# Assignment Summary

For this assignment, you will review the experimental design and results of a laboratory experiment investigating the cellular respiration of peas, and the effect of temperature on respiration. You will construct a graph for the rate of CO2 production for dormant peas, germinating peas, and cold-germinating peas. You will then analyze the rate of CO2 production for the different peas, and write a conclusion for the laboratory investigation based on the evidence in the graph. Last, you will evaluate the experimental design, identifying sources of error and/or points of refinement.

Background Information

Living cells require energy from fuel molecules to perform tasks necessary to sustain life. For example, cells use energy to build polymers, transport molecules, and reproduce. Heterotrophs obtain energy by eating, while autotrophs are able to make their own food. Food molecules must then be converted into usable energy for the cell. The most efficient catabolic pathway in eukaryotic organisms is cellular respiration. Glucose is metabolized in the presence of oxygen, and carbon and water are released. The purpose of cellular respiration is to convert glucose into ATP molecules to provide usable energy for the cell.

Respiration consists of five major stages: glycolysis, pyruvate oxidation, the citric acid cycle, the electron transport chain, and chemiosmosis. Glycolysis occurs in the cytoplasm. This process metabolizes glucose into two molecules of pyruvate. During this stage, a net of two ATP molecules are made and two NADH molecules are made. In the presence of oxygen, pyruvate then moves into the mitochondria. Pyruvate is oxidized into acetyl-CoA. Acetyl-CoA then delivers acetate to the citric acid cycle. The cycle uses acetyl-CoA and carbon dioxide to make three NADH, one FADH2, and two CO2 through redox reactions. Two ATP are formed during the citric acid cycle. The electron carriers NADH and FADH2 enter the electron transport chain (ETC). The ETC is powered by electrons from electron carrier molecules NADH and FADH2. The last stage in cellular respiration is chemiosmosis. In this final stage, oxidative phosphorylation occurs in the inner membrane of the mitochondria. The electrons provide the energy to the proteins of the ETC to actively transport hydrogen ions against their concentration gradient and into the inner membrane space, creating a concentration gradient. At the end of the ETC, the electrons from the ETC bind to the final electron acceptor of oxygen. Two hydrogen ions then join and water is formed. The hydrogen ions moved by the ETC then move back down their concentration gradient through enzyme ATP synthase, which links ADP and an inorganic phosphate to create ATP. A total of 32 ATP molecules are produced.

Peas undergo cellular respiration during germination. Do peas undergo cell respiration before germination? How does temperature affect the rate of germinating pea respiration? The laboratory investigation in this lesson explores the respiration of germinating and non-germinating peas.

Materials

* Writing and drawing supplies (colored pencils, paper, etc.)
* Access to the internet, lesson, student edition, and other reference materials

# Assignment Instructions

For this project, you are expected to submit:

1. A completed version of this guide, featuring your graph and written analysis

**Step 1: Prepare for the project.**

1. Read through this guide before you begin so you know the expectations for this project.
2. If anything is unclear to you, be sure to ask your teacher.

**Step 2: Review the experimental design.**

1. Read through the procedure for investigating the cellular respiration of peas. Consider the independent variables, dependent variables, and control. Consider the experimental steps and apparatus. Also, determine the measurement techniques and sources of measurement error. Finally, be sure to review the results obtained.

**Step 3: Draw a line graph showing the rate of CO2 production for peas, germinating peas, and cold-germinating peas.**

1. In the section below, draw a line graph that shows the change in CO2 production over time for both types of peas.
2. Draw a line graph that shows the change in CO2 production over time for cold-germinating peas.
3. Create a key for the graph, compose a title, and label the axes, including units.

**Step 4: Write a conclusion for the laboratory experiment.**

1. Analyze the trends in the graph you have created.
2. In a well-structured paragraph, draw conclusions about the rate of CO2 production for both types of peas in question 1 of the Written Analysis section below.

**Step 5: Evaluate the experimental design, identifying sources of error and/or points of refinement.**

1. Evaluate the experimental design for adequate controls and measurement techniques in question 2 in the Written Analysis section.
2. Comment on possible sources of error in question 3 of the Written Analysis section.
3. Suggest improvements in the experimental design in question 4 of the Written Analysis section.

**Step 6: Evaluate your project using this checklist.**

If you can check off each box below, you are ready to submit your project.

* Did you create a graph of the rate of CO2 production for peas and germinating peas? Does your graph have a key, labels with units, and a title?
* Did you write a conclusion for the laboratory experiment based on evidence and trends in the graph?Did you discuss the differences between peas and germinating peas? Did you comment on the effect of temperature on the rate of respiration?
* Did you complete the Written Analysis section, including evaluating the experimental design, identifying sources of error, and suggesting improvements?

**Step 7: Revise and submit your project.**

1. If you were unable to check off all of the requirements on the checklist, go back and make sure that your project is complete. Be sure to save your project before submitting it.
2. Turn in your graph and written analysis to your teacher. Make sure your name is on it.
3. Congratulations! You have completed your project.

Investigation of CO2 Production for Peas and Germinating Peas

Read the following experimental design and the data table of results carefully.

**Purpose:**

The purpose of this lab is to determine the rate of cellular respiration in germinating and non-germinating peas by measuring CO2 production. It also investigates the effect of temperature on cellular respiration.

**Materials:**

Computer 25 germinating peas Two 100 mL beakers

Vernier computer interface 25 non-germinating peas Thermometer

Vernier CO2 Gas Sensor 250 mL respiration chamber Paper towels

BioChamber 250 Ice cubes

**Procedure:**

Using the CO2 Gas Sensor, you will monitor the carbon dioxide produced by peas during cell respiration. Both germinating and non-germinating peas will be tested.

1. If your CO2 Gas Sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the CO2 Gas Sensor to Channel on the Vernier computer interface.
2. Prepare the computer for data collection by opening the file “05 Cell Resp M1 CO2 O2” from the Advanced Biology with Vernier folder of LoggerPro.
3. Obtain 25 germinating peas and blot them dry between two pieces of paper towel. Use the thermometer to measure the room temperature. Record the temperature in Table 1.
4. Place the germinating peas into the respiration chamber.
5. Place the CO2 Gas Sensor into the neck of the respiration chamber.
6. Wait 4 minutes for readings to stabilize, and then begin collecting data. Collect data for 10 minutes.
7. When data collection has finished, remove the sensors from the respiration chamber. Place the peas in a 100 mL beaker filled with cold water and ice.
8. Fill the respiration chamber with water, and then empty it. Thoroughly dry the inside of the respiration chamber with a paper towel.
9. Obtain 25 germinating peas from the cold-water bath and blot them dry between two pieces of paper towel. Use the thermometer to measure the temperature. Record the temperature in Table 1.
10. Place the CO2 Gas Sensor into the neck of the respiration chamber.
11. Wait 4 minutes for readings to stabilize, and then begin collecting data. Collect data for 10 minutes.
12. When data collection has finished, remove the sensors from the respiration chamber. Fill the respiration chamber with water, and then empty it. Thoroughly dry the inside of the respiration chamber with a paper towel.
13. Obtain 25 non-germinating peas and place them in the respiration chamber.
14. Repeat steps 1 through 6 for the non-germinating peas. The non-germinating peas will not be placed in ice water.

Table 1: Comparison of the Rate of Carbon Dioxide Production in Germinating and Non-Germinating Peas

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CO2 Production** (ppm)**Pea Type** | Initial  | **2 min.** | **4 min.** | **6 min.** | **8 min.** | Final  | Total Change in **CO2** Concentration (ppm) | Rate of **CO2** Production (ppm/s) |
| dry, dormant  | 490 | 490 | 491 | 491 | 491 | 492 | 21 | 0.01 |
| room-temperature germinating  | 564 | 599 | 650 | 803 | 924 | 1108 | 544 | 3.02 |
| cold-germinating  | 418 | 490 | 575 | 680 | 703 | 780 | 362 | 2.01 |

Rate of CO2 Production for Peas, Germinating Peas, and Cold-Germinating Peas

In the box below, graph the data collected from the laboratory investigation of the rate of CO2 production for dormant peas, germinating peas, and cold-germinating peas. Create a key with units labeled and compose a title.

Written Analysis

Answer the questions below.

1. In a well-structured paragraph, draw conclusions about the rate of CO2 production for the two types of peas. Include conclusions about the effect of temperature on the rate of cellular respiration.
2. Evaluate the experimental design for adequate controls and measurement techniques.
3. Comment on possible sources of error in the experiment.
4. Suggest improvements in the experimental design.