Cellular respiration of muscle

FizziQ activity · High school · 25 min

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High-school biology: fresh beef in a sealed chamber, with CO_2, O_2 and humidity sensors read in FizziQ on smartphone or tablet, shows cellular respiration at work.

Learning objectives

- Demonstrate cellular respiration in animal (muscle) cells
- Measure the simultaneous evolution of CO_2, O_2, and humidity in a sealed chamber
- Interpret gas exchange in terms of the respiration equation
- Calculate CO_2 production rate and relate it to metabolic activity
- Understand why cellular respiration continues after death

Instruments and sensors

SCD40 sensor (CO_2, temperature, humidity) · O_2 sensor

Materials

- Smartphone or tablet with FizziQ Connect
- SCD40 sensor (CO_2, temperature, humidity)
- O_2 sensor
- M5 Stack module and multiport hub
- Small sealed chamber
- Fresh raw beef (about 50 g)
- Note: the protocol remains adaptable to any comparable gas-sensing data acquisition tool.

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 three quantities are accessible: CO_2 concentration (ppm), O_2 concentration (%), and relative humidity (%).
4. Place the piece of fresh raw beef in the sealed chamber. Position the sensors so they are not in direct contact with the meat.
5. Start recording in FizziQ Connect with the chamber still open for 1-2 minutes to establish baseline values.
6. Seal the chamber and note the exact time of closure.
7. Record for 10 to 15 minutes without touching the setup. Observe the real-time evolution of the three measured quantities.
8. Observe the trends: CO_2 and humidity increase, O_2 decreases slightly.
9. Stop the recording. Open the chamber to ventilate and remove the meat.
10. Analyze the graphs in FizziQ Connect: identify the moment the chamber was sealed and calculate the rates of change for CO_2, O_2, and humidity.

Expected results

A clear increase in humidity (from about 52% to 67%) and CO_2 concentration (from 400-800 ppm to over 16,000 ppm) is observed once the chamber is sealed. The increase is nearly instantaneous after sealing, confirming active respiration. O_2 decreases slightly but the change may be within the sensor's precision limits.

Questions

- Why do muscle cells continue to respire after the animal's death?
- How can we explain that the humidity increase accompanies the CO_2 increase?
- What would happen if the chamber were left sealed for several hours?
- Why is the O_2 variation harder to detect than the CO_2 variation?
- At what point would the cells stop respiring? What would limit them?
- How does temperature affect the respiration rate of muscle cells?

Going further

- Modify the temperature (37°C water bath, ice bath at 0°C) to study the effect of temperature on respiration rate
- Compare the respiration rate of different types of meat (beef, chicken, fish)
- Test whether cooked meat also produces CO_2 (it should not)
- Vary the mass of meat and verify that CO_2 production rate scales with mass
- Compare muscle tissue respiration with plant tissue respiration