Measuring the Rate of Cellular Respiration

The relative volume of O_2 consumed by organisms under different conditions can be used as a measure of the rate of cellular respiration. In this experiment, the rate of cellular respiration was measured in germinating and nongerminating (dry) peas kept at two different temperatures. Remember that seeds are living but dormant. A seed contains a plant embryo and a food supply surrounded by a seed coat. When conditions are favorable, germination occurs.

Cellular respiration is the process aerobic cells use to release energy from organic molecules by the oxidation of those molecules in the mitochondria. The process is represented by the equation below:

$C_6H_{12}O_6 + 6O_2$ -----> $6\ CO_2 + 6\ H_2O$ + 686 kilocalories of energy/mole of glucose oxidized

Q. 1 a) Write a hypothesis about the rate of cellular respiration of germinating and dry seeds.
b) Write a hypothesis about the rate of cellular respiration at cooler temperature and warmer temperature.

The equation suggests there are three ways cellular respiration could be measured. We could measure the:
1. Measuring the amount of O_2 consumed.
2. Measuring the amount of CO_2 produced.
3. Measuring the amount of energy released**.**

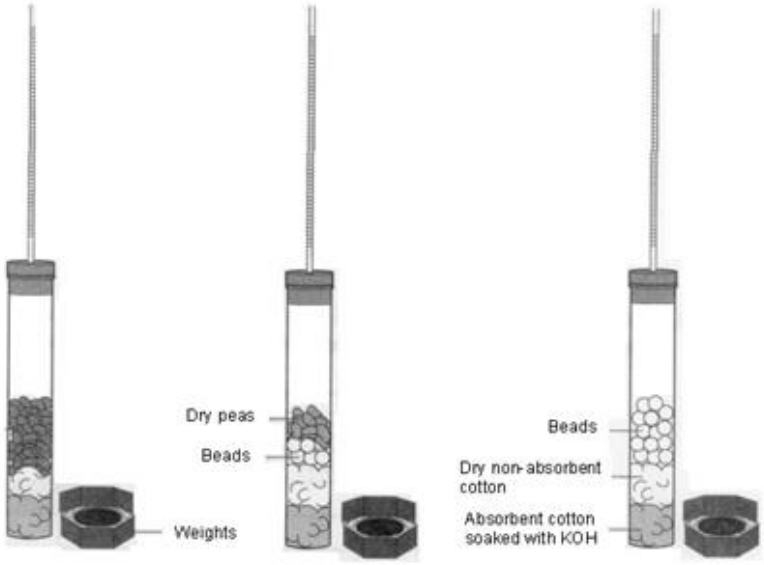
In this experiment, the relative volume of O_2 consumed by germinating and dry peas at two different temperatures was measured.

The apparatus used in the experiment takes advantage of the laws that govern the behavior of gases. The laws are summarized in the general gas law that states:

$PV = nRT$ where, P is the pressure of the gas,
V is the volume of the gas,
n is the number of molecules of gas,
R is the gas constant
T is the temperature of the gas (in ^oK).

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:

$$CO_2 + 2KOH \rightarrow K_2CO_3 + H_2O$$



The experiment was performed in a device called a respiromoter (see Figure 1). 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. During respiration, oxygen will be consumed and the volume of gas in the respirometer will be reduced because 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, allowing water to move into the tube. The amount of O_2 consumed will be measured over a period of time.

Figure 1 Assembled Respiromoters

Six respirometers were prepared, as outlined in Table 1. It is important that each respirometer contained the same volume of materials.

Table 1: Preparation of respirometers

Respirometer	Temperature (°C)	Contents
1	25	25 Germinating Seeds
2	25	25 Dry Seeds + Beads
3	25	Beads
4	10	25 Germinating Seeds
5	10	25 Dry Seeds + Beads
6	10	Beads

Each respirometer tube was placed in a water bath of the appropriate temperature so that the end of the pipette was under water. Water entered the pipettes for a short distance and then stopped. The initial position of the water in each pipette was recorded to the nearest 0.01 mL as time 0. The position of the water was then recorded every 5 minutes for 20 minutes and recorded in Table 1.

Table 1: Measurement of O_2 Consumption by Soaked and Dry Pea Seeds at 25°C and 10°C

Temp (°C)	Time (min)	Beads Alone		Germinating Peas			Dry Peas and Beads		
		Reading at time X	Diff.*	Reading at time X	Diff.*	Corrected diff.**	Reading at time X	Diff.*	Corrected diff.**
25	Initial	0.93		0.91			0.92		
	5	0.91		0.84			0.89		
	10	0.90		0.77			0.87		
	15	0.90		0.71			0.87		
	20	0.90		0.64			0.85		
10	Initial	0.95		0.92			0.91		
	5	0.94		0.88			0.90		
	10	0.92		0.85			0.87		
	15	0.93		0.83			0.86		
	20	0.93		0.80			0.85		

* Difference = (initial reading at time 0) - (reading at time X)
** Corrected difference = (initial pea seed reading at time 0 - pea seed reading at time X) - (initial bead reading at time 0 - bead reading at time X)

Questions

2. Identify some of the variables that were controlled in the experiment.
3. Explain why water moved into the respirometers.
4. Draw a graph of O_2 consumption versus time for all four treatment groups.
5. Describe and explain the relationship between O_2 consumption and time.
6. From the slope of the four lines on the graph, determine the rate of O_2 consumption (in mL O_2 /min) for all four treatment groups. Remember from math class that the rate can be found by calculating $\Delta Y/\Delta X$. (I guess math is useful after all!)
7. Why is it necessary to correct the readings from the peas with the readings from the beads?
8. Explain the difference in O_2 consumption between germinating and dry peas.
9. a) Predict the results of a similar experiment using a 25 g mammal and a 25 g reptile at 10°C. Justify your answer.

b) Predict the results of a similar experiment using a small mammal at 10°C and at 25°C. Justify your answer.