OUR LADY OF FATIMA UNIVERSITY

COURSE UNIT

BACHELOR OF SCIENCE IN COMPUTER SCIENCE: HUMAN BIOLOGY

COURSE MODULE	COURSE UNIT	WEEK
2	7	8
Muscular System and Neurons		

CHECK LIST

- ✓ Read course and unit objectives
- ✓ Read study guide prior to class attendance
- ✓ Read required learning resources; refer to unit terminologies for jargons
- ✓ Proactively participate in classroom discussions
- ✓ Participate in weekly discussion board (Canvas)
- ✓ Answer and submit course unit tasks

UNIT EXPECTED OUTCOMES (UEOs)

At the end of this unit, the students are expected to:

Cognitive:

1. Describe how muscle contraction permits movement
2. Explain how nerves control muscle contraction and identify the energy sources that fuel muscle activity
3. Describe how nerve cells communicate with muscle cells and one another

Affective:

1. Listen attentively during class discussions
2. Challenge ideas and opinions raised by the classmates and instructors with tact and respect.

3. Appreciate how the coordination of neurons and muscles result in various complex body movements

Psychomotor:

1. Participate actively during online and face-to-face discussions

REQUIRED READINGS

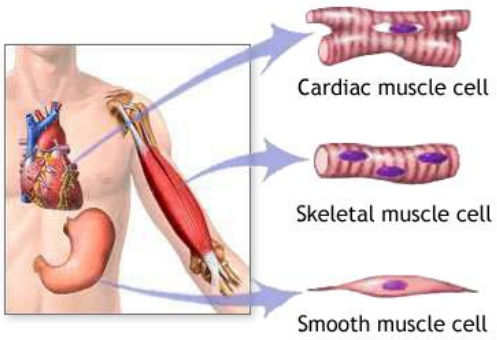
Goodenough, J. and McGuire, B. A. 2011. Human Biology. Majority of the modules are based on the book Biology of Humans (4th Edition): Concepts, Application, and Issues (pp. 102-128). San Francisco, CA: Pearson

STUDY GUIDE

Muscular System

Types of muscles

There are three types of muscles, which are identified as skeletal, smooth, and cardiac. Despite the different types of muscles, the types of muscle cells all feature the following characteristics, which are excitable, contractile, extensible, and elastic.



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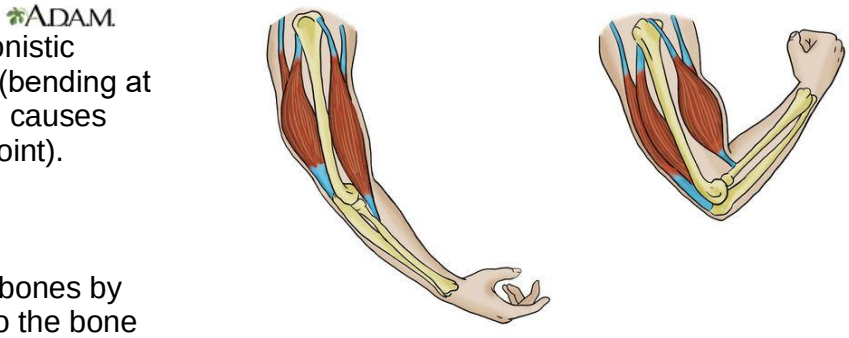
Skeletal Muscles Work in Pairs

Many of the skeletal muscles of the body are arranged in pairs that are antagonistic to each other. These muscles have actions that opposes the action of the other.



One member of a pair of antagonistic muscles usually causes flexion (bending at the joint) while the other muscle causes extension (straightening at the joint).

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These muscles are attached to bones by tendons and the end attached to the bone that is more stationary during the muscle's movement is called the origin. Meanwhile, the end attached to the bone that moves is called the

insertion.

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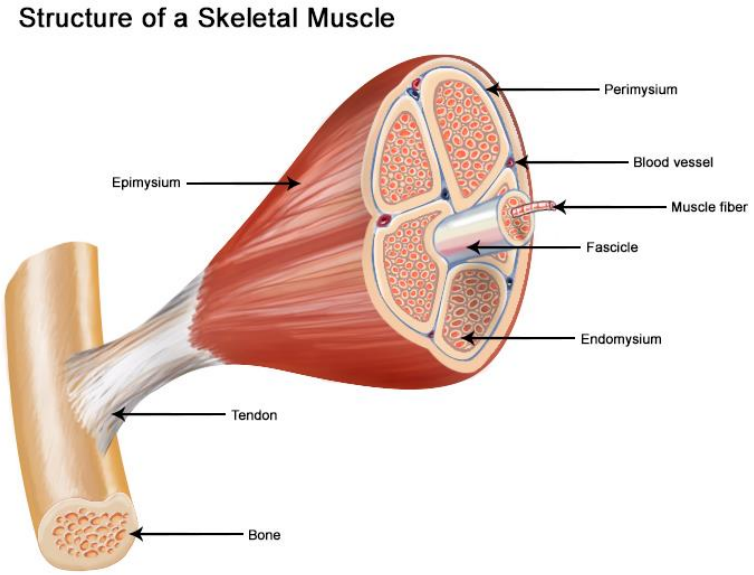

Contraction of Muscles

A muscle cell is packed with myofibrils. The myofibrils are composed of myofilaments, which are in turn comprised of the contractile proteins actin and myosin.

During the process of contraction, the muscle contracts when myosin heads bind to actin and pull the actin toward the midlines of sarcomeres. causing the actin and myosin filaments to slide past one another and increase their degree of overlap.

Contraction is controlled by the availability of calcium ions, which are stored in the sarcoplasmic reticulum of muscle cells. Once released when a motor nerve sends an impulse, these ions interact with two proteins on the actin filament—troponin and tropomyosin. These proteins determine whether myosin can bind to actin.

Motor nerves get into contact and communicate with the muscle cells at neuromuscular junctions.

When the nerve impulse reaches a neuromuscular junction, acetylcholine is released. This neurotransmitter causes a change in the permeability of the muscle cell's membrane. The calcium ions will then be released from the sarcoplasmic reticulum.

Voluntary Movement

The extent and strength of contraction can be changed either by changing the number of muscle cells that simultaneously contract or by modifying the strength of contraction of component cells of the muscles. A motor unit is comprised of the motor neuron and the motor cells activated by the same motor neuron. A twitch refers to the response of a muscle cell to a single brief stimulus, and it is usually observed in the laboratory.

Summation occurs when a second stimulus arrives before the muscle has relaxed, which results to the the second contraction building upon the first. Repeated frequent stimulation could cause a sustained contraction, called tetanus, and many muscle movements require the muscles to be in tetanus.

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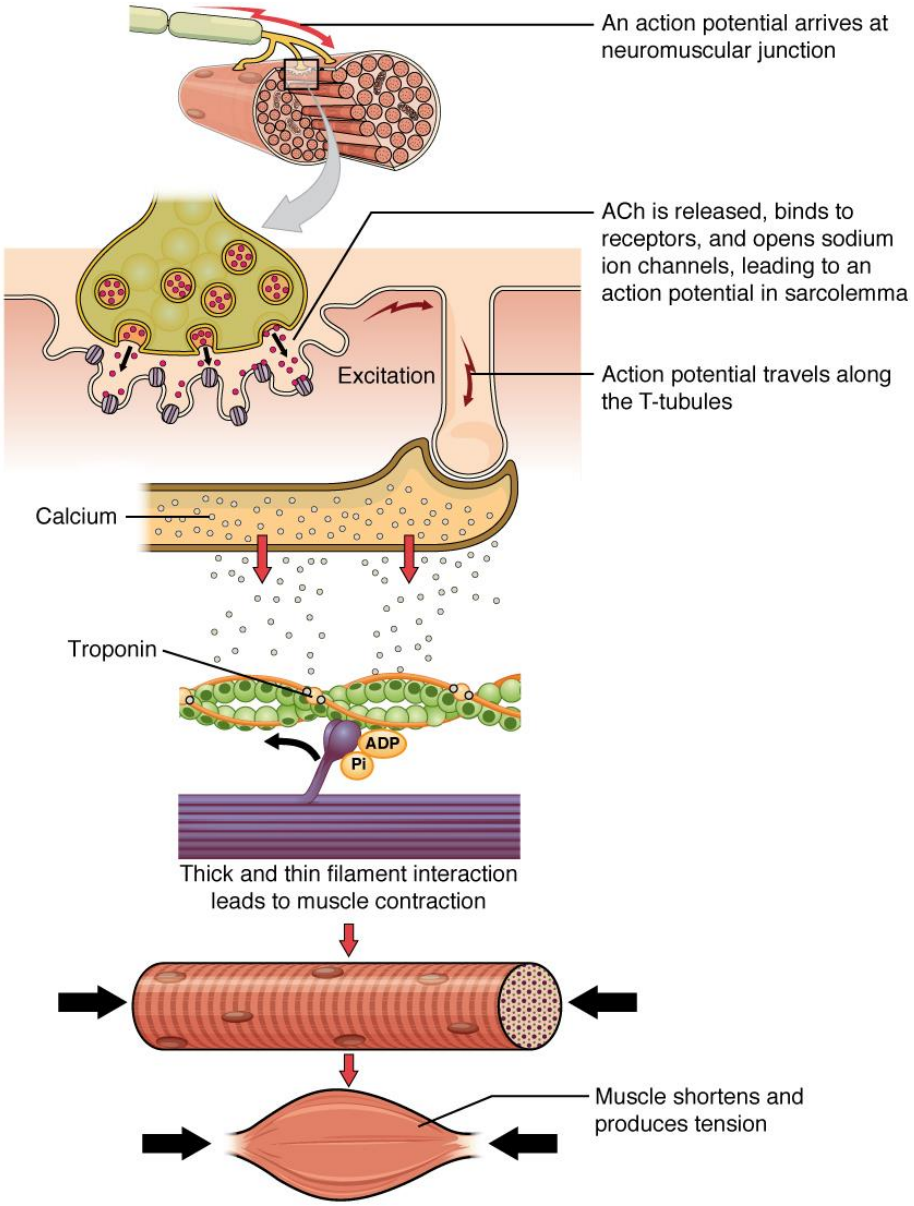


Energy for Muscle Contraction

For everytime, myosin and actin attachment forms and breaks, two ATP molecules are used. The sources of ATP could include stored ATP, creatine phosphate, anaerobic metabolic pathways, and aerobic respiration.

Slow-Twitch and Fast-Twitch Muscle Cells

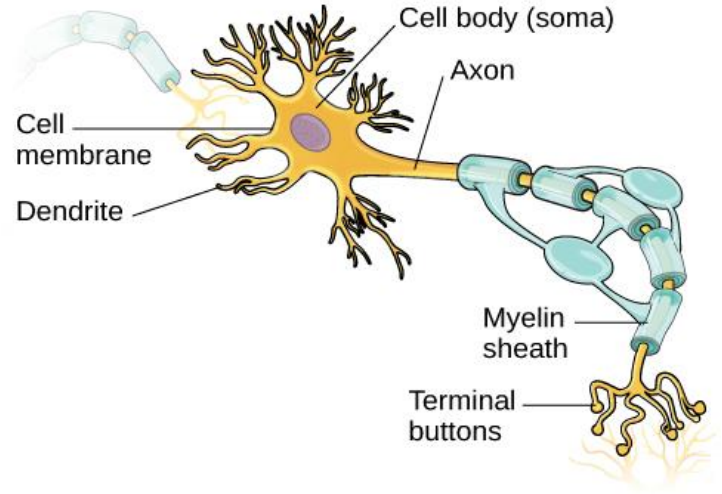
There are two types of muscle cells depending on the speed of contraction and endurance. Slow-twitch muscle cells contract slowly but these cells have enormous endurance. Meanwhile, fast-twitch muscle cells contract quickly and powerfully but with significantly less endurance.

Building Muscle

To increase muscle size, resistance exercise is often performed and required. Forcing muscles to exert more than 75% of their maximal strength results in the addition of myofilaments to existing muscle cells. This results in an increase in the cell diameter, resulting in increased muscle mass.

Neurons

Cells of the Nervous System



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Two types of specialized cells comprise the nervous system, and these include the neurons (nerve cells) and neuroglial cells. There are more neuroglial cells than neurons, and the neuroglial cells provide structural support for neurons. These cells also provide nerve growth factors and form myelin sheaths around certain axons.

Meanwhile, neurons are responsible of the transmission of information between different parts of the body. There are three general categories of neurons, which are identified as the sensory neurons, motor neurons, and association neurons.

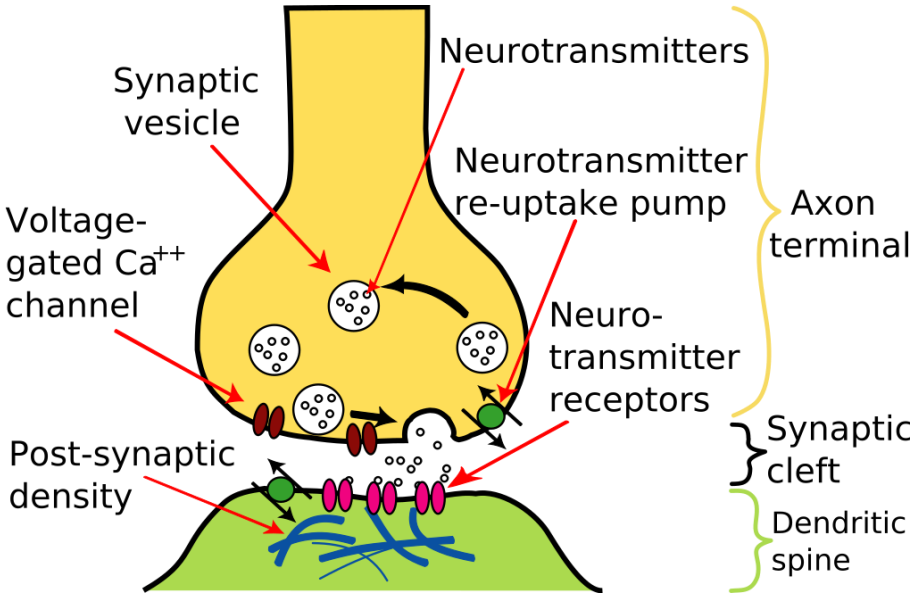
Sensory (or afferent) neurons are responsible for transmitting information from the sensory receptors toward the central nervous system, while the motor (or efferent) neurons convey information from the central nervous system to an effector like a skeletal muscle or a gland. Located in the central nervous system, association neurons, which are also called interneurons, are found between the sensory and motor neurons.

Structure of Neuron

Neurons are cells responsible for communicating with other cells, and the neurons have a number of common parts. A typical neuron has a cell body containing the organelles that maintain the cell, and branching from the neuron are the dendrites and the axons. Dendrites have many branching fibers and these fibers conduct messages toward the cell body, while on the opposite side, a single long axon carries impulses away from the cell membrane. Furthermore, an axon may be enclosed in an insulating layer called a myelin sheath that is created by the wrapping around the axon of the plasma membrane of Schwann cells (a type of neuroglial cells). The myelin sheath allows for faster movement of impulses along an axon. Furthermore, it also plays a role in the regeneration of damaged or cut axons in the peripheral nervous system.

Nerve Impulses

The message conducted by a neuron is called a nerve impulse or action potential. These impulses caused by the movement of sodium ions (Na^+) and potassium ions (K^+) across the neuron's plasma membrane. The ions move through the ion channels in the plasma membrane. These channels are small pores through which specific ions move without the use of cellular energy. However, the sodium-potassium pump requires cellular energy to pump sodium ions out of the cell



and potassium ions into the cell, since the movement of both ions are against their concentration gradients. The cellular energy that is used up by this process is in the form of ATP

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In the resting state, a neuron has an electrical potential difference, called the resting potential, across its plasma membrane. These potential differences occurs when an unequal distribution of charges across the membrane that makes the neuron more negative inside than outside; there are many negatively charged proteins inside the cell.

Usually, sodium ions are in greater concentration outside the neuron, and potassium ions are in greater concentration inside. The process of the action potential begins once the sodium ions move across the plasma membrane after the membrane become permeable, and the action potential is generated when there are sufficient sodium ions through opened sodium channels that have entered to reach a threshold. Once many sodium ions entered, the interior of the nerve cell in that region of the membrane temporarily positive (depolarization).

After the entry of the sodium ions, potassium ions then leave the cell which makes that region inside more negative than the outside (repolarization). The same events are repeated all along the axon in a wave of depolarization and repolarization. These repeated movement is called an action potential, which continues to the end of the axon without diminishing in strength.

At the end of an action potential, the sodium-potassium pump moves sodium ions out of the neuron and potassium ions into the neuron, which restores the original ion distribution.

During the brief refractory period that comes after an action potential, the neuron cannot be stimulated.

Synaptic Transmission

Synapse is the point or space wherein neuros meet each other. The neuron sending the message is called the presynaptic neuron while the neuron receiving the message is called the postsynaptic neuron. These two neurons are separated by a small space identified the synaptic cleft.

Calcium ions enter the presynaptic cell once the nerve impulses reach the end of axon. The entrance of calcium ions causes synaptic vesicles which hold neurotransmitters fuse with the plasma membrane of the presynaptic neuron. Once these vesicles fuse with the plasma membrane, they will release their contents into the synaptic cleft. The neurotransmitter diffuses

across the gap and the receptors on the membrane of the postsynaptic neuron capture these neurotransmitters.

A synapse can be identified as excitatory and inhibitory. An excitatory synapse increases the likelihood that the postsynaptic cells will generate a nerve impulse by allowing sodium ions to enter the cell. Meanwhile, an inhibitory synapse reduces the likelihood that the postsynaptic neuron will generate a nerve impulse by increasing the charge difference across the membrane of the receiving neuron.

Postsynaptic cells may get both excitatory and inhibitory input from many cells and integrate these impulses. If a certain threshold is reached, an action potential is generated in the postsynaptic cell, resulting in further transfer of information.

The neurotransmitter is removed from the synapse quickly either by enzymatic breakdown or by transport back into the presynaptic neuron to prevent continued stimulation. Examples of neurotransmitters used in both the peripheral and central nervous systems include acetylcholine, epinephrine, and norepinephrine. Many neurotransmitters are found in the brain, and each of these neurotransmitters have distinct functions. Different ones are active in different behavioral systems and disturbances in brain chemistry affect mood and behavior.

TERMINOLOGIES

Muscle Contraction – tension generation that occurs within the muscle fibers
Saltatory Conduction – movement of action potential from one node of Ranvier to another along myelinated axons.

FURTHER READINGS

The University of Queensland. (9 November 2017). Action potentials and synapses. https://qbi.uq.edu.au/brain-basics/brain/brain-physiology/action-potentials-and-synapses

UNIT TASKS

Study Questions

- What type cell is affected by Guillain-Barre syndrome? How does it affect the functioning of the limbs?
- Create an exercise program aimed at increasing the muscle mass of a 20-year old college student along with logical progression of activity. Do not forget to include sources used in creating the exercise program.

REFERENCES

Goodenough, J. and McGuire, B. A. 2011. Human Biology. Majority of the modules are based on the book Biology of Humans (4th Edition): Concepts, Application, and Issues (pp. 102-128). San Francisco, CA: Pearson

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