an abstract painter and theorist. His most famous paintings make up the series *Homage to the Square* in which he explored the interaction of colors with nested squares. Each composition is three or four squares nested within each other in square formats ranging from .406 m x.406 m to 1.22 m x.1.22 m. Two of these compositions are shown in the slides.

From the book, “An Eye for Color: The Story of Josef Albers” by Natasha WIng: "*As a child, Josef Albers loved to watch his handyman father paint houses. When Josef grew up and became an artist, he reduced each image to its simplest shapes, breaking it down into blocks of color. He made an incredible discovery: he could alter the entire mood of a painting just by changing the way he combined the colors! Josef spent his entire life studying color, and what he found revolutionized the way people look at art.*"

ACTIVITY 7 – RED SQUARES

Josef Albers noticed a color appears different when contrasted with other colors, for example, red may appear different when surrounded by yellow, purple, black or white. To see any difference really requires natural light. Try to do all observations using the light coming through the windows or take the activity outdoors.

In this activity does the red square look the same on both background colors or does one background color make it look more orange? Which one?

ACTIVITY 8 – DULL AND DANCING

Red on the white background should appear "brilliant”. Again, the colors should be viewed under natural light.