Cellular Respiration Lab

Overview

In this experiment you will work with seeds that are living but dormant. A seed contains an embryo plant and a food supply surrounded by a seed coat. When the necessary conditions are met, germination occurs and the rate of cellular respiration greatly increases. In this lab you will:

1. measure oxygen consumption during germination
2. measure the change in gas volume in respirometers containing either germinating or nongerminating pea seeds
3. measure the rate of respiration of these peas at two different temperatures.

Introduction

Aerobic cellular respiration is the release of energy from organic compounds by metabolic chemical oxidation in the mitochondria within each cell. Cellular respiration involves a series of enzyme-mediated reactions.

The equation below shows the complete oxidation of glucose. Oxygen is required for this energy-releasing process to occur.

$$\mathbf{C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + 686\ kilocalories\ of\ energy}$$

By studying the equation above, you will notice there are three ways cellular respiration could be measured. One could measure the:

1. Consumption of O_2 (How many moles of O_2 are consumed in cellular respiration?)
2. Production of CO_2 (How many moles of CO_2 are produced in cellular respiration?)
3. Release of energy during cellular respiration

In this experiment the relative volume of O_2 consumed by germinating and nongerminating (dry) peas at two different temperatures will be measured.

Background Information

In this experiment the CO_2 produced during cellular respiration will be removed by potassium hydroxide (KOH) and will form solid potassium carbonate (K_2CO_3) according to the following reaction:

$$\mathbf{CO_2 + 2KOH \rightarrow K_2CO_3 + H_2O}$$

Since the CO_2 is being removed, the change in the volume of gas in the respirometer will be directly related to the amount of oxygen consumed.

In the experimental apparatus shown in Figures 5.1 and 5.2, the water will move toward the region of lower pressure. During respiration, oxygen will be consumed. Its volume will be reduced, and the CO_2 produced is being converted to a solid. The net result is a decrease in gas volume within the tube and a related decrease in pressure in the tube.

The tube with beads alone will allow detection of any changes in volume due to atmospheric pressure changes or temperature changes. It also allows for detection of the amount of CO_2 removed by the KOH.

The amount of O_2 consumed will be measured over a period of time. Six respirometers should be set up as follows:

Respirometer	Temperature	Contents
1	Room	Germinating Seeds
2	Room	Dry Seeds + Beads
3	Room	Beads
4	10°C	Germinating Seeds
5	10°C	Dry Seeds + Beads
6	10°C	Beads

Questions

What is the rate of cellular respiration in germinating versus nongerminating seeds?

What is the effect of temperature on the rate of cell respiration in germinating versus nongerminated seeds?

Hypothesis

[Predict the results for each respirometer and answer the questions. Give explanations]

Variables

independent: [what condition(s) differ for the respirometers?]
dependent: [what is directly affected by the independent variable?]
operational definition of the dependent variable: [what is measured in the experiment that is connected to the dependent variable?]
constants: [what conditions are the same for all respirometers?]

Method

1. Both a room-temperature bath (25°C) and a 10°C bath should be set up immediately to allow time for the temperature of each to adjust. Add ice to attain 10°C.

2. **Respirometer 1**: Obtain a 100-mL graduated cylinder and fill it with 50 mL of H_2O. Drop *25* germinating peas in the graduated cylinder and determine the amount of water that was displaced (which is equivalent to the volume of the peas). Record the volume of the 25 germinating peas. Remove these peas and place them on a paper towel. They will be used in respirometer 1. Pea Volume _____ mL

3. **Respirometer 2**: Refill the graduated cylinder with 50 mL of H_2O. Drop 25 dried peas (not germinating) into the graduated cylinder and then add enough beads to attain a

volume equivalent to that of the expanded germinating peas. Remove these peas and beads and place them on a paper towel. They will be used in respirometer 2.

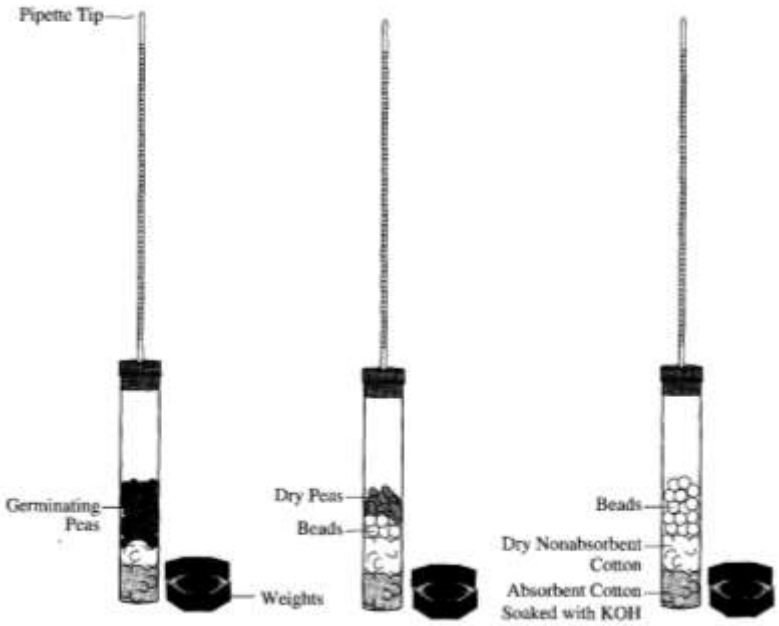
4. **Respirometer 3**: Refill the graduated cylinder with *5*0 mL of H_2O. Determine how many beads would be required to attain a volume equivalent to that of the germinating peas. Remove these beads and place them on a paper towel. They will be used in respirometer 3.

5. Repeat Steps 1—4 to prepare a second set of germinating peas, dry peas plus beads, and beads for use in respirometers 4, 5, and 6, respectively.

6. To assemble the six respirometers, obtain six test tubes, each with an attached stopper and pipette. Label them 1, 2, 3, 4, 5, 6. Place the first set of germinating peas, dry peas plus beads, and beads in tubes 1, 2, and 3, respectively. Place the second set of germinating peas, dry peas plus beads, and beads in vials 4, *5,* and 6, respectively. Place a small piece of cotton on top of the peas/beads of each tube. **Add 1 g of KOH on top of the cotton. It should not touch the peas. Place a small piece of cotton on top of the KOH. (see Figure 5.1 but note that the order is not the same because Figure 5.1 uses aqueous KOH).**

7. Insert the stopper fitted with the calibrated pipette. Place a weighted collar on each end of the tube (see Figure *5.2).*

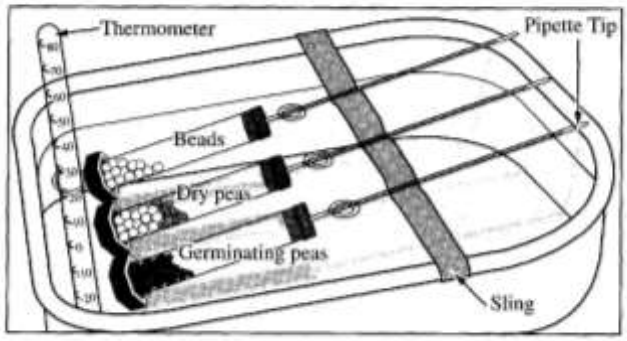
Figure 5.1: Assembled Respirometers



Note: This is the correct order:

←Cotton
←KOH
←Cotton
←Peas/Beads

Figure 5.2: Respirometers Equilibrating in the Water Bath



8. Make a sling of masking tape attached to each side of each of the water baths to hold the pipettes out of the water during an equilibration period of seven minutes. Vials 1, 2, and 3 should rest in the room-temperature water bath (approximately 25°C) and vials 4, *5,* and 6 should rest in the 10°C water bath (see Figure 5.2).

9**.** After the equilibration period of seven minutes, immerse all six respirometers *entirely* in their water baths. Water will enter the pipettes for a short distance and then stop. If the water continues to move into a pipette, check for leaks in the respirometer. Work swiftly and arrange the pipettes so that they can be read through the water at the beginning of the experiment. They should not be shifted during the experiment. Hands should be kept out of the water bath after the experiment has started. Make sure that a constant temperature is maintained.

10. Allow the respirometers to equilibrate for three more minutes and then record, to the nearest 0.01 mL, the initial position of water in each pipette (time 0). Check the temperature in both baths and record it in Table 5.1. Every 5 minutes for 20 minutes, take readings of the water's position in each pipette and record the data in Table 5.1.

Results

Table 5.1: Measurement of O_2 Consumption by Germinating and Nongerminating Pea Seeds at Room Temperature (25°C) and 10°C Using Volumetric Methods

Temp (°C)	Time (min.)	Beads Alone		Germinating Peas			Dry Peas and Beads		
		Volume at time X	Difference*	Volume at time X	Difference*	Corrected difference**	Volume at time X	Difference	Corrected difference**
	0								
	5								
	10								
	15								
	20								
	0								
	5								
	10								
	15								
	20								

*__Difference__ = (volume at time X) — (volume at time 0)

**__Corrected difference__ = (volume at time X — volume at time 0) — (Beads Alone volume at time X — Beads Alone volume at time 0)

[Processed Data: make a graph to display your results. The rate is equal to the slope of the line. The slope of the line = change in y-axis/change in x-axis]

[Written description: describe the results and any observations made during the experiment. Describe the processed data: how was the rate was calculated]

Conclusion

[Explain the difference for germinating and nongerminating seeds. Explain the difference for the two temperatures. What was the *Beads Alone* respirometer for, and what is the *corrected difference*? What was the purpose of the KOH? Why did the water move? (Include mistakes in following the method that may have affected your results)]

Evaluation

[Criticism of the experiment (not mistakes in following the method)]
[New experimental questions]

Your lab report will be assessed by the IB rubric below. Please read the rubric. The IB assessment will be included in the AIS assessment.

IB Assessment: Data Collection and Processing – DCP

Levels/marks	Aspect 1 Recording raw data	Aspect 2 Processing raw data	Aspect 3 Presenting processed data
Complete/2	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Processes the quantitative raw data correctly.	Presents processed data appropriately and, where relevant, includes errors and uncertainties.
Partial/1	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Processes quantitative raw data, but with some mistakes and/or omissions.	Presents processed data appropriately, but with some mistakes and/or omissions.
Not at all/0	Does not record any appropriate quantitative raw data **or** raw data is incomprehensible.	No processing of quantitative raw data is carried out **or** major mistakes are made in processing.	Presents processed data inappropriately **or** incomprehensibly.

AIS Assessment

Title	**Completely**	**Partially**		**Insufficient**
Title summarizes and states the purpose of the experiment.	2	1		0
Problem/Question and Hypothesis	**Completely**	**Mostly**	**Partially**	**Insufficient**
Specific hypotheses/predictions and explanations are provided.	3	2	1	0
Variables	**Completely**	**Mostly**	**Partially**	**Insufficient**
All variables are clearly identified: independent, dependent, constants, and/or operational definition.	3	2	1	0
Results	**Completely**	**Mostly**	**Partially**	**Insufficient**
IB Assessment	6-5	4-3	2-1	0
Conclusion	**Completely**	**Mostly**	**Partially**	**Insufficient**
Explains the results in terms of the hypothesis.	3	2	1	0
Evaluation	**Completely**	**Mostly**	**Partially**	**Insufficient**
Evaluates the experiment critically and offers extensions to the experiment.	3	2	1	0
Format	**Completely**	**Partially**		**Insufficient**
Follows lab report template.	2	1		0

Total ___ / 22 = DCP ___