Career: Environmental Chemist
The Chemistry of Bioluminescence

"I've always been interested in living things, and as I learned more and more about the complexities of cells, I knew that I wanted to study the lives of cells as a career. Understanding how a single cell functions, and how cells interact with each other can help us understand entire organisms.

In my research, I explore gene and protein functions and what effects those genes and proteins have on cell processes and health. Usually, this isn't something that you can see with your own eyes since proteins are so small. Bioluminescence is special since it is a protein interaction that we can observe without the help of microscopes, making it more tangible. In the lab, lots of things go wrong, and solving problems is the only way to move ahead on a project. It took time for me to learn to be more patient and stick with a problem even when I am frustrated. Problem-solving helps me be a better scientist in the lab, but also helps in everyday life! Knowing how cells operate helps me appreciate the beauty and complexities of organisms even more."

Amber Hale, Ph.D.
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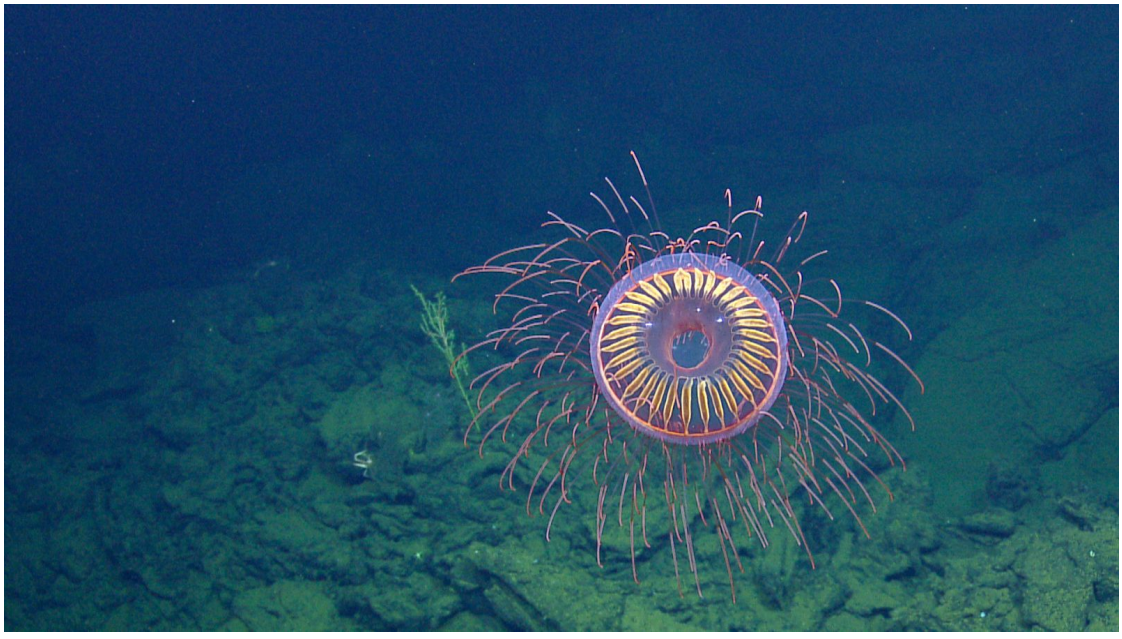
Science Communication Fellow in the Corps of Exploration



Career Connection Activity

Background and Brainstorming

Read the introduction to bioluminescence (bi-o-lu-mi-nes-cence) and answer the following questions with a partner!

1. Describe what *bioluminescence* means in your own words.

2. Have you seen any bioluminescent creatures? Name at least three creatures that make their own light helping them in their environment.

3. Think about why an animal might want to make their own light. Describe two scenarios where making light would be helpful to an organism.

4. Practice pronouncing this vocabulary in your group. Look up the definitions and an example of terms you don't know.

   **Endergonic* **Exergonic*

   Based on what you know about bioluminescence and reaction types circle the type of reaction you think a bioluminescent reaction represents? Why did you choose your answer?

   Endergonic **Exergonic**

5. In the reaction below, indicate whether each component is a reactant, product, or enzyme. Put a check beside each component.

	Reactant	Product	Enzyme
Luciferin			
Oxygen			
Luciferase			
Oxyluciferin			
Carbon dioxide			

Teacher Demonstration & Group Experiments

Instructor Materials	**Lab Group Materials**
• Glow stick, large-diameter rod • Shallow dish • Eye protection (safety goggles) • Hydrogen Peroxide • Cutters (wire cutters are best, box cutter or scalpel) • Quart size freezer bag (optional)	• 2 glow sticks, long necklace-type (less expensive) or thicker rod type • 2 clear bowls • Ice water • Hot water

Demonstration: Anatomy of a glow stick

We advise instructors to try this experiment before teaching with lab groups to know what to expect.

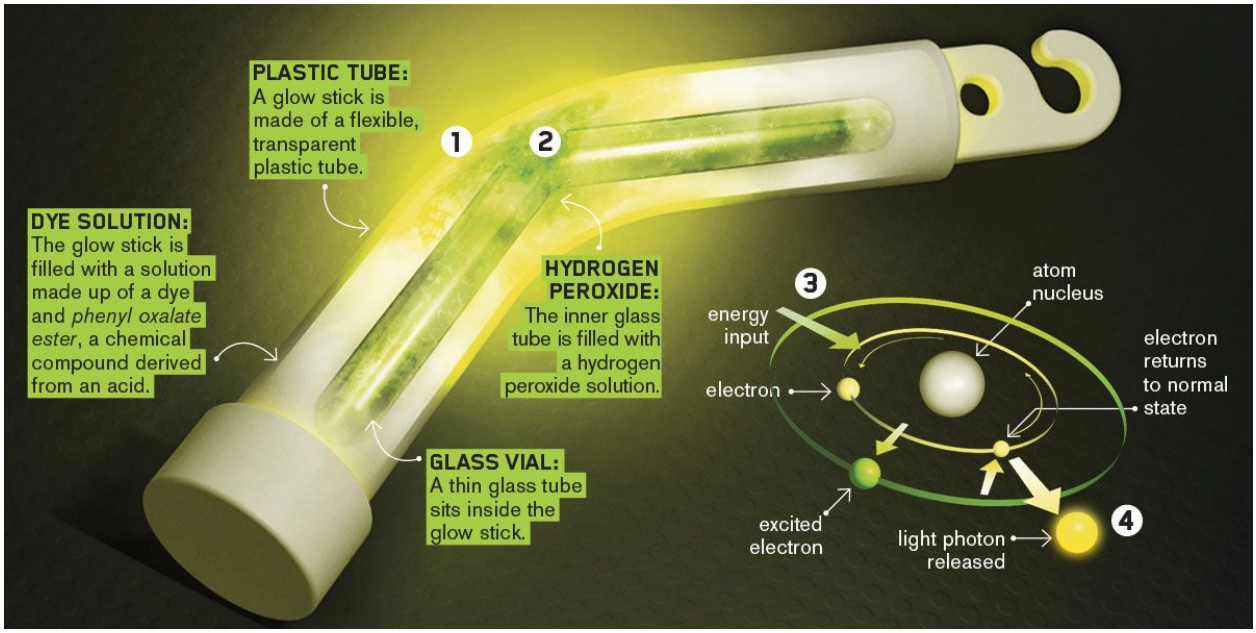


Image by Scholastic Science World

Hand each group a glow stick and instruct students NOT to bend/break them. Ask students to closely observe the individual parts of the glow stick. After seeing each part, discuss how the glow stick might work. What is being separated? Why?

Use wire cutters to carefully cut (on paper plate or cutting board) between the end of the glow stick and the inner glass ampule. Pour the fluid (hydrogen peroxide) that surrounds the ampule into a shallow dish.

Carefully remove the glass ampule place it inside the freezer bag. Use cutters to crush the ampule being careful of sharp fragments. Coax the fluid into a lower corner of the freezer bag. Trim the corner of the bag at a 45° angle to make a spout. Slowly pour the ampule liquid into the shallow dish of hydrogen peroxide. When the solutions meet watch for a chemiluminescence reaction.[1] If your hydrogen peroxide spilled while dissecting the glow stick, use store-bought hydrogen peroxide to fill a shallow dish. If demonstrating several times, vary the ratio of ampule dye: hydrogen peroxide. Ask students to suggest explanations for any changes seen.

[1] The chemicals inside the glass ampule are a mixture of a dye and diphenyl oxalate, a chemical derived from acid. The dye determines the color of the chemiluminescence.

Experiment: Temperature Effects on Chemical Reactions

After students familiarize with glow stick anatomy, challenge them with an experiment to examine temperature's impact on chemical reactions. Direct students to survey the lab group materials and come up with a plan to test the effect of temperature on chemical reactions. Groups should diagram / record their experimental design plans on the worksheet BEFORE they get started.

Here is an example of a well-designed experiment:

1) Fill one bowl with ice water and one with very warm water.

2) Activate two intact glow sticks at the same time (or as closely as possible).

3) Place one glow stick in the ice water and one in the warm water.

4) Observe for 5 minutes and record differences between the brightness of the glow.

Note: Expect the glow stick in the very warm water will shine brighter and react faster than the glow stick in the cold water. Educators could guide discussion on reaction rate and temperature-regulated reactions if appropriate. Students could move the glow stick from the ice water to the warm water to illustrate the point further.

Student Experimental Questions

1. Construct a hypothesis explaining how the glow stick works.

2. Design an experiment using the materials you have been provided to test whether or not temperature has an effect on the chemical reaction happening inside the glow stick. Describe and/or diagram your experiment here.

3. Record your observations from your experiment.

4. Did the results of the experiment support your hypothesis? How did the temperature impact or not impact your glowsticks?

5. What about bioluminescence might be challenging for a deep sea organism? Try to relate your observations to your answer.