Going Deep

Activity 3: Grades 5-8

Light Stick Chemistry

Sunlight that penetrates the ocean is absorbed as it passes through the surface layers of the water. Since solar radiation does not reach the ocean depths, the bottom of the deep ocean remains largely in complete darkness. However, certain animals in this extreme environment can generate light to communicate with each other, and even to lure prey, thanks to a process known as bioluminescence.

Bioluminescence is a form of chemiluminescence - the production of light through chemical means. In contrast to light generated by high temperatures which allows objects to get hot (such as light bulbs, stars, or fireplace pokers), this "cool" process relies on chemical reactions. When chemicals combine, they release the energy that has been stored in their chemical bonds. In chemiluminescent reactions, this stored energy is released as light. In most bioluminescent deep sea animals two basic chemicals - luciferin and luciferase-combine to produce light as a by-product of the reaction.

You may also have seen chemiluminescent sticks, bracelets, or other items that depend upon chemical reactions to produce light. If you examine these items closely, you will find that they consist of a sealed vial immersed within another liquid. When the inner vial is crushed, its contents mixes with the surrounding fluid. As the chemicals combine, they generate visible light. In this activity, you'll explore how the temperature of the chemicals that combine affects a chemiluminescent reaction.

This activity page will offer:

- Introduction to chemiluminescence and bioluminescence
- Opportunity to observe the effect of temperature on reaction
- Activity that integrates art and science

MATERIALS

- Three chemiluminescent sticks (also called "cool light sticks")
- Thermometer Beakers (large enough to submerge one stick)
- Ice water
- Warm water
- Room-temperature water
- Timer
- Digital camera (optional)

NOTE: Cool light sticks are available at many toy stores, marine supply stores, party goods stores, and stores offering camping and fishing supplies.

PROCEDURE

1. Work in a team of three students. Identify a space in which the lights can be turned off and the shades drawn shut.
2. Fill one beaker with ice water. Fill another with room temperature water. Fill a third one with lukewarm water.
3. Insert a light stick in each of the water-filled beakers, but do not activate it. Try to immerse as much of the stick in the water bath as possible.
   NOTE: You may have to tie a small weight onto the stick to insure that it does not float to the surface.
4. Wait several minutes. Then use a thermometer to measure the temperature of the water in each of the three beakers. Record these values.
5. Activate all three light sticks.
6. Shut the room lights. Compare and contrast the brightness of the generated light. Which beaker contains the brightest stick? Which beaker contains the dimmest stick? Record you observations.
7. If you have a digital camera, use it to capture a record of the light generated by these side-by-side tubes. Make sure that all three glowing sticks are included in the same single image. Once the image is taken, you can return the room lights to their normal level.
8. At 15-minute intervals, dim the room lights. Use the digital camera to capture additional images of the three glowing light sticks.
9. Continue comparing and contrasting the relative brightness of the three sticks. If applicable, note the time at which each stick no longer appears to glow.

Questions

1. In step 3, why was it necessary to place the light sticks in the water-filled beakers for several minutes before performing the activity?
2. In step 6, why was it necessary to include all three sticks in the same image?
3. In which beaker did the stick glow brightest?
4. In which beaker did the stick glow dimmest?
5. In which beaker did the glow last longest?
6. In which beaker did the glow go away the quickest?
7. Is the brightness of the glow related to the time that this effect lasts? Explain.
8. The rate of a reaction is dependent upon several factors, including the temperature of the reaction vessel. How can this concept be applied to your observations?

EXTENSIONS

Glowing Artwork

Some animals have light organs that are concentrated around the eyes. Other organisms have strands of light spots that extend their whole body length. Check out this site:*http://www.bio.davidson.edu/Courses/anphys/1999/Cody/fish.html*to learn more about the placement patterns of light organs in fish, cephalopods, jellyfish and other organisms.

For this activity, you'll need both a set of standard watercolor paints and a small vial of glow-in-the-dark paint. You can obtain all of these non-toxic paints from a local art store or an Internet outlet. Use the standard paints to produce images of various deep-sea fish and invertebrates. Then, use the glowing paint to add a pattern of glowing spots to each drawing. Challenge students to identify the painted subjects by only the glowing patterns that are revealed in dimmed lighting.

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Answers

Questions

1. In step 3, why was it necessary to place the light sticks in the water-filled beakers for several minutes before performing the activity?
   (During this time the temperature of the light stick chemicals changed to reflect the temperature of the surrounding water.)
2. In step 6, why was it necessary to include all three sticks in the same image?
   (This way you could compare the relative brightness of the sticks).
3. In which beaker did the stick glow brightest?
   (warm water)
4. In which beaker did the stick glow dimmest?
   (ice water)
5. In which beaker did the glow last longest?
   (ice water)
6. In which beaker did the glow go away the quickest?
   (warm water)
7. Is the brightness of the glow related to the time that this effect lasts? Explain.
   (Yes. The brightest glow (warm water) lasts the shortest time. Likewise, the dimmest glow (ice water), lasts the longest.)

8. The rate of a reaction is dependent upon several factors, including the temperature of the reaction vessel. How can this concept be applied to your observations?
(Warm water beaker: At a higher temperature, the reaction proceeded at a faster rate. This produced a brighter glow. Since the reactants were used up quicker, the glow ended sooner. Cold water beaker: In contrast, the cooled stick contained a slower reaction. This produced a reduced glow that lasted a longer period.)

CURRICULUM LINKS

General Science :
Observation and Inference
Physical Science:
Energy
Chemistry:
Reactions
Biology:
Bioluminescence

NATIONAL SCIENCE STANDARDS (Grades 5-8)

Science as Inquiry- Content Standard A
Students will conduct an investigation and make systematic observation and comparison.
Students will use scientific tools such as thermometers and mathematics to collect data.
Students will analyze data and make a statement about a cause and effect relationship.
Physical Science - Content Standard B
Students will learn about chemical reactions and the new substances they form.
Students will observe potential energy transferring in a chemical reaction and explore how heat and light are involved.
Life Science - Content Standard C
Students will learn that in certain organisms specialized cells perform specialized functions.