Photosynthesis
Light intensity

Teacher Notes

BIOLOGY
Plant Physiology

Driving Question:
What is the relationship between the photosynthesis rate and the light intensity?

Applied Technology: Data-logging

Student Level: High School Level (15-18)

Duration: 1 lesson period

Recommended Settings: Student Investigations

Learning Objectives

- To measure changes in CO_2 gas concentration resulting from photosynthesis (and respiration) of green leaves.
- To determine the rate of photosynthesis.
- To investigate the relationship between the rate of photosynthesis and light intensity.

Didactical Approach

In this activity students monitor photosynthesis. They use the CO_2 gas sensor (if possible in combination with the O_2 gas sensor) and measure the concentration of carbon dioxide in a container with fresh green leaves. They compare the production of carbon dioxide by submitting green leaves to dark and bright light, to investigate the relationship between the photosynthesis rate (the rate of consuming) and the light intensity.

Common student difficulties:

- Difficulty in understanding the autotrophic feeding of plants; a commonly held idea is that plants obtain their food from the soil.
- Difficulty concerning the process of respiration, as well as its relationship to photosynthesis, and confusion of photosynthesis with respiration (some students understand respiration as synonymous with breathing, while others understand plant respiration as an inverse gaseous exchange compared with that of animals).
- Difficulty with the concept of energy and energy exchange during photosynthesis.
- Difficulty in recognizing and understanding of the concept of chemical change. Examples of misconceptions concerning photosynthesis and respiration in plants are:
  - Carbon dioxide is used in respiration, which only occurs in green plants when

there is no light energy to photosynthesize
- Respiration in plants takes place in the cells of the leaves only
- Respiration is the exchange of carbon dioxide and oxygen gases through plant stomata
- Green plants take in carbon dioxide and give off oxygen when they respire
- Green plants respire only at night when there is no light energy
- Green plants do not respire; they only photosynthesize
- Photosynthesis provides energy for plant growth
- Plants respire when they cannot obtain enough energy from photosynthesis and animals respire continuously, because they cannot photosynthesize

Concepts learnt in this activity:

- Photosynthesis, rate of photosynthesis.

Materials

In your investigations you will use:

- Data-logger or interface e.g. CMA CLAB,
- CO_2 gas sensor, and/or
- [optional] O_2 gas sensor,
- [optional] Light sensor,
- Bright light source,
- Special photosynthesis chamber or a sampling bottle delivered with the CO_2 sensor and a glass container filled with water (heat sink),
- Fresh green leaves e.g. fresh spinach,
- Aluminium foil.

Procedure

- Connect the CO_2 gas sensor to input 1 of your data-logger.
- Open the Coach Activity 'Photosynthesis (light intensity)'.
- Help students set up the experiments.
- Let students perform the investigations.

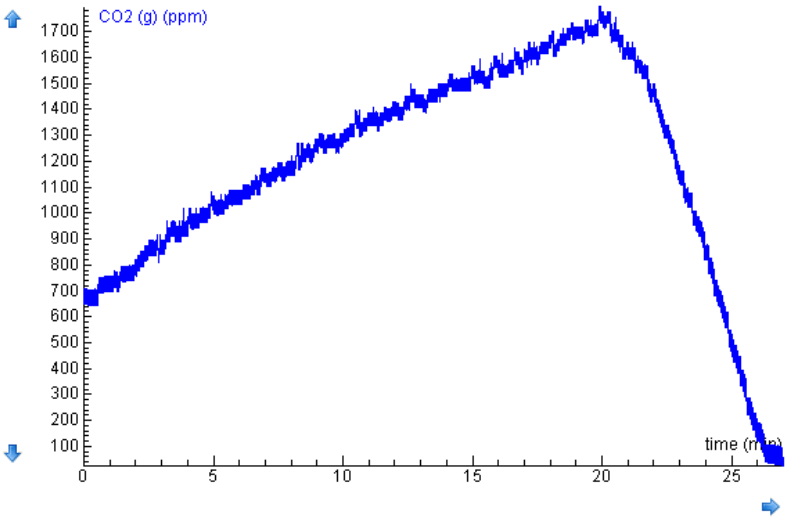
Questions and Assignments

- What process is responsible for this?
- What is the effect of daylight on the CO_2 gas concentration?
- What is the effect of strong light on the CO_2 gas concentration?
- What processes are responsible for such behavior?
- Determine the rate of respiration in these three situations, no light, daylight and strong light.
- Determine the rate of photosynthesis in these three situations, no light, daylight and strong light.

- How does the light intensity influence the rate of respiration?
- How does the light intensity influence the rate of photosynthesis?

Data Analysis

The first experiment is relatively short and can be performed during one lesson. The exemplary data are shown in the graph below. In this experiment fresh spinach leaves were placed in the sampling bottle delivered with the CO_2 sensor.



First 10 minutes of the measurement the sampling bottle with leaves was wrapped in the aluminum foil. During this period the CO_2 gas concentration increases; the rate of CO_2 production is 77 ppm/min (determined by using the Slope option). In this part of the experiment only the respiration process takes place. Green leaves harvest energy, stored in glucose molecules by oxidizing the glucose, then CO_2 gas is produced. The CO_2 gas is produced by plants in the dark and used for photosynthesis in light.

For the second ten minutes of the measurement (10 to 20 min), the aluminum foil is removed and the bottle is placed in ambient light (circa 700 Lux). The CO_2 gas concentration still increases but more slowly, with a rate of 44 ppm/min. More carbon dioxide is produced in respiration then there is used by photosynthesis.

For the last 7 minutes of the measurement the lamp producing bright light is turned on. The CO_2 gas concentration decreases very fast. The process of photosynthesis takes place much faster now. The CO_2 gas is used in the photosynthesis process to form sugar. Spinach leaves purchased from a grocery store work well and are available any time of the year. For best results, keep the leaves cool until they are to be used. Just before use, expose the leaves to bright light for 5 minutes. There should be enough leaves in the

bottle, then the CO_2 changes are faster.

Resources

Coach Activity: Photosynthesis (light intensity).cma7

Copyright

Authors: CMA Team