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Lab Activity: Exercise & Cellular Respiration

Purpose: The purpose of this lab activity is to analyze the effect of exercise on cellular respiration by measuring carbon dioxide production, breathing rate and heart rate.

Background: Cellular respiration is a chemical reaction that occurs in your cells to create energy (see chemical equation below); when you are exercising your muscle cells are creating ATP to contract. Cellular respiration needs oxygen (which is breathed in) and produces carbon dioxide (which is breathed out).

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + 36\ ATP\ (energy)$$

This lab will investigate how exercise (increased muscle activity) affects the rate of cellular respiration. You will measure 3 different indicators of cellular respiration: breathing rate, heart rate, and carbon dioxide production. You will measure these indicators at rest (with no exercise) and after 1 and 2 minutes of exercise. Breathing rate is measured in breaths per minute, heart rate in beats per minute, and carbon dioxide in the time it takes bromothymol blue (BTB) to change color. Carbon dioxide production can be measured by breathing through a straw into a solution of BTB. BTB is an acid indicator; when it reacts with acid it turns from blue to yellow. When carbon dioxide reacts with water, a weak acid (carbonic acid) is formed (see chemical equation below). The more carbon dioxide you breathe into the BTB solution, the faster it will change color to yellow.

$$6\ CO_2 + 6\ H_2O \rightarrow 6\ HCO_3 + 6\ H^+$$

Materials:

- 2 test tubes
- Bromothymol blue solution (BTB)
- 2 Straws
- Stop watch/timer

Pre-Lab: Use your background information AND your Cellular Respiration notes to answer the following pre-lab questions:

1. What is the **equation for cellular respiration**? Label the reactants and the products.

2. In what **part of the cell** does cellular respiration occur?

3. Does cellular respiration happen **in ALL types of cells**? Explain why or why not.

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4. Write a hypothesis: do you think your body will produce **more or less** carbon dioxide as you exercise?

Hypothesis:

_____

_____

_____

Safety concerns in this lab
Label Hazard Warning:
CAUTION! MAY BE HARMFUL IF SWALLOWED. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT

Procedure:

PART A: Resting (no exercise) – DO THIS BEFORE EXERCISING!!

Measuring Carbon Dioxide Production:

1. Use a graduated cylinder to measure out 20 mL of tap water and pour it into a test tube.

2. Use a dropper to add 8 drops of bromothymol blue to make a BTB solution.

3. Using a straw, exhale *SLOWLY* into the BTB solution. **(CAUTION: Do not inhale the solution!)**

4. Have one partner time how long it takes for the solution to turn yellow. Record the time in Table 1.

5. Wash out the test tube and repeat steps 1-4 twice more. Average the results of the 3 trials and record this in Table 1.

Measuring Breathing Rate:

1. Count the number of breaths (1 breath = inhale + exhale) you take in 1 minute. Record this in Table 2.

2. Repeat this 2 more times and average the 3 trials to get your average breathing rate. Record this in Table 2.

Measuring Heart Rate:

1. While you calculate your breathing rate, have your partner take your pulse.

2. Count the number of beats in 30 seconds and multiply that number by 2. Record in Table 3.

3. Repeat this 2 more times and average the 3 trials to get your average heart rate. Record this in Table 3.

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PART B: Increased Muscle Activity (Exercise) – DO THIS AFTER EXERCISING FOR 1 and 2 MINUTES!!

1. Exercise for exactly 1 minute by doing **jumping jacks**.

2. While you are exercising, your partner should get the BTB solution ready as in Part A.

3. After 1 minute of exercise, immediately exhale *SLOWLY* through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in Table 1.

4. Quickly calculate your breathing and heart rates as you did before. You only need to do this once.

5. Record these values in Tables 2 & 3. Remake your BTB solution.

6. Exercise as you did before, but for 2 continuous minutes by doing **jumping jacks**.

7. Immediately exhale *SLOWLY* through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in Table 1.

8. Quickly calculate your breathing and heart rates as you did before. You only need to do this once.

9. Record these values in Tables 2 & 3.

10. If there is time, have your lab partner repeat the entire procedure. Record data from 1 OR 2 other students in the class to get more data.

Results:

Table 1. Carbon Dioxide Production (time it takes BTB to change color in test tube)

		Student 1	Student 2	Student 3	AVERAGE
RESTING (before exercise)	Trial 1				
	Trial 2				
	Trial 3				
	AVERAGE				
EXERCISE	1 minute				
	2 minutes				

Table 2. Breathing Rate (BPM – breaths per minute)

		Student 1	Student 2	Student 3	AVERAGE
RESTING (before exercise)	Trial 1				
	Trial 2				
	Trial 3				
	AVERAGE				
EXERCISE	1 minute				
	2 minutes				

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Table 3. Heart Rate (BPM – beats per minute)

		Student 1	Student 2	Student 3	AVERAGE
RESTING (before exercise)	Trial 1				
	Trial 2				
	Trial 3				
	AVERAGE				
EXERCISE	1 minute				
	2 minutes				

Analysis & Conclusions: Answer the questions below using your BACKGROUND information in the lab, as well as your lab data. **ANSWER THE QUESTIONS IN COMPLETE SENTENCES**

1. How did exercise affect the time needed for the solution to change color? Explain why the color change occurred (how does BTB work?)

2. What can you conclude about the effect of exercise on the amount of carbon dioxide that is present in your exhaled breath? Why is this so?

3. What can you conclude about the effect of exercise on breathing rate? Why is this so?

4. What can you conclude about the effect of exercise on heart rate? Why is this so? What do your muscles need during exercise that the blood carries?

5. Was your hypothesis correct or incorrect? Explain. Make sure to discuss what you think is going on in the muscles of the body as muscle activity is increased. *Remember, you need to get oxygen to the muscle cells while also getting rid of carbon dioxide; this is how our muscles get the energy they need to contract.*