Lab: Muscle Fatigue & ATP Production

Name: _____

K /5 C /5 T /12

Purpose: In this activity you will investigate lactic acid fermentation and the factors that affect skeletal muscle fatigue.

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: [5K]

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]

   A. _____ B. _____

2. Write the chemical equations for aerobic respiration and lactic acid fermentation. [2]

   Aerobic: _____

   Anaerobic: _____

3. In terms of ATP, how much more energy does the aerobic respiration process produce than anaerobic respiration? [1] _____

4. How are the reactants for aerobic & anaerobic respiration delivered to the cell? [1] _____

Materials:

Clothes pin 

Timer 

Procedure:

1. Hold a clothes pin in the thumb and index finger of your dominant hand. Open and open it all the way and close it **as fast as possible in 30 seconds** while the other fingers of the hand are held out **straight**. Have a partner record the number so you can **continue without resting**.

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 FINGERS BETWEEN TRIALS

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

Observations:

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

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

Investigation Questions: [T9]

1. a. What happened to your energy & ability to pinch the clothes pin as you progressed through each trial? **WHY?** [2]

   b. How does your graph show this? [1]

2. What might cause one to be able to get more squeezes, in other words, to have less fatigue? Explain [2] *Think in terms of biology*

3. Your muscles would probably recover enough after 10 minutes to operate at the original efficiency. Explain why. [2]

4. Explain how the products of anaerobic respiration cause your cells to be less efficient. [2]

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 **1 Joule/Squeeze**

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

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

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

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

Total 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:

_____Total 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:

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

_____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

_____Moles of ATP X 6.02×10^{23} ATP/mole = _____ATP's Used

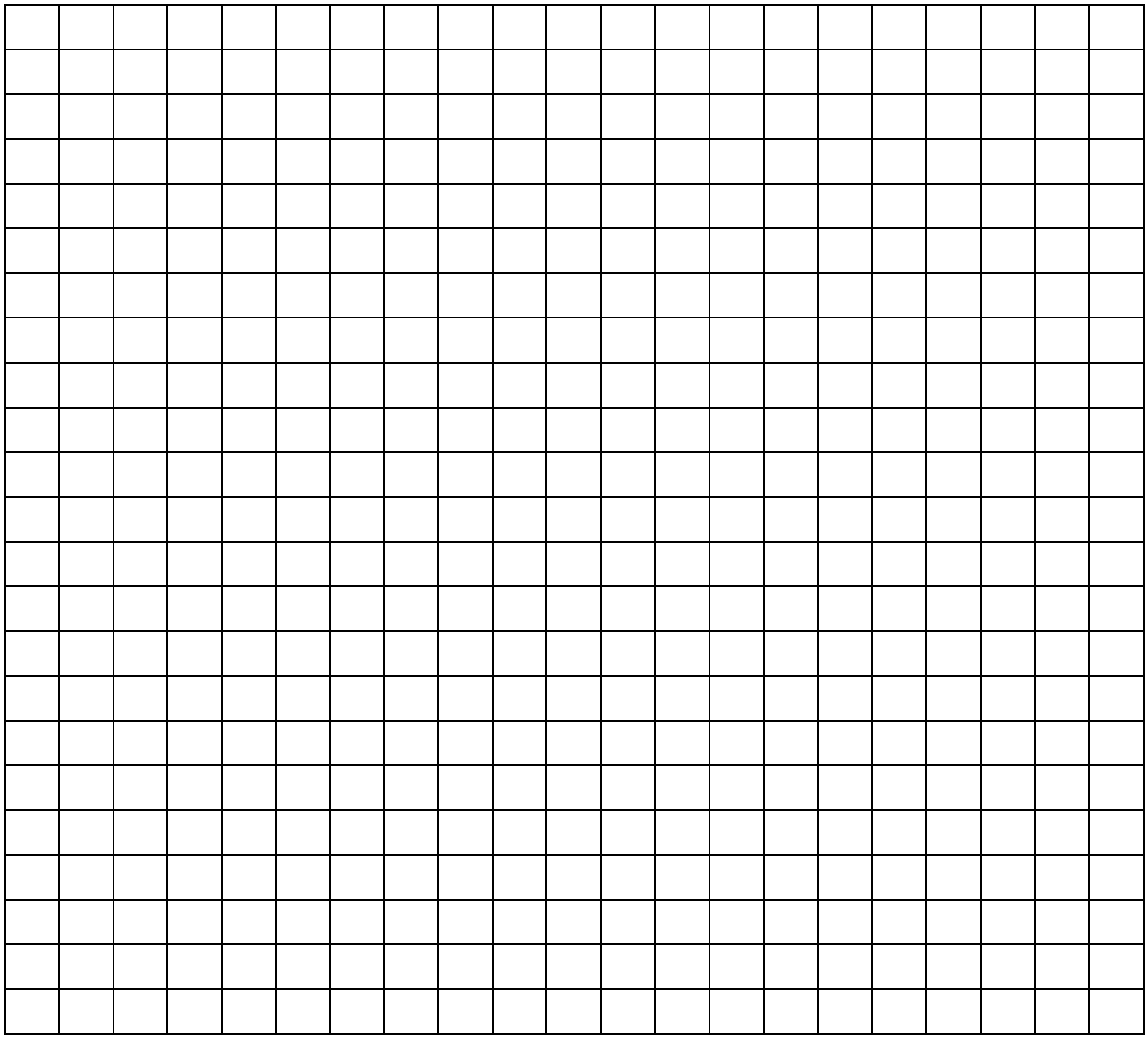
Conclusion: [T 3]
5. How many molecules of glucose needed to be broken down in order to produce this much ATP if:
a) It the ATP was produced aerobically?[1]

b) It the ATP was produced anaerobically? [1]

6. When do you suspect your energy production went from aerobic to anaerobic? How could you tell?

Graph [C5]

Squeezes Per **Minute**



Trial

Legend:

- ○ Dominant Hand
- ○ Non-Dominant Hand