Autonomic nervous system (ANS)

- It is the part of nervous system that is responsible for homeostasis & controls most visceral functions of the body independently (autonomously) & continuously without conscious effort.
- Innervations to all organs is supplied by ANS; except for skeletal muscle, which gets its innervation from somatic nervous system.
- **Nerve terminal location**: This system transmits sensory information from visceral organs to CNS & controls visceral functions by regulating the actions of:
  1. Smooth muscle (eg, blood vessels, gut wall, urinary bladder).
  2. Cardiac muscle.
- Portions of ANS respond to emotional stress & prepare the body to meet demands of strenuous physical activity.
- ANS has the following divisions:
  1. **Sympathetic (symp.)** NS.
  2. **Parasympathetic (parasymp.)** NS.
    - Some target organs (viscera) are innervated by both divisions. So, impulses on one set of fibers may activate an organ, while impulses on the other set inhibit it (action antagonistically).
    - Other target organs are controlled by only one division.
  3. **Enteric nervous system (ENS)** within GIT.

Anatomic Organization Of Autonomic Outflow

An ANS pathway consists of two neurons that synapse in a ganglion:
Peripheral motor portions of ANS are made up of 2 neurons: preganglionic & postganglionic.

**Ganglion** is a biological mass of nerve cell bodies.

**Preganglionic**: a neuron that transmits signals from CNS to a ganglion.

**Post ganglionic**: Axon in ANS, axon that leaves, rather than goes to, a ganglion.

- Cell bodies of pregang. neurons are located in;
  - Intermediolateral column (IML) of spinal cord.
  - Motor nuclei of some cranial nerves.
- Pregang. axon diverges to 8 - 9 postgang. neurons. So, autonomic output is diffused.

**SYMPATHETIC DIVISION**

- Symp. pregang. neurons are located in IML of only 1st thoracic to 3rd or 4th lumbar segments( In contrast to motor neurons, which are located at all spinal segments). This is why symp. NS is called thoracolumbar division of ANS.
- usually involved in preparing the body for physical activity.
- Axons of symp. pregang. neurons leave spinal cord at level at which their cell bodies are located & exit via ventral root along with axons of motor neurons. They then separate from ventral root via white rami communicans & project to adjacent symp. paravertebral ganglion, where some of them end on cell bodies of postganglionic neurons.
- Paravertebral ganglia located adjacent to each thoracic & upper lumbar spinal segment; in addition, there are a few ganglia adjacent to cervical & sacral spinal segments.
- These ganglia form sympathetic chain bilaterally.
Ganglia are connected to each other via axons of pregang. neurons that travel rostrally or caudally to terminate on postgang. neurons located at some distance.

- **Pregang. neurons** project to adjacent symp. paravertebral ganglion, where:
  - Some of them end on cell bodies of postganglionic neurons.
  - Some of them pass through paravertebral ganglion chain & end on postgang. neurons located in **prevertebral (or collateral) ganglia** close to viscera, including celiac, superior mesenteric, & inferior mesenteric ganglia.
  - There are pregang. Neurons whose axons terminate directly on effector organ (*adrenal gl*).

- **Axons of postgang. neurons**:
  - Some of them leave chain ganglia & reenter spinal nerves via **gray rami communicans** & are distributed to autonomic effectors in areas supplied by these spinal nerves. These postgang. Symp. nerves terminate mainly on smooth muscle (eg, blood vessels, hair follicles, airways) & on sweat glands in limbs.
  - Other Postgang. fiber leave chain ganglia to enter thoracic cavity & terminate in visceral organ.
  - Postganglionic fibers from prevertebral ganglia also terminate in visceral targets.
PARASYMPATHETIC DIVISION
- It is called craniosacral division of ANS because of the location of its pregang. neurons.
- usually involved in activating vegetative functions such as digestion, defecation, & urination.
- Parasympathetic nerves supply visceral structures;
  - In head via oculomotor, facial, & glossopharyngeal nerves,
  - In thorax & upper abdomen via vagus nerves.
  - Pelvic viscera via branches of 2nd to 4th sacral spinal nerves.
- Parasymp. pregang. fibers synapse on ganglia cells clustered within walls of visceral organs; thus parasymp. postganglionic fibers are very short.

CHEMICAL TRANSMISSION AT AUTONOMIC JUNCTIONS
Acetylcholine (Ach) & Norepinephrine (NE)
- Transmission at synaptic junctions between pre- & Postgang. neurons & between postgang. neurons & autonomic effectors is chemically mediated.
- The principal transmitter involved are Ach & NE.
- Neurons that are cholinergic (ie, release Ach) are;
  1. all preganglionic neurons,
  2. all parasympathetic postganglionic neurons,
  3. sympathetic postganglionic neurons that innervate sweat glands,
  4. sympathetic postganglionic neurons that end on blood vessels in some skeletal muscles & produce vasodilation when stimulated (sympathetic vasodilator nerves).
- The remaining sympathetic postganglionic neurons are noradrenergic (ie, release NE).
- In addition to these NTs, some autonomic fibers also release neuropeptides (Neuropeptide Y)
- Adrenal medulla is essentially a sympathetic ganglion in which postgang. cells have lost their axons & secrete NE & epinephrine directly into bloodstream. Cholinergic pregang. neurons to these cells have consequently become secretomotor nerve supply of this gland.
- Ach binds to two classes of receptors, nicotinic (Relating to the stimulating action of Ach & other nicotine-like agents on autonomic ganglia, adrenal medulla, & motor end-plate of striated muscle) & muscarinic receptors (Acetylcholine-binding receptors of ANS’s target organs; names for activation by mushroom poison muscarine), alpha & beta adrenergic receptors.
On the basis of effects like these, Emergency-induced discharge of noradrenergic nervous system called "preparation for flight or fight.

Symp. discharge is ↓ ed in fasting animals & ↑ when fasted animals are refed. These changes may explain ↓ BP & metabolic rate produced by fasting & the opposite changes produced by feeding.

DESCENDING INPUT TO AUTONOMIC PREGANGLIONIC NEURONS

Activity of autonomic nerves is dependent on:

- Reflexes (eg, baroreceptor & chemoreceptor reflexes).
- Descending excitatory & inhibitory input from several brain regions, which are:
  - Direct projections to autonomic preganglionic neurons include:
    - (a) hypothalamic paraventricular nucleus,
    - (b) parabrachial nucleus,
    - (c) nucleus of solitary tract,
    - (d) ventrolateral medulla,
    - (e) medullary raphé (not shown in diagram).
  - Indirect projections include:
    - (a) cerebral cortex,
    - (b) Amygdala,
    - (c) Periaqueductal grey matter.
ENTERIC NERVOUS SYSTEM (ENS)

- It is located within wall of digestive tract, all the way from esophagus to the anus. It is composed of two well-organized neural plexuses;
  - **Myenteric plexus**: located between longitudinal & circular layers of smooth muscles; it is involved in control of digestive tract motility.
  - **Submucosal plexus**: located between circular muscle & luminal mucosa; it senses environment of lumen & regulates GIT blood flow & epithelial cell function.
- ENS contains as many neurons as the entire spinal cord; so, sometimes referred to as a "mini-brain" as it contains all elements of nervous system including:
  - Sensory neuron innervating receptors in mucosa that respond to mechanical, thermal, osmotic, & chemical stimuli.
  - Motor neuron control motility, secretion & absorption by acting on smooth muscle & secretory cells.
  - Interneurons integrate information from sensory neurons & feedback to enteric motor neurons.
- Parasymp. & symp. nerves connect CNS to ENS or directly to digestive tract.
- Although ENS can function autonomously, normal digestive function often requires communication between CNS & ENS.