Arrgh!!! The Secret of the Pirate Patch
Dark Adaptation

When you first walk into a darkened movie theater. do you have trouble seeing clearly? What about after a middle-of-the-night trip to the bathroom? In this activity, we'll discover the neurobiological basis of this phenomenon and how we can develop and retain "night vision".

Materials
- Eye patch (e.g. "pirate patch", one per student)*
- Tea candle and matches or lighter
- Bright objects – poster, flowers, fruit
- Flashlight
- Materials to cover windows or other sources of light in the classroom

** Note: You may purchase "pirate" eye patches at www.deadmentellnotales.com I ordered code # EPSC type 1 singles for $0.29 each. Beware that these are mixed groups of sizes. so some may need to have modified elastic to fit comfortably, especially on older students. You can also make pirate patches out of black felt and thin, round elastic or look for a costume shop near you.*

To Do and Notice

Preparation

Mask any windows and sources of light in your classroom, so that when the lights are turned off only a tiny amount of light enters the room - there must be a very small amount of light, not complete darkness.

Pass out the eye patches to students, and have them wear them during class. One eye must be closed for a minimum of 20 minutes (30 is better) for the activity to work. During this time,- proceed with class as usual.

After 20 – 30 minutes, shut off all the lights (remember, there should be a tiny amount of light entering the room). How much can the students see clearly with the uncovered eye? After discussing this, have the students lift the eye patch. Does this eye "see" differently? Replace the eye patch. **Caution!!!** *Warn the students that the eye that was not closed may feel that it is closed, even though it is open! This sensation is a common sensory illusion experienced during this activity, and they should not poke or prod this eye. The sensation will pass as the eye accommodates to the darkness.*

Light a small tea light. How do students perceive the surroundings now? Compare observations using each eye separately (briefly lift the eye patch).

Direct the students' attention to an object in the room that is brightly colored. Are the colors visible when using either eye (again, briefly lift the eye patch)? Shine a flashlight on the object. Does the appearance of the object change?

Karen Kalumuck
Exploratorium Teacher Institute

Have the students remove the eye patches and continue to make observations with both eyes open for a few minutes. Turn on the lights, then off again within a few seconds. Has the light affected their ability to see in the dark?

Encourage the students to explain their observations, and suggest additional experiments about this phenomenon.

What's Going On?

The retina of the eye contains two types of photoreceptors – rods and cones. Cones are sensitive to "colored" wavelengths of light, while rods are insensitive to color. There are about 120 million rods in the retina, and between six and seven million cones that are concentrated in the central *fovea* of the retina, the site of our sharpest vision. Rod vision tends to be less sharp than cone vision. Rods are about one thousand times more sensitive to light than cones, and it is believed that they are capable of detecting single photons of light.

Photoreceptors contain photopigments that absorb photons of light. When the pigment absorbs light, a signal is sent to the brain via the optic nerve. The signals of many photoreceptors are interpreted as an image by the brain. In a process called *bleaching*, the light absorption also chemically changes the pigment so that it can no longer respond to light. The pigment must regenerate in the dark. The pigment in cones regenerates in about one minute. However, it takes about 30 minutes in the dark for the rod pigments to regenerate, thereby facilitating maximal vision in twilight or darker circumstances. The process of having fully regenerated rod pigment, leading to clear vision in the dark, is referred to as *dark adaptation*.

By wearing the pirate patch for at least twenty minutes, we dark-adapted one eye. With low levels of light, it becomes clear that the dark-adapted eye sees much better in very low light than the non-adapted eye. Because rods do not respond to colored light, everything in the room appears gray. When a weak flashlight beam is shined on a colorful object, the non-dark adapted eye (this one is called "light adapted) responds to the light and "sees" color. A flashlight beam shined briefly on an object does not create enough light to bleach the rods in the dark-adapted eye.

After about 20 minutes, the non-dark adapted eye will show fairly good adaptation. If you turn on the classroom lights, however, all of the rods will be bleached, and vision in the dark will again be very limited.

So What?

Dark adaptation is very important evolutionarily. The ability to see in the dark is intimately tied to an ability to see and flee from predators, and in some instances find prey. The galago, a squirrel-like mammal, has retinas packed only with rods. Because of this, and its large eyes, it is successfully active at night but cannot see colors or fine details that come from cone-vision. Similarly, in low levels of light humans see rough shapes in shades of gray.

Try This!
The next time you are looking at stars, find a faint one and focus on it. Then, look slightly away from it –can you see it more clearly? This is a trick used by astronomers – our center of sharpest vision, the fovea, is located near the center of the retina. We naturally "look" at objects with this spot. However, the fovea is packed with cones that do not respond to dim light. If you shift your vision slightly, the rods respond and provide a brighter image of the star.

Tidbits
- The technical name for the photopigment in rods is *rhodopsin.*
- The rhodopsin in unbleached rods appears purple, which explains another name for rhodopsin, *visual purple*. When light is absorbed by rhodopsin, the pigment is "bleached" and the color changes from purple to nearly clear. The purple color is regenerated, along with the functioning pigment, in the dark.
- Using rod vision, humans can see the flickering of a candle, in darkness, up to 25 miles away.