Amerman Active-Learning Workbook: Chapter 10 Answers

Key Concept: What is the function of all types of muscle tissue? What structural properties do they all share?
All muscle tissues generate a force called muscle tension, and share the properties of contractility, excitability, conductivity, extensibility, and elasticity. Structurally, they all have contractile proteins (actin and myosin), contain a special cytoplasm called the sarcoplasm, and contain a modified smooth endoplasmic reticulum called the sarcoplasmic reticulum.

Key Concept: What produces the characteristic striations of skeletal muscle fibers? Striations, or alternating dark and light bands, are caused by the arrangement of the myofilaments. The dark bands are found where the thick and thin filaments overlap, and the light bands are found where only thin filaments are found.

Key Concept: What is a sarcomere? Why is it considered the functional unit of contraction?
The sarcomere is the functional unit of contraction, consisting of thearea from one Z-disc to the next. It therefore constitutes one complete set of myofilaments that allow the muscle fiber to contract.

Key Concept: What is a membrane potential? What is the value of a skeletal muscle fiber's resting membrane potential?
A membrane potential is an unequal distribution of electrically charged ions near a cell's plasma membrane. A muscle fiber's resting membrane potential measures about -85 mV, which can be altered as a signal to the muscle cell that eventually triggers the contraction mechanism.

Key Concept: What is an action potential?
An action potential is a temporary, fast reversal in the membrane potential. It consists of depolarization (when Na^+ ions enter the cell and the membrane potential becomes more positive), and repolarization (when K^+ ions exit the cell to return it to its resting potential).

Key Concept: What is the structural and functional relationship between neurons and skeletal muscle fibers?
Motor neurons synapse with a muscle fiber at a structure called the neuromuscular junction. The basic function of the neuromuscular junction is to transmit a nerve impulse (or action potential) from the neuron to the sarcolemma of the muscle fiber.

Key Concept: Why does an increase in calcium ion concentration in the cytosol lead to a muscle contraction?
Calcium ions bind to troponin which results in movement of troponin and tropomyosin away from the active sites. This allows the myosin head to bind to an actin molecule, thereby initiating the crossbridge cycle that leads to the sliding of myofilaments.

Key Concept: How does a muscle fiber generate tension via a series of crossbridge cycles?
Over a series of crossbridge cycles, myosin heads grab onto actin molecules, pulling the thin filaments progressively closer to the center of the sarcomere. As the crossbridge cycles repeat, the crossbridges pull actin along the length of the myosin and generate tension as the fiber shortens.

Key Concept: What happens when the motor neuron stops releasing ACh? Why?
The enzyme acetylcholinesterase will break down ACh, and end-plate potentials in the muscle fiber would not be generated. This would eventually bring an end to the contraction mechanism.

Key Concept: Why do skeletal muscles need ATP?
In addition to being necessary to maintain proper resting potentials and function of the SR, ATP is important to two parts of the contraction mechanism. 1) ATP attaches to the myosin head to break the attachment of myosin to actin after the power stroke; and 2) ATP hydrolysis "cocks" the myosin head to prepare it for its next power stroke when it attaches to actin.

Key Concept: What energy source(s) must one use to sustain muscle activity for several minutes? Why?
The far more efficient oxidative energy sources are needed for longer term muscle activity. "Immediate" energy sources like creatine phosphate may only last for several seconds, and glycolytic energy sources deplete stored glycogen in about 30-40 seconds.

Key Concept: How does the frequency of stimulation of a muscle fiber impact tension production? Why?
Repeated stimulation of a muscle fiber results in twitches with progressively greater tension because the calcium ion pumps in the SR do not pump all of the released calcium ions back into the SR before the fiber is stimulated again. The calcium ion concentration in the cytosol increases with each stimulus and tension increases.

Key Concept: How does the starting length of a muscle fiber impact tension production, and why?

In the concept of length-tension relationship, the optimal length of the sarcomere is the length of the muscle fiber at which the most crossbridges can quickly and easily form. Too much or too little overlap of thin and thick filaments can (respectively) reduce the number of crossbridges that can form, or not give myosin enough initial opportunity to grab the actin molecules and quickly generate tension.

Key Concept: What factors influence tension production at the organ level?

Type of motor unit (fast or slow), recruitment of additional muscle fibers, and degree of muscle tone all influence tension production in muscles. Generally, the nervous system initially stimulates slow motor units, and recruits additional fibers including fast motor units only when greater tension is needed.

Key Concept: How do the three types of contraction differ?

In isotonic concentric contraction the force generated by the muscle is greater than that of the external load and the muscle shortens. In isotonic eccentric contraction, the force generated by the muscle is less than that of the external load and the muscle lengthens (as in putting down something you have lifted). In isometric contractions the length of the muscle doesn't change as the force generated by the muscle is equal to that applied to it.

Key Concept: How does a muscle fiber change with endurance training, resistance training, and disuse?

With endurance training, the muscle fiber increases the amounts of oxidative enzymes, mitochondria and mitochondrial proteins, and number of blood vessels. With resistance training, the number of myofibrils and the diameter of the muscle fibers increase. With disuse, muscle atrophy occurs, as the diameter of the muscle fiber decreases due to loss of myofibrils.

Key Concept: What are the causes of muscular fatigue? Which homeostatic imbalances does excess postexercise oxygen consumption help to correct?

Muscle fatigue is caused by depletion of metabolites (e.g. creatine phosphate, glycogen, and glucose), which makes the muscle fiber less able to replenish ATP. It is also caused by decreased oxygen availability, accumulation of chemicals that slow oxidative catabolism or excitation-contraction coupling, and environmental conditions such as extreme heat. Increased postexercise

breathing rate exhales extra carbon dioxide, which helps return body fluid pH to normal, and provides for extra ATP production to return ion balance to normal.

Key Concept: How does smooth muscle contraction differ from skeletal muscle contraction? Why?

The filaments in smooth muscle are arranged differently and lack troponin. Instead, calcium ions bind to the protein calmodulin, which activates enzymes that allow myosin crossbridge formation. This contributes to smooth muscle contracting slower but being able to main tension with less effort and ATP consumption.

Key Concept: What are important structural and functional differences between cardiac muscle tissue and skeletal muscle tissue?

Cardiac muscle cells are typically shorter, branched cells with one or two nuclei and abundant myoglobin. They have more mitochondria, and are connected by intercalated discs that connect cardiac muscle cells physically and electrically, allowing the heart to contract as a unit. Also, stimulation of cardiac muscle is autorhythmic, controlled by pacemaker cells rather than stimuli directly from motor neurons.