NOAA Ship *Okeanos Explorer:* America's Ship for Ocean Exploration. Image credit: NOAA. For more information, see the following Web site: *http://oceanexplorer.noaa.gov/okeanos/welcome.html*

Section 2: Key Topic – Ocean Exploration

Journey to the Unknown

(adapted from the 2002 Galapagos Rift Expedition)

Focus

Ocean Exploration

Grade Level

5-6 (Life Science/Earth Science)

Focus Question

What information can you use to determine where you are in an unknown area?

Learning Objectives

- Students will experience the excitement of discovery and problem-solving to learn what organisms could live in extreme environments in the deep ocean.
- Students will understand the importance of ocean exploration.

Materials

- NOAA and Woods Hole Oceanographic Institution photos of deep-sea animals (*http://oceanexplorer.noaa.gov/gallery/gallery.html* and *http://shiva.whoi.edu/ims/login.jsp;jsessionid=3bg7feo4j35* respectively). Other useful deep-sea animal pictures can be found at *http://extremescience.com/life-in-the-deep.htm*, *http://tqjunior.thinkquest.org/4106*, and *http://www.ocean.udel.edu/deepsea/gallery/gallery.html*
- Octocoral photos (*http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html*)
- One or more photos of remotely operated vehicles (*http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html*) for each student group
- One pint Ziploc bag of sand, one for each student group
- One pint Ziploc bag of mud, one for each student group
- (Optional) Hands-On Activity Guides: *How to Posterize Images*, and *LED Ultraviolet Illuminator Construction Guide*, one for each student or student group
- (Optional) *Student Data Sheet* – 1 per student for use with Extension #3

Audiovisual Materials

- None

Teaching Time

Two 45-minute class periods

Ocean Exploration and Research

Seating Arrangement

Groups of three or four students

Maximum Number of Students

30

Key Words and Concepts

Explore
Technology
Submersible
Biodiversity

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 may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

> ***"We know more about the dead seas of Mars than our own ocean."***
> *– Jean Michel Cousteau*

Our current estimation is that 95% of Earth's ocean is unexplored. At first, this may be hard to believe, particularly if we look at recent satellite maps of Earth's ocean floor. These maps seem to show seafloor features in considerable detail. But satellites can't see below the ocean's surface. The "images" of these features are estimates based on the height of the ocean's surface, which varies because the pull of gravity is affected by seafloor features. And if we consider the scale of these maps, it is easy to see how some things might be missed. To show our planet's entire ocean, a typical wall map has a scale of about 1 cm = 300 km. At that scale, the dot made by a 0.5 mm pencil represents an area of over 60 square miles! The fact is, most of the ocean floor has never been seen by human eyes.

On August 13, 2008, the NOAA Ship *Okeanos Explorer* was commissioned as "America's Ship for Ocean Exploration;" the only U.S. ship whose sole assignment is to systematically explore our largely unknown ocean for the purposes of discovery and the advancement of knowledge. To fulfill its mission, the *Okeanos Explorer* has specialized capabilities for finding new and unusual features in unexplored parts of Earth's ocean, and for gathering key information that will support more detailed investigations by subsequent expeditions. These capabilities include:

- Underwater mapping using multibeam sonar capable of producing high-resolution maps of the seafloor to depths of 6,000 meters;
- Underwater robots (remotely operated vehicles, or ROVs) that can investigate anomalies as deep as 6,000 meters; and
- Advanced broadband satellite communication and telepresence.

Capability for broadband telecommunications provides the foundation for telepresence: technologies that allow people to observe and interact with events at a remote location. This allows live images to be transmitted from the seafloor to scientists ashore, classrooms, newsrooms and living rooms, and opens new educational opportunities, which are a major part of *Okeanos Explorer's* mission for advancement of knowledge. In addition, telepresence makes it possible for shipboard equipment to be controlled by scientists in shore-based Exploration Command Centers. In this way, scientific expertise

A spectacular photo of the NOAA Ship *Okeanos Explorer* Control Room while ROV operations are underway. Image credit: NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.

Okeanos Explorer Vital Statistics:

Commissioned: August 13, 2008; Seattle, Washington
Length: 224 feet
Breadth: 43 feet
Draft: 15 feet
Displacement: 2,298.3 metric tons
Berthing: 46, including crew and mission support
Operations: Ship crewed by NOAA Commissioned Officer Corps and civilians through NOAA's Office of Marine and Aviation Operations (OMAO); Mission equipment operated by NOAA's Office of Ocean Exploration and Research

For more information, visit http://oceanexplorer.noaa.gov/okeanos/welcome.html.
Follow voyages of America's ship for ocean exploration with the *Okeanos Explorer* Atlas at *http://www.ncddc.noaa.gov/website/google_maps/OkeanosExplorer/mapsOkeanos.htm*

can be brought to the exploration team as soon as discoveries are made, and at a fraction of the cost of traditional oceanographic expeditions.

Learning Procedure

1. To prepare for this lesson review introductory information on the NOAA Ship *Okeanos Explorer* at *http://oceanexplorer.noaa.gov/okeanos/welcome.html*. You may also want to consider having students complete some or all of the lesson, *To Boldly Go*....

2. If you have not previously done so, briefly introduce the NOAA Ship *Okeanos Explorer*, emphasizing that this is the first Federal vessel specifically dedicated to exploring Earth's largely unknown ocean. Include a short discussion of reasons that ocean exploration is important.

3. Tell students to close their eyes, and say that they are part of an expedition to an unexplored region of Earth's ocean.

4. Read the following imaginary series of events that might take place in the *Okeanos Explorer's* Control Room or in an Exploration Command Center, but do not mention either of these locations at this point:
   a. You are a scientist on a mission. You are seated in a control room with several other scientists and technicians. Several large video monitors are on the wall in front of you.
   b. One of the monitors shows an image of a sun-lit ocean, just a few feet above the surface. A technician sitting in a chair next to you says "Here we go," as she moves a large joystick slightly. As you watch, the sea surface seems to rise up. There is a sudden splash in front of the lens and the monitor now shows rays of sunlight shining through the blue ocean water.
   c. Every minute or so, the pilot with the joystick calls out a number. As the numbers increase, the scene on the monitor grows steadily darker. By the time the pilot says "Fifty meters," the monitor is almost completely black.
   d. The pilot touches a switch and beams of light shine out into the darkness. She continues to call out larger and larger numbers. Strange animals appear in the path of the lights, then quickly disappear. Time passes, but no one wants to look away from the monitor because they might miss something amazing. The scientists keep up a running conversation about what they see, and their words are recorded along with the video images.
   e. Suddenly the scene on the monitor changes as the pilot says "Two thousand meters." You see a horizontal surface that must be the ocean bottom. Large branching objects seem to be growing out of the seafloor. You ask the pilot to collect a few samples of these. A mechanical claw attached to a metal arm appears on the monitor, tightens onto one of the branching objects, and then pulls the object back toward the video camera. The claw and the sample disappear, and the pilot says, "OK, it's in the basket."
   f. Another scientist notices things moving in the mud, and asks the pilot to collect more samples. As the camera moves around, you can see that the ocean floor is covered with animals, tracks, and holes.
   g. After collecting more samples, the pilot says, "Let's watch for a few minutes with the lights off." The monitor is completely black for what seems like a long time, but then a glowing object flashes across the screen. "WHAT WAS THAT???" There is another flash of light, and it almost seems to be following the first object. Several scientists are busily speaking into their microphones to record every detail of something they have never seen before.

Dr. Amy Baco-Taylor, Deep-sea biologist.
Image credit: Tyler Fox.
http://oceanexplorer.noaa.gov/edu/oceanage/04baco_taylor/welcome.html

Hugo Marrero, Submersible Pilot, Harbor Branch Oceanographic Institute.
http://oceanexplorer.noaa.gov/edu/oceanage/06marrero/welcome.html

Dr. Roy Cullimore, Microbiologist.
Image credit: Jeremy Weirich.
http://oceanexplorer.noaa.gov/edu/oceanage/04cullimore/welcome.html

Who Are Today's Ocean Explorers? [OceanAGE]

Ocean exploration requires new ways of thinking and close collaboration among biologists, chemists, climatologists, computer programmers, educators, engineers, geologists, meteorologists, physicists, anthropologists, and many other fields of expertise. Through the Ocean Explorer OceanAGE Careers Web page *http://oceanexplorer.noaa.gov/edu/oceanage/welcome.html*, marine explorers provide students with first-hand knowledge of exciting careers through live interviews, profiles, and mission logs. Career profiles include:

- Deep-sea Biologist – Amy Baco-Taylor
- Fish Ecologist – Peter Auster
- Geophysicist – Bob Embley
- Marine Ecologist – Peter Etnoyer
- Marine Geoarchaeologist – Beverly Goodman
- Marine Mammal Biologist – Kristin Laidre
- Microbiologist – Roy Cullimore
- Natural Products Biologist – Shirley Pomponi
- NOAA Corps Officer – Brian Kennedy
- Oceanographer – Robert Ballard
- Submersible Pilot – Hugo Marrero

h. Finally, the pilot begins calling out numbers again, but this time each number is smaller than the one before. Everyone has been in the control room for hours, but they can't wait to begin analyzing the samples from part of the Earth that has never been seen before.

5. Have students open their eyes and have a discussion about where they think that they have been and why. If necessary, stimulate the discussion by asking some or all of the following:
   - Were you excited?
   - Where were you?
   - Where did the video images on the monitor come from?
   - Why was it dark?
   - What were the glowing objects?
   - What were the branching objects?
   - What were the things moving in the mud?
   - Do you think that scientists get excited when they are making discoveries?

6. Tell students that you are going to provide them with some materials to help them try to determine where they went on their imaginary voyage. Give each table copies of several photos of deep-sea creatures, a picture of a remotely operated vehicle, a Ziploc bag full of sand and one of mud. (Do not explain the materials yet). Tell the students to think about the things that they saw and heard, including the pilot's words. Give them 10-15 minutes to explore, discuss, and ask questions.

7. As a class, have students discuss their ideas, answering questions, and challenging ideas. Then tell them that they were on an imaginary mission in a control room for the NOAA Ship *Okeanos Explorer*. Explain that one of the important capabilities of the ship is telepresence, which allows people to observe and interact with events at remote locations. Telepresence technologies allow live images to be transmitted from the seafloor to scientists ashore, classrooms, newsrooms and living rooms, and are a major part of the *Okeanos Explorer's* mission for advancement of knowledge. Telepresence also makes it possible for shipboard equipment to be controlled by scientists in shore-based Exploration Command Centers. In this way, scientific expertise can be brought to the exploration team as soon as discoveries are made, and at a fraction of the cost of traditional oceanographic expeditions. So, their imaginary mission might have taken place aboard the *Okeanos Explorer*, but it could also have happened thousands of miles away in an Exploration Command Center.

8. (Optional) Posterize images of deep-sea creatures, and construct an ultraviolet LED poster illuminator (See Student Handouts).

A benthic fish called a Sea Robin. This fish has several sets of modified fins - some modified for perching on the seafloor, and 'wing-like' fins for swimming. Image captured by the *Little Hercules* ROV at 279 meters depth on a site referred to as 'Zona Senja' on August 2, 2010. Image credit: NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/hires/batfish_hires.jpg

A deep-sea chimaera. Chimaeras are most closely related to sharks, although their evolutionary lineage branched off from sharks nearly 400 million years ago, and they have remained an isolated group ever since. Like sharks, chimaeras are cartilaginous and have no real bones. The lateral lines running across this chimaera are mechano-receptors that detect pressure waves (just like ears). The dotted-looking lines on the frontal portion of the face (near the mouth) are ampullae de Lorenzini and they detect perturbations in electrical fields generated by living organisms. Image credit: NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/hires/chimaera_hires.jpg

The BRIDGE Connection

www.vims.edu/bridge/ – Scroll over "Lesson Plans," then "5th Grade" for resources and activities related to ocean exploration.

The "Me" Connection

Have a discussion of products from the sea, and the potential to discover new species, new medicines, and new ways of transferring energy. (Use *www.obia.com* and *www.coralreefalliance.org/aboutcoralreefs* Web sites from Resources section.)

Connections to Other Subjects

Biology, English/Language Arts, Mathematics

Assessment

Have students write a log entry with illustrations about what was seen on the deep-sea dive. Ask them to include the newly-learned vocabulary terms in their entry.

Extensions

1. Follow events aboard the *Okeanos Explorer* at *http://oceanexplorer.noaa.gov/okeanos/welcome.html*.
2. Research the Internet to find more species that live at depths of 2,000 meters and beyond. Have students make posters using the information about particular animals and share the posters with classmates. If students use fluorescent paints or markers to color their posters, you may also want to construct one or more ultraviolet illuminators as directed in the *LED Ultraviolet Illuminator Construction Guide*, page 50.
3. Conduct a simulated deep-ocean bottom exploration on the playground or other outside location. Have students pretend that they are exploring it for the first time. Ecological surveys often make use of frames called "quadrats" that enclose a known area. Quadrats may be made of wood, plastic, or other materials, and are usually square (although they can be any shape as long as the enclosed area is known). Several quadrats are spaced over the area to be surveyed; the exact number of quadrats usually depends upon the time and personnel available to complete the survey. Students can make quadrats with meter sticks taped together to form squares, or hula hoops to form circular quadrats. Have students draw their entire quadrat and record observations of both living and nonliving components on the *Student Data Sheet*, page 53.

Multimedia Discovery Missions

http://www.montereyinstitute.org/noaa/ Click on the links to Lessons 3, 6, 11, and 12 for interactive multimedia presentations and Learning Activities on Deep-Sea Corals, Deep-Sea Benthos, Energy from the Oceans, and Food, Water, and Medicine from the Sea.

Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

(All of the following Lesson Plans are targeted toward Grades 5-6)

A Piece of Cake (from the Cayman Islands Twilight Zone 2007 Expedition)
http://oceanexplorer.noaa.gov/explorations/07twilightzone/background/edu/media/cake.pdf
Focus: Spatial heterogeneity in deepwater coral communities (Life Science)
Students will explain what a habitat is, describe at least three functions or benefits that habitats provide, and describe some habitats that are typical of deepwater hard bottom communities. Students will also explain how organisms, such as deepwater corals and sponges, add to the variety of habitats in areas such as the Cayman Islands.

Deep Gardens (from the Cayman Islands Twilight Zone 2007 Expedition)
http://oceanexplorer.noaa.gov/explorations/07twilightzone/background/edu/media/deepgardens.pdf
Focus: Comparison of deep-sea and shallow-water tropical coral communities (Life Science)

Students will compare and contrast deep-sea coral communities with their shallow-water counterparts, describe three types of coral associated with deep-sea coral communities, and explain three benefits associated with deep-sea coral communities. Students will explain why many scientists are concerned about the future of deep-sea coral communities.

Let's Make a Tubeworm! (from the 2002 Gulf of Mexico Expedition)
http://oceanexplorer.noaa.gov/explorations/02mexico/background/edu/media/gom_tube_gr56.pdf
Focus: Symbiotic relationships in cold-seep communities (Life Science)
Students will describe the process of chemosynthesis in general terms, contrast chemosynthesis and photosynthesis, describe major features of cold-seep communities, and list at least five organisms typical of these communities. Students will also define symbiosis, describe two examples of symbiosis in cold-seep communities, describe the anatomy of vestimentiferans, and explain how these organisms obtain their food.

Chemists with No Backbones (from the 2003 Deep Sea Medicines Expedition)
http://oceanexplorer.noaa.gov/explorations/03bio/background/edu/media/meds_chemnobackbones.pdf
Focus: Benthic invertebrates that produce pharmacologically-active substances (Life Science)
Students will identify at least three groups of benthic invertebrates that are known to produce pharmacologically-active compounds and describe why pharmacologically-active compounds derived from benthic invertebrates may be important in treating human diseases. Students will also infer why sessile marine invertebrates appear to be promising sources of new drugs.

Keep Away (from the 2006 Expedition to the Deep Slope)
http://oceanexplorer.noaa.gov/explorations/06mexico/background/edu/gom_06_keepaway.pdf
Focus: Effects of pollution on diversity in benthic communities (Life Science)
Students will discuss the meaning of biological diversity and compare and contrast the concepts of variety and relative abundance as they relate to biological diversity. Given information on the number of individuals, number of species, and biological diversity at a series of sites, students will make inferences about the possible effects of oil drilling operations on benthic communities.

What's In That Cake? (from the 2006 Expedition to the Deep Slope)
http://oceanexplorer.noaa.gov/explorations/06mexico/background/edu/gom_06_cake.pdf
Focus: Exploration of deep-sea habitats (Life Science)
Students will explain what a habitat is, describe at least three functions or benefits that habitats provide, and describe some habitats that are typical of the Gulf of Mexico. Students will also describe and discuss at least three difficulties involved in studying deep-sea habitats and describe and explain at least three techniques scientists use to sample habitats, such as those found in the Gulf of Mexico.

Other Resources

See page 217 for Other Resources.

Send Us Your Feedback

We value your feedback on this lesson, including how you use it in your formal/informal education settings.
Please send your comments to:
oceanexeducation@noaa.gov

For More Information

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http://oceanexplorer.noaa.gov

Next Generation Science Standards

Lesson plans developed for Volume 1 are correlated with *Ocean Literacy Essential Principles and Fundamental Concepts* as indicated in the back of this book. Additionally, a separate online document illustrates individual lesson support for the Performance Expectations and three dimensions of the Next Generation Science Standards and associated Common Core State Standards for Mathematics and for English Language Arts & Literacy. This information is provided to educators as a context or point of departure for addressing particular standards and does not necessarily mean that any lesson fully develops a particular standard, principle or concept. Please see: *http://oceanexplorer.noaa.gov/okeanos/edu/collection/wdwe_ngss.pdf.*

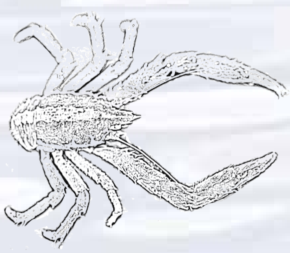
How to Posterize Images

1

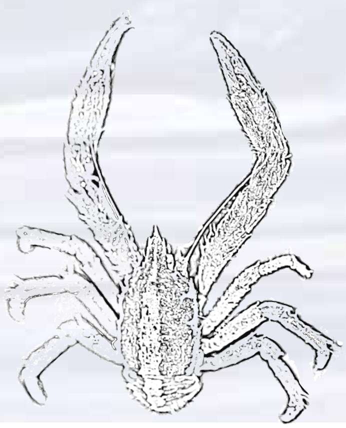
http://oceanexplorer.noaa.gov/explorations/03mex/logs/sept25/media/dsc_0055_100.jpg

2

3



4



There are many techniques and software programs that convert photographic images to simpler outlines or images that contain fewer colors. Here is a simple technique using Adobe Illustrator® that produces outline images that can be colored with markers, crayons, or pencils.

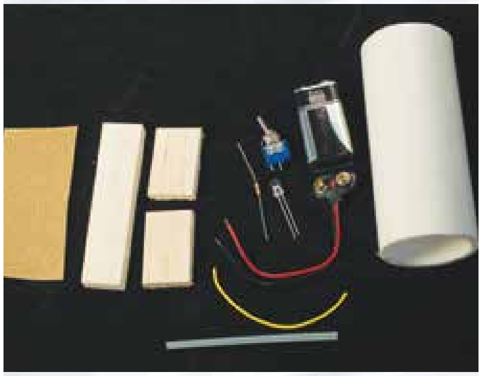
1. Select an image. In general, higher resolution images will produce more detailed outlines, but may take longer to process. This is an image of a three-toothed squat lobster (*Munidopsis tridentata*) from the Ocean Explorer Gallery (*http://oceanexplorer.noaa.gov/gallery/gallery.html*).

2. Open the image in Adobe Illustrator®, and select the image with the solid arrow tool. Scroll over "Sketch" in the "Effect" drop-down menu, then select "Photocopy." Adjust the "Detail" and "Darkness" controls until you like the image, then click "OK." Note: You may need to adjust the magnification box in the lower left corner so you can see the entire image. Select "Fit on Screen" from the pop-up window that appears when you click the magnification box.

3. If you want to remove unwanted portions of the image, click on "Live Trace" in the "Object" drop-down menu, then "Make and Expand" (if you don't like the result, choose "Tracing Options" from the "Live Trace" menu and experiment with the presets to find one you like). When the tracing is complete, use the open arrow tool and eraser tool to remove unwanted material. Take your time, save often, and use the magnification tool to zoom in when necessary.

4. Rotate your image to the desired orientation, and you are ready to color! If you use fluorescent markers or crayons, you can use the Ultraviolet Illuminator for dramatic effects in a darkened room. This is especially useful to illustrate bioluminescence, which was studied during the Bioluminescence 2009: Living Light on the Deep-Sea Floor, Operation Deep Scope 2005, and Operation Deep Scope 2004 Expeditions (*http://oceanexplorer.noaa.gov/explorations/09bioluminescence/welcome.html*, *http://oceanexplorer.noaa.gov/explorations/05deepscope/welcome.html* and *http://oceanexplorer.noaa.gov/explorations/04deepscope/welcome.html*, respectively).

LED Ultraviolet Illuminator Construction Guide



Materials

- 1 Piece balsa or bass wood, 3-1/2" x 1" x 3/8" thick
- 2 Pieces balsa or bass wood, 1-5/8" x 1" x 1/4" thick
- 1 Toggle switch, SPST (Radio Shack Part No. 275-0612, or equivalent)
- 1 Resistor, 330 ohms, 1/4 watt (Radio Shack Part No. 271-1315, or equivalent)
- 1 9-volt Battery
- 1 9-volt Battery snap connector (Radio Shack Part No. 270-325, or equivalent)
- 1 Ultraviolet light emitting diode (Mouser Electronics Part No. 593-VAOL5GUV8T4, or equivalent)
- 3" Length, 22 gauge insulated hookup wire
- 3" Length, heat shrink tubing, 1/8" inside diameter
- 5-1/4" Length, 1-1/2" inside diameter PVC pipe
- Small piece of medium (100 grit) sandpaper

[NOTE: Mention of trademarks or proprietary names does not imply endorsement by NOAA]

Tools

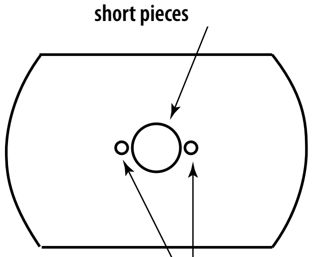
- Longnose pliers
- Wire cutters
- (Optional) Wire stripper
- Craft saw or coping saw
- Hand or electric drill
- 1/16" and 1/4" drill bits
- Hot glue gun
- Hair dryer or heat gun
- Soldering iron and rosin-core solder (do not use acid core solder in electronic circuits!)
- Safety glasses or goggles

A note about soldering: If you have never soldered before, you may want to visit *http://www.instructables.com/id/How-to-solder/*. Be sure to wear safety glasses or goggles when soldering, and work in a well-ventilated space (you can set up a small fan if necessary to blow away soldering fumes).

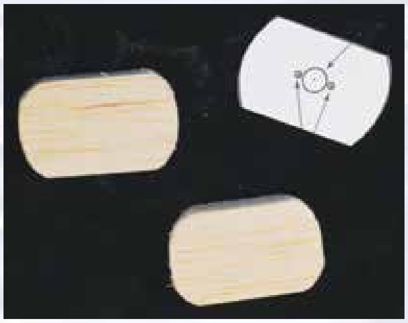
Construction Procedure

1. Use a craft saw or coping saw to cut the two short pieces of wood according to Pattern 1. These pieces should fit snugly inside the PVC pipe. Adjust the fit with sandpaper if necessary.

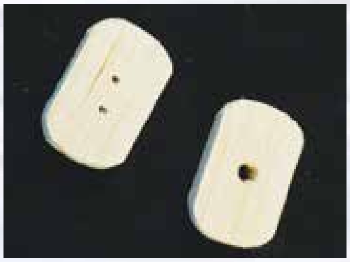
Pattern 1:



1

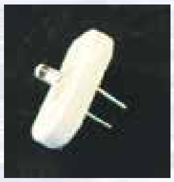


2

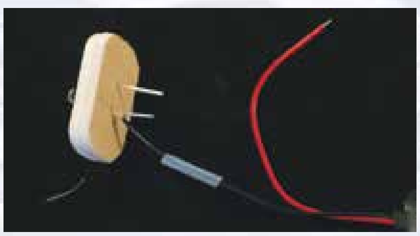


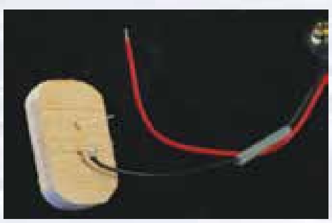
3

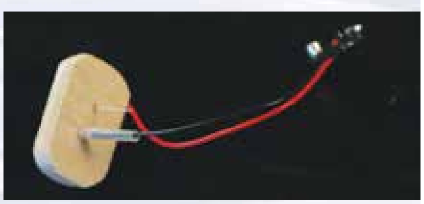

4a

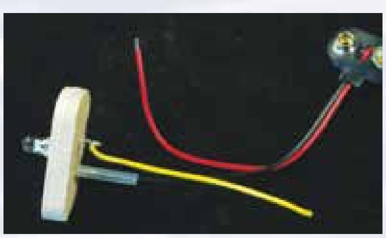

4b


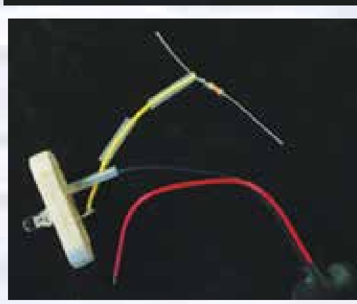
5a


5b


6a


6b


7


8a


2. Drill two 1/16" diameter holes in one of the short wood pieces in the locations indicated on Pattern 1. Drill one 1/4" hole in the other short wood piece as indicated on the pattern (Figure 2).

3. Mount the toggle switch on the short piece of wood with the 1/4" hole. The switch comes with two hex nuts, a flat washer, and a lockwasher. Remove all of the hardware and insert the threaded portion of the switch through the hole. You may have to press the body of the switch slightly into the balsa wood to expose enough thread to start one of the hex nuts. Tighten the nut two or three turns, then remove the nut, install the flat washer, and re-install the nut. Tighten several turns until the switch is securely mounted (Figure 3). NOTE: The photograph shows the switch in the "Off" position. Be sure your switch stays in this position until all steps are completed. This is a good time to mark "Off" on the wood near the switch handle.

4. Bend the wire leads of the LED as shown so that the leads will fit through the 1/16" holes in the other short piece of wood (Figure 4a). Put a small dab of hot glue on the wood between the holes, and hold the LED in place until the glue sets (Figure 4b).

5. Notice that the base of the LED is flattened on one side (FIgure 5a). The lead that is closest to the flattened site is the cathode of the LED which connects to the negative side of the battery. Remove about 1/2" of insulation from the black lead of the 9-volt battery snap connector. Twist the strands together, then put a 3/4" piece of heat shrink tubing over the black lead. Now, wrap the bare wire around the cathode lead from the LED about 1/4" from where it emerges from the piece of wood (a pair of longnose pliers can be helpful for this step) (Figure 5b).

6. Solder the connection by holding the heated soldering iron against the twisted wires, then touching the solder to the opposite side of the connection (don't touch the solder to the soldering iron, because the wires being soldered must be hot enough to melt the solder; otherwise the joint will be weak) (Figure 6a). Trim the excess lead coming from the LED and slide the heat shrink tubing over the joint (Figure 6b).

7. Remove about 1/2" of insulation from one end of the piece of hookup wire. Twist the strands together, then wrap the bare wire around the other lead from the LED and solder the connection. Trim the excess lead coming from the LED (Figure 7).

8. Remove about 1/2" of insulation from the other end of the hookup wire and twist the strands together. Put two 3/4" pieces of heat shrink tubing over the wire, then wrap the bare wire around one lead of the resistor about 1/4" from where it emerges from the resistor body. Solder the connection. Trim the excess lead coming from the resistor. Slide the heat shrink tubing over the joint with the LED and the joint with the resistor (FIgure 8).

9. Put a 3/4" piece of heatshrink tubing over the other lead of the resistor. Bend the end of the lead into a U-shaped hook, and slide the hook through one terminal of the toggle switch. Crimp the hook tightly onto the switch terminal, then solder the connection (Figure 9).

10. Remove about 1/4" of insulation from the red lead of the 9-volt battery snap connector, and twist the strands together. Bend the end of the lead into a U-shaped hook, and slide the hook through the other terminal of the toggle switch. Crimp the hook tightly onto the switch terminal, then solder the connection (FIgure 10).

11. Heat all pieces of heat shrink tubing so that they shrink around the wires and connections they are covering.

12. Using hot melt glue, glue the 9-volt battery near the center of the long piece of wood (Figure 12).

13. Bend the long lead of the resistor as shown so that it will fit over the battery (FIgure 13a), then glue the short pieces of wood to the ends of the long piece of wood using hot melt glue (FIgure 13b).

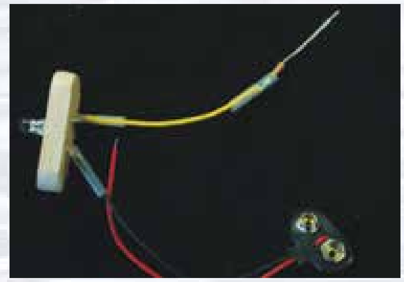
14. Check to be sure the switch is in the "Off" position (see Step 3). Attach the snap connector to the battery, and slide the assembly into the PVC pipe so that the piece of wood with the switch is flush with one end of the pipe. If necessary, use a small amount of hot glue to hold the assembly inside the pipe (Figure 14). Your Ultraviolet Illuminator is finished! Test your illuminator by turning the switch on in a darkened room. Remember: NEVER LOOK DIRECTLY AT A SOURCE OF ULTRAVIOLET LIGHT!

Notes About Components

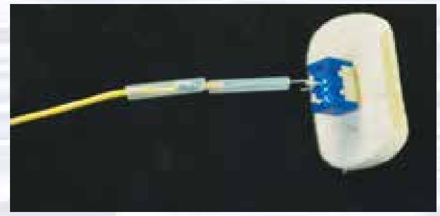
A light emitting diode (LED) is a device that acts as a one-way gate to electric current, and that under some conditions will emit light. A diode is made with two small blocks of two different silicon compounds. The two blocks are held together by an encapsulating material, and a wire lead is attached to each block. One block is called the anode and the other is called the cathode. When the anode is more positive than the cathode, an electric current will flow through the diode. In an LED, this current flow causes light to be emitted. LEDs emit only one color of light, which depends upon the specific chemistry of the silicon compounds.

A resistor is an electrical device that resists the flow of electric current. The unit for resistance measurement is the "ohm." Resistors may have a single fixed resistance, or may be variable. Photoresistors and thermistors are variable resistors whose resistance changes with exposure to light and heat respectively. The resistor used in the Ultraviolet Illuminator is a fixed resistor made with a mixture of carbon and a glue-like binder.

8b



9



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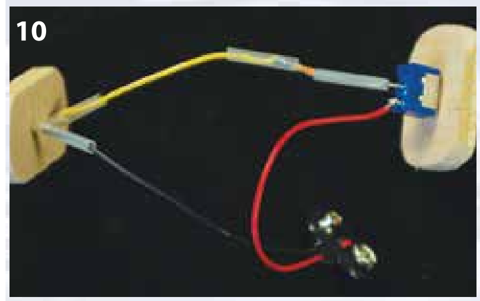

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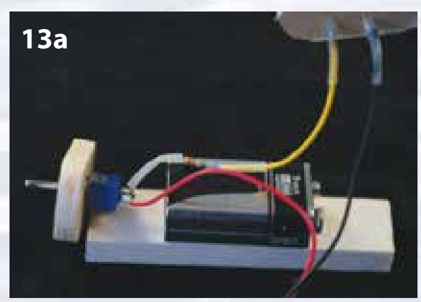
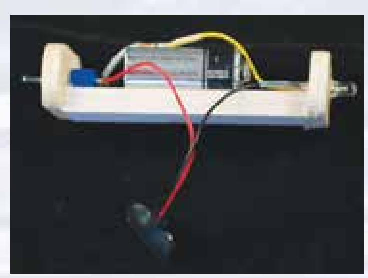
13a



13b



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Student Data Sheet for Quadrat Exploration

(See Extension #3, page 47)

Quadrat No.________

Animals		**Plants**		**Burrows & Mounds**		
Description	No.	Description	No.	Description	No.	Soil Description

Going Deeper: Many scientists, including those that explore the deep ocean, use quadrats as tools for quantifying organisms. Do you think this is a good method? Why or why not?

Notes: