ANATOMY OF AUTONOMIC NERVOUS SYSTEM AND PATHWAYS

I. OVERVIEW OF AUTONOMIC NERVOUS SYSTEM - Autonomic nervous system (= Visceral nervous system) is considered part of peripheral nervous that is not under voluntary control (Autonomic means automatic or self-regulating)

A. **OVERVIEW** -

1. Autonomic nervous system innervates visceral structures: smooth and cardiac muscles, blood vessels, glands (sweat glands, salivary glands, etc) and internal organs (ex. GI tract, heart, etc.).

2. The autonomic nervous system is **often thought of as reactive** to stimuli (ex. fight or flight). However, many autonomics provide pathways for the CNS to **continuously regulate and control body functions**:

examples 1) Thermoregulation - regulate body temperature; 2) Cardiovascular function in heart and blood vessels - monitor and regulate heart rate, blood pressure, etc.;3) GI function - secretion, motility.

B. Basic pathway - 2 neuron arc; **pre-ganglionic neuron is in CNS**; axon leaves CNS; synapses in autonomic ganglion - post-gangliionic cell in autonomic ganglion innervates smooth muscle, glands, etc.

C. Divergence - Why have a two neuron arc? Autonomics can activate many targets at the same time. A single pre-ganglionic neuron synapses on many post-ganglionic neurons (ratio 1 pre/15 post up to 1 pre/200 post). This divergence can allow for widespread effects (ex. in thermoregulation, many sweat glands are activated simultaneously).

D. Parts Autonomic Nervous System - Sympathetic and Parasympathetic: Review:

1. **Sympathetics: 'FIGHT OR FLIGHT'** - Out CNS at **Thoraco-Lumbar levels**; **ganglia close to CNS** (paravertebral); pre-ganglionics short, post-ganglionics long; Actions - ex. Increase heart rate, decrease gastric movements and secretions, decrease secretion of salivary glands.

2. **Parasympathetics: 'REST AND DIGEST'** - Out CNS at **Cranio-Sacral levels** (Cranial nerves and Sacral Spinal nerves); **ganglia close to target**; pre-ganglionics long, post-ganglionics short; Actions - ex. decrease heart rate, increase gastric movements and secretions; increase secretion of salivary glands.

E. **Asymmetry - Some body structures receive only Sympathetics NOT Parasympathetics - Classic description: 'Parasympathetics do not go to body wall'; examples:**

1. **Skin** - **sweat glands and arrector pilae** muscles **are only innervate by Sympathetics** not Parasympathetics.

2. **Peripheral blood vessels** - Blood vessels are innervated by Sympathetics not parasympathetics.

Consequence of Asymmetry: **Sympathetics are much more widely distributed than Parasympathetics** - pathways are more complex.

F. **Thermoregulation by sweating** - sweating decreases body temperature by evaporation; mediated by Sympathetics to skin.

G. **CNS Regulation** - Centers in the CNS regulate autonomic function (ex. brainstem reticular formation). The **Hypothalamus** (part of CNS) is a major center for regulation of autonomic function.

II. ANATOMICAL ORGANIZATION OF SYMPATHETIC PATHWAYS

A. **Pathways** - Sympathetics (pre-ganglionic neurons) come out Spinal cord (at Thoracic and Upper Lumbar Levels); can do three things.

1. **Synapse in ganglion at level of outflow** - Pre-ganglionics course in Communicating rami (connect to Sympathetic ganglion); Post-ganglionics join spinal nerve of that segment. (ex. Skin of thorax - innervated by Intercostal nerves).
2. **Ascend or descending chain and synapse in other ganglia of chain**; Post-ganglionics then course in Communicating rami to join spinal nerves at those segments (ex. cervical spinal nerves of Brachial plexus).

3. **Not synapse in chain; pre-ganglionics continue to ganglia nearer to target organ**; ex. Splanchnic nerves to gut (covered in Spring semester)

III. WHY IS THE AUTONOMIC NERVOUS SYSTEM A MESS? - EVOLUTION OF AUTONOMIC NERVOUS SYSTEM - starts as primitive nerve net (meshwork of neurons) - organization preserved in innervation of human GUT (GI tract) = ENTERIC NERVOUS SYSTEM
1. Structure - ganglia (neurons, glia) in wall of gut produces contractions (peristalsis) in gut muscle cells; can operate independent of autonomic nervous system but modulated by it (Splanchnic nerves)
2. recent research: immune system acts on and interacts with Enteric nervous system

Reference if this interests you (not required) : Yoo BB, Mazmanian SK. The Enteric Network: Interactions between the Immune and Nervous Systems of the Gut. Immunity. 2017;46(6):910-926. link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5551410/