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Student Name

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The nervous system is one of the most intricate and complex systems on the planet. It consists of the brain, spinal cord, sensory organs, and all the nerves that connect these organs with the rest of the body. The nervous system’s job is to coordinate the body’s voluntary and involuntary actions and transmits signals between different parts of the body. This includes collecting information from sensory receptors that monitor the body’s internal and external environments. The nervous system can be broken down into two divisions: the central nervous system, which includes the brain and spinal cord, and the peripheral nervous system, which include the cranial and spinal nerves.

The nervous system is made up of mainly 2 cells, neurons and neuroglia. Neurons are nerve cells and communicate within the body by transmitting electrochemical signals (Barclay, 2019). Neuroglia are non-neural cells in both the central and peripheral nervous systems that do not produce electrical impulses; they maintain homeostasis, form myelin, and provide support and protection for neurons. There are many more neuroglia within the nervous system compared to neurons. Neurons are so specialized that once they are damaged or gone, they are unable to repair and replace themselves. Neurons can further be classified as preganglionic or postganglionic. Preganglionic neurons originate in the brain-stem or spinal cord in the autonomic nervous system. They connect the central nervous system to ganglia (Lumen Learning, n.d.). Post ganglionic neurons meet with preganglionic neurons at the synapse between them. Most neurons make two or more types of each neurotransmitter and can release just one, or all at the same time. Neurotransmitters can be classified as excitatory, meaning they increase the likelihood of a neuron firing off an action potential, or they are inhibitory and do the opposite, decrease the likelihood of a neuron firing off an action potential. They are considered chemical messengers which allow one neuron to communicate with neighboring neurons (Britannica, n.d.). There are also conventional and unconventional neurotransmitters. Conventional neurotransmitters share certain basic features, such as being stored in synaptic vesicles, they are released when positively charged calcium ions enter the axon terminal in response to an action potential, and they act by binding to postsynaptic cell membrane receptors (Khan Academy, n.d.).

While there are over 50 different neurotransmitters, there are 3 major neurotransmitters: acetylcholine, norepinephrine, and epinephrine. Both sympathetic and parasympathetic nervous systems have nicotinic acetylcholine receptors that receive signals from preganglionic neurons. All Preganglionic and post ganglionic neurotransmitters in the parasympathetic nervous system release acetylcholine. Acetylcholine is a chemical compound of acetic acid and choline. It serves as a neurotransmitter within both the central and peripheral nervous systems (Lieberman, n.d.).

In the Parasympathetic nervous system, neurons are cholinergic, which means choline is the primary neurotransmitter responsible for the communication between neurons on the parasympathetic pathway. Acetylcholine (ACh) is synthesized by the enzyme choline acetyltransferase from the compounds choline and acetyl-CoA. The cholinergic neurons are capable of producing Ach. ACh originates at the synaptic knob of a lightly myelinated preganglionic axon. Acetylcholine is released into the neuromuscular junction (Powerpoint, n.d.). Muscarinic and nicotinic receptors are activated by ACh release. These receptors mediate many functions of the parasympathetic nervous system and are located on various organs throughout the body such as cardiac, musculoskeletal, pulmonary, and digestive systems. Acetylcholine (ACh) released in the Parasympathetic Nervous System main function is to stimulate skeletal muscle contraction and activate glandular function in the endocrine system. It also plays a role in pain sensation, learning and memory formation, and REM sleep cycles. (Lieberman, n.d.) Once released, ACh binds to a postsynaptic membrane of a muscle fiber. Permeability of the membrane is changed, causing positively charged sodium ions to rush into the muscle cell. Once the threshold is met, sodium channels are fully activated, and the muscles contract.

In the sympathetic nervous system, neurons are mostly adrenergic, which means epinephrine and norepinephrine are the major neurotransmitters. Preganglionic neurons originate in the first thoracic and third lumbar segments of the spinal cord. All preganglionic fibers release acetylcholine as well. Postganglionic fibers that serve sweat glands also release Ach. Postganglionic fibers are lightly myelinated neurons. Acetylcholine is released into the adrenal medulla, which is made up of postganglionic neurons without dendrites or axons. Here, the cells are chromaffin cells, or modified postganglionic nerves without dendrites and axons. The sympathetic nervous system is responsible for the “fight or flight” response. It is the part of your nervous system that is activated in stressful situations, which prepares your body to either fight or run from harm.

When norepinephrine and epinephrine are released, they are released directly into the bloodstream as hormones instead of a neuromuscular junction. It is both a neurotransmitter and a hormone, but primarily a neurotransmitter. Norepinephrine is synthesized from dopamine by dopamine β-hydroxylase. Norepinephrine’s jobs as a neurotransmitter include controlling heart rate, blood pressure, liver function, among others. As a hormone, it’s job is to regulate sleeping, dreaming, learning, attentiveness, vasoconstriction which causes an increase in heart rate, and emotions. Norepinephrine works by binding to α- and β-adrenergic receptors in different tissues (Britannica, n.d.). In stressful situations, norepinephrine also increases as part of the fight or flight response to ready the body and brain for action.

Epinephrine is the other major neurotransmitter of the sympathetic nervous system. Also known as adrenaline, it is produced during the final step of the conversion of tyrosine. Tyrosine is converted in a cycle by various enzymes into L-Dopa, dopamine, norepinephrine, and finally, epinephrine (Kapalka, 2010). It’s also both a neurotransmitter and a hormone, but functions primarily as a hormone. Since epinephrine and norepinephrine are closely related, epinephrine does not have its own receptors. Instead, it stimulates the same receptors as norepinephrine (Kapalka, 2010). The effects of epinephrine also mimic the effects of norepinephrine; it’s just a little more intense in peripherals. They are extremely prevalent in situations of “fight or flight” due to the hormone being suddenly released in higher dosages. The effects this hormone causes can include but are not limited to: increased heart rate, blood pressure, increased respiration, etc. (Lanese, 2019).

While the different nerve fibers have many similarities in both systems, they also have extremely important differences, functions, and target areas as well. The parasympathetic and sympathetic nervous systems and their respective neurotransmitters also work hand in hand, at the same time, although in opposition to each other to maintain balance within the body. While the sympathetic nervous system causes an adrenaline rush, the parasympathetic uses that same to allow you to physically move your body as needed. The two main cells, pre-ganglia and post-ganglia, also play a major role in transmitting the necessary neurotransmitters where they need to go.

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