Photosynthesis

A Carolina Essentials™ Investigation

Overview

This investigation is a visual way to introduce students to photosynthesis. As *Elodea* uses carbon dioxide from the initial solution, a change in pH occurs, causing a color change in the solution. The change is detectable in as little as 30 minutes to an hour. The investigation may be used as an introductory guided inquiry or a student-led inquiry investigation. In the latter, students devise a way to quantify the CO_2 concentration (pH) over a set amount of time.

Life Sciences
Grades: 9–12

Essential Question

What is photosynthesis, and what substances are used (reactants) and created (products) during the process?

Investigation Objectives

1. Describe the process of photosynthesis and the indicators that it takes place.
2. Explain how carbon dioxide use during photosynthesis can be quantified.

Next Generation Science Standards* (NGSS)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Safety Procedures and Precautions

Bromothymol blue will stain your hands and clothing. Wear gloves and goggles, and practice safe laboratory procedures when performing this activity.

Disposal

Bromothymol blue is categorized as non-hazardous. Dispose in a manner consistent with federal, state, and local regulations. Let *Elodea* dry out completely and dispose of it on dry land.

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TIME REQUIREMENTS

PREP	ACTIVITY
30 min	30 min

Teacher Prep: 30 min
Student Activity: 20-30 min to prepare tubes and make observations; 30 min-24 hr to expose tubes to light

SAFETY REQUIREMENTS

MATERIALS (PER GROUP)

Diluted 0.04% bromothymol blue solution, 200 mL

2 6-cm sprigs of *Elodea*

Aluminum foil, 20 cm × 10 cm

1 marker or wax pencil

2 culture tubes with caps, 25 × 150 mm

1 7-mL dropping pipet

Paper towels

Light bank (if there is no access to natural sunlight)

HELPFUL LINKS

Carolina's Solution Preparation Manual

Carolina™ CareSheet: Elodea

REFERENCE KITS

Carolina BioKits®: Photosynthesis

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Preparation

1. Rinse the *Elodea* in spring water or conditioned tap water to remove any small leaf pieces or sediment. Use scissors to cut two 6-cm sprigs of Elodea for each group. Place the *Elodea* in a bowl of spring water or conditioned water for easy student access.
2. Prepare or purchase a diluted 0.04% bromothymol blue solution.
3. Shortly before the lab starts, add carbon dioxide to the bromothymol blue. Pour the diluted bromothymol blue solution into a beaker. Place a straw in the liquid and exhale gently into it. Allow the exhaled air to bubble through the liquid until the solution turns yellow-green. This will take 15 to 30 minutes. **Important:** Do not inhale through the straw, and never bring the fluid toward your mouth. Blowing too vigorously may splash liquid into your face or onto your skin. Wear protective goggles. To prevent splashing, cover the beaker containing the liquid with a piece of cardboard or aluminum foil.
4. Cut out aluminum foil pieces (20 cm × 10 cm) to wrap capped tubes.

Student Procedure	Teacher Preparation and Tips
1. With a permanent marker or wax pencil, write your initials or other mark to identify your group on the capped tubes. Toward the top of a tube, write “D” for dark. On the other tube write “L” for light.	*There are many items for students to pick up. It may be helpful to place the equipment in a basket or resealable bag.*
2. Obtain two 6-cm sprigs of *Elodea* and place a sprig in each tube.	
3. While working over a paper towel, use the dropping pipet to fill both tubes to overflowing with the yellow-green bromothymol blue solution and cap both tightly. Clean up any spills.	*Make sure students keep Elodea in a strand and do not tear off leaves.*
4. Quickly make observations of both tubes.	
5. Immediately wrap the tube marked “D” with aluminum foil. Cover the entire tube to prevent any light from reaching the *Elodea*.	*Make sure the tube is **completely** covered by the aluminum foil. No light should penetrate the tube.*
6. Place both tubes in the sunlight or under a light bank.	*The time can vary to fit your schedule, but allow a minimum of 30 to 45 minutes.*
7. Wait 1 hour or the time designated by your teacher. Record your observations.	

Data and Observations

Record observations.

	Light	Dark
Before	*Yellow-green*	*Yellow-green*
After	*Dark green to blue, depending on the time*	*Yellow-green*

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Analysis and Discussion

1. Describe and compare the color of the bromothymol blue solution in the tubes.

   The solution in both tubes was a yellow-green color. The one exposed to light turned dark green and then blue.

2. Explain the chemistry behind any color change that has occurred in any tube

   The tube exposed to light turned a darker green to blue depending on the amount of exposure time. This occurred because the Elodea *photosynthesized, using up the carbon dioxide in the solution.*

   Since the reactions exist in equilibrium, more carbonic acid dissociates to form more carbon dioxide and water, replacing the carbon dioxide removed from the solution by the Elodea*.*

   As the carbonic acid dissociates, the solution becomes more basic and turns more green. Over enough time it can turn blue. Bromothymol blue is a pH indicator that turns green and then blue as a solution becomes more basic

3. Summarize the process of photosynthesis using chemical formulas and a color coding scheme that matches lab data.

   $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

TEACHER NOTES