

Hands-On Science



Light & Color

W. Michael Margolin

Illustrated by Lloyd Birmingham

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Contents

<i>To the Teacher</i>	v
<i>Journals and Lab Reports</i>	vii
<i>National Science Education Standards Correlations</i>	viii
<i>General Rubric</i>	xix
1. What Is the Nature of Light?	1
2. Does Light Travel in Straight Lines?	6
3. How Can We Describe the Image in a Plane Mirror?	12
4. How Does a Plane Mirror Reflect Light?	21
5. How Do Different Materials Affect the Absorption of Light?	28
6. What Kinds of Images Do Curved Mirrors Produce?	36
7. How Can We Design and Construct a Fun-House Mirror?	44
8. How Is a Shadow Formed?	50
9. How Can We Make a Pinhole Camera?	58
10. What Happens When Light Passes into a New Medium?	65
11. What Is Total Internal Reflection?	74
12. How Does Distance Affect the Spread of a Light Spot?	80
13. How Do Chemicals Produce Light?	89
14. How Does Light Affect Photosensitive Chemicals?	95
15. How Is White Light Separated into Colors?	102
16. What Determines the Color of an Object?	110
17. What Happens When Different Colors of Light Are Mixed?	120
18. Why Do the Colors of a Soap Bubble Change?	127
19. How Can We Separate Pigments?	136
20. How Can We Determine the Magnification of a Lens?	144
<i>Glossary</i>	152

13. How Do Chemicals Produce Light?

TEACHER RESOURCE PAGE



INSTRUCTIONAL OBJECTIVES

Students will be able to:

- record observations
- draw conclusions based on observations
- define the term *chemiluminescence*
- explain the importance of controlling variables in an experiment



NATIONAL SCIENCE EDUCATION STANDARDS CORRELATIONS

GRADES 5–8

Content standard	Bullet number	Content description	Bullet number(s)
A	1	Abilities necessary to do scientific inquiry	1–7
B	1	Properties and changes of properties in matter	1, 2
B	3	Transfer of energy	1, 3
E	2	Understandings about science and technology	1, 3, 4

GRADES 9–12

Content standard	Bullet number	Content description	Bullet number(s)
A	1	Abilities necessary to do scientific inquiry	1, 2, 6
B	3	Chemical reactions	1, 2, 4
B	6	Interactions of energy and matter	1, 3
E	2	Understandings about science and technology	1, 3



VOCABULARY

- **chemiluminescence:** the production of light without heat by a chemical reaction
- **control:** a standard of comparison for checking or verifying the results of an experiment
- **dependent variable:** the event studied and expected to change when the independent variable is changed
- **immerse:** to place a body or an object completely under water or other liquid
- **independent variable:** a manipulated variable in an experiment that determines the change in the dependent variable

13. How Do Chemicals Produce Light?

TEACHER RESOURCE PAGE



MATERIALS

- three light sticks
- three 400-ml beakers
- thermometer
- 500-ml graduated cylinder
- water at room temperature
- ice water
- hot water (approximately 60°–70°C)



 = Safety icon

HELPFUL HINTS AND DISCUSSION

Time frame: one period

Structure: individual students or cooperative learning groups

Location: classroom or lab

A light stick consists of several chemicals in a thin glass ampule surrounded by other chemicals, all contained within a flexible plastic tube. When the tube is bent, the ampule breaks and releases its contents, which mix with the chemicals in the outer layer. Light sticks are perfectly safe to use and can be disposed of with ordinary trash. Allow students to take the light sticks home for further investigation, but warn them not to break or puncture them, since the contents will stain clothes. Light sticks should be stored in their wrappers until you are ready to use them.

To spark enthusiasm for this activity, you can demonstrate chemiluminescence. A dramatic example is the oxidation of luminol, the substance used to detect blood at crime scenes. In this demonstration, you pour a colorless liquid and a blue liquid simultaneously into a glass funnel attached to a spiral delivery tube that empties into a beaker. The mixed liquids emit a blue light through the tube. (Conduct this demonstration in a darkened room for maximum effect.) Here is how to prepare the two solutions:

Solution A

1. In a 1-liter flask, dissolve 4 g of sodium carbonate in 500 ml of distilled water. Add 0.2 g luminol and stir to dissolve.
2. Add 24 g of sodium bicarbonate, 0.5 g ammonium carbonate monohydrate, and 0.4 g copper (II) sulfate penthydrate and stir to dissolve.
3. Dilute this solution to 1 liter.

Solution B

Dilute 50 ml of 3% hydrogen peroxide to 1 liter with distilled water.

MEETING THE NEEDS OF DIVERSE LEARNERS

For students who need extra challenges, introduce factors affecting reaction rates. Discuss the design of this experiment, and emphasize the importance of controlling variables. Define *control*, as well as *independent variable* and *dependent variable*. Encourage students to do the Follow-up Activities, particularly activities 2 and 3.

For students who need extra help, discuss designing experiments and explain the importance of controlling variables. Elicit the reason for immersing all three light sticks in the beakers of water at the temperatures suggested.

13. How Do Chemicals Produce Light?

TEACHER RESOURCE PAGE

SCORING RUBRIC

Students meet the standard for this activity by:

- explaining the relationship between temperature and the speed of chemical reactions
- correctly using the term *chemiluminescence*
- designing an effective experiment to predict the outcome of the ongoing chemical reactions
- accurately recording water temperature and observations



RECOMMENDED INTERNET SITES

- **About.com: Chemistry—How Do Lightsticks Work?**
<http://chemistry.about.com/od/howthingsworkfaqs/a/howlightsticks.htm>
- **Herper.com—Bioluminescence & Biological Fluorescence**
www.herper.com/Bioluminescence.html
- **Yahoo! Directory—Science Education**
www.yahoo.com/Science/Education



ANSWER KEY

1. The light stick was placed in water at room temperature for two reasons. First, it showed that the light stick did not give off heat, since the temperature did not increase. Secondly, it was a control showing that water did not affect the light stick.
2. The water temperature was checked before and after the light stick was immersed in the beakers of water to show that heat was not given off.
3. Water at different temperatures was used to test the effect of temperature on the reactions in the light stick.
4. Answers will vary. Heating the light stick made the reaction occur more rapidly, so more light was given off. Students might expect the light stick placed in hot water to fade first because the reactants would be used up first.
5. Answers will vary. Students could find the amount of time it takes for the light sticks to fade when placed in beakers of water at different temperatures. It would be necessary to keep the water at constant temperatures and to check the light sticks for fading at regular time intervals.

13. How Do Chemicals Produce Light?

STUDENT ACTIVITY PAGE



OBJECTIVE

To observe and describe the effect of environmental factors on **chemiluminescence**

BEFORE YOU BEGIN

Energy can be changed from one form to another. For example, when a piece of paper or wood burns, chemical energy is changed into two other forms of energy, light and heat. Some chemical reactions release light at room temperature. We call light produced without heat “cool light.” You might have seen examples of such “cool light” at a circus or carnival where they sold light tubes that you could wear as bracelets or necklaces. The process by which chemical energy is released as “cool light” is called chemiluminescence. In this activity, you will investigate this phenomenon.



MATERIALS

- three light sticks
- three 400-ml beakers
- thermometer
- 500-ml graduated cylinder
- water at room temperature
- ice water
-  hot water (approximately 60°–70°C)

 = Safety icon



PROCEDURE


Carry out all of the procedures in a darkened room.

1. Measure the air temperature in the room with the thermometer.
2. Use the graduated cylinder to measure 250 ml of water at room temperature. Pour the water into one of the beakers.
3. Use the thermometer to check the temperature of the water in the beaker. If it is not at room temperature, let it sit for several minutes. When it is room temperature, record the starting temperature in the Data Table in the Data Collection and Analysis section.
4. Remove the wrapper from the first light stick and bend it enough to break the vial inside. Shake the light stick to mix its contents and observe the reaction.
5. Describe the appearance of the light stick. What color is its light? Does the entire stick glow or just the chemicals inside?
6. When the water has reached room temperature, **immerse** the light stick in the beaker. Leave the light stick in the beaker of water for 5 minutes.
7. After 5 minutes, check the temperature of the water with your thermometer. Has the water temperature changed? Record the finish water temperature in the Data Table.
8. Look at the light stick. How brightly is it glowing? Describe your results in the Data Table.
9. Use the graduated cylinder to measure 250 ml of ice water. Pour the water into one of the beakers.

13. How Do Chemicals Produce Light?

STUDENT ACTIVITY PAGE

- Repeat steps 4 through 8 using 250 ml of ice water and the second light stick.
- Use the graduated cylinder to measure 250 ml of hot water. Pour the water into one of the beakers.

 **Safety note:** Be sure that the temperature of the water is not greater than 70°C. Be careful when pouring hot water to avoid burns.

- Repeat steps 4 through 8 using 250 ml of hot water and the third light stick.
- Place the three light sticks side by side on a table and compare the intensity of light that each produces.



DATA COLLECTION AND ANALYSIS

- On a separate sheet of paper, describe the color and position of the glow emitted by each light stick.
- In the table below, write your observations of the three light sticks.

DATA TABLE

Light stick	Water temperature at start	Water temperature at finish	Intensity of glow after immersion
1 (water at room temperature)			
2 (ice water)			
3 (hot water)			

- What is the effect of temperature on the intensity of light that the light sticks produce?
- Did the reaction that produced light also produce heat? What evidence do you have to support your statement?



CONCLUDING QUESTIONS

- Why was the first light stick placed in water at room temperature?

13. How Do Chemicals Produce Light?

STUDENT ACTIVITY PAGE

2. Why was the water temperature checked both before and after immersing the light sticks?

3. What was the reason for using water at different temperatures?

4. Assuming that all of the light sticks contained the same amount of chemicals, which of the three do you hypothesize would fade first? Explain your answer.

5. Design an experiment to test your hypothesis concerning which light stick would fade first.



FOLLOW-UP ACTIVITIES

1. Take one of the light sticks home and put it in the freezer overnight. Observe the effect of placing the light stick in the freezer. Observe what happens after it is allowed to return to room temperature and is left out for 1, 2, and 5 hours. Write your observations in a report.
2. Devise an experiment to test how freezing and thawing a light stick affects chemiluminescence.
3. Research bioluminescence. Present your findings to the class in a format approved by your teacher.
4. Report on how a firefly produces light.