AUTONOMICS I
General Characteristics of ANS

IN VOLUNTARY EFFERENT (MOTOR) SYSTEM; (Plus SENSORY hitchhikers)

VISCERAL - innervates 3 target areas:
  - smooth muscle (eg, GI tract, blood vessels, etc.)
  - cardiac muscle (heart)
  - Glands (eg, sweat, mucous, lacrimal, etc.)

TWO MAJOR COMPONENTS:
  a) **sympathetic nervous system** (SNS = thoracolumbar)
  b) **parasympathetic nervous system** (PSNS = craniosacral)

Minor third component that is gut-related:
  c) enteric

TWO NEURON SYSTEM from CNS to target structures:
  a) **preganglionic neuron** (cell body in CNS)
  b) **postganglionic neuron** (cell body in autonomic ganglion)
Somatic vs. Autonomic

Body Wall & Limbs
- Motor
  - Skeletal m.
  - Pain
  - Pressure
  - Proprioception
  - Temp
  - Touch
- Sensory

Visceral (glands, smooth and cardiac muscle)
- Motor
  - Glands
  - Cardiac m.
  - Smooth m.
- Sensory
  - Physiological (reflex)
  - Pain
- Sympathetic
  - Rest / Digest
  - Fight / Flight
- Parasympathetic
  - Body Cavities
  - Everywhere

Voluntary external environment
Involuntary internal environment
Outflow of autonomics from CNS

- Sympathetic chain and paravertebral (chain) ganglia - cervical to sacral
- Pre-aortic sympathetic ganglia

**SNS**
- Thoraco-lumbar (T1-L2)
- (CN 3, 7, 9, 10)
- Cranio-sacral (S2-4)

**PSNS**
Parasympathetic - Craniosacral

Cranio - from the brain: preganglionic cell bodies in brainstem nuclei associated with CN III, VII, IX, X (Vagus)
Vagus is the only cranial parasympathetic cranial nerve functioning in the cervical, thoracic and lumbar regions, serving parasympathetics to visceral structures in the neck, thorax and abdomen

Sacral - sacral or pelvic region: preganglionic cell bodies in spinal cord segments S2,3,4 - functioning in the pelvic region (called pelvic splanchnic nerves)

There are NO PARASYMPATHETIC INNERVATIONS TO THE BODY WALL and LIMBS (thus, parasympathetic fibers can only be found on nerves leaving the CNS (CN III, VII, IX, X and S2-4), and then distributed to organs in the body cavities)
Sympathetic – Thoraco-lumbar

1) Preganglionic cell bodies are located in lateral horn of spinal cord segments T1 – L2
2) **All** preganglionic axons enter the sympathetic chain through white rami communicans
3) From the above outflow into the sympathetic chain, sympathetics are supplied to the entire body, (body wall/limbs as well as organs in body cavities). Thus, there must be routes from the sympathetic chain that lead to organs as well as the body wall.
Visceral afferents - sensory fibers that accompany both sympathetic and parasympathetic fibers (these visceral afferents are “hitch-hiking” with sympathetics and parasympathetics and are not technically part of the SNS or PSNS)
**Autonomic Ganglia** - collections of nerve cell bodies outside the CNS are called ganglia – autonomic ganglia contain postganglionic sympathetic or parasympathetic nerve cell bodies

**Sympathetic Ganglia**
1) Sympathetic chain ganglia (paravertebral ganglia) – chain ganglia are found at all levels of the spinal cord / spinal nerves
2) Preaortic (prevertebral) sympathetic ganglia are only located in the abdomen, and are associated with major branches of the abdominal aorta

**Parasympathetic Ganglia** – discrete parasympathetic ganglia are only found in the head; FOR THE REST OF THE BODY, postganglionic parasympathetic cell bodies are found scattered near or in the walls of target organs
Autonomics Schematic

CNS

Sympathetic
Cell bodies in CNS nuclei
Preganglionic axons
Myelinated

Parasympathetic
Cell bodies in CNS nuclei
Postganglionic axons
Unmyelinated

Target:
Smooth m.
Cardiac m.
Glands

PNS

Short
Long

Cell bodies in PNS ganglia

Target:
Smooth m.
Cardiac m.
Glands

Long
Short
Spinal Cord - repeating similar units = cord segments

- 8 Cervical Segments
- 12 Thoracic Segments
- 5 Lumbar Segments
- 5 Sacral Segments
- 1 Coccygeal Segment

Sympathetic chain

grc

ganglia

wrc & grc
Dorsal root ganglion

Ventral root

Sympathetic chain & ganglion

Dorsal root

Spinal nerve

Dorsal ramus of spinal nerve

Ventral ramus of spinal nerve

Dorsal ramus of spinal nerve

Lat. horn

Gray ramus communicans (GRC)

Ventral ramus communicans (WRC)

Sympathetic chain anywhere between T1 – L2
Skin and muscles of the back

Skin and muscles of the body wall and limbs

SENSORY (PPPTT = pain, pressure, proprioception, touch, temperature)

MOTOR

Somatic innervation of the body wall

Skin and muscles of the body wall and limbs
Sympathetics to Body Wall

For spinal nerves above T1, preganglionic axons ascend in the chain to cervical chain ganglia.

ALL preganglionic sympathetics have cell bodies in the lateral horn of spinal gray matter from T1-L2; axons travel on spinal nerve ventral roots and enter the sympathetic chain via white rami communicantes.

For spinal nerves below L2, preganglionic axons descend in the chain to lumbar and sacral chain ganglia.
All preganglionic sympathetic cell bodies are located in the lateral horn of spinal segments T1–L2: therefore, lateral horns for sympathetic outflow are only located from T1-L2

All preganglionic sympathetic nerves enter the sympathetic chain via WRCs: therefore WRCs are only found in association with spinal nerves & chain ganglia from T1–L2
Above T1 spinal cord segment and below L2 spinal cord segment, there are **no** lateral horns (**no** preganglionic sympathetic outflow above T1 or below L2). Thus there are **no** WRCs **above** T1 or **below** L2, since there are **no** preganglionic sympathetic outflow to enter the chain above T1 or below L2.

GRCs are the “on-ramps” used by **postganglionic** sympathetics destined only for the **body wall and limbs** – GRCs **ONLY** lead to spinal nerves, the nerves of the body wall and limbs. GRCs are found at **ALL** levels of the full extent of the sympathetic chain (cervical to sacral).
Sympathetic fibers – routes from the chain

ALL preganglionic sympathetics enter the chain via WRCs

From the chain, there are routes (everywhere):
1) To the body wall and limbs
2) To thoracic organs (heart, airways, thoracic esophagus)
3) To abdominal organs
4) To pelvic organs
5) To structures in the head
Sympathetics to spinal nerves T1–L2:

a) preganglionics with cell bodies in lateral horn of spinal segments T1–L2 enter the sympathetic chain via WRCs →

b) synapse in ganglia at the same spinal level

c) postganglionics exit the chain via gray rami → spinal nerves T1–L2 → dorsal and ventral rami of these spinal nerves

d) → innervate sweat glands, arrector pili muscles and vascular smooth muscle in the body wall at T1 – L2 levels
Sympathetics to spinal nerves above T1:
a) preganglionics with cell bodies in lateral horn of upper thoracic segments enter the chain via WRCs
b) → ascend in chain to synapse in cervical chain ganglia →
c) postganglionics exit chain via gray rami communicans → spinal nerves C1-C8
d) → dorsal and ventral rami of these spinal nerves → supply neck / upper limbs above T1 level
Sympathetics to Body Wall and Limbs

Sympathetics to spinal nerves below L2:

a) preganglionics with cell bodies in lateral horn of upper lumbar spinal segments enter the sympathetic chain via WRCs
b) → descend in chain → *synapse in lower lumbar and sacral chain ganglia* →
c) postganglionics exit chain via gray rami → spinal nerves L3-S5 → dorsal and ventral rami of these spinal nerves → innervate body wall & lower limbs below L2 level
What Targets Do Sympathetics Innervate In the Body Wall and Limbs?

There are only 2 types of sympathetic targets in the body wall and limbs:
1) Sweat glands
2) Smooth muscle (erector pili muscles, blood vessels in the skin, in connective tissues and in skeletal muscles)
Dorsal root is **sensory only** (and so far we have only seen somatic sensory nerves coming from the body wall and limbs via the dorsal and ventral rami of spinal nerves)
Ventral root is motor only, both somatic motor and preganglionic sympathetics (visceral motor).
Spinal nerve and its branches (dorsal ramus and ventral ramus) are mixed nerves: somatic motor, somatic (and visceral) sensory and postganglionic sympathetics (visceral motor)