Go Green to Grow Green-
Photosynthesis and Cellular Respiration

Science

Grade Level: 9-12

Equivalent Standards:

- (Cell Biology 1.b) *Students know* enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of the enzymes depend on the temperature, ionic conditions, and the pH of the surroundings.
- (Cell Biology 1.f) *Students know* usable energy is captured from the sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.
- (Ecology 1.d) *Students know* how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
- (Biogeochemical Cycles 7.a) *Students know* the carbon cycle of photosynthesis and respiration and the nitrogen-cycle

Duration: 60 minutes

Description: This lesson teaches students the impact of climate change on plant survival. Students will observe how variation in temperature can affect the photosynthetic rate of plants by performing a simple experiment with Elodea.

Objectives: Students will understand:

1. The inputs and outputs of photosynthesis
2. The correlation between photosynthesis and climate change

Introduction: Photosynthesis is the process by which plants take carbon dioxide from the atmosphere, absorb water, and use the energy from sunlight to produce sugar. Photosynthesis occurs in the chloroplast, an organelle in plant cells that contains the molecule chlorophyll. Chlorophyll absorbs the energy of sunlight. That light energy is converted into chemical energy through the steps of photosynthesis. The reactions of photosynthesis can be divided into two major types: light-dependent reaction and light-independent reaction. The light-dependent reaction converts energy from the sun into a form that chloroplast can use to make sugar from carbon dioxide; oxygen is produced as a waste product. The light-independent reaction uses that energy to make glucose from carbon dioxide and water.

Materials Provided (per group):

- 1- 9 ml glass test tube
- 1- test tube rack
- 1- red liquid thermometer
- 1- 100 ml graduated beaker
- 1- 1 ml plastic transfer pipette
- 50 ml phenol red (diluted 1:100)
- 1- 30 ml syringe
- 1- CO_2 generator (125 ml Erlenmeyer flask with a 2-hole rubber stopper and plastic tubing)
- 1- single edge blade
- 1- box baking soda (per class)
- 1- gallon vinegar (per class)
- 3- heat lamps (per class)
- 3- 32 oz plastic containers (per class)

Perishable Materials:

- 3- Elodea sprigs (available online or at your local pet store)
- 1- 5 lb bag of ice (per class)

Vocabulary:

- Chlorophyll
- Chloroplast
- Thylakoid
- Grana
- Lumen
- Stroma
- RuBisCO
- RuBP
- Greenhouse gases
- ATP

Procedure:

PREP

- Set up lab stations, enough to have no more than 4 students per group
  - Station 1- turn on the heat lamp prior to the lab experiment; set test tube rack underneath
  - Station 2- poor ice into ice buckets
  - Station 3- place test tube rack at room temperature
- Review background information on photosynthesis and respiration
- Dilute phenol red (1:100)
- Purchase Elodea (available online or at local pet stores), ice, baking soda and vinegar

INTRODUCTION

- Explain to students that they will be investigating the carbon cycle as it relates to global climate change
- Pass out handouts to the class
- Review the background information
- Prepare a CO_2 generator as a sample for the class (see generator procedure below)
  - Fill 3 test tubes ¾ full with dilluted phenol red (this will be the constant)
  - Repeat with acidic phenol red
- Review the lab procedure and predictions
- Get students into groups of 3 or 4

AVTIVITY

Follow the steps below to successfully complete the lab.

1. Make a CO_2 generator:
   a. fill the bottom of a 125 ml flask with 1 TblSp of baking soda.
   b. Place the two-hole rubber stopper (containing the plastic tubing) on the flask.
   c. Fill the beaker with 50 ml of phenol red.
   d. Submerge the opposite end of the plastic tubing into the phenol red.
   e. Slowly inject 30 ml of vinegar into the flask through the rubber stopper using a 30 ml syringe.

   *CO_2 will bubble through the solution turning the phenol red acidic. The color changes from red to orange-yellow. (**The more acidic the phenol red, the longer it will take the Elodea plant to absorb the CO_2**).

2. Fill the test tube ¾ full with the acidic phenol red solution.
3. Set the test tube with solution and thermometer at one of the lab stations (i.e. hot, room temperature, or cold)
4. Submerge a sprig of Elodea (3” in length) upside down into the test tube once your solution has reached the appropriate temperature.
5. Record the time you first see the bubbles.
6. Observe and record the number of bubbles generated every minute for five minutes.
7. Repeat steps 2-7 at two more lab stations.
8. Record all data in the table below and answer the discussion question that follow.

Data:

Table 1. Number of bubbles observed in 5 minutes at three different temperatures.

	Hot Temperature ___ ˚C	Room Temperature Temperature ___ ˚C	Cold Temperature ___ ˚C
Start Time			
Time of First Bubble			
# of bubbles in 1st minute			
# of bubbles in 2nd minute			
# of bubbles in 3rd minute			
#of bubbles in 4th minute			
# of bubbles in 5th minute			
Color change observations			

Results:

$$\text{Rate of photosynthesis} = \frac{\text{number of bubbles}}{\text{time}}$$

1. Calculate the rate of photosynthesis in # of bubbles per second for each station.
2. Graph your results. Place time on the x-axis and bubble count on the y-axis. Create three lines, one for each temperature, and label each one accordingly.
3. Calculate the time it took for each sprig to begin photosynthesizing using the equation: First bubble time – Start time.

Discussion:

1. Explain what the bubbles are and why do they occur?
2. What does this tell you about the importance of plants in our environment?
3. At which temperature was photosynthesis most efficient?
4. What is the purpose of using the acidic phenol red, i.e. what does it display?
5. Is global warming good for plants? Why?
6. What could be the cause for errors in this experiment?
7. What are some other variables that could be manipulated to test photosynthesis rates?

Extension: Prepare slides with a cross-section of a leaf. Have students sketch and label the guard cells and stomata under a microscope with a 40x objective lens.

Resources

CSI: Climate Status Investigation. Terrestrial Sequestration- Photosynthesis and Cellular Respiration. (n.d.). Retrieved February 9, 2011 from <http://www.keystonecurriculum.org/highschool/2009_lesson_intros/21_Terrestrial_Sequest_HS09.html>

The Biology Corner. Rate of Photosynthesis. (n.d.). Retreived March 20, 2011 from <http://www.biologycorner.com/worksheets/photosynthesis_rate.html>