Photosynthesis and Cellular Respiration

Strand Life Systems

Topic Investigating photosynthesis and cellular respiration

Primary SOL

LS.5 The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include
- a) energy transfer between sunlight and chlorophyll;
- b) transformation of water and carbon dioxide into sugar and oxygen; and
- c) photosynthesis as the foundation of virtually all food webs.

LS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
- c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data.

Related SOL

LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include
- a) cell structure and organelles.

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include
- a) the relationships among producers, consumers, and decomposers in food webs.

Background Information

Energy is a basic need of all living things. Photosynthesizing organisms obtain their energy from the sun and are often called producers because of their ability to produce sugar (glucose). Organisms that can perform photosynthesis are the foundation of virtually all food webs and food pyramids.

Photosynthesis is the process that transforms light energy into chemical energy, the means by which a plant uses sunlight to produce food. Through a series of chemical reactions, light energy converts raw materials (water and carbon dioxide) into products (sugar and oxygen). The cellular organelles necessary for photosynthesis include chloroplasts containing the green pigment and chlorophyll, which traps sunlight.

Respiration is the process in which cells use food produced to release stored energy. Plants perform cellular respiration as well as photosynthesis.

Students should understand both photosynthesis and respiration. They should easily identify the appropriate process when presented with the reactants and products.

Materials

- Examples of living green plants
- Construction paper
- Scissors

- Tape or paperclips
- Pea seeds (or other fast-growing seeds)
- Paper towels
- Petri dishes
- Warm tap water
- Egg cartons (plastic or foam) or seeding starter trays with at least 12 seed wells
- Dry potting soil
- Triple beam or electronic balances
- Metric rulers
- Clear glass jars large enough to hold one eggcup section
- Lids for jars
- Student lab notebook for recording measurements and observations.
- Diagram/chart showing photosynthesis
- Digital camera (optional)

Vocabulary

chemical formula, chemical reaction, chlorophyll, chloroplast, energy, glucose, mitochondria, oxygen, photosynthesis, products, reactants, respiration, yield

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

1. Explain chlorophyll's role in photosynthesis, and show students that chlorophyll is present in green plants. Tape or paperclip pieces of construction paper on the leaves of a plant placed in bright sunlight. Ask students to predict what will occur after four or five days.
2. After four or five days, remove the paper from the leaves, and ask students to observe the leaves and explain their observations.
3. Ask students to identify the source of energy for seed growth. Explain that students will be growing seeds in various conditions (encourage light and dark locations) and measuring the length and mass of the seedlings each day. Group students into lab teams, and guide them in conducting the following five-day experiment.
4. On Day One of the experiment (preferably a Monday), have lab teams start the germination of the pea seeds by placing them on damp paper towels in the Petri dishes and covering the seeds with warm tap water. Have each lab team place their dish in a location with indirect sunlight. The seed coats should split, and the first growth should be visible in two or three days.
5. After the seeds begin to sprout (on Day Three or Day Four), they are ready to be planted in the egg-carton "pots" or seeding starter trays. Have each lab team prepare the egg-carton pots by cutting a carton in half lengthwise to yield two strips with six cups each. Direct students to cut off and discard one cup from each strip and put a small drainage hole in the bottom of each of the remaining 10 cups. Have teams label one strip "Light" and the other "No Light" and number the cups in each strip from 1 to 5. Direct teams to fill each cup with soil up to 1/2 in. from the top.

6. Have teams measure and record the mass of each of their seedlings. Then have each team place one seed on the soil in each cup and cover it with 1/4 inch of soil. Next, students sprinkle water over the top of the soil until the soil is well saturated and water comes out of the bottom of each cup. If cameras are available, have each lab team photograph their planter strips.
7. Direct each team to place their "Light" planter strip in a well-lit place and their "No Light" strip in the designated dark area. Try to select areas where the temperatures will be similar.
8. Allow both sets of seeds to grow for two to four days. Have teams water each day as necessary for the soil to remain slightly damp but not wet. You may encourage students to draw daily observations in addition to the writing component.

Monday Observations

9. After two to four days (on the following Monday), have teams remove the planter strips from their designated areas. If applicable, have teams photograph each tray. This step should be done on a Monday to allow for observations over five consecutive days.
10. Have teams carefully separate the #1 cups from their "Light" and "No Light" sets and return the remaining cups to their designated areas.
11. Direct teams to compare the two seedlings: Carefully remove the seedlings from the soil, and rinse them gently to remove all soil. Measure and record their length (straighten gently to measure from tip of root to tip of seedling), and write a physical description comparing their roots, stems, and leaf development, as well as their colors. Weigh each seedling, and record the two masses. Photograph the seedlings, and then discard them.

Tuesday and Wednesday Observations

12. Repeat steps 9–11 with the second and third cups. On Wednesday, direct students to not return the "No Light" cups to the dark location but to leave them in the light.

Thursday Observations

13. Repeat steps 9–11 with the fourth cups. Have students place the fifth cups in glass jars, seal the jars, and leave them in the light.

Friday Observations

14. Have lab teams observe the jars and record all observations. Photograph the jars with the seedlings.
15. Have students remove the seedlings from the jars and repeat steps 9–11. All observations are now complete.
16. Have students construct a line graph showing the growth of the seedlings (length) over five days. A line graph can also be constructed for the mass of the seedlings. Students should explain the changes that occurred.

After the Experiment

17. Discuss with students the importance of photosynthesis to food webs and the role of producers. Have students draw a diagram of the process of photosynthesis. Introduce the chemical formula showing the chemical reaction that takes place.
18. Explain to students the process of respiration. Compare the processes of photosynthesis and respiration. Compare the formulas of photosynthesis and respiration.

Assessment

- **Questions**
  - Compare the growth of the seedlings in the light and the dark. Were there any differences?
  - Did the "No Light" seedlings change their growth patterns when they were placed in the light? Explain.
  - What did you observe in the jar on the final day? What caused it?
  - Why is photosynthesis such an important component of all food chains?
- **Journal/Writing Prompts**
  - Explain the process of photosynthesis.
  - Explain why photosynthesizing organisms are an important part of food webs.
  - Explain how you rely on photosynthesis in order to live.
  - A plant destroying fungus is affecting a large part of an environmental ecosystem. Describe the effect this will have on the other organisms in that ecosystem.
- **Other**
  - Construct models of food chains and food webs. Producers are the foundation of most all food webs.

Extensions and Connections (for all students)

- Literature connection: Have students read *Top Secret,* by John Reynolds Gardiner, in which the protagonist, Allen Brewster, decides to perform an experiment about human photosynthesis.

Strategies for Differentiation

- Give students this higher level writing topic: "It is the year 2040, and you are a research scientist. The amount of sunlight that reaches the earth has been drastically reduced due to a major event like pollution, fires, or volcanoes. Farmers are asking you for help to save their failing crops. Devise ways that you might help."
- Have students draw, color, and label diagrams of both processes. Once completed, ask students to identify similarities and differences, guiding them to make the connection that these are OPPOSITE processes containing IDENTICAL components.