

I. Autonomic Nervous System

A. Background

1. Supplies impulses to cardiac muscle, smooth muscle and glands.
2. Operates **involuntarily**.
3. Operates mainly via reflexes.
 - a. Sensory impulses are generated by receptors that monitor internal conditions (blood gasses, blood pressure, stretch in an organ wall) and are received by the hypothalamus, brain stem or spinal cord.
 - b. Motor impulses are sent to cardiac muscle, smooth muscle or glands to either excite or inhibit the organ.
4. Works with the endocrine system to maintain homeostasis and allows the body to respond to stress.

B. Basic anatomy

1. Autonomic nervous system pathways consist of 2 motor neurons that extend from the brain stem or spinal cord to the effector (muscle or gland).
 - a. The first neuron is the **preganglionic neuron**.
 - i. The cell body is located within the lateral horn of gray matter in the spinal cord, or in the brain stem.
 - ii. The axon will extend to a **ganglion** (a collection of cell bodies outside of the central nervous system), where it synapses with the second neuron.
 - b. The second neuron is the **postganglionic neuron**.
 - i. The cell body is located within the ganglion.
 - ii. The axon will extend from the ganglion to the muscle or gland it will innervate.

C. Divisions

1. The autonomic nervous system has 2 divisions, the **parasympathetic division** and the **sympathetic division**.
 - a. Most organs receive **dual innervation** (impulses from both divisions); however the 2 divisions are antagonistic at those organs (one will excite the organ while the other inhibits it).
 - b. In everyday low energy situations the parasympathetic division dominates.
 - c. In higher energy and/or fight or flight situations the sympathetic division dominates.
 - d. The 2 divisions are controlled and coordinated by the hypothalamus.
 - e. Except under extreme circumstances, both systems work together to assure that smooth and cardiac muscle and glands are contracting or secreting the right amount.
2. Parasympathetic (**Craniosacral**) Division
 - a. Enhances **“rest-and-digest”** activities.
 - b. Have long preganglionic neurons and short postganglionic neurons.
 - c. Cranial portion
 - i. The preganglionic neurons have their cell bodies in the brain stem.
 - ii. Their axons are found in the **3rd, 7th, 9th and 10th** cranial nerves.
 - iii. The axons extend to and synapse **in terminal ganglia**.
 - iv. **Note:** terminal ganglia are located close to or on the organs being innervated.

- v. The preganglionic neuron will release the neurotransmitter **acetylcholine**, which binds to a **nicotinic receptor** on the postganglionic neuron.
 - vi. The postganglionic neurons have their cell bodies within the terminal ganglia.
 - vii. Their axons emerge from the terminal ganglia and terminate at the muscle or gland.
 - viii. The postganglionic neurons release the neurotransmitter **acetylcholine**, which binds to **muscarinic** receptors on the organ.
 - ix. If the neurons are using cranial nerves 3, 7 and 9 the organs being innervated are in the head.
 - x. If the neurons are using cranial nerve 10 the organs being innervated are in the thoracic and abdominal cavities.
- d. Sacral portion
- i. The preganglionic neurons have their cell bodies within the lateral gray matter of the 2nd through the 4th sacral segments of the spinal cord.
 - ii. The axons of the preganglionic neurons exit the spinal cord through the anterior (ventral) root of the spinal cord.
 - iii. The axons extend to **terminal ganglia** where they synapse with postganglionic neurons.
 - iv. The postganglionic neurons have their cell bodies within the ganglia.
 - v. Their axons are distributed to the ureters, urinary bladder, reproductive organs, and portions of the colon.
 - vi. The neurotransmitters and receptors are the same as those used by the cranial portion.
3. Sympathetic (**thoracolumbar**) division
- a. Enhances **“fight-or-flight”** activities.
 - b. A single preganglionic neuron can synapse with 20 or more postganglionic neurons.
 - c. Preganglionic neurons have their cell bodies within the lateral horns of gray matter of the thoracic and lumbar regions of the spinal cord.
 - d. The axons of the preganglionic neurons exit the spinal cord through the anterior (ventral) root of the spinal cord and enter spinal nerves.
 - e. The axons follow the white rami (branch) off the spinal nerve to:
 - i. Terminate in the nearest **sympathetic trunk (chain) ganglia** that it reaches where it synapses with a postganglionic neuron.
 - ii. **Or** it may ascend or descend to another more superior or inferior **sympathetic trunk (chain) ganglia** before synapsing with a postganglionic neuron.
 - iii. **Or** it may pass through the **sympathetic trunk (chain) ganglia** to terminate at a **prevertebral (preaortic) ganglia** within the abdominal cavity, synapsing with a postganglionic neuron.
 - iv. A few preganglionic neurons travel directly to the medulla of the **adrenal gland** where they stimulate the production of **adrenaline (epinephrine)**.
Note: there is no postganglionic in this instance.
 - (a) Adrenaline augments the effects of the sympathetic nervous system.

- f. All preganglionic neurons release the neurotransmitter **acetylcholine** which binds to **nicotinic receptors** on the surface of the postganglionic neuron.
- g. Axons of postganglionic neurons exit the ganglia and
 - i. If their cell body is located in a **sympathetic trunk (chain) ganglia**
 - (a) Some will supply impulses that result in dilation of blood vessels found in skeletal muscle and sweat glands; constriction of vessels supplying skin; and contraction of **arrector pili muscles** of hairs. At these locations **acetylcholine** is the neurotransmitter released and binds to **muscarinic** receptors.
 - (b) Some will go to structures within the head and thoracic cavity.
 - (i) **Norepinephrine** is the neurotransmitter released.
 - (ii) Can bind to **alpha receptors** (excitatory to smooth muscle).
 - (iii) Can also bind to **beta receptors** (excitatory to cardiac muscle, inhibitory to smooth muscle).
 - ii. If their cell body is located in a **prevertebral (preaortic) ganglia** their axons are distributed throughout the abdominal and pelvic cavities where they also release **norepinephrine** that binds to **alpha** and **beta receptors**.