Gas exchange of a plant

FizziQ activity · High school · 30 min

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Sealed in a chamber, plants shift from photosynthesis to respiration: an SCD40 sensor tracks CO_2 in light then darkness, logged by FizziQ Connect on smartphone.

Learning objectives

- Demonstrate the gas exchange associated with photosynthesis and cellular respiration
- Measure the evolution of CO_2 concentration in a sealed chamber containing plants
- Identify the role of light as an energy source for photosynthesis
- Compare the rates of CO_2 consumption (light) and production (dark)
- Understand the net gas exchange balance of a plant

Instruments and sensors

CO_2 concentration meter · O_2 concentration meter (optional) · SCD40 sensor · O_2 sensor

Materials

- Smartphone or tablet with FizziQ Connect
- SCD40 sensor (CO_2, temperature, humidity)
- O_2 sensor (optional)
- M5 Stack module and multiport hub
- Transparent sealed chamber
- Fresh green leaves (lettuce, spinach)
- Opaque cloth to block light
- Note: the protocol remains adaptable to any comparable gas-concentration data acquisition system.

Protocol

1. Connect the O_2 and SCD40 sensors to the I2C port of the M5 Stack module via the multiport hub.
2. Open FizziQ Connect on your smartphone or tablet and connect to the M5 Stack via Bluetooth.
3. Verify that both sensors are detected: you should see the CO_2 concentration (in ppm) and the O_2 concentration (in %).
4. Place freshly cut plant material (lettuce leaves, spinach) in the transparent sealed chamber, along with the sensors.
5. Seal the chamber and place it in daylight (near a sunny window).
6. Start simultaneous recording of CO_2 and O_2 concentrations in FizziQ Connect.
7. Leave the chamber in the light for 10 minutes. Observe the evolution: photosynthesis dominates, CO_2 decreases.
8. Without opening the chamber, cover it completely with the opaque cloth to block all light.
9. Continue recording for 10 more minutes in darkness. Observe the slope change: CO_2 now increases (only respiration occurs).
10. Stop the recording and analyze the graphs. Identify the exact moment of the slope change and compare the CO_2 consumption rate (light) with the production rate (dark).

Expected results

A very clear slope change in CO_2 concentration occurs nearly instantly when the chamber is covered. In light,

CO_2 decreases as photosynthesis consumes it faster than respiration produces it. In darkness, CO_2 increases because only respiration is active. The CO_2 consumption rate in light is typically 2-5 times the production rate in darkness.

Questions

- Why is the slope change in CO_2 concentration nearly instantaneous when switching to darkness?
- If respiration occurs both day and night, why is the net CO_2 exchange negative in light?
- What would happen if the experiment continued for several hours in the dark?
- How does light intensity affect the rate of CO_2 consumption?
- What is the compensation point where photosynthesis exactly balances respiration?
- Why do forests act as carbon sinks during the growing season?

Going further

- Vary the light intensity (strong sunlight, weak light, artificial light) and compare CO_2 consumption rates
- Use different types of leaves and compare their photosynthetic activity
- Measure the effect of temperature on photosynthesis rate
- Record for a full light-dark-light cycle to verify reproducibility
- Calculate the net carbon fixation rate in grams of CO_2 per hour per gram of leaf