Muscle Contraction

EQ: How do muscles contract?

- I. Motor Unit or Neuromuscular Junction
 - a. MOTOR END PLATE folded area where muscle and neuron communicate
 - b. NEUROMUSCULAR JUNCTION where a nerve and muscle fiber come together



- d. Sarcomere shortens when muscle contracts
 - i. Shortening of the sarcomeres in a myofibril produces the shortening of the myofibril
 - ii. And, in turn, of the muscle fiber of which it is a part
- e. The neurotransmitter that crosses the gap is ACETYLCHOLINE
 - i. This is what activates the muscle!!!!!
 - ii. Acetylcholine (ACH) is stored in vesicles
 - iii. ACH is broken down by cholinesterase
- II. Muscle Contraction
 - a.

c.

- i. SLIDING FILAMENT THEORY (MODEL)
 - 1. The <u>theory</u> of how muscle CONTRACTS
 - occurs as the thin filament slide past the thick filaments.
- b. Step 1: Ach released, binging to receptors
- c. Step 2: Action potential reaches T-tubule
- d. Step 3: Sarcoplasmic reticulum releases Ca²⁺
- e. Step 4: Active-site exposure, cross-bridge binding
 - i. Ca⁺² binds with the troponin molecules and causes tropomyosin molecules on the thin fibers to move exposing the actin molecules.
 - ii. This allows the myosin head of the thick fibers to form a cross bridge.
 - iii. But this requires Adenosine triphosphate or ATP
 - iv. Cross Bridging
 - 1. At rest: The myosin head is attached to ADP and a phosphate.
 - 2. Step 4: When the calcium comes in to the myofibril, it moves the tropomyosin off the actin monomers. The myosin heads can then attach to the actin (removing the ADP + Phosphate).
 - 3. Myosin head then attaches to the actin monomer and moves the actin filament thus contracting the muscle.
 - 4. Step 8: An ATP molecule binds to the myosin head allowing it to cock back to be ready to cycle again.
 - 5. This cycle repeats until while the actin monomers are exposed.
- f. Step 6: Ach removed by AChE



- g. Step 7: Sarcoplasmic reticulum recaptures Ca²⁺
 - i. Ca⁺² is pumped (active transport) back to the SR and the muscle is "relaxed".
- h. Step 8: Active sites covered, no cross-bridge interaction
 - i. A new molecule of ATP shows up and binds with the myosin head causing the head to release from actin the cross bridge breaks down.
- i. Step 9: Contraction ends
- j. Step 10: Relaxation occurs, passive return to resting length
- III. Energy Source
 - a. ATP is produced by <u>CELLULAR RESPIRATION</u> which occurs in the mitochondria
- IV. Slow- & Fast-Twitch Fibers
 - a. Two types of fibers based on speed of contraction
 - i. Slow-twitch or type I fibers
 - ii. Fast-twitch or type II fibers
 - b. The eye lids use type II, a muscle in your calf (soleus) would use mostly type I
 - c. Characteristics of Type I & II
 - i. Type I have a lot of blood vessels and many mitochondria, with a lot of myoglobin.
 - 1. Myoglobin is similar to the blood protein hemoglobin and brings plenty of oxygen to the muscle.
 - 2. These fibers are also called red fibers (dark meat).
 - ii. Type II have fewer of the above and can run off glycogen w/o a lot of O_2 present.
 - 1. These fibers are also called white fibers (white meat)
- V. Origin and Insertion
 - a. Origin = the immovable end of the muscle
 - b. Insertion = the movable end of the muscle
- VI. What is rigor mortis?
 - a. A muscle becomes rigid after death because the tissue loses its ability to produce ATP.
 - b. ends after about 48 hr. as the muscle proteins that make the cross bridges start to rot.
 - c. important in forensic medicine for determining the time of death.
- VII. What is tetanus?
 - a. Tetanus causes cholinesterase to not break down the acetylcholine in the synapse.
 - b. This results in a person's muscles contracting and NOT relaxing!!
 - i. A tetanus shot must be administered shortly after exposure to the bacteria.
 - ii. Once you develop tetanus, there is NO cure.
- VIII. Other Vocab
 - a. All-or-None Response Fibers do NOT contract partially, they either do or they don't
 - b. Motor Unit The muscle fiber + the motor neuron
 - c. Recruitment more and more fibers contract as the INTENSITY of the stimulus increases
 - d. **Muscle Tone -** <u>Sustained</u> contraction of individual fibers, even when muscle is at rest
 - e. **Hypertrophy** muscles enlarge (working out or certain disorders)
 - f. Atrophy muscles become small and weak due to lack of use
 - g. Muscle Fatigue muscle loses ability to contract after prolonged exercise OR strain
 - h. Muscle Cramp a sustained involuntary contraction
 - i. Oxygen Debt
 - i. oxygen is used to create ATP
 - ii. not have enough oxygen causes Lactic Acid to accumulate in the muscles
 - 1. Causes soreness