Exercise & Cellular Respiration

Purpose:

The purpose of this lab activity is to analyze the affect of exercise on cellular respiration.

Background:

I. Purpose.

- To observe the effects of exercise on cellular respiration.
- To identify the role of carbon dioxide production, breathing rate, and heart rate in determining the rate of cellular respiration.

II. Background Information.

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

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

This lab will address 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 bromthymol blue to change color.

Carbon dioxide production can be measured by breathing through a straw into a solution of bromthymol blue (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 reaction below*) . The more carbon dioxide you breathe into the BTB solution, the faster it will change color to yellow.

$$6\ CO_2 + 6\ H_2O \longrightarrow 6\ HCO_3 + 6\ H+$$

Materials:

Beaker/Test tube/cup
bromthymol blue solution (BTB)
straw
stop watch

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** which items are the **reactants** and the **products**.
2. In what part of the cell does cellular respiration occur?
3. **Write a prediction/hypothesis** of how exercise will affect your body's production of carbon dioxide (i.e. do you think your body will produce *more* or *less* carbon dioxide as you exercise). Make sure you **EXPLAIN WHY** you feel that way.

Procedure:

PART A: Resting (no exercise)

Measuring Carbon Dioxide Production:

1. Use a graduated cylinder to measure out 20 mL of tap water and pour it into a small beaker.
2. Use a dropper to add 8 drops of bromthymol blue to make a BTB solution.
3. Using a straw, exhale into the BTB solution. (CAUTION: Do not inhale the solution!)
4. Time how long it takes for the blue solution to turn yellow. Record the time in **Table 1**.
5. Wash out the beaker repeat steps 1-4 twice more.
6. Average the results of the 3 trials. 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.
3. 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 this in **Table 3**.
3. Repeat this 2 more times.
4. Average the 3 trials to get your average heart rate. Record this in **Table 3**.

PART B: Increased Muscle Activity (Exercise)

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 through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in **Table 1**.
4. Then 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.
7. Immediately exhale through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in **Table 1**.
8. Then 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, repeat the entire procedure for your lab partner. Record data from 2 OR 3 other subjects in the class to get more data depending on if you partner was able to go or not.

Results:

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

		Student 1	Student 2	Student 3	Student 4	Average
RESTING	Trial 1					
	Trial 2					
	Trial 3					
	Average					
EXERCISE	1 minute					
	2 minutes					

Table 2. Breathing Rate (breaths/minute)

		Student 1	Student 2	Student 3	Student 4	Average
RESTING	Trial 1					
	Trial 2					
	Trial 3					
	Average					
EXERCISE	1 minute					
	2 minutes					

Table 3. Heart Rate (beats/minute)

		Student 1	Student 2	Student 3	Student 4	Average
RESTING	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 brings?

5. State whether your hypothesis was correct or incorrect and why. In doing so, discuss what you think is going on in the muscles of the body as muscle activity is increased. Address the need to get oxygen to the muscles and get rid of carbon dioxide, as well as how the muscles cells get the energy needed to continue contracting.