Lab: Chapter 9 Muscle Fatigue & ATP Production

Name: _____
Hour: _____ **Date:** _____
_____/20 Points

Purpose: In this activity students will investigate cellular respiration, and the factors that affect skeletal muscle fatigue.

Objectives:
. To observe skeletal muscle fatigue.
. To explain the relationship between muscle fatigue, cellular respiration and ATP production.
. To chart and interpret the results obtained.

Background Information:
Just as an automobile must be supplied with gasoline as a source of energy before it can move, so too your muscles require energy in order to contract. This energy, in the form of ATP, can be produced with oxygen (Aerobic respiration) or without oxygen (Anaerobic respiration). In animal cells the anaerobic process is called Lactic Acid Fermentation, and it occurs when there isn't any oxygen available in the cells for aerobic respiration. This buildup of lactic acid, as a product of this anaerobic respiration, reaches a point where the muscles have a reduced ability to contract, until eventually exhaustion sets in and contraction of the muscle will stop. This is muscle fatigue. Similarly, in the case of the automobile when the waste products (exhaust) cannot be removed and build up inside the engine, the automobile will stop (stall).

Pre Lab Questions:
1. Describe two situations that you are aware of that you are unable to maintain or supply the demand for oxygen for certain muscles. **(1 Point)**

A. _____ B. _____

2. Write the chemical equations for aerobic respiration and anaerobic respiration (lactic acid fermentation). **(2 Points)**
   Aerobic: _____

   Anaerobic: _____

3. In terms of ATP, how much more energy does the aerobic respiration process produce? **(1 Point)** _____

4. How are the reactants delivered to the cell? **(1 Point)**_____

Materials
- Clothes pin 
- Timer 

Procedure:

1. Hold a clothes pin in the thumb and index finger of the dominant hand and open and close it while the other fingers of the hand are held out straight. The number of times the clothes pin opens to its maximum distance in 30 seconds is recorded. Students should attempt to squeeze quickly and completely, to get the maximum number of squeezes for each trial.

2. Repeat this process for nine more 30 second trials recording the result for each trial. **Do not rest the fingers between trials.**

3. Repeat steps 1 and 2 for the non-dominant hand. Record all data in the table below. **(5 Points)**

Number of Squeezes in 30 Seconds

TRIAL	# of Squeezes in 30 Seconds Dominant Hand	# of Squeezes in 30 Seconds Non-Dominant Hand
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

4. Prepare a **line graph** of the data you collected. There is a graph on the next page. The trial number is the independent variable and the number of squeezes is the dependent variable. Make sure to label your axes clearly and give your graph a clear, detailed title. **(5 Points)**

Investigation Questions (1 Point Each)

1. What happened to your "strength" as you progressed through each trial? How does your graph show this? _____

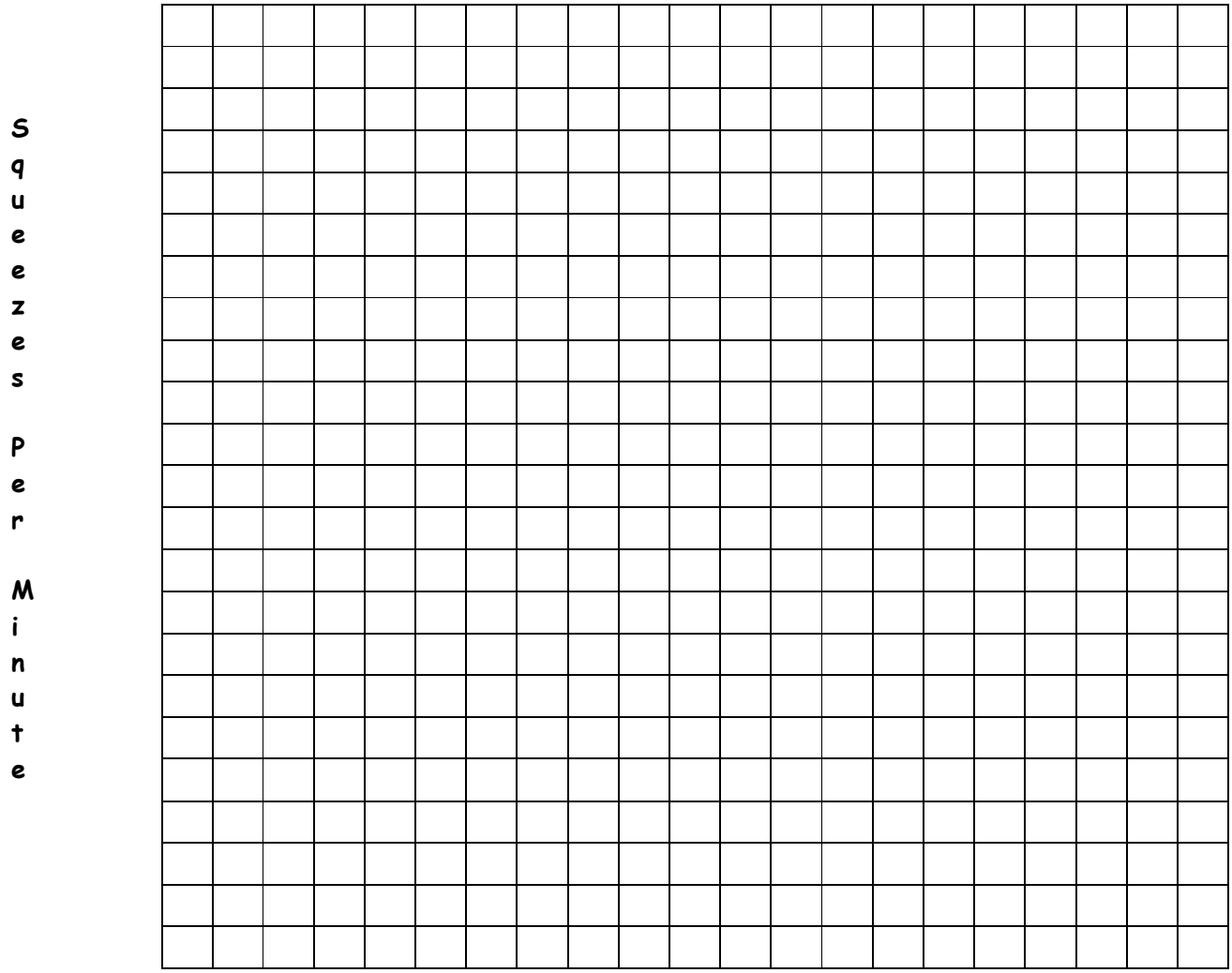
2. What physiological (body) factors might cause one to get more squeezes, in other words, to have less fatigue?(Hint: consider how the reactants of aerobic respiration get to your muscle cells)____
   _____
   _____

3. Your muscles would probably recover enough after 10 minutes to operate at the original efficiency. Explain why._____

4. Explain how the products of anaerobic respiration cause your cells to be less efficient. _____
   _____

5. What is the relationship between the strength of your heart and aerobic respiration? _____
   _____

Graph Title: _____



Key:

- Dominant Hand
- Non-Dominant Hand

Calculations

To open and close the clothes pin, we must overcome the force of the spring holding the clothes pin together. To do this requires work. Energy is used to perform work. Work is measured in units known as ***joules***. The amount of work needed to squeeze open the clothes pin completely is equivalent to:

Work = 1 Joule/Squeeze

To find the total work expended by your hand, you will need to multiply the amount of work needed to open the clothes pin by the number of times the clothespin was squeezed open. You must first **ADD** up the total number of times(for all 10 trials) the clothes pin was opened for the dominant and non-dominant hand. Write those values below.

TOTAL # OF SQUEEZES FOR DOMINANT HAND = _____
TOTAL # OF SQUEEZES FOR NON-DOMINANT HAND = _____

Do the following mathematical calculations to figure out the total work each hand did:

Total Work = 1 Joule/Squeeze X _____ Total # of Squeezes for Dominant Hand = _____ Joules of Work

Total Work = 1 Joule/Squeeze X _____ Total # of Squeezes for Non-Dominant Hand = _____ Joules of Work

Joules can be converted into units of energy known as ***calories***:

1 Joule = .24 Calories

To convert the joules (those produced during total squeezes for the dominant and non-dominant hands) to calories, use the following equation:

_____Dominant Hand Joules of Work x .24 Calories/Joule = _____Calories
_____Non-Dominant Hand Joules of Work x .24 Calories/Joule = _____Calories

It requires 7,300 calories to create 1 mole of ATP. One mole of ATP can also use 7,300 calories to perform work. (In our case, the movement of muscles to open and close a clothes pin) Remember that the word "mole" is referring to a specific amount:

602,000,000,000,000,000,000,000 ***-or-*** (6.02×10^{23})

To determine the actual number of moles of ATP used in opening the clothes pin for 10 trials, complete the following equation:

$$\frac{\text{\# of Calories Used to Open Clothes Pin}}{\text{7300 Calories/Mole of ATP}} = \text{Moles of ATP Used}$$

For Dominant Hand: _____Calories Used ÷ 7300 = _____ Moles of ATP Used

For Non-Dominant Hand: _____Calories Used ÷ 7300 = _____ Moles of ATP Used

To determine the actual number of ATP's used in opening and closing the clothes pin, complete the following equation:

(# of Moles of ATP) **X** $(6.02 \times 10^{23}$ ATP/mole) = # of ATP's Used

For Dominant Hand: _____Moles of ATP **X** 6.02×10^{23} ATP/mole = _____ATP's Used

For Non-Dominant Hand: _____Moles of ATP **X** 6.02×10^{23} ATP/mole = _____ATP's Used

Conclusion: Which one used more ATP's during the 10 trials of opening and closing the clothes pin, the dominant or non-dominant hand? Explain this finding. _____