Cellular Respiration and Photosynthesis

INTRODUCTION

Respiration is important in maintaining the energy needs of the cell. In photosynthesis light energy is changed to chemical energy and stored in food. As organisms carry on life functions, food passes through the steps of glycolysis. In yeast and some bacteria when oxygen is not present (anaerobic), alcoholic fermentation is the metabolic pathway for the release of ATP. When oxygen is present (aerobic), the metabolic pathway proceeds through the steps of respiration, namely the Krebs cycle and the electron transport phosphorylation for a higher yield of ATP.

Objectives

Having completed the labs on respiration and photosynthesis, the student will be able to:

1. Describe alcoholic fermentation, naming the substrate and products.
2. List reactants and products in anaerobic and aerobic respiration.
3. Correlate temperature to rates of anaerobic respiration.
4. Discuss the role of chlorophyll in photosynthesis.
5. Explain why a green plant, when kept in the dark, dies.
6. State the value of starch as a plant storage product.
7. Explain the relationship between matter, energy, respiration, and photosynthesis.
8. Explain which organisms conduct respiration and which conduct photosynthesis.

PART I

YEAST AND ANAEROBIC FERMENTATION

In alcoholic fermentation, sugars are broken down into ethyl alcohol (ethanol) and carbon dioxide. In the process, some of the energy that had been stored in the glucose bonds is used to form high energy bonds in ATP. The enzymes that function in this conversion are affected by pH, temperature, salt concentration, amounts of enzyme, and substrates used. This exercise demonstrates only one variable.

Materials

Yeast in 20% sucrose solution (Instructor will prepare 30 minute before class: 3 g yeast in 150 mL 20% sucrose solution at room temperature), 3 small test tubes, 3 large vials, thermometer, ice, felt marking pen, metric ruler, slide, cover slip, compound microscope, and three 150 mL beakers.

Procedure

1. Prepare water baths of 50 mL each in three 150 mL beakers. Using hot water from the tap, adjust the temperature in one beaker to 34°C, in the second adjust the temperature to 22°C, and in the third add ice to adjust the temperature to 10°C.

2. Fill three small test tubes with the yeast suspension in 20% sucrose. Place a vial over each test tube and with the opening of the test tube against the bottom of the vial invert each of the vials. The yeast suspension will remain in the inverted test tube.

3. Mark the level of the yeast suspension on each vial with a felt marking pen.

4. Place one of the inverted yeast vials in the hot water (34°C), one in the cold water (10°C), and one in the bath at room temperature (22°C).

5. Check the vials at 5 minute intervals and measure any changes in the level of the yeast suspension from the original marked level using a ruler. Record measurements (mm) in the table below.

Table 1. Fermentation-measured by the decrease in fluid level (mm)

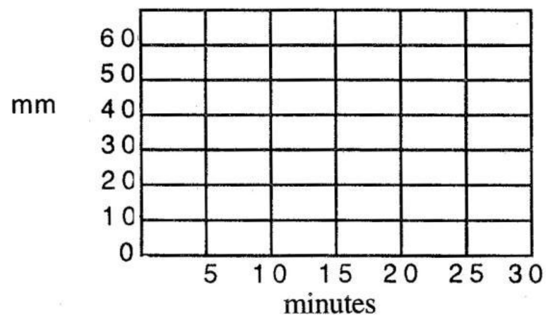
Minutes	10ºC	22ºC	34ºC
0	0 mm	0 mm	0 mm
5			
10			
15			
20			
25			
30			

6. Maintain temperature of the hot water and cold water within 3°C of the original temperatures by adding hot water or ice to the beakers.

7. Allow the experiment to continue 30 minutes ***or*** until the level of the yeast suspension in any one tube becomes too low to measure.

8. Plot the drop in fluid level in each tube against time on the graph. ***Label*** each line on the graph.

Graph 1. Fermentation rates



9. What is the effect of temperature on anaerobic respiration?

10. Give the OVERALL reaction of the anaerobic respiration found in yeast.

11. Name the gas produced in the tube(s).

12. Where did the matter that makes up this gas come from?

PLANT METABOLISM

Respiration is a process by which living organisms extract energy from food. In the previous section, you observed the process of anaerobic fermentation, which does not use oxygen. Aerobic respiration requires oxygen and is used by most living organisms.

Photosynthesis is a chemical process whereby radiant energy is changed to chemical energy and stored in a transfer product. This transfer product is in the form of the basic food nutrients: carbohydrates, lipids, and proteins. Organisms such as plants and algae are photoautotrophs, meaning that they make their own food using solar energy.

1. In each of 12 petri dishes, place a 7.5-cm paper filter. Note: Absorbent paper towels or coffee filters can be substituted for the filter paper.
2. To 6 Petri dishes, add 3 ml of distilled water (dH_2O).
3. Measure 12 sets of radish seeds, each having a mass of 1.5 g using a digital balance.
4. To each dish, add the seeds, spaced relatively evenly across the filter paper.
5. Wrap 3 dry dishes and 3 dishes with dH_2O in a single piece of foil to keep them dark.
6. Place all of the dishes near the window. Incubate the seeds for 4-7 days.

Experimental Design, Hypotheses and Predictions

1. What are your treatments in the plant experiment?

2. What is the response variable (dependent variable) in this experiment?

3. What patterns do you expect to observe in each of the treatments and why?

PART II

PLANT METABOLISM, CONT.

7. At the end of the incubation period, dry the content of the dishes in a drying oven for an hour. When dry, measure the mass of the plant material (including seeds) of each plate using a balance.

Table 2. Dry mass of radishes (g).

	Initial Dry Mass (g)			Final Dry Mass (g)		
Treatment	**Plate 1**	**Plate 2**	**Plate 3**	**Plate 1**	**Plate 2**	**Plate 3**
Dark, No Water	1.5 g	1.5 g	1.5 g			
Dark, Water	1.5 g	1.5 g	1.5 g			
Light, No Water	1.5 g	1.5 g	1.5 g			
Light, Water	1.5 g	1.5 g	1.5 g			

Table 3. Change in dry mass of radishes (g).

	Change in Dry Mass		
Treatment	**Plate 1**	**Plate 2**	**Plate 3**
Dark, No Water			
Dark, Water			
Light, No Water			
Light, Water			

Data Analysis and Interpretation

1. Graph your results for the plant experiment below.

2. Did the data support your hypotheses? Why or why not?

3. What metabolic processes might explain the patterns that you have observed? Name the metabolic process(es) that is/are taking place in the plant experiment. Provide relevant OVERALL reaction(s).

Effect of Plant Pigments

Chlorophyll and Anthocyanin

Sugars produced in excess of need will be stored as starch in the leaves of *Coleus*. The red pigment of plants is called anthocyanin.

Materials

Variegated Coleus leaf, alcohol, water, 150 mL beaker, 400 mL beaker, hot plate, petri dish, Iodine solution.

Procedure

1. Select a *Coleus* leaf showing white, red, and green regions and make a drawing of the leaf, noting various ***colors*** in the leaf.

2. Soften the leaf by boiling it in water 20 – 30 seconds. Use 250 mL of water in the 400 mL beaker. ***Draw*** the leaf noting any color changes.

3. Place 50 mL of alcohol in a 150 mL beaker and set into the 400 mL boiling water bath. Transfer the leaf to the alcohol and heat the water bath until the chlorophyll dissolves from the leaf. ***Draw*** the leaf noting any color changes.

4. Transfer the leaf to a petri dish and cover with Iodine solution for five minutes. ***Draw*** the leaf noting any color changes.

Questions

1. In what solvent is anthocyanin soluable?

2. In what solvent is chlorophyll soluable?

3. What is the purpose of Iodine solution in this exercise?

4. Compare all your drawings: Indicate yes or no if starch was found under these pigments (colors) of the ***original leaf***.

	Is starch present?
chlorophyll only (green only)	
anthocyanin only (red only)	
chlorophyll and anthocyanin (purple/brown	
only) no pigment (white/light yellow)	

5. Starch is a measure of the occurrence of photosynthesis in this exercise. Which pigment(s) is/are ***required*** for photosynthesis?

6. Cite evidence *from this exercise*, that starch is a good storage product?

Effect of Light

Materials

A *Coleus* leaf partially covered with cardboard and exposed to 24 hours of visible light plus the materials used in the preceding experiment.

Procedure

Select a leaf partially covered with cardboard. ***Remove*** the cardboard and repeat the preceding exercise.

Drawing (with cardboard removed)

Drawing (after boiling in water)

Drawing (after boiling in alcohol)

Drawing (after covering with Iodine solution)

Questions

1. What areas of the leaf contain no starch.

2. What effect does covering the leaf have upon starch production (photosynthesis)?

3. Would the part of the leaf receiving no visible light be ***dead*** at the end of the 24-hour period? Explain. (Hint: Compare the covered area to the areas of the leaf that have no pigment or anthocyanin only.)