Cellular Respiration ID: 16146

By Texas Instruments

TEACHER GUIDE

Time required
45 minutes

Topic: Respiration

- *Observe reactants and products of cellular respiration*
- *Determine factors that influence the rate of cellular respiration*

Activity Overview

In this activity, students will use a carbon dioxide gas sensor to measure the rate at which non-germinating and germinating peas undergo cellular respiration. Students also investigate the influence of temperature on the rate of cellular respiration.

Materials

To complete this activity, each pair of students will require the following:

- *TI-Nspire™ technology*
- *EasyLink*
- *Carbon Dioxide Gas Sensor*
- *Non-germinating and germinating peas*
- *Small cup*
- *Reaction bottle*
- *Warm water in a large bowl*
- *Ice water in a large bowl*

TI-Nspire Applications

Data & Statistics, Lists & Spreadsheet, Notes

Teacher Preparation

Students should be familiar with the reactants and products of cellular respiration. Students should also be familiar with photosynthesis.

- *The day before doing this activity, empty a packet of garden pea seeds into a large beaker. Cover the seeds with water and let them sit overnight. This will be sufficient to get the peas "active" and ready to germinate.*
- *The Carbon Dioxide Gas Sensor uses a lot of power. Be sure that the TI-Nspire devices have fresh batteries before beginning this activity.*
- *The screenshots on pages 2–5 demonstrate expected student results.*
- ***To download the .tns file, go to education.ti.com/exchange and enter "16146" in the search box.***

Classroom Management

- *This activity is designed to be **student-centered**, with the teacher acting as a facilitator while students work cooperatively. The student worksheet guides students through the main steps of the activity and includes questions to guide their exploration. Students may record their answers to the questions on blank paper or answer in the .tns file using the Notes application.*
- *The ideas contained in the following pages are intended to provide a framework as to how the activity will progress. Suggestions are also provided to help ensure that the objectives for this activity are met.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following questions will guide student exploration during this activity:

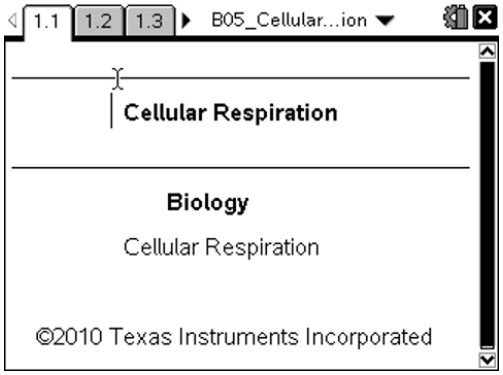
- What are the products of cellular respiration?
- How could you measure the rate of cellular respiration?
- How might temperature affect cellular respiration?

Students will investigate the rate at which CO_2 is produced by non-germinating and germinating peas. Students will plot data and use a linear regression to determine the rates of cellular respiration. They will also investigate how CO_2 production is affect by germinating peas in hot and cold environments. Finally, students will draw conclusions about variables that affect cellular respiration rates.

Problem 1 – Preliminary Questions

Step 1: Students should open the .tns file **B05_Cellular_Respiration.tns** and read pages 1.1–1.2.

Step 2: Students should then answer questions 1–8.



Q1. Which of the following is NOT a reasonable way to measure the rate of cell respiration in a high school science lab setting?

A. *Measure how fast glucose is made*

Q2. In which cellular organelle is glucose MADE?

A. *Chloroplast*

Q3. Whereas animal cells can do only cell respiration, plant cells can only do photosynthesis.

A. *False*

Q4. Eukaryotic cells have nuclei.

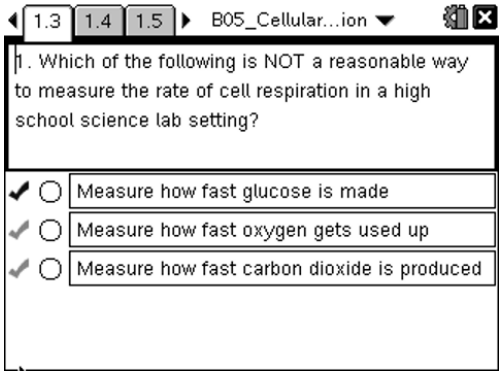
A. *True*

Q5. Eukaryotic cells have mitochondria.

A. *True*

Q6. Prokaryotic cells contain:

A. *Neither nuclei nor mitochondria*



Q7. Which of the following is NOT a eukaryotic cell?

A. *A lactobacillus bacterium*

Q8. Consider the following chemical equation:
$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$

When this equation is correctly balanced, the coefficients for oxygen and CO_2 should be:

A. *6, 6*

Problem 2 – Reaction Rate Data Collection

Step 1: Next, students set up the experimental apparatus. Students connect the EasyLink to the TI-Nspire, and then they connect the Carbon Dioxide Gas Sensor to the EasyLink. They should set the TI-Nspire to collect data every 10 seconds for 10 minutes.

Step 2: Students place 10 non-germinating peas in the small cup. Students should allow 1 – 2 minutes for the probe to warm-up and for the display to stabilize. During this time, they should answer questions 9 and 10.

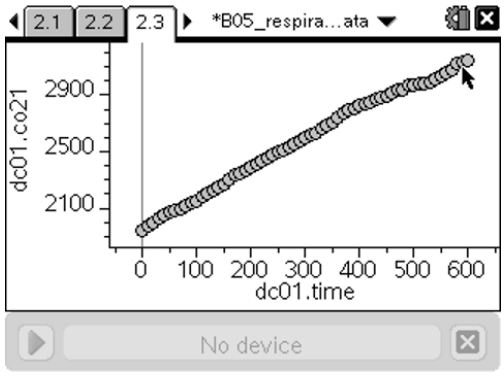
Q9. During this portion of the experiment, what do you predict will happen with the carbon dioxide level in the reaction bottle? I predict it will:

A. *Answers will vary.*

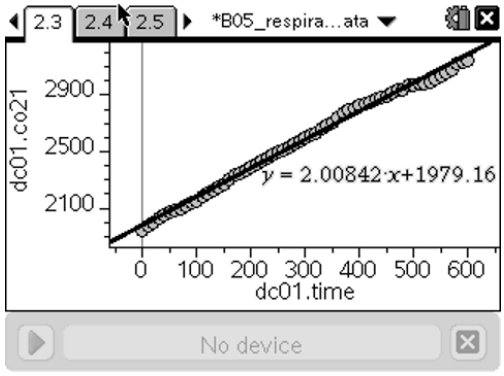
Q10. In a scientific experiment, this component would be called the:

A. *Control*

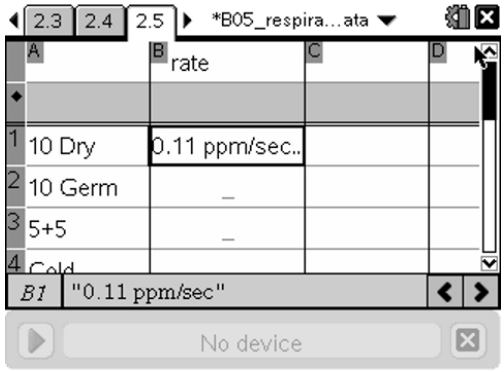
Step 3: Students then pour the non-germinating peas into the reaction bottle, place the probe into the opening in the bottle, and begin data collection on the TI-Nspire. Students should watch as the data plots in the *Data & Statistics* application on page 2.3. (Note: data shown in the screenshot on the right is for the germinating peas, which will be investigated later in experiment.)



Step 4: Students then use the **Linear Regression** tool to fit a line to the collected data.



Step 5: Students should observe the slope of the line on page 2.3 and record this into the *Lists & Spreadsheets* application on page 2.4.



Step 6: Students then answer questions 11 and 12.

Q11. Were you correct in the prediction you made earlier?

A. *Answers will vary.*

Q12. What should the "data label" be for the rate of change in this experiment?

A. *Sample answers: ppm CO2/second or %O2/second*

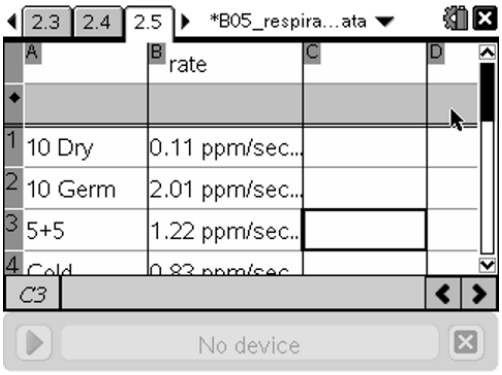
TI-Nspire Navigator Opportunity: *Quick Poll*
Quick Poll can be used here to have students make a prediction. Ask students to predict what they think will happen when the germinating peas are added to the reaction bottle. Have students think about how and why this would be different than the investigation with the non-germinating peas.

Problem 3 – Manipulation of Reaction Variable

Step 1: Students modify a variable in the investigation and then repeat steps from Problem 2.

Step 2: Each time they repeat the experiment, students should fill the reaction bottle with water and then pour it out to remove any residual carbon dioxide left from the previous trial. Students should view the collected data on page 2.3.

Step 3: For each set of newly collected data, students determine the rate of reaction and record it on page 2.5.



Problem 4 – Analysis

Step 1: Students should answer questions 13–24.

Q13. Why did you perform one trial using peas that were not yet germinating?

A. *Answers will vary, but students should note that the non-germinating peas were a "control" for the experiment.*

Q14. Non-germinating peas are in a state of dormancy. What would you expect the carbon dioxide production to be?

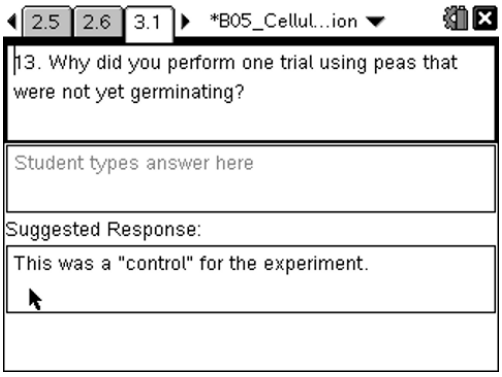
A. *Answers will vary, but students should note that the carbon dioxide production would be very low.*

Q15. What would the predicted CO_2 production be if 5 germinating peas were used instead of 10?

A. *Answers will vary, but the CO_2 production should be about half as much.*

Q16. If there was CO_2 production from the non-germinating peas, what mathematical adjustments need to be made for the CO_2 production from the germinating peas?

A. *I should subtract the CO_2 production from the non-germinating to the germinating data*



Q17. Which would you predict would have a greater CO_2 production rate: 10 peas at room temperature or 10 peas in warm water? Explain.

A. *Answers will vary, but students should note that heat speeds up the rate of CO_2 production. Thus, the peas in warm water should have a greater CO_2 production.*

Q18. If you had used an oxygen gas sensor instead of a CO_2 sensor, what results would you have expected?

A. *Answers will vary, but students should note that the O_2 levels would decrease during the course of the reactions.*

Q19. Were your germinating peas undergoing photosynthesis? Explain by citing evidence from the experiment.

A. *Answers will vary, but students should note that the germinating peas were not undergoing photosynthesis because they did not have any leaves. Also, CO_2 levels would have decreased, not increased, during photosynthesis.*

Q20. Which biochemical process can be performed by plants?

A. *Both photosynthesis and cell respiration*

Q21. What cellular organelles would you expect to find in plant cells?

A. *Both mitochondria and chloroplasts*

Q22. Which cellular organelles would you expect to find in animal cells?

A. *Mitochondria*

Q23. OVERALL, the process of photosynthesis is:

A. *Anabolic*

Q24. OVERALL, the process of cellular respiration is:

A. *Catabolic*