

## Through Other Eyes

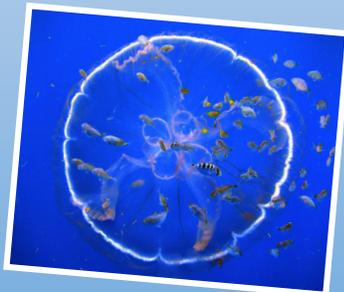


Image captions on Page 2.

# lesson plan

### Focus

Vision in marine organisms

### Grade Level

9-12 (Life Science)

### Focus Question

What are some characteristics of photoreceptors in some marine organisms that give these organisms visual capabilities that exceed those of humans?

### Learning Objectives

- ⊗ Students will be able to describe the overall structure of the crustacean compound eye.
- ⊗ Students will be able to describe the eyes of stomatopods, and explain features that give these organisms visual capabilities that exceed those of humans.
- ⊗ Students will be able to discuss three ways in which deep-sea animals may benefit from visual capabilities such as those found in stomatopods.
- ⊗ Students will be able to describe an artificial system that might replicate some of the features of photoreceptors in deep-sea organisms.

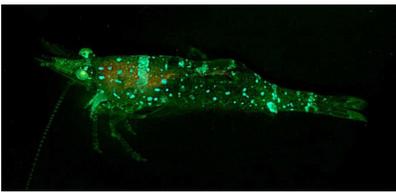
### Materials

- ✂ Copies of "Stomatopod Vision Inquiry Guide," and "Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide," one copy for each student group
- ✂ Copies of "Eye Design and Color Signaling in a Stomatopod Crustacean *Gonodactylus smithi*", <http://web.neurobio.arizona.edu/gronenberg/nrsc581/colorvision/stomatopod.pdf>, one copy for each student group
- ✂ Cadmium sulfide photocells, one for each student group (Radio Shack Part Number 276-1657 or equivalent); one for each student group
- ✂ Light emitting diode (Radio Shack Part Number 276-0017 or equivalent); one for each student group



The lobate ctenophore *Ocyropsis maculata* as viewed under unpolarized light (top) and polarized light (bottom). Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug27/media/ocyropsis\\_unpolarized\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug27/media/ocyropsis_unpolarized_600.jpg)  
[http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug27/media/ocyropsis\\_polarized\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug27/media/ocyropsis_polarized_600.jpg)



Unidentified *Sargassum* shrimp bearing two colors of fluorescent patches. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug22/media/fluorescent\\_shrimp\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug22/media/fluorescent_shrimp_600.jpg)

#### Images from Page 1 top to bottom:

The Eye-In-The-Sea camera system deployed on the edge of a brine pool, over 2,100 ft deep in the Gulf of Mexico. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/04deepscope/logs/aug8/media/eye\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/04deepscope/logs/aug8/media/eye_600.jpg)

A flotilla of fish follow a transparent drifting jellyfish, *Aurelia aurita*. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/sep3/media/aurelia\\_rs\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/sep3/media/aurelia_rs_600.jpg)

The pontellid copepod *Pontella securifer*. Various parts glow fluorescent green when viewed under blue light. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug26/media/horned\\_copepod\\_mf\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/aug26/media/horned_copepod_mf_600.jpg)

Deep Scope 2005 science crew examines recently collected specimens. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/sep4/media/examining\\_specimens\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/05deepscope/logs/sep4/media/examining_specimens_600.jpg)

- ✂ Resistor, 330 ohms, 1/4 watt (Radio Shack Part Number 271-1315 or equivalent); one for each student group
- ✂ Inexpensive multimeter (Radio Shack Part Number 22-810 or equivalent); one for each student group
- ✂ 9-volt battery; one for each student group
- ✂ 9-volt battery snap connector (Radio Shack Part Number 270-325 or equivalent); one for each student group
- ✂ Jumper cables (Radio Shack Part Number 278-1157 or equivalent); four for each student group
- ✂ Piece of balsa wood, approximately 3/4" x 3" x 3/8"; one for each student group
- ✂ Black construction paper
- ✂ Cellophane or masking tape
- ✂ Lighting filters (see Learning Procedure Step 1c)

### Audio/Visual Materials

- 📷 (Optional) Images of deep-sea environments and organisms that use bioluminescence (see Learning Procedure)

### Teaching Time

Two 45-minute class periods, plus time for student research

### Seating Arrangement

Groups of 3-4 students

### Maximum Number of Students

30

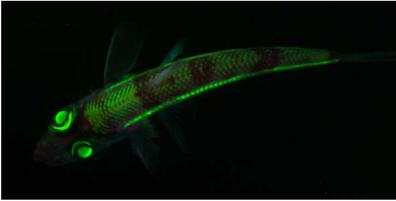
### Key Words

Stomatopod  
Compound eye  
Ommatidia  
Color vision  
Retinula  
Rhabdomere

### Background Information

[NOTE: *Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators usually will need to adapt the language and instructional approach to styles that are best suited to specific student groups.*]

Deep ocean environments are almost completely dark; yet light is still important in these environments. Many marine species are able to produce "living light" through a process known as bioluminescence, but very little is known about specific ways that



The shortnose greeneye fish gets its name from fluorescent eyes. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/04deepscope/logs/aug16/media/greeneye\\_fluor\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/04deepscope/logs/aug16/media/greeneye_fluor_600.jpg)



Under white light, the greeneye fish looks very different, but its green lenses are still apparent. Image credit: NOAA.

[http://oceanexplorer.noaa.gov/explorations/04deepscope/logs/aug16/media/greeneye\\_600.jpg](http://oceanexplorer.noaa.gov/explorations/04deepscope/logs/aug16/media/greeneye_600.jpg)

deep-sea organisms use this ability. Part of the problem is that these organisms are difficult to observe: turning on bright lights can cause mobile animals to move away, and may permanently blind light-sensitive sight organs. In addition, transparent and camouflaged organisms may be virtually invisible even with strong lights, and many types of bioluminescence can't be seen under ordinary visible light. Overcoming these obstacles is a primary objective of the Bioluminescence 2009: Living Light on the Deep Sea Floor Expedition.

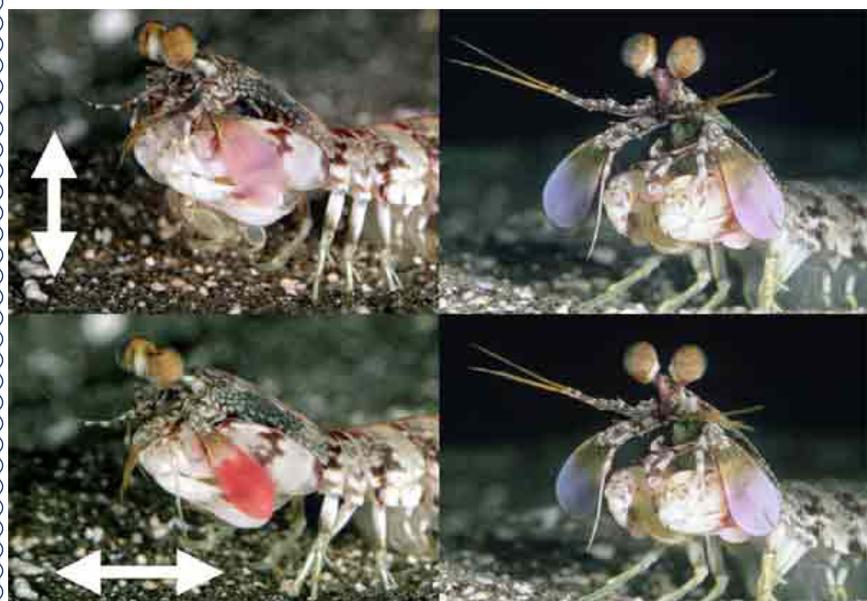
Like the 2004 and 2005 Ocean Exploration Deep Scope Expeditions (<http://oceanexplorer.noaa.gov/explorations/04deepscope/welcome.html> and <http://oceanexplorer.noaa.gov/explorations/05deepscope/welcome.html>), Bioluminescence 2009 will use advanced optical techniques to observe animals under extremely dim light that may reveal organisms and behaviors that have never been seen before. In addition, these techniques will allow scientists to study animals whose vision is based on processes that are very different from human vision.

We already know that some deep sea organisms are able to produce and detect forms of light that are invisible to human eyes, such as infrared and ultraviolet. One of the most highly developed eyes discovered to date is found in stomatopods (also known as mantis shrimp; besides having amazing vision, these animals are among the fastest and most aggressive predators known; see <http://www.blueboard.com/mantis/> for more information). The visual abilities of these crustaceans offer a tantalizing hint of what still remains to be discovered among the bottom-dwelling animals of the deep ocean.

Like other arthropods, stomatopods have compound eyes, which are composed of hundreds (or thousands) of "simpler" eyes called

Male (left) and female (right) mantis shrimps showing a clear difference in polarizing signals. The photographs on the left are of a male mantis shrimp—note the two eyes, the round balls at the top of the photo. The photographs on the right are of a female and she does not show the same change of color in her front paddles that the male shows when the filter is changed from a vertical orientation (top photos) to a horizontal one (bottom photos). We think this way of communication—only visible to animals that can see polarized light—may be important for mating. Image credit: NOAA.

<http://oceanexplorer.noaa.gov/explorations/04deepscope/background/polarization/media/fig3.html>



ommatidia (singular = ommatidium). Closeup images of insect eyes often show a spherical shape covered by numerous smaller spheres; the smaller spheres are the ommatidia. Each ommatidium is covered on the outside by a transparent cornea, beneath which are crystalline cone cells. The cornea and cone cells focus light onto an area known as the retinula which contains seven or eight retinal cells arranged around a central axis. Each retinal cell has a region called the rhabdomere that contains photopigment, which provides the light-sensing capability. Photopigments are molecules that change when they are hit by a photon, and in turn cause a change in a nerve cell (axon) that produces a nerve impulse. The rhabdomeres of the retinal cells in each ommatidium are collectively called the rhabdom. The rhabdom of each ommatidium is protected from scattered light from adjacent ommatidia by cells containing screening pigments. Nerve structures called axons lead away from the retinal cells and carry signals to the brain that are interpreted as vision. In addition to protecting against scattered light from adjacent ommatidia, screening pigments also can selectively absorb some colors. This means that individual ommatidia can be sensitive to a specific range of color. If the pigments absorbed red and blue light, for example, the ommatidium would be sensitive to light in the orange to green spectral range.

Stomatopod compound eyes have several additional features. Instead of having ommatidia uniformly distributed over the surface of their compound eyes, stomatopods have six parallel rows of ommatidia arranged around the equator of the eye (like a tire tread). These six rows are called the "midband" region. The portions of the eye above and below the midband are called the dorsal and ventral hemispheres. A single object can be seen by individual ommatidia in each of these three regions. This means that a single stomatopod eye has trinocular vision, and consequently, depth perception (humans require two eyes to achieve depth perception through binocular vision).

The top four rows of ommatidia in the midband contain at least eight different classes of visual pigments that respond to different wavelengths of light, including the entire color spectrum visible to humans as well as ultraviolet light (some stomatopods have as many as 16 different classes of visual pigments; human eyes have three). The two bottom rows of ommatidia are specialized for detecting light polarization, and are capable of distinguishing three different forms of polarized light (to replicate this ability, humans would have to wear trifocal polarized glasses with three different lenses for each eye). Stomatopod eyes are mounted on mobile stalks and can move independently of each other. Eye motion may be slow, scanning movements or very rapid movements that allow the shrimp's gaze to be re-directed without blurring the visual image.

Not surprisingly, images produced by compound eyes are probably very different from those produced by human eyes. Because the light focusing systems of ommatidia are less complex, the images they produce cannot have as much detail. But a more complex photopigment system, polarization vision, and thousands of individual images give the compound eye much greater ability to distinguish color variations and to detect motion.

This lesson guides student inquiry into the structure and function of stomatopod eyes, and provides direct experience with interpreting scientific literature. Portions of this inquiry are adapted from a lesson on color vision presented in a course on Neural Mechanisms of Behavior by Prof. Wulfilu Gronenberg at the University of Arizona (<http://web.neurobio.arizona.edu/gronberg/nrsc581/colorvision/color.htm>).

### Learning Procedure

1. To prepare for this lesson:
  - a. Read introductory essays for the Bioluminescence 2009 Expedition (<http://oceanexplorer.noaa.gov/explorations/09deepscope/welcome.html>).
  - b. Review questions and procedures on the “Stomatopod Vision Inquiry Guide” and the “Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide.”
  - c. Assemble materials required for student inquiries. Lighting filters may be obtained from theatrical supply houses, music stores, or via the Internet (e.g., <http://sldlighting.com/>). Each group should have at least four filters ranging from blue to red. Try to obtain filters that have roughly the same percent transmittance. Some companies (such as Rosco and Apollo) offer inexpensive swatch books of filters they supply, which include data on wavelength and percent transmittance, and are ideal for this purpose.
  - d. Optional: Download or copy several images showing light and color in deep-sea environments and organisms from one or more of the following Web sites:  
[http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean\\_coral.html](http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html)  
<http://www.pbs.org/wgbh/nova/abyss/life/bestiary.html>  
<http://www.lifesci.ucsb.edu/~biolum/>
2. Briefly discuss the mission plan and activities of the 2009 Bioluminescence Expedition. You may want to show images of stomatopods, deep-sea environments, and other organisms. Briefly introduce stomatopods, and point out that not only are they among the fastest and most aggressive predators known, but also have visual capabilities far beyond those of human eyes.

3. Provide each student group with a copy of the “Stomatopod Vision Inquiry Guide”; the “Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide.” and the “Eye Design and Color Signaling in a Stomatopod Crustacean *Gonodactylus smithii*” paper. Tell students that the paper by Chiao *et al.* is written for professional researchers who are familiar with the anatomical and physiological details of stomatopod vision. Students should be encouraged to take the time to find definitions for unfamiliar technical terms in the introductory section, but should not be concerned if they have difficulty following all of the procedures in subsequent parts of the paper.
4. Discuss results of student inquiries.
- General features of stomatopod eyes are discussed in “Background Information.”
  - Two ideas about why mantis shrimp have so many different photoreceptors are:
    - a. The color spectrum of light in the ocean environment varies widely depending upon depth and water conditions (e.g., turbidity). Being able to distinguish small differences in color may allow stomatopods to continue using color information even under changing light conditions.
    - b. At least some stomatopod species have brightly colored body areas that are used as signals between other members of the same species. Finely tuned color perception may augment this color signalling system and help stomatopods distinguish their own signals from those of other species.
  - The study by Chiao *et al.* hypothesized that the color vision of *Gonodactylus smithii* enhances the detection of intraspecific color signals. In other words, the visual capabilities of this stomatopod makes it easier to detect color signals from other members of the same species. Earlier in the introduction, the authors state that such signals may be important during aggressive (agonistic) social interactions, as well as during male-female interactions. They concluded that the stomatopod eye enhances color signals of their own species, as well as color signals from other species. So, the shrimp’s visual capabilities may increase the visibility of color signals from their own species, but may also have other functions that involve other species.
  - Investigations of photocell spectral sensitivity should have revealed that the photocells are not equally sensitive to all of the wavelengths investigated. Designs for a simple robotic eye should include some mechanism for filtering the light that falls on the photocells to provide the ability to distinguish between



### Multimedia Discovery Missions

<http://oceanexplorer.noaa.gov/edu/learning/welcome.html>

Click on the link to Lesson 6 for interactive multimedia presentations and Learning Activities on Deep-Sea Benthos.

### Other Relevant Lessons from NOAA's Ocean Exploration and Research Program

#### Where Is That Light Coming From?

<http://oceanexplorer.noaa.gov/explorations/04deepscope/background/edu/media/WhereisLight.pdf>

(6 pages, 208Kb) (from the Operation Deep Scope 2004 Expedition)

Focus: Bioluminescence

In this activity, students explain the role of luciferins, luciferases, and co-factors in bioluminescence and the general sequence of the light-emitting process. Additionally, students discuss the major types of luciferins found in marine organisms, define the "lux operon" and discuss at least three ways that bioluminescence may benefit deep-sea organisms. Students give an example of at least one organism that actually receives each of the benefits discussed.

#### Light at the Bottom of the Deep, Dark Ocean???

[http://oceanexplorer.noaa.gov/explorations/02sab/background/edu/media/sab\\_light.pdf](http://oceanexplorer.noaa.gov/explorations/02sab/background/edu/media/sab_light.pdf)

(8 pages, 476k) (from the 2002 Islands in the Stream Expedition)

Focus: Biology - Adaptations of deepwater organisms

In this activity, students will participate in an inquiry activity; relate the structure of an appendage to its function; and describe how a deepwater organism responds to its environment without bright light.

### Other Resources

*The Web links below are provided for informational purposes only.*

*Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.*

<http://oceanexplorer.noaa.gov/explorations.09deepscope/welcome.html> – The Bioluminescence 2009 Expedition Web site

Caldwell, R.L. and H. Dingle. 1975. Stomatopods. *Scient Am* 234:80-89.

Chiao C-C, T.W. Cronin, and N.J. Marshall. 2000. Eye design and color signaling in a stomatopod crustacean *Gonodactylus smithii*. *Brain Behav Evol* 56:107-122; <http://web.neurobio.arizona.edu/gronenberg/nrsc581/colorvision/stomatopod.pdf>

<http://www.lifesci.ucsb.edu/~biolum/> —The Bioluminescence Web Page

[http://www.bioscience-explained.org/ENvol1\\_1/pdf/BiolumEN.pdf](http://www.bioscience-explained.org/ENvol1_1/pdf/BiolumEN.pdf) – Marine bioluminescence by Edith A. Widder; Bioscience Explained; Vol 1:1.

[http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean\\_coral.html](http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html) – Ocean Explorer photograph gallery

[http://www.bioscience-explained.org/ENvol1\\_1/pdf/PhotoEN.pdf](http://www.bioscience-explained.org/ENvol1_1/pdf/PhotoEN.pdf) – Bacterial Illumination, by Dean Madden, D. and B-M. Lidesten; Bioscience Explained; Vol 1, No. 1; Procedures for Culturing Bioluminescent Bacteria

[http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean\\_coral.html](http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html) – Ocean Explorer photograph gallery

**National Science Education Standards**

**Content Standard A: Science As Inquiry**

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Content Standard B: Physical Science**

- Structure of atoms
- Structure and properties of matter
- Chemical reactions

**Content Standard C: Life Science**

- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

**Content Standard E: Science and Technology**

- Abilities of technological design
- Understandings about science and technology

**Content Standard F: Science in Personal and Social Perspectives**

- Natural resources

**Ocean Literacy Essential Principles and Fundamental Concepts**

**Essential Principle 5.**

**The ocean supports a great diversity of life and ecosystems.**

*Fundamental Concept d.* Ocean biology provides many unique examples of life cycles, adaptations and important relationships

among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

### **Essential Principle 7.**

#### **The ocean is largely unexplored.**

*Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation’s explorers and researchers, where they will find great opportunities for inquiry and investigation.

*Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

*Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

*Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

### **Send Us Your Feedback**

We value your feedback on this lesson, including how you are using it in your formal/informal education setting.

Please send your comments to:  
oceanexeducation@noaa.gov

### **For More Information**

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## Through Other Eyes

# Stomatopod Vision Inquiry Guide

### A. Web Inquiry

1. Visit <http://www.blueboard.com/mantis> and read the section, "What are Stomatopods" (and you thought the velociraptor was scary!).
2. Read the Abstract, Introduction, and last paragraph of "Eye Design and Color Signaling in a Stomatopod Crustacean *Gonodactylus smithi*", <http://web.neurobio.arizona.edu/gronenberg/nrsc581/colorvision/stomatopod.pdf> (you are welcome to read the rest of the paper as well, but keep in mind that the authors assume you already know a lot about stomatopod eyes).

Here are some definitions that may be useful:

*Photoreceptor* — a sensory cell or group of cells that is capable of reacting to light energy

*Chromatic* — color

*Narrow-band spectral class* — groups of photoreceptors that respond to a specific color

*Color constancy* — a condition in which colors will be perceived as the same under varying lighting conditions

*Spatially* — referring to geographic position

*Temporally* — referring to time (time of day, season of the year, etc)

*Intraspecific* — within a single species

*Agonistic* — aggressive social behavior within a single species

*Conspecific* — organisms of the same species

*Co-evolve* — evolutionary changes in two or more characters that happen over a similar period of time

*Chromaticity* — information that defines a particular color

*Reflectance spectrum* — the range of colors that are reflected from a particular surface

### B. Interpret

1. Describe the general design of the mantis shrimp eye. What are some of its distinguishing features? Be sure to include and explain the following:
  - Ommatidia
  - Cornea
  - Crystalline cone
  - Retinula
  - Rhabdomere
  - Photopigment
  - Rhabdom
  - Midband
  - Dorsal and ventral hemispheres

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## Through Other Eyes

### Stomatopod Vision Inquiry Guide - continued

#### C. Experiment

Underwater robots are among the most valuable tools available to ocean explorers. Robot designers often look to living systems for ideas about ways to give their creations various useful abilities. Suppose you want to design a robotic eye that has some of the capabilities found in stomatopod eyes. For simplicity, you decide to build the first version of the robotic eye using photocells, which are electronic devices whose resistance changes in response to light. Typically, a photocell will have high resistance to electric current in the dark, but will have much lower resistance when the photocell is exposed to light. You want the first version of your robotic eye to be able to distinguish different colors, but you aren't sure whether the photocells you have available are equally sensitive to all colors. To find out, proceed as directed on the "Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide."

Now that you know a bit more about your photocells, design a simple robotic eye that can distinguish between red, green, and blue light, and write a brief explanation of how your design is intended to work.

## Through Other Eyes

# Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide



Tools and Materials

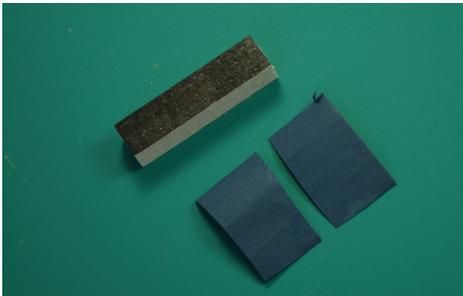
### Materials

- ✂ Piece of balsa wood, approximately 3/4" x 3" x 3/8"; one for each student group
- ✂ Cadmium sulfide photocell
- ✂ Light emitting diode
- ✂ Resistor, 330 ohms, 1/4 watt
- ✂ Multimeter
- ✂ 9-volt battery
- ✂ 9-volt battery snap connector
- ✂ Four jumper cables
- ✂ Black construction paper
- ✂ Cellophane or masking tape
- ✂ Black felt tip marker
- ✂ Red, green, and blue lighting filters

### Tools

- ✂ Longnose pliers
- ✂ Scissors
- ✂ (Optional) Wire strippers

1 & 2



### Construction Procedure

1. With a felt tip marker, color one side of the piece of balsa wood so that it is completely black.

2. Cut two pieces of black construction paper, about 1-1/4" x 2-1/4".

3



3. Notice that the base of the LED is flattened on one side. The lead that is closest to the flattened site is the cathode of the LED which connects to the negative side of the battery. Separate the leads of the LED as shown, and twist the 330 ohm resistor onto the lead that is NOT next to the flattened side (this is the anode of the LED).

4 & 5



4. Tape the LED onto one end of the balsa wood.

5. Tape the cadmium sulfide photocell onto the opposite end of the balsa wood so that the top (with the squiggly line) of the photocell is about 1/2" from the end. Be sure not to place the tape over the top of the photocell.

## Through Other Eyes

### Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide -2



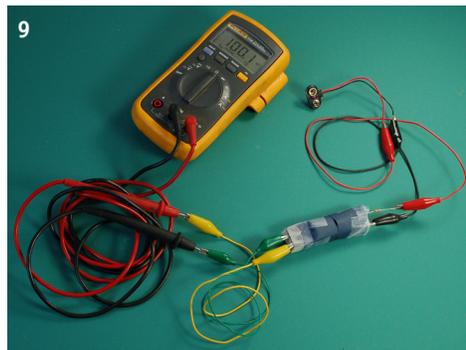
6. Tape one of the pieces of black construction paper over the LED so that it forms a dome. Press down on the end of the construction paper that is near the end of the balsa wood and tape it in place.



7. Repeat Step 6 to place a dome over the photocell. Leave a very small gap between the two pieces of construction paper that is just wide enough to slip the filter between the photocell and the LED.



8. Using jumper cables, connect the multimeter leads to the two leads of the photocell, and set the meter to read resistance (ohms; abbreviated  $\Omega$ ). It does not matter how you connect the leads, as long as each of the two multimeter leads are connected to one of the photocell leads.

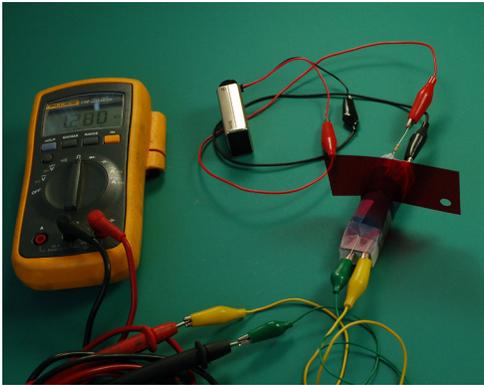


9. Strip about 1/2" of the insulation from each lead on the 9-volt battery snap connector. Using jumper cables, connect the red (positive) lead to the lead from the resistor that is not connected to the LED. Connect the black (negative) lead to the the lead from the LED that is next to the flattened side.

10. Attach the snap connector to the battery. The LED should turn on. Now disconnect the battery from the snap connector. Your Test Jig is finished!

## Through Other Eyes

# Photocell Spectral Sensitivity Test Jig Construction and Inquiry Guide -3



### Inquiry Procedure

A resistor is an electrical device that resists the flow of electric current. The unit for resistance measurement is the “ohm.” Greater resistance means less electricity will flow through the component. Photocells (sometimes called “photoresistors”) are resistors whose resistance changes in response to light. Typically, a photocell will have high resistance to electric current in the dark, but will have much lower resistance when the photocell is exposed to light. The following procedure is designed to determine whether the response of your photocell to light depends upon the color of the light.

1. With the multimeter connected as described above and the battery disconnected, record the resistance of the photocell.
2. Connect the battery (the LED should turn on) and record the resistance of the photocell. This is the fully illuminated state.
3. Slip one of the filters through the gap between the two pieces of construction paper so that light from the LED must pass through the filter before it reaches the photocell. Be sure the edge of the filter is flat against the balsa wood so that no light escapes beneath the filter. When the filter is in place, record the resistance of the photocell and make a note of the filter color.
4. Repeat Step 3 with the other two filters. If the resistance of the photocell is different with differently colored filters, this is an indication that the response of your photocell to light depends upon the color of the light. This could also be due to variations in the transmittance of light through the filters (for example, more light would pass through a pale blue filter than would pass through a dark red filter), but your teacher has probably selected filters that have about the same transmittance.