

**Title of Lesson:** Relating Photosynthesis & Cellular Respiration Using Algae

**Target Grades:** High School Biology I

**Time Required:** 10 minutes of set up, leave overnight, 10 minutes of observation and clean up

**Alignment to Standards:**

**BIO1.LS1:8** Create a model of photosynthesis demonstrating the net flow of matter and energy into a cell. Use the model to explain energy transfer from light energy into stored chemical energy in the product.

**BIO1.LS2:2** Create a model tracking carbon atoms between inorganic and organic molecules in an ecosystem. Explain human impacts on climate based on this model.

**Materials Needed:**

Safety goggles  
Bromothymol blue (BTB) solution  
Straw  
4 test tubes  
Spirogyra (filamentous algae)  
Aluminum foil  
4 stoppers  
Tape  
Marker  
Test tube rack  
Light source

**Background Information:**

Photosynthesis and cellular respiration should have been taught in class prior to this activity. Photosynthesis is a series of chemical reactions that some cells use to create sugars from carbon dioxide and water in the presence of sunlight. This produces oxygen gas as a waste product. Photosynthesis occurs in chloroplasts of eukaryotic cells such as plants and many protists like green algae. Many bacteria can also do photosynthesis even though they do not have true chloroplasts.

Cellular respiration is a series of chemical reactions that occur in the mitochondria of cells which breaks down sugars in the presence of oxygen to release energy. This process gives off carbon dioxide and water as waste products.

Both photosynthesis and carbon dioxide are important parts of the carbon cycle. Carbon moves between living and nonliving components of the environment through the carbon cycle. Carbon in decaying organisms became fossil fuels and is released back into our atmosphere through

burning as auto and factory emissions. The carbon dioxide can be used by organisms through photosynthesis, removing it from the atmosphere.

Bromothymol blue (BMB) is an indicator dye that turns yellow in the presence of acid. When carbon dioxide is added to the solution, it creates carbonic acid, lowering the pH of the solution. BMB is blue when the pH is greater than 7.6, green when the pH is between 6-7.6, and yellow when the pH is less than 6.

**Lesson Objectives:**

Students will be able to explain the relationship between photosynthesis and cellular respiration.

Students will be able to analyze data to draw a conclusion.

Students will be able to demonstrate the necessity of light for photosynthesis.

Students will be able to determine the effect of photosynthesis on the carbon cycle.

**Laboratory Activity:**

1. Pour 80mL of water into an Erlenmeyer flask. Add 8 drops of bromothymol blue. Swirl to mix. Using a straw, exhale gently into the solution until it turns yellow. Do not suck on the straw!
2. Pour 20mL of the yellow BTB solution into each of 4 test tubes.
3. Place an equal amount of spirogyra into two of the test tubes. Leave the other two without any algae. Tightly stopper the tubes. Record the initial color of the solution.
4. Cover one test tube containing spirogyra and one test tube without spirogyra completely with aluminum foil.
5. Use the tape and marker to label the test tubes.
6. Place them in the test tube rack under the light.
7. Check on them tomorrow and record the color of the solution.

**Safety and Clean Up:**

Instruct students to exhale very gently on the straw so as not to become dizzy. The color change in the BMB doesn't have to occur quickly. If a student becomes dizzy, he/she should sit down and stop blowing into the solution.

Stress that students should not suck on the straw and ingest the BMB solution. BMB will irritate the gastrointestinal tract and may cause nausea and vomiting. In the event of ingestion, wash mouth out with water and get medical aid.

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

## Relating Photosynthesis & Cellular Respiration

### Materials

Bromothymol blue (BTB) solution  
Straw  
3 test tubes  
Spirogyra (filamentous algae)  
Aluminum foil  
3 stoppers  
Tape  
Marker  
Test tube rack  
Light source

### Procedure

*Wear safety goggles to protect your eyes.*

1. Pour 80mL of water into an Erlenmeyer flask. Add 8 drops of BMB. Swirl to mix. Using a straw, exhale gently into the solution until it turns yellow. **Do not suck on the straw!**
2. Pour 20mL of the yellow BTB solution into each of 4 test tubes.
3. Place an equal amount of spirogyra into two of the test tubes. Leave the other two test tubes without any algae. Tightly stopper the tubes. Record the initial color of the solution.
4. Cover one test tube containing spirogyra and one test tube without spirogyra completely with aluminum foil.
5. Use the tape and marker to label the test tubes.
6. Place them in the test tube rack under the light.
7. Check on them tomorrow and record the color of the solution.

### Data Table

Tube Contents	Treatment	Initial Color	Final Color
BTB, CO <sub>2</sub> , Spirogyra	Dark		
BTB, CO <sub>2</sub> , Spirogyra	Light		
BTB, CO <sub>2</sub>	Dark		
BTB, CO <sub>2</sub>	Light		

### Questions

1. Write the equation for photosynthesis. Where does this occur in a cell?
2. Write the equation for cellular respiration. Where does this occur in a cell?
3. What caused the BTB to turn yellow?

4. What could cause the BTB to return to its original blue color?
  
5. What is the purpose of the tubes without algae?
  
6. What is the purpose of the tubes covered in aluminum foil? (Be very specific)
  
7. Explain how your results demonstrate that photosynthesis and cellular respiration depend on one another.
  
8. Algae are being investigated by Oak Ridge National Laboratory scientists as a source of bioenergy. Using bioenergy to power cars and provide electricity could reduce the amount of harmful carbon dioxide emissions in Earth's atmosphere. If algae begin to be grown on a large scale across the country for production into biofuels, what other effect might the algal growth have on the carbon cycle?

### Answer Key

Tube Contents	Treatment	Initial Color	Final Color
BTB, CO <sub>2</sub> , Spirogyra	Dark	Yellow	Yellow
BTB, CO <sub>2</sub> , Spirogyra	Light	Yellow	Blue
BTB, CO <sub>2</sub>	Dark	Yellow	Yellow
BTB, CO <sub>2</sub>	Light	Yellow	Yellow

### Questions

1. Write the equation for photosynthesis. Where does this occur in a cell?

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$  This occurs in the chloroplasts of cells.

2. Write the equation for cellular respiration. Where does this occur in a cell?

$\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$  This occurs in the mitochondria of cells.

3. What caused the BTB to turn yellow?

Input of carbon dioxide from my breath created carbonic acid, which lowered the pH of the solution resulting in a color change of the indicator. The pH is less than 6.

4. What could cause the BTB to return to its original blue color?

Removal of the carbon dioxide would cause the pH of the solution to rise back above 7.6. Carbon dioxide can be removed by a photosynthetic organism.

5. What is the purpose of the tubes without algae?

These are controls. Any color change in the tubes without algae would indicate that a color change in the tubes with algae was not caused by the presence of the algae.

6. What is the purpose of the tubes covered in aluminum foil? (Be very specific)

The aluminum foil blocks the light. A color change in the tubes covered with aluminum foil would indicate that the change is not caused by the light.

7. Explain how your results demonstrate that photosynthesis and cellular respiration depend on one another.

The BMB changed to yellow due to the presence of carbon dioxide created by a human's cells performing cellular respiration. That same carbon dioxide was removed from the solution by the spirogyra performing photosynthesis. The products of cellular respiration are the reactants of photosynthesis.

8. Algae are being investigated by Oak Ridge National Laboratory scientists as a source of bioenergy. Using bioenergy to power cars and provide electricity could reduce the amount of harmful carbon dioxide emissions in Earth's atmosphere. If algae begin to be grown on a large scale across the country for production into biofuels, what other effect might the algal growth have on the carbon cycle?

Algae perform cellular respiration which uses carbon dioxide. This would capture CO<sub>2</sub>, decreasing the amount in the atmosphere.