Homework due February 24, 2015 at 8am – KEY

ACTIVITY 1 The Muscle Twitch and the Latent Period

1. Define the terms *skeletal muscle fiber, motor unit, skeletal muscle twitch, electrical stimulus,* and *latent period.*
   See definitions provided in the Introduction.

2. What is the role of acetylcholine in a skeletal muscle contraction?
   Acetylcholine binds to receptors in the motor end plate, initiating a change in ion permeability that results in the end-plate potential.

3. Describe the process of excitation-contraction coupling in skeletal muscle fibers.
   Excitation-contraction coupling is the release of calcium which binds to troponin, removing the blocking action of tropomyosin so that myosin can bind to actin.

4. Describe the three phases of a skeletal muscle twitch.
   Latent period is the time preparing for contraction. Contraction is when muscle tension peaks. The relaxation period is at the end of muscle contraction.

5. Does the duration of the latent period change with different stimulus voltages? How well did the results compare with your prediction?
   The latent period did not change with changes in stimulus voltage.

6. At the threshold stimulus, do sodium ions start to move into or out of the cell to bring about the membrane depolarization?
   Sodium would move into the cell to bring about membrane depolarization.

ACTIVITY 2 The Effect of Stimulus Voltage on Skeletal Muscle Contraction

1. Describe the effect of increasing stimulus voltage on isolated skeletal muscle. Specifically, what happened to the muscle force generated with stronger electrical stimulations and why did this change occur? How well did the results compare with your prediction?
   The active force increased as predicted to the point in which it reached a plateau and was no longer able to increase.

2. How is this change in whole-muscle force achieved in vivo?
   This is achieved by the recruitment of more muscle cells over time.

3. What happened in the isolated skeletal muscle when the maximal voltage was applied?
   All of the muscle cells have been recruited and so the maximal force has been achieved.

ACTIVITY 3 The Effect of Stimulus Frequency on Skeletal Muscle Contraction

1. What is the difference between stimulus intensity and stimulus frequency?
   The stimulus intensity is the electrical changes that relate to the action potential. The

frequency is the number of action potentials per minute.

2. In this experiment you observed the effect of stimulating the isolated skeletal muscle multiple times in a short period with complete relaxation between the stimuli. Describe the force of contraction with each subsequent stimulus. Are these results called treppe or wave summation?
   With complete relaxation, it would be treppe. This is the staircase effect, where you see an increase in the force/tension produced.

3. How did the frequency of stimulation affect the amount of force generated by the isolated skeletal muscle when the frequency of stimulation was increased such that the muscle twitches did not fully relax between subsequent stimuli? Are these results called treppe or wave summation? How well did the results compare with your prediction?
   The voltage needed to increase because the tension wasn't great enough at the lower voltage. This is consistent with wave summation.

4. To achieve an active force of 5.2 g, did you have to increase the stimulus voltage above 8.5 volts? If not, how did you achieve an active force of 5.2 g? How well did the results compare with your prediction?
   Yes, it was necessary to increase the voltage above 8.5 volts to achieve the active force of 5.2 grams.

5. Compare and contrast frequency-dependent wave summation with motor unit recruitment (previously observed by increasing the stimulus voltage). How are they similar? How was each achieved in the experiment? Explain how each is achieved in vivo.
   Both frequency-dependent wave summation and increased motor unit recruitment are ways of increasing the force exerted by the muscle. However, wave summation depends on the FREQUENCY of stimulation by the nervous system, while motor unit recruitment depends on the "intensity" of a given stimulus (how many of the motor units were activated).

ACTIVITY 4 Tetanus in Isolated Skeletal Muscle

1. Describe how increasing the stimulus frequency affected the force developed by the isolated whole skeletal muscle in this activity. How well did the results compare with your prediction?
   The force developed increases as the stimulus frequency increases—to a point.

2. Indicate what type of force was developed by the isolated skeletal muscle in this activity at the following stimulus frequencies: at 50 stimuli/sec, at 140 stimuli/sec, and above 146 stimuli/sec.
   At 50 stimuli/sec: 5.12 g. At 140 stimuli/sec: 5.91 g. Above 146 stimuli/sec: 5.95 g.

3. Beyond what stimulus frequency is there no further increase in the peak force? What is the muscle tension called at this frequency?
   After 146 stimuli/sec there is no further increase in force. This is the maximal tetanic tension.

ACTIVITY 5 Fatigue in Isolated Skeletal Muscle

1. When a skeletal muscle fatigues, what happens to the contractile force over time?
   When skeletal muscle fatigues, the contractile force decreases over time.

2. What are some proposed causes of skeletal muscle fatigue?
   The buildup of lactic acid, ADP, and inorganic phosphate are thought to be involved in muscle fatigue.

3. Turning the stimulator off allows a small measure of muscle recovery. Thus, the muscle will produce more force for a longer time period if the stimulator is briefly turned off than if the stimuli were allowed to continue without interruption. Explain why this might occur. How well did the results compare with your prediction?
   When you increase the rest periods, you see an increase in the muscle tension produced.

4. List a few ways that humans could delay the onset of fatigue when they are vigorously using their skeletal muscles.
   They could periodically rest during vigorous exercise. [This is a bad answer to a bad question.]

ACTIVITY 6 The Skeletal Muscle Length-Tension Relationship

1. What happens to the amount of total force the muscle generates during the stimulated twitch? How well did the results compare with your prediction?
   Total force can increase or decrease depending upon the starting resting length. This is due to the length-tension relationship of the sarcomere.

2. What is the key variable in an isometric contraction of a skeletal muscle?
   The muscle's length, which will determine the amount of force according to the length-tension relationship.

3. Based on the unique arrangement of myosin and actin in skeletal muscle sarcomeres, explain why active force varies with changes in the muscle's resting length.
   The active forces vary with the number of actin-myosin crossbridges formed, which changes with the length of the muscle.

4. What skeletal muscle lengths generated passive force? (Provide a range.)
   The muscle lengths from 80 to 100 mm generated passive force.

5. If you were curling a 7-kg dumbbell, when would your bicep muscles be contracting isometrically?
   No, they would be changing in length, so this would not be isometric contraction.

ACTIVITY 7 Isotonic Contractions and the Load-Velocity Relationship

1. If you were using your bicep muscles to curl a 7-kg dumbbell, when would your muscles be contracting isotonically?
   Yes, because your muscles are changing in length.

2. Explain why the latent period became longer as the load became heavier in the experiment. How well did the results compare with your prediction?
   The latent period became longer because it takes more time to generate the force required.

3. Explain why the shortening velocity became slower as the load became heavier in this experiment. How well did the results compare with your prediction?
   It takes more time to generate the force required to lift the heavier load.

4. Describe how the shortening distance changed as the load became heavier in this experiment. How well did the results compare with your prediction?
   The shortening distance decreased with the heavier load.

5. Explain why it would take you longer to perform 10 repetitions lifting a 10-kg weight than it would to perform the same number of repetitions with a 5-kg weight.
   The velocity of shortening decreases with a heavier load, so the repetitions will take longer with a 10-kg weight.

6. Describe what would happen in the following experiment: A 2.5-g weight is attached to the end of the isolated whole skeletal muscle used in these experiments. Simultaneously, the muscle is maximally stimulated by 8.5 volts and the platform supporting the weight is removed. Will the muscle generate force? Will the muscle change length? What is the name for this type of contraction?
   The muscle will still generate force. It will get longer. The type of contraction is eccentric.