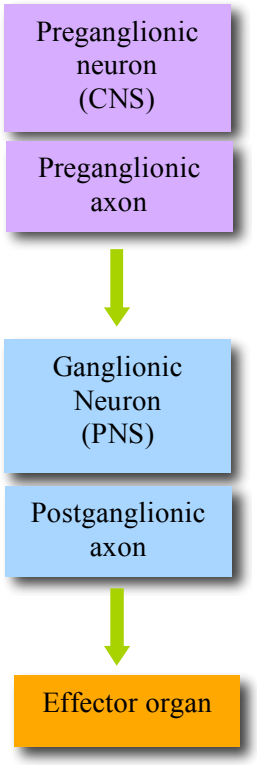
Chapter 14
Autonomic Nervous System

GENERAL FEATURES OF THE ANS

First of all, the ANS uses a **two-neuron chain** to its effectors. The cell body of the first neuron (***preganglionic neuron***) resides in the brain or spinal cord. Its axon (the preganglionic axon), synapses with the second motor neuron (***the ganglionic neuron***).



The EFFECTOR ORGAN (such as the stomach or other visceral organs) is innervated by the postganglionic axon. Examples of tissues that are innervated by the autonomic system are cardiac muscle, smooth muscle and glands.

NEUROTRANSMITTERS OF THE ANS

- Acetylcholine (Ach) is secreted:
  - ALL ganglionic synapses of the PANS/SANS
  - ALL parasympathetic effector sites
  - SOME sympathetic effector sites
- Norepinephrine is secreted:
  - MOST sympathetic effector sites

ANS ANATOMY

The sympathetic and parasympathetic divisions are distinguished by:

1. **Their unique origin sites**: Parasympathetic fibers emerge from the brain (cranial nerve nuclei) and gray matter in the sacral spinal cord (craniosacral), sympathetic fibers originate from the lateral gray horns in the the thoracolumbar region of the spinal cord.

preganglionic

Thoracolumbar = T1-L2

2. **The relative lengths of their fibers**. The parasympathetic division has long preganglionic and short postganglionic fibers. The sympathetic division has the opposite conditions (short preganglionic and long postganglionic).

<u>Preganglionic axon</u>
PANS is long
SANS is short

<u>Postganglionic axon</u>
PANS is short
SANS is long

3. **The location of their ganglia**. In the PANS, it is very close to or in the effector organ. In the SANS, it is in the paraspinal region, very close to the output from the spinal cord.

Postganglionic axon

WHAT THE HECK IS DUAL INNERVATION?
Most body organs/tissues are innervated by both the PANS and the SANS because they usually perform opposing functions. NOTE that the PANS never works by itself, and the SANS sometimes works by itself. In the places where the SANS is working solo, then it secretes Acetylcholine.

THE PARASYMPATHETIC NERVOUS SYSTEM! **THE PANS!**
The overall function of the PANS is "rest and digest." It is the dominant system when the body is at rest and non-stressed. The PANS allows for relaxed completion of daily activities, and it maintains homeostasis under normal conditions. The PANS is also known as the craniosacral division, because of the location of where the preganglionic axons originate.

THE NERVES OF THE PANS consist of four cranial nerves and some sacral nerves.
The **cranial nerves** are the oculomotor nerve, the facial nerve, the glossopharyngeal nerve and the vagus nerve.

- The **oculomotor nerve** (CN III) mediates papillary constriction and accommodation (focusing). The cell bodies of the ganglionic neurons are in the **ciliary ganglia** within the eye orbits.
- The **facial nerve** (CN VII) is involved with secretions from salivary, nasal and lacrimal glands. The nerve branches! The preganglionic fibers synapse with ganglionic neurons in the **pterygopalatine ganglia** (lacrimal and nasal), and in the **submandibular ganglia** (salivary glands)**.**
- The **glossopharyngeal nerve** (CN IX) causes salivation by stimulating the parotid gland. This nerve synapses at the **otic ganglion** near the ear.
- The **vagus nerve** (CN X) processes the majority of parasympathetic outflow. This creates a large network of nerves with lots of branches. It eventually innervates organs of the thoracic and abdominal viscera. These ganglia are located IN the walls of the organs.

The **sacral nerves** arise from neurons located in the lateral gray matter of spinal cord segments S2-S4. They innervate the distal colon and pelvic organs. The ganglia are located within the walls of the organs.

GANGLIA OF THE PANS! There are four named ganglia.

- TERMINAL GANGLIA is the collective term for ganglia associated with CN III, VII, IX. These are located near the organs.
- The ganglia without special names are the INTRAMURAL GANGLIA. These go into the wall of the effector organ. These are associated with CN X (Vagus) and sacral nerves.

THE SYMPATHETIC NERVOUS SYSTEM…THE SANS!
The overall function of the SANS is very broad and the whole body gets involved. It is "fight or flight." The SANS dominates when the body is stressed.

It selectively **INCREASES** blood flow to	It selectively DECREASES blood flow to
Skeletal muscle	Digestive system
Brain	Urinary system
Heart	Reproductive system
lungs	

The function of the SANS is more extensive than the PANS. It innervates more organs! The PANS and SANS together innervate the thoracoabdominal viscera, while the SANS alone innervates the cutaneous sweat glands, arector pili smooth muscle, blood vessel smooth muscle. So lots of stuff!

The SANS is also known as the thoracolumbar division because the preganglionic axons arise from T1-L2 segments.

GANGLIA OF THE SANS are in three general areas.
The sympathetic chain is a collection of ganglia that forms a pathway:å

1. Preganglionic axon leaves the spinal cord via the ventral root and spinal nerve. It passes out of the spinal nerve via the white ramus of the rami communicantes and goes to the ganglion, where the fiber may synapse on the ganglionic neuron at the same spinal level, or at any other ganglion due to the profusion of collateral axons.
2. The postganglionic axon returns to the spinal nerve via the gray ramus, which is more medial. From the spinal nerve, the axon continues to lots of places!
    a. Superficial blood vessels
    b. Cutaneneous glands
    c. Smooth muscle
    d. Skeletal muscle
    e. Heart, lungs, esophagus, aorta (via plexuses)
    f. Eyes (opens pupils) nasal, salivary glands (stops secreting)

Pathways with synapses in collateral ganglia:

1. Preganglionic axon leaves the spinal cord via the ventral root & spinal nerve (T5-L2). It passes out of the spinal nerve via the white ramus, but doesn't stop there! It goes through the chain ganglia ***without synpasing***. It continues as the splanchnic nerve, which then forms plexuses in the thorax and abdomen.
2. Plexuses contain four main ganglia!
    a. Celiac ganglion
    b. Superior mesenteric ganglion
    c. Infererior mesenteric ganglion
    d. Inferior hypogastric ganglion
3. The postganglionic axons innervate abdominopelvic organs and are mainly inhibitory…it shuts stuff down!

Pathways with synapses in the adrenal medulla:

1. The preganglionic axon originates at the lateral gray horn and leaves the spinal column via the ventral root and spinal nerves T5-T9 only. It passes through the sympathetic chain via the white ramus, and then passes through the celiac ganglion via the splanchnic nerve. It keeps going! It continues on to the adrenal medulla (on the kidney), and here is where it synapses on ganglionic cell.
2. "Ganglionic cells" are neurosecretory cells. They are neurons, but they don't secrete neurotransmitter like other cells do…they secrete it as though it were a hormone…into the blood!
3. The axons of the adrenal medulla don't leave the adrenal medulla, they secrete norepinephrine (noradrenaline) and epinephrine (adrenaline), which are both

technically hormones. This enhances the overall sympathetic affect…a power boost! Because it travels through the blood, the SANS is very widespread!

NEUROTRANSMITTERS of the autonomic nervous system.
Acetylcholine (Ach) is secreted at ALL autonomic ganglia, ALL parasympathetic effector sites and SOME sympathetic effector sites when the SANS is working on its own with the PANS (sweat glands, skeletal muscle, blood vessels.)

Recall!
Acetylcholine is secreted by all neuromuscular junctions in the somatic motor system.

The effect a neurotransmitter has depends on the receptor sites.

- Niconic receptor
  - At nicotinic sites Ach always causes an EPSP
  - Found on ALL autonomic ganglionic sites (and also on some somatic neuromuscular junctions)
- Muscarinic receptor
  - Response may be excitatory or inhibitory
  - Found at all Ach-secreting effector sites.

Norepinephrine is secreted at MOST sympathetic receptor sites, exclusions are sweat glands, skeletal muscle, blood vessels and adrenal medulla.

The affect depends on the subtype:

- Alpha (alpha-1, alpha-2)
- Beta (beta-1, beta-2, beeta-3)œ

Generally…
The odd #s are excitatory.
The even #s are inhibitory.