Name **Period** **Date**

13. Cellular Respiration and the Carbon Cycle

Driving Questions

When dormant seeds are exposed to water, they begin to germinate. By measuring the level of CO_2 gas in closed systems containing dormant or germinating seeds, you can explore the following:

- What happens to carbon dioxide gas concentrations in a closed system containing germinating seeds and air?
- What does cellular respiration have to do with the carbon cycle?
- Can germinating seeds serve as a model for cellular respiration? Why or why not?

Background

In the germinating seed, cells within the growing plant embryo use energy-storage molecules (oils, starches, sugars) stored in the seed for food to fuel its life processes. The energy from the food is extracted through a process of cellular respiration. In a series of hundreds of biochemical reactions, the carbon atoms that are bound in the large energy-storage molecules are combined with oxygen gas to produce carbon dioxide gas, water vapor, and energy that is vital to living processes.

The carbon dioxide gas that is released into the environment is then available to plants for use in the process of photosynthesis. During photosynthesis, plants trap energy from the sun to convert carbon dioxide gas and water into complex sugar molecules that store potential chemical energy. The carbon dioxide gas and water vapor molecules released into the atmosphere during cellular respiration also function as natural "greenhouse gases," causing the atmosphere to retain more of the sun's energy through the natural greenhouse effect.

Materials and Equipment

For each student or group:

- Data collection system
- CO_2 gas sensor
- Sampling bottle (included with sensor)
- Dissecting microscope or magnifying glass
- Knife or scalpel
- Dry bean seeds (11)
- Germinating bean seeds (11)

Safety

Add this important safety precaution to your normal laboratory procedures:

- Use care with the knife or scalpel.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

Part 1 – Observing and comparing the morphology of dormant and germinating bean seeds

1. ☐ Obtain one dry seed and one soaked seed. Use a knife or scalpel to bisect the seeds longitudinally into halves.

2. ☐ Use a magnifying glass or dissecting microscope to observe the interior of the seed.

3. ☐ Sketch the major morphologic features of the bean seed. Label the cotyledon, embryo, and seed coat.

4. ☐ List some differences you observe in the appearance of the dry versus the soaked seed.

5. ☐ What is a sign that the seed has changed from a dormant state to a growing state, in other words, that the seed is germinating?

Part Two – Comparing the CO_2 gas concentrations of a closed system containing dormant seeds versus a closed system containing germinating seeds

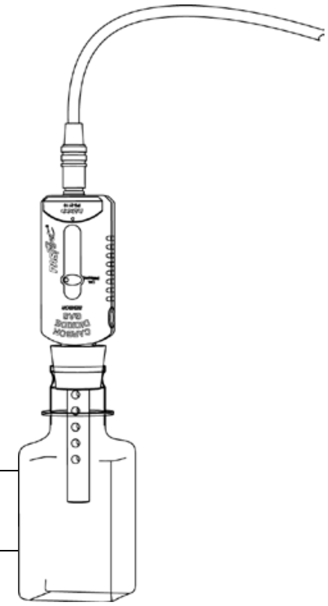
Set Up

6. ☐ Start a new experiment on the data collection system.

7. ☐ Connect a CO_2 gas sensor to the data collection system using an extension cable.

8. ☐ Display CO_2 gas concentration on the y-axis of a graph with Time on the x-axis.

9. ☐ Why is a parameter versus time graph chosen to view the data? What is another way to view the data?



10. ☐ Put 10 dry seeds into one sampling bottle and 10 soaked seeds in the other sampling bottle.

11. ☐ Insert the end of the CO_2 gas sensor into the sampling bottle containing the dry seeds and firmly plug the end of the sampling bottle with the rubber stopper.

12. ☐ Why are you using dry and soaked seeds?

13. ☐ Predict what will happen to the CO_2 concentration during data recording? Why?

Collect Data

15. ☐ Start data recording.

Note: Avoid bumping the equipment because jarring or bumping the sensor might cause the sensor to record erratically.

16. ☐ Data collection will stop automatically after 10 minutes.

    Write the run number here___________.

17. ☐ Switch the sensor to the other sampling bottle.

18. ☐ Start recording data.

19. ☐ Data collection will stop automatically after 10 minutes.

    Write the run number here____________.

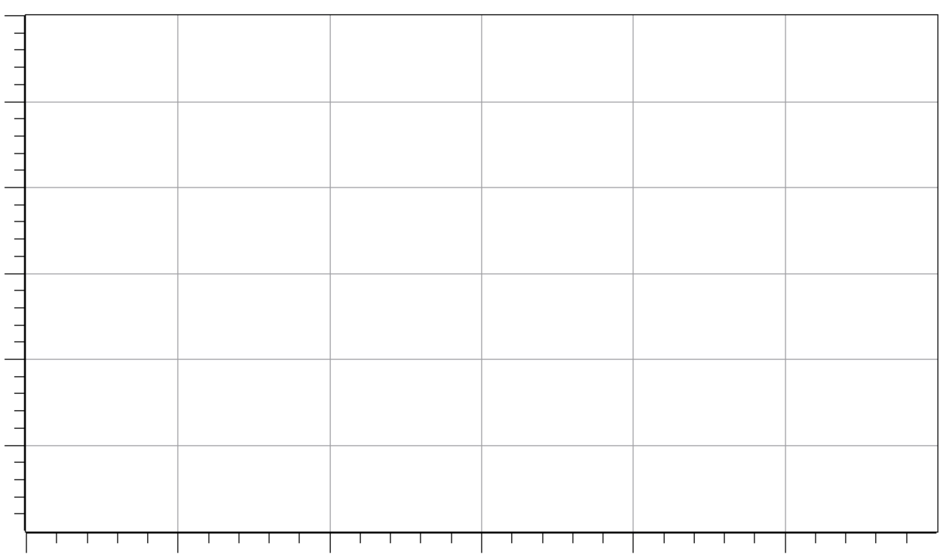
20. ☐ Save your experiment, and clean up according to your teacher's instructions.

Data Analysis

1. ☐ Display both data runs on the graph display.

2. ☐ Adjust the scale of the graph to show all data.

3. ☐ On the graph below, sketch the plotted data on your graph display. Be sure to label the x-axis and y-axis regarding parameter and units of measurement. Label each data run.



4. ☐ Find the initial and final CO_2 concentrations for each run and record them in the data table.

5. ☐ Calculate the change in CO_2 concentration for each experimental condition and record these values in Table 1.

Table 1: CO_2 concentration of dry seeds and germinating seeds

	Initial CO_2 Concentration (ppm)	**Final CO_2 Concentration (ppm)**	**Change in CO_2 Concentration (ppm)**
Dry seeds			
Germinating seeds			

Analysis Questions

1. **Compare the change in CO_2 concentration for dry seeds versus soaked seeds.**

2. **What can you conclude about the soaked seeds regarding CO_2?**

3. **Compare your prediction to the data you collected. Were you correct or incorrect in your prediction? Explain.**

4. **In this experiment, what is the independent variable and what is the dependent variable?**

5. **What would you expect to happen to the concentration of oxygen gas in the bottle? Why? How could you test this hypothesis?**

6. **What are the gaseous products of cellular respiration that are released from the cells of the germinating seeds?**

7. **Where did the seed get the fuel (glucose) for cellular respiration?**

Synthesis Questions

Use available resources to help you answer the following questions.

1. **Consider the following overall summary equation of the hundreds of biochemical reactions involved in aerobic cellular respiration:**

$$C_6H_{12}O_6 + 6O_2 + ADP + P_{inorganic} \rightarrow 6CO_2 + 6H_2O + ATP$$

Write this equation using words instead of chemical symbols. Write an equation for this process using chemical notation.

2. **In this activity, a germinating seed is used as a model to represent cellular respiration in all living things. Why is it reasonable to create a model for cellular respiration?**

3. **What is the effect of cellular respiration on the atmosphere? How is the natural greenhouse effect influenced?**

4. **What role does cellular respiration in plants and other living organisms play in the carbon cycle?**

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. **The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. In this activity, which of the following is an example of a chemical element being recombined as it passes through a link in the food web?**

   A. Carbon dioxide is being passed from the energy storage molecule in the bean seed to the atmosphere.

   B. Carbon from the energy storage molecule (glucose) in the bean seed is being recombined with oxygen and passed as CO_2 gas into the atmosphere.

   C. Oxygen gas (O_2) from the atmosphere is being recombined in the bean seed into different molecules (H_2O and CO_2).

   D. Both B and C are examples.

2. **How did the energy-storage molecules in the bean seed get there?**

   A. The bean seed gathered these molecules from its surrounding environment.

   B. The plant that made the seeds gathered energy from the sun through photosynthesis and stored it in the energy-storage molecules in the seed.

   C. The germinating seed gathered energy from the sun and stored it in the energy-storage molecules.

   D. Both B and C are correct answers.

3. **The food energy that the plant uses for cellular respiration is stored in the seed's**

   A. Cell wall
   B. Embryo
   C. Cotyledons
   D. DNA

4. **Beans and coal both have stored energy. Where did the energy originally come from that is stored in beans and coal?**

   A. From the earth's gravity
   B. From the sun's light
   C. From the heat in the earth's core
   D. From the carbon dioxide in the air

5. **What natural "greenhouse gases" were produced by the bean seeds during cellular respiration?**

   A. Carbon dioxide gas
   B. Oxygen gas
   C. Water vapor
   D. Both A and C are correct