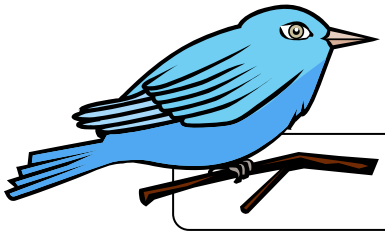

Creatures that "glow" in the night

Summary:
Students observe and experiment with bioluminescent dinoflagellates, learning how and why they produce light.

Background Information:

Many organisms have bioluminescent properties. In the Midwest, the most common animal observed is the firefly, which uses flashes of light to attract a mate of the correct species.

In the ocean, where light can be scarce, bioluminescence is far more common than on land. Squid, fish, copepods, jellyfish, many of which live in deep sea environments use bioluminescence to attract mates, lure prey, and camouflage themselves from predators lurking below. A common and readily available organism for classroom observation of bioluminescence is the dinoflagellate, *Pyrocystis fusiformis.* These dinoflagellates are single-celled algae, often found concentrated in calm, tropical, oceanic bays.

P. fusiformis bioluminesces according to a circadian rhythm by photosynthesizing during the day and producing enzymes and proteins (luciferase and luciferin) at night. *P. fusiformis* only creates flashes of light when it is disturbed. Scientists believe this may be a defensive mechanism to scare away its main predator, the copepod. The flash of light attracts fish, which are likely to eat the copepod.

One famous related species of dinoflagellate, *Pyrodinium bahamense*, lives in the Mosquito Bay of Vieques Island, Puerto Rico. The shape of the Bay calms the water preventing wave action from moving the phytoplankton. Mangrove forests that surround the Bay provide the essential nutrient, vitamin B12, in the water through bacterial decomposition of their leaves. The dinoflagellates become highly concentrated in this Bay, and night time boat tours provide visitors with an amazing show of the sparkling waters.
Bioluminescent dinoflagellates are fun, easy to grow organisms for use in the classroom. This activity allows students to learn about bioluminescence through open-ended scientific exploration.

Grade Level: High School 9-12, adaptable to middle school

Goal: To practice experimental design and scientific writing through the study of bioluminescence.

Key Concepts: experimental questioning and design, bioluminescence

Objectives: Upon completion of this lesson, students will:

1) Explain why some organisms bioluminescent
2) Be able to design and analyze a scientific experiment

Teaching Location: Classroom

Lesson Time: Introduction: 30-40 minutes
Lecture: 20-25 minutes
Investigation: 2-5 days

Subject Areas for Infusion:
Science, environmental education

Standards:
Environnemental Education
A.12.3-4

Science
C.12.1-2
F.12.7
F.12.11

Materials:

- *Pyrosystis fusiformis*, or other bioluminescent dinoflagellate
- Microscopes
- Slides and cover slips
- Eyedroppers
- Small clear vials or other viewing chambers
- Cool white fluorescent light box(es) on 12 hour timer
- Photos of bioluminescent organisms

Vocabulary

Bioluminescence: emission of light by living organisms.

Phosphorescence: the emission of light caused by the absorption of radiation, such as UV light, and continuing for a noticeable time after the radiation source has stopped. An example is phosphorus

Set-Up:

Pyrosystis fusiformis are sold by a few suppliers. Sunnyside Sea Farms (see References) sells dinoflagellates, vials and culture material. The organisms only bioluminesce during the dark part of their cycle so they must be ordered at least 5 days in advance so you can retrain them to suit your teaching schedule. The best viewing is 2-6 hours after "nightfall." You may want to have two sets of dinoflagellates on opposite time schedules to observe both photosynthesis (during the "day") and bioluminescence (at "night"). More information on growing dinoflagellates is available on-line (see References)

Be sure your classroom is as dark as possible on days you want to observe bioluminescence; the glow is not strong enough to compete with outside lights.

Procedure:

Step 1—Introduction

1. Demonstrate the bioluminescence of the dinoflagellates without telling them what they is in the containers. Ask them to explain what they see (tiny points of light) and what they think is causing it.
2. Is the light chemical or biological in origin? Why do they think so? How could they tell?
3. Have students create wet mounts of the organisms and look at them under a microscope. First observe them with the light as they would normally use a microscope so students can determine that this is a uni-cellular organism. They should write down observations and sketch what they see. (They may see chloroplasts within the cell.) Set up some microscopes in a darkened area for observation. (They may see chloroplasts within the cell.) Is the organisms glowing? (probably not). If you disturb the slide does it glow? (probably not much if at all).
   *Note: Do not leave the microscope light on for extended periods of time, as it may harm the organisms.
4. . If you have created a set of organisms on the opposite time schedule, present the students with these organisms, pointing out that they do not bioluminesce. Observe these under the microscope. What differences do they notice (especially in the chloroplasts)? Bring the students back together for a discussion of what they have seen. Make a list of questions they have on the board and in their notebooks.

Step 2—Lecture

1. Explain to the students that what they have just observed is *Pyrocystis fusiformis*, a bioluminescent dinoflagellate (a kind of algae) found in tropical oceans.
2. Define the words "phosphorescence" and "bioluminescence," helping the students to understand the difference between the chemical and biological nature of these two types of light.
3. Ask students for examples of bioluminescence (fireflies, deep sea creatures, mushrooms, bacteria, etc.)
4. Provide students with an overview of bioluminescence through photographs and discussion. What kinds of organisms bioluminesce? Why would they want to create this kind of light? (defense, lure prey, mating, camouflage-- www.biolum.org has a good presentation with photographs prepared to answer these very questions. Project the website on screen or have students go through this on their own concentrating on the "living lights" and "why make light?" sections.)
5. After doing the overview, bring the discussion back to bioluminescent dinoflagellates. Puerto Mosquito on Vieques Island (see www.biobay.com) is one of the best places in the world to find these organisms. Explain briefly how the shape of the bay and connection with the mangrove forest helps create a highly concentrated population.

Step 3—Investigation

1. Add more questions the students have to the list they made previously.
2. With teacher guidance, groups of students should develop questions and simple experiments to run on the dinoflagellates. The Bioluminescent Web Page and the Scripps Institution (see references) has experiment ideas. Studies of pH, circadian rhythms and population growth are recommended.

Assessment:

1.) Students should write a simplified lab report with a question, methods, results and conclusion section. Regardless of the outcome of the experiment, have students critique the quality of their experiment and suggest further research or experimentation needed to properly answer their initial question.
2.) When grading the report look for use of controls, systematic data collection, logical interpretation of results and thoughtful critiques. Show the students photos of different organisms that bioluminesce and ask them to explain the function of that adaptation.

Extensions:

1.) Discuss the mechanism of light production in the dinoflagellate (luciferin and luciferase) as part of a discussion of enzyme function or metabolism. (see reference from Scripps Institution of Oceanography)
2.) Assign students to research another bioluminescent organism and to write a report or create a poster describing its habitat, behavior and mechanism of bioluminescence.

3.) Further discuss the connection between mangroves and dinoflagellates. Mangroves provide Vitamin B12 used by the dinoflagellates in metabolic processes. What are the implications for conservation of the Bio Bay in Vieques?
4.) Discuss the uses of bioluminescence genes in biotechnology. Conduct a biotransformation activity available from many supply catalogs.

Adaptations:
For upper elementary and middle school, conduct the introduction and lecture sections only.

References:

Bernache - Baker B. 1995. The Bioluminescent Bays of Vieques
http://biobay.com/cd/articlew/barb1.htm (ecological article)

Haddock, S.H.D.; McDougall, C.M.; Case, J.F. .2004. "The Bioluminescence Web Page",
http://www.lifesci.ucsb.edu/~biolum/organism/dinohome.html (good starter page for teachers)

Island Adventures Bio-Bay Ecotours, 2004. http://www.biobay.com/ (photos of bay, tour information)

More about Bioluminescence. 2000, Harbor Branch Oceanographic Institution http://www.biolum.org/
(prepared presentation on bioluminescence)

Morell, V. 2004. "Way Down Deep." National Geographic. June. Vol 205(6): 36-55.
(good photographs of other bioluminescent deep sea creatures)

Scripps Institution of Oceanography, 1996. Bioluminescence.
http://siobiolum.ucsd.edu/Dino_intro.html (detailed life history and chemical descriptions, lab ideas)

Sunnyside Sea Farms, 475 Kellogg Way, Goleta CA 93117. sunnyside@SeaFarms.com Phone: 805-964-5844 Fax: 805-964-0045 (dinoflagellate supplier and lesson plans)