THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Into the Light

How does light affect a plant's use of Carbon dioxide?

GRADES 6–8

Life Science

VAN ANDEL EDUCATION INSTITUTE

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INQUIRY-BASED SCIENCE

Life Science

Into the Light

Grade Level/Content	6–8/Life Science
Lesson Summary	Students will use Bromothymol blue (btb) as an indicator to show the presence of dissolved Carbon dioxide in water before being used by an aquatic plant, in the presence of light, to make glucose during the process of photosynthesis.
Estimated Time	2, 45-minute class periods
Materials	Light source, 6 test tubes large enough to hold a sprig of *Elodea*, test tube rack that allows light to penetrate the test tubes, straws, Bromothymol blue (btb) solution, aluminum foil, *Elodea*, transparent heat sink, Internet, Investigation Plan, journal
Secondary Resources	Photosynthesis for Kids What is Photosynthesis Connecting Cellular Respiration and Photosynthesis
NGSS Connection	**MS-LS1-6** Construct a scientific explanation based on evidence of the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
Learning Objectives	• Students will determine the effect of light on the use of Carbon dioxide by aquatic plants. • Students will explain the process of photosynthesis, including the requirements of water, Carbon dioxide, and light energy for the plant to create glucose (food) and oxygen. • Students will explore the broader role of photosynthesis in cycling matter within ecosystems.

How does light affect a plant's use of Carbon dioxide?

Photosynthesis is critically important as it provides the oxygen required to support respiration in nearly all non-autotrophic organisms on earth. Providing students with an opportunity to observe photosynthetic activity is a great way to introduce students to this phenomena.

In this lesson, students use Bromothymol blue (btb) as an indicator to determine the presence and absence of dissolved Carbon dioxide in water. Observations from several conditions are compared to determine if an aquatic plant, in the presence of light, is undergoing photosynthesis to make glucose.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Collect the materials necessary for each student group to perform the guided investigation.

- light source
- 6 test tubes large enough to hold a sprig of *Elodea*
- test tube rack that allows light to penetrate the test tubes
- straws
- Bromothymol blue (btb) solution (5mL of commercial btb indicator + 150mL of distilled water)
- aluminum foil
- Elodea – Available for purchase from Carolina Biological Supply Company. If *Elodea densa* is restricted in your state, use *Elodea canadensis* or *Chara*.
- transparent heat sink – heat sinks absorb heat from the light source while allowing the light to pass through. Any glass or clear plastic container with water can serve as a heat sink.
- Internet
- Investigation Plan
- journal

Part 2

INVESTIGATION FACILITATION

Question

Introduce the investigation question.

How does light affect a plant's use of Carbon dioxide?

Personal Knowledge

Students capture what they already know about plants, Carbon dioxide and photosynthesis.

- Have students identify key components of the investigation question.
- Ask them to write ideas in their journal before sharing them with their table partners. They should record new ideas shared by their table partners in their journal.
- Encourage students to review their list and circle ideas and concepts that they are not sure about.

RICH LANGUAGE

Using each letter of the word photosynthesis, have students create a short phrase that begins with that letter and reflects their understanding of photosynthesis. They can write photosynthesis from top to bottom and then use each letter as the first letter of a short phrase about photosynthesis.
Example:
P – Plants perform photosynthesis.
H – Higher levels of light result in more photosynthesis.
O – One important result is the production of oxygen gas.
T –
O –
S –
etc.

Prediction

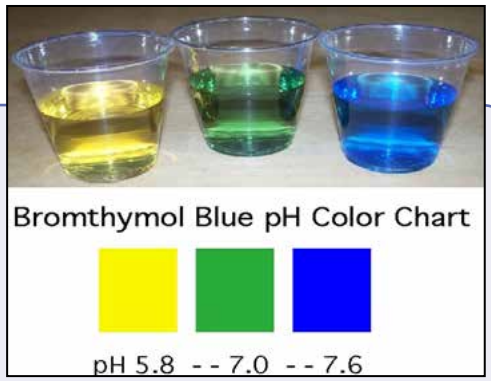
Students communicate an expected outcome, based on prior knowledge.

- Students write their predictions in the format: *I predict* _____ *because* _____.

Secondary Knowledge

Provide background information about the use and behavior of the chemical indicator Bromothymol blue.

- Bromothymol blue is a pH indicator. It is blue in a base, green at neutral, and yellow in an acid.
- Share with students that when Carbon dioxide is dissolved in water, it forms Carbonic acid. In the test tubes, holding their aquatic plants, students will use btb color changes as an indicator of changes in dissolved Carbon dioxide.

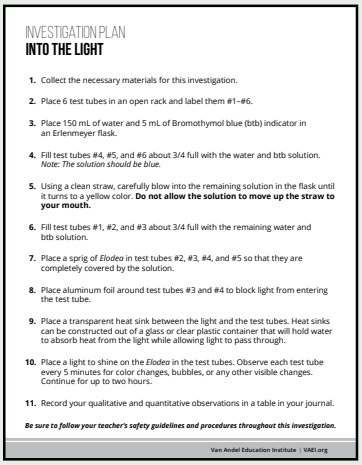


btb Color Chart

Investigation Plan

Students conduct six tests under different conditions to observe the impact of light on photosynthetic activity.

- Have students work in teams of 2–3.
- Review the materials and preparations necessary to set up the six test tubes for observation.
- Have students follow the Investigation Plan.
- All test tubes will have a heat sink and a light source as shown in the picture.
- Test tube 1 will contain water and btb with Carbon dioxide (will be yellow).
- Test tube 2 will contain water and btb with Carbon dioxide and sprig of *Elodea* (will be yellow).
- Test tube 3 will contain water and btb with Carbon dioxide and sprig of *Elodea* (will be yellow). The test tube will be covered in aluminum foil.
- Test tube 4 will contain water, btb, and sprig of *Elodea* without Carbon dioxide (will be blue). The test tube will also be covered in aluminum foil
- Test tube 5 will contain water, btb, and sprig of *Elodea* without Carbon dioxide (will be blue).
- Test tube 6 will contain water, btb, without Carbon dioxide (will be blue).



INVESTIGATION PLAN
INTO THE LIGHT

1. Collect the necessary materials for this investigation.
2. Place 6 test tubes in an open rack and label them #1–#6.
3. Place 150 mL of water and 5 mL of Bromothymol blue (btb) indicator in an Erlenmeyer flask.
4. Fill test tubes #4, #5, and #6 about 3/4 full with the water and btb solution. *Note: The solution should be blue.*
5. Using a clean straw, carefully blow into the remaining solution in the flask until it turns to a yellow color. **Do not allow the solution to move up the straw to your mouth.**
6. Fill test tubes #1, #2, and #3 about 3/4 full with the remaining water and btb solution.
7. Place a sprig of *Elodea* in test tubes #2, #3, #4, and #5 so that they are completely covered by the solution.
8. Place aluminum foil around test tubes #3 and #4 to block light from entering the test tube.
9. Place a transparent heat sink between the light and the test tubes. Heat sinks can be constructed out of a glass or clear plastic container that will hold water to absorb heat from the light while allowing light to pass through.
10. Place a light to shine on the *Elodea* in the test tubes. Observe each test tube every 5 minutes for color changes, bubbles, or any other visible changes. Continue for up to two hours.
11. Record your qualitative and quantitative observations in a table in your journal.

Be sure to follow your teacher's safety guidelines and procedures throughout this investigation.

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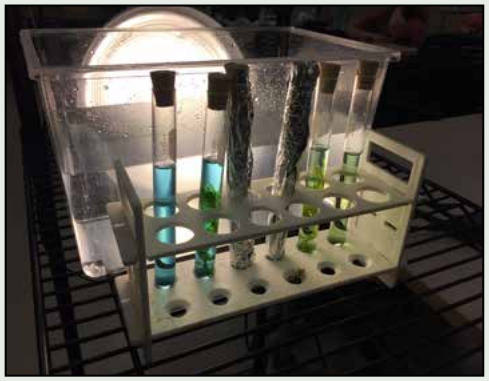
Investigation Plan

CRITICAL THINKING

Use the Fair Test checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they will be in their results.

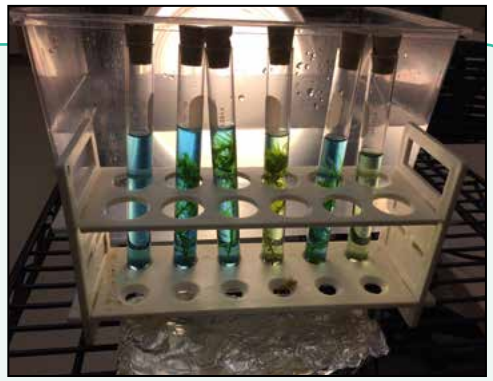


Test Tube Set-up

Observation

Students record their data.

- Students will record observations every five minutes for each of the six test tubes.
- Ask students to create a data table to organize their observations.
- They are specifically looking for btb indicator color changes as well as bubbles. Both are indications of photosynthetic activity from the aquatic plant.
- Student data tables should include space to record qualitative observations for color, and general observations for all six test tubes similar to the sample student observation.



Test Tube Observations

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM

Data Analysis

Students make sense of their data by organizing it and representing it visually.

- Have students analyze their data. They may wish to use the Data Analysis prompt as a guide.
- Have students **evaluate** their data for trustworthiness.
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning.
- Students should identify small bubbles and a color change from the btb indicator in test tube #2. Test tube #3 serves as a reference point for the changes taking place in test tube #2 by blocking out the light source. Students can also compare results from test tube pairs #1 and #6 as well as #4 and #5.
- Have students **interpret** what the identified patterns or trends mean.
- Ensure they have enough data that it can be used as evidence to support a claim.

CRITICAL THINKING

Have students dig deeper into their data by considering possible errors or unaccounted factors impacting their trials. Remind students that these ideas should be included in their reasoning when developing their explanation.

Secondary Knowledge

Students use secondary sources to understand photosynthetic activity in plants.

- Use these resources (or your own) to help students understand how plants use light energy, Carbon dioxide, and water to produce oxygen and water as well as the role plants play in cycling carbon.
  - Photosynthesis for Kids
  - What is Photosynthesis?
  - Connecting Cellular Respiration and Photosynthesis
- Students use this information in the reasoning portion of their explanation.

Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to write an explanation that answers their investigation question.
- Students may wish to use the Explanation prompt as a guide. Have them write their explanation in their journal.
- Have students develop a **Claim** to answer the question: How does light affect a plant's use of Carbon dioxide?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Claim

Light allows aquatic plants to use dissolved Carbon dioxide during photosynthesis.

Evidence

Once placed under the light source, each of our two test tubes, #2 and #5, with the Elodea plant that was exposed to light showed signs of photosynthesis. The btb indicator in test tube #2 changed back to blue while we saw bubbles in test tubes #2 and #5. Test tubes #3 and #4 were pairs for #2 and #5, but they had light blocked from them. We did not see the same observations in these test tubes.

Reasoning

Investigation: We followed the investigation plan and made careful observations. The data was consistent with our prediction and there were not any surprises. Therefore, we believe our data is valid and reliable.

Science: From our class discussions and Internet research, we learned that plants on land and in water use light energy, Carbon dioxide, and water to produce oxygen, gas, and sugar. As the Elodea plants exposed to light began photosynthesis, they began using the dissolved Carbon dioxide in the water. Test tubes #2 and #5 looked the same, but #2 had the indicator in it giving us additional information about the use of Carbon dioxide. As a result of our data, we do not believe that the plant went through any photosynthesis in test tubes #3 and #4 (the ones with aluminum foil blocking the light).

- Once the explanation is written, have students discuss their results using a Present and Defend.

DISCOURSE

Select two groups to conduct a Present and Defend. This helps develop presentation and audience participation skills. Research teams present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their explanation with evidence and reasoning.

Evaluation

Students reflect on the investigation.

Have students discuss:

- What surprised me?
- What role did btb play in this investigation?
- What question would I like to investigate next?
- What alternative explanations should be considered for the data I collected?

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students demonstrate their understanding by exploring the broader role of photosynthesis in cycling matter and capturing energy from the sun.

- Have students think about the broader implications of the role photosynthesis plays in cycling matter and the flow of energy into and out of organisms. How does photosynthesis, in conjunction with cellular respiration, allow for matter and energy to support life on Earth?
- Extend this investigation by providing students with an opportunity to research the relative amounts of photosynthesis that takes place in various terrestrial and aquatic ecosystems. Use this research as an opportunity to highlight and expand upon the importance of marine ecosystems in the cycling of matter and energy on Earth.

Assessment

Determine how well students:

- determine the effect of light on the use of Carbon dioxide by aquatic plants.
- explain the process of photosynthesis including the requirements of water, Carbon dioxide, and light energy for the plant to create glucose (food) and oxygen.
- explore the broader role of photosynthesis in cycling matter within ecosystems.

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