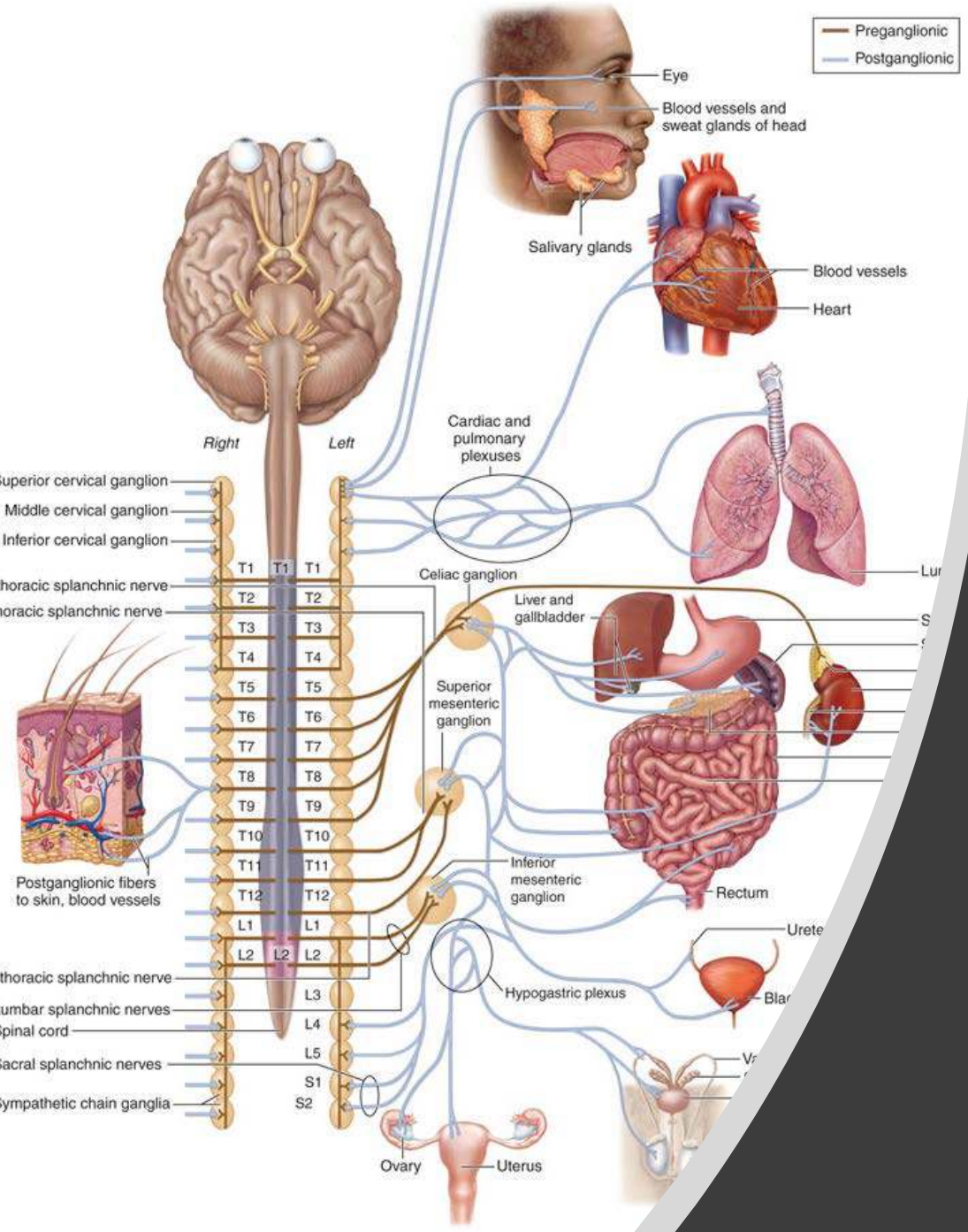


Abdominal Nerve Supply (Emphasis on the Digestive System)

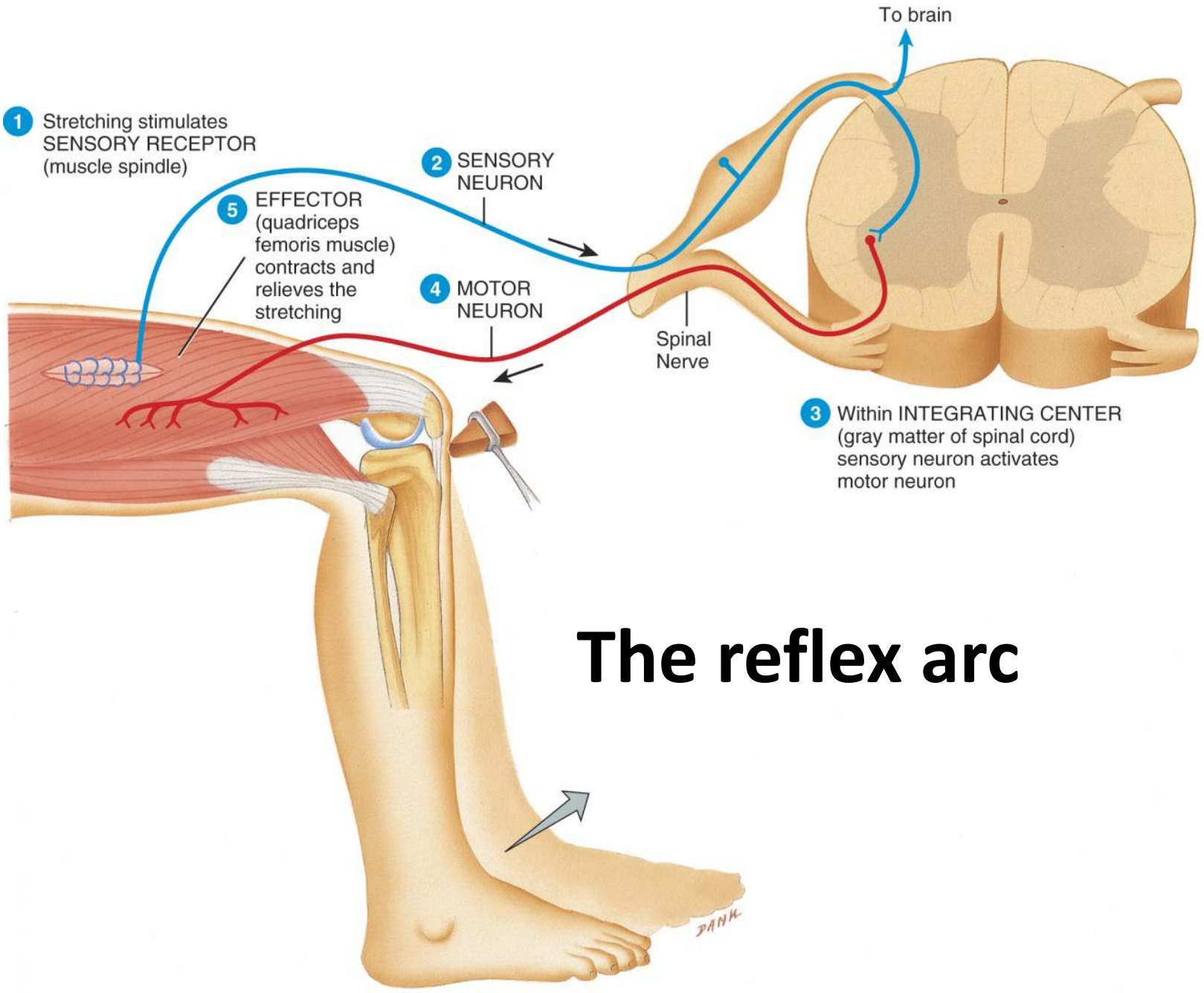
Prof Oluwadiya KS

www.oluwadiya.com

Introduction to the Nervous System

The reflex arc

- The simplest basis of nervous system function
- Consists basically of the following:
  - The sensory organ
  - The sensory neuron
  - ± Interneuron in the CNS
  - The motor neuron
  - Effector organ



The reflex arc

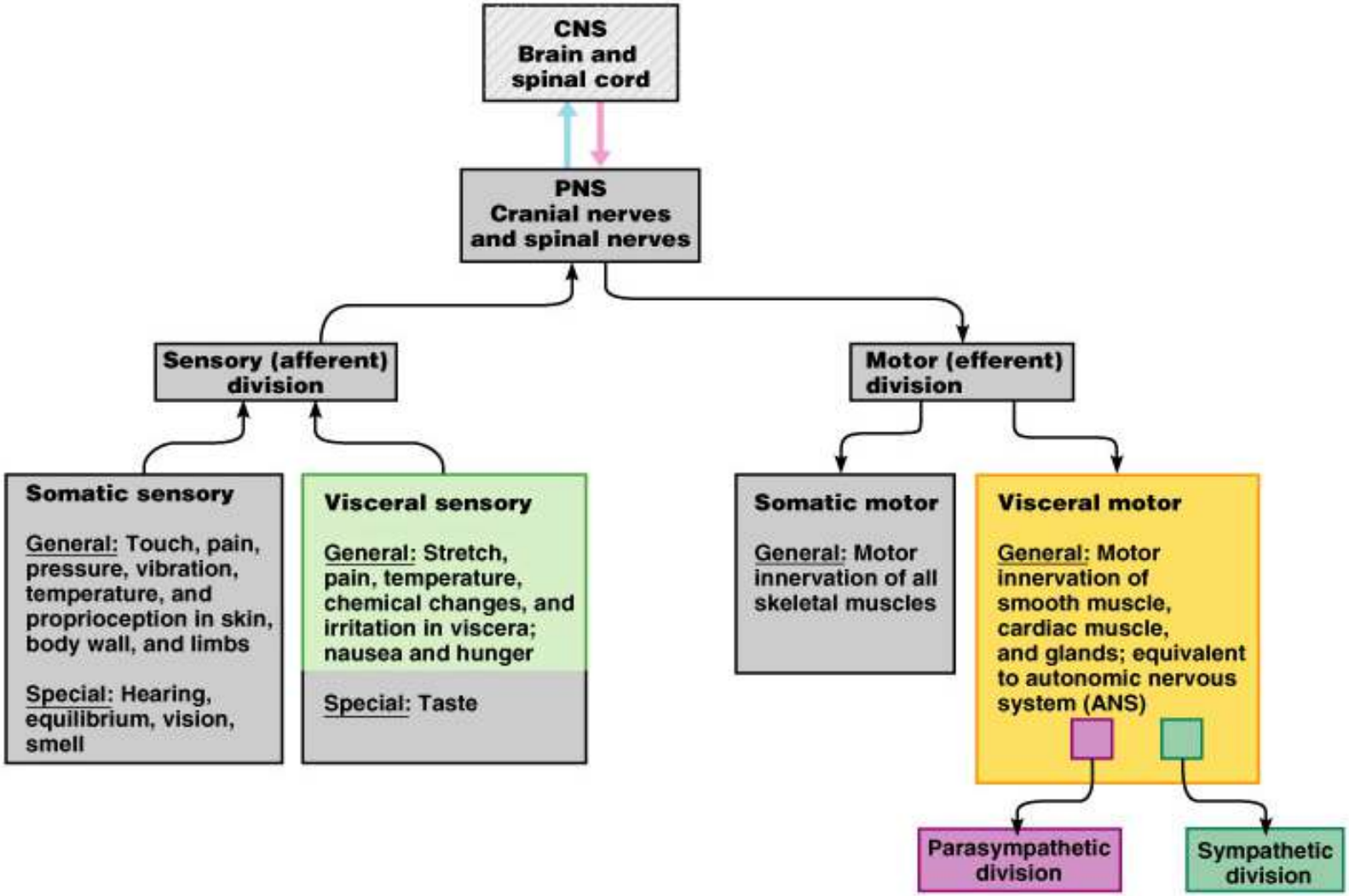
Spinal nerves

- Comprise the peripheral nervous system (PNS)
- Connect the CNS to muscles, sensory receptors and glands
- 31 pairs of spinal nerves
- Have posterior and anterior roots (mixed nerves)

Nervous system

- Divided into:
    i. Somatic Nervous System (SNS)
    ii. Autonomic Nervous System (PNS)

Nervous system

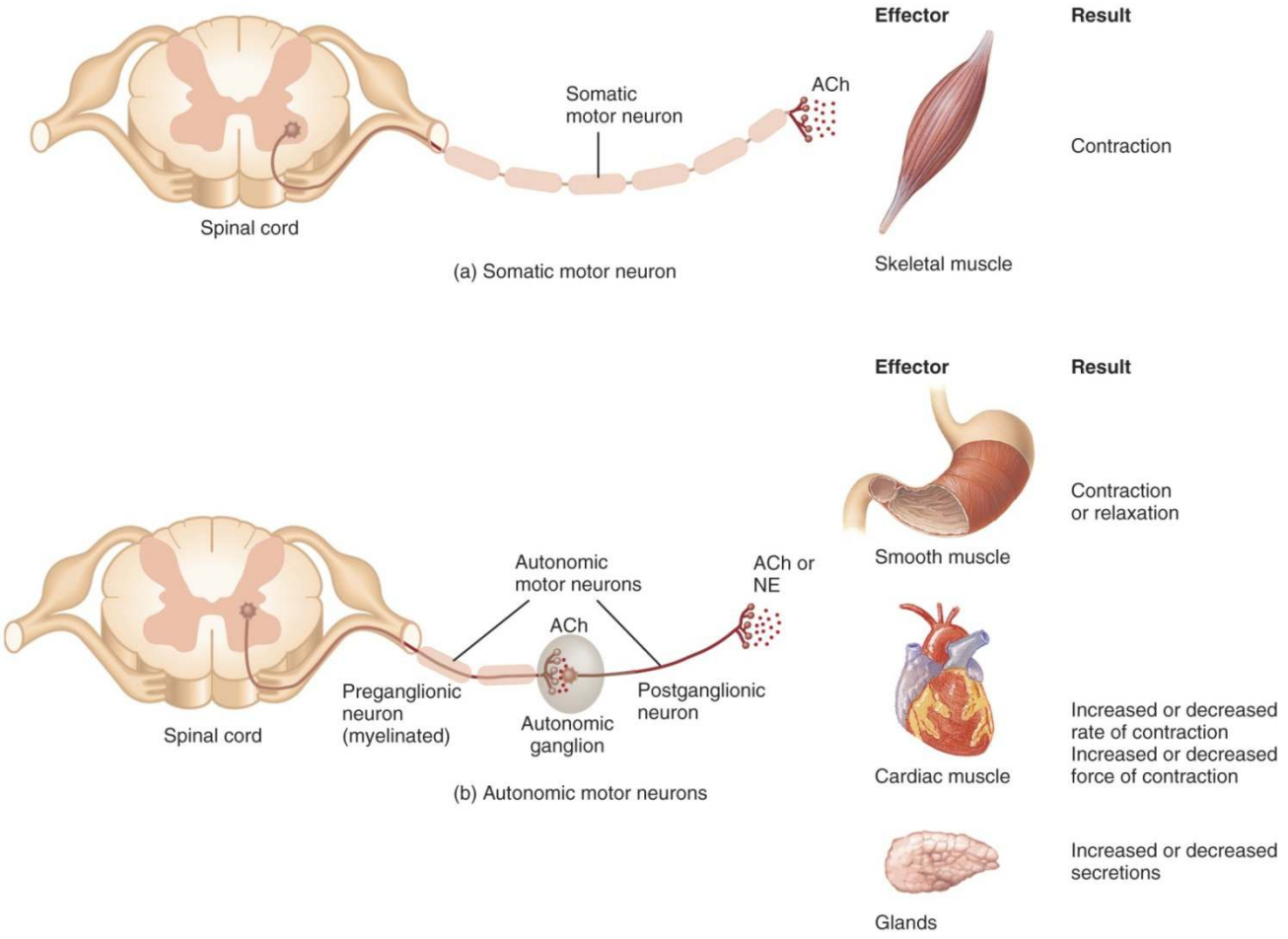


Comparison of Somatic and Autonomic Nervous Systems

- Both the SNS and the ANS use sensory and motor neurons.
- In the SNS somatic motor neurons innervate skeletal muscle fibers, causing conscious voluntary movement.
- ANS motor neurons innervate smooth muscle fibers, cardiac muscle fibers, or glands.
- ANS motor neurons can either excite or inhibit cells in the viscera.

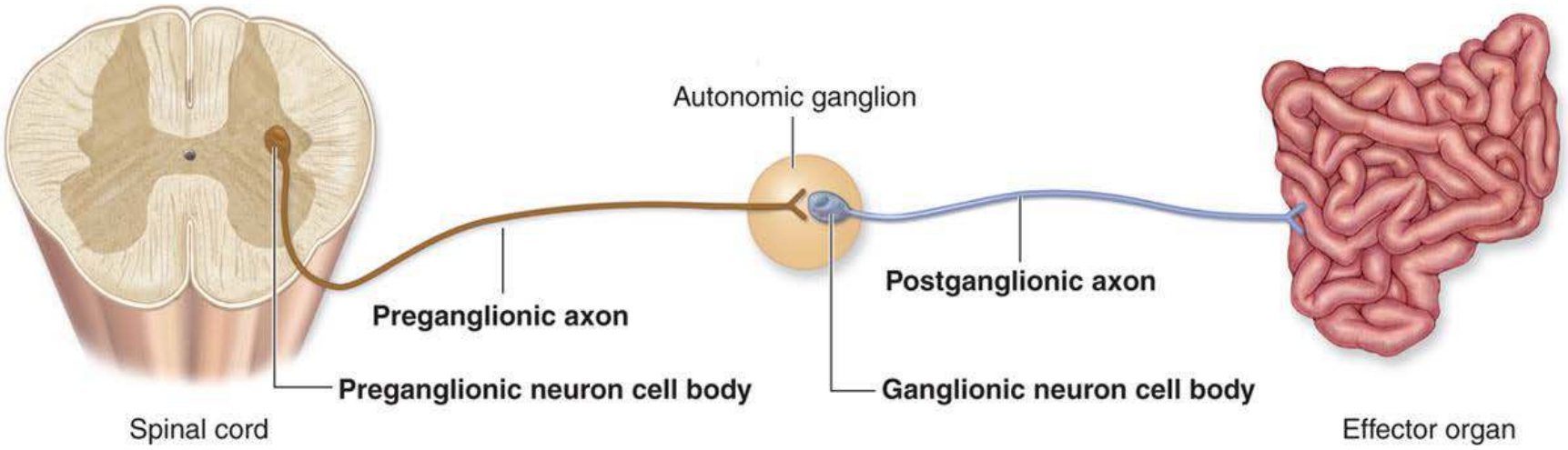
Comparison of Somatic and Autonomic Nervous Systems

- **SNS**--a single lower motor neuron axon extends uninterrupted from the spinal cord to one or more muscle fibers.
- **ANS**--two neurons chain to innervate muscles and glands.

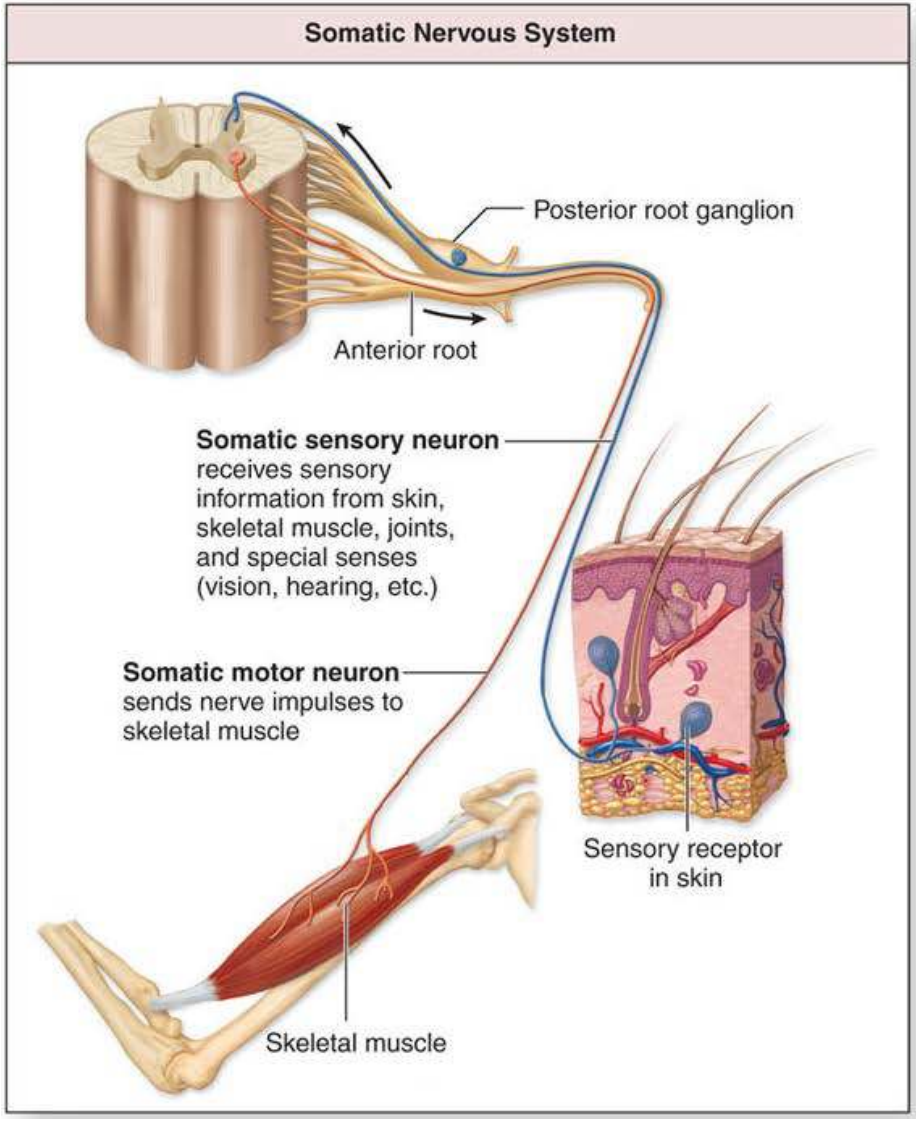


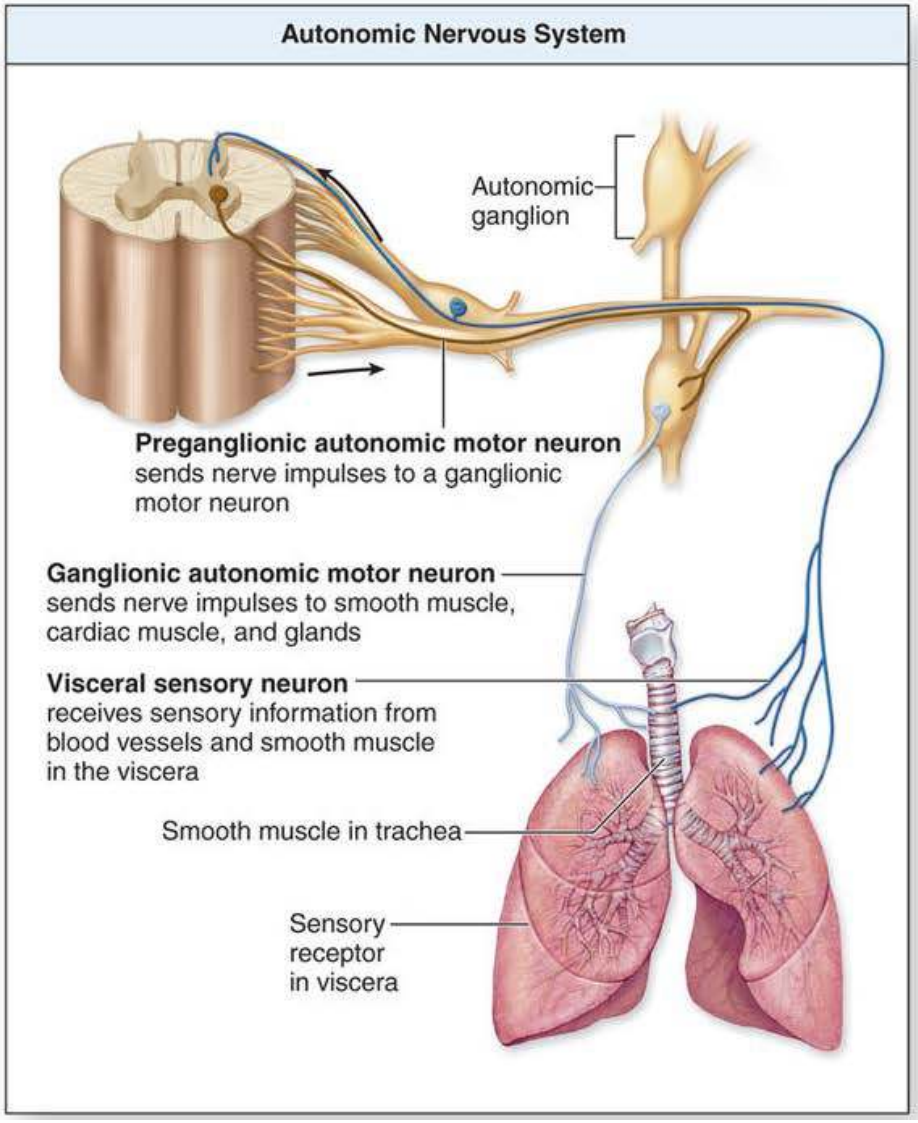
Two-Neuron Chain in ANS

- The first neuron in the ANS pathway is the ***preganglionic neuron***. Its cell body is in the brain or spinal cord.
- A ***preganglionic axon*** extends to the second cell body housed within an autonomic ganglion in the peripheral nervous system.
- The second neuron in the pathway is called a ***ganglionic neuron***.
- A ***postganglionic axon*** extends from its cell body to effector (target) cells.



Comparison of Somatic and Autonomic Nervous Systems





Comparison of Somatic and Autonomic Motor Nervous Systems

Feature	Somatic Nervous System	Autonomic Nervous System
Type of Control	Voluntary control (from cerebral cortex; input from basal nuclei, brainstem, cerebellum, and spinal cord)	Involuntary control (from brainstem, hypothalamus, limbic system, and spinal cord)
Number of Neurons in Pathway	One neuron in pathway; somatic motor neuron axon extends from CNS to effector	Two neurons in pathway; preganglionic neuron in CNS projects preganglionic axon to ganglionic neuron; ganglionic neuron projects postganglionic axon to effector
Ganglia Associated with Motor Neurons	None	Autonomic ganglia: sympathetic trunk ganglia; prevertebral ganglia; terminal or intramural ganglia
Sensory Input	General somatic senses, proprioceptors; special senses	Some somatic and visceral senses
Ganglia Associated with Sensory Input	Posterior root ganglia; sensory ganglia of cranial nerves	Posterior root ganglia; sensory ganglia of cranial nerves
Effector Organs	Skeletal muscle fibers	Cardiac muscle fibers, smooth muscle fibers, glands
Response of Effector	Excitation only	Either excitation or inhibition of effectors
Neurotransmitter Released	Acetylcholine (ACh)	ACh from all preganglionic axons and parasympathetic postganglionic axons, and a few sympathetic postganglionic axons; norepinephrine (NE) from most sympathetic postganglionic axons
Axon Properties	Myelinated, thick; fast conduction	Preganglionic axons are thin, myelinated; postganglionic axons are thinner, unmyelinated, have slow conduction

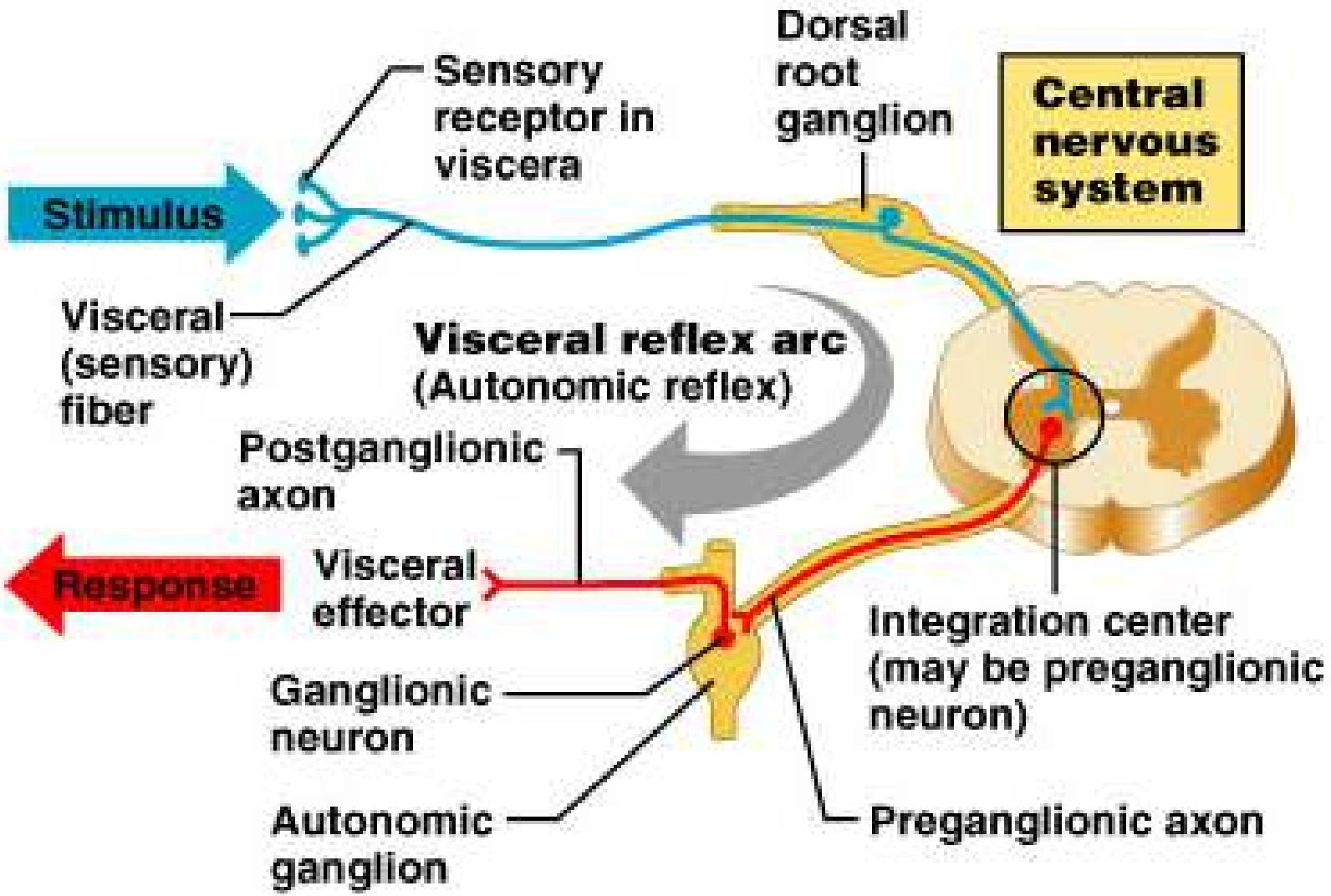
The Autonomic Nervous System

Divisions of Autonomic Nervous System

- **Parasympathetic Division**--conservation of energy and replenishment of nutrient stores ("rest and digest").

- **Sympathetic Division**--preparation of body for emergencies ("fight-or-flight"). Increased activity of this division results in increased alertness and metabolic activity.

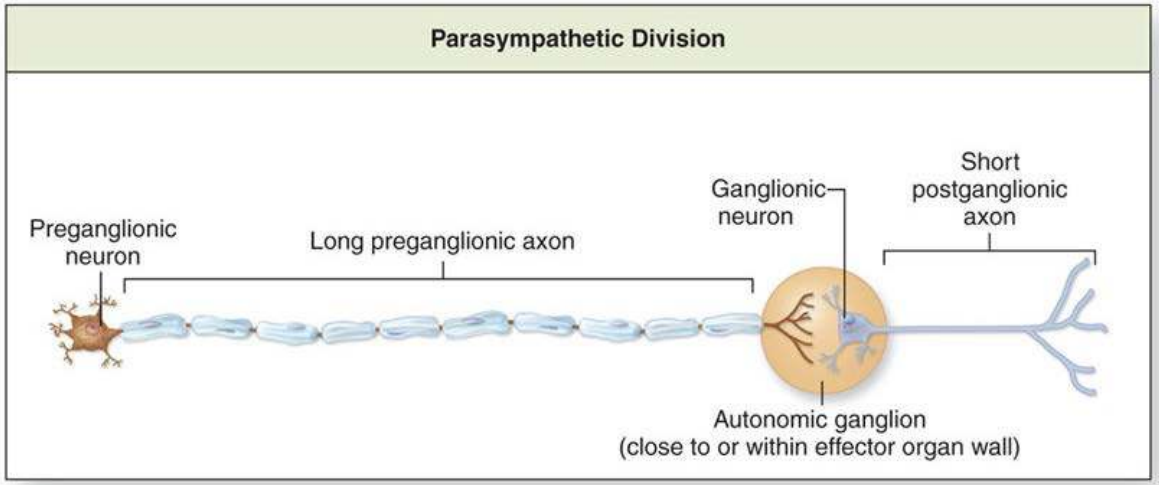
Visceral Reflex Arc

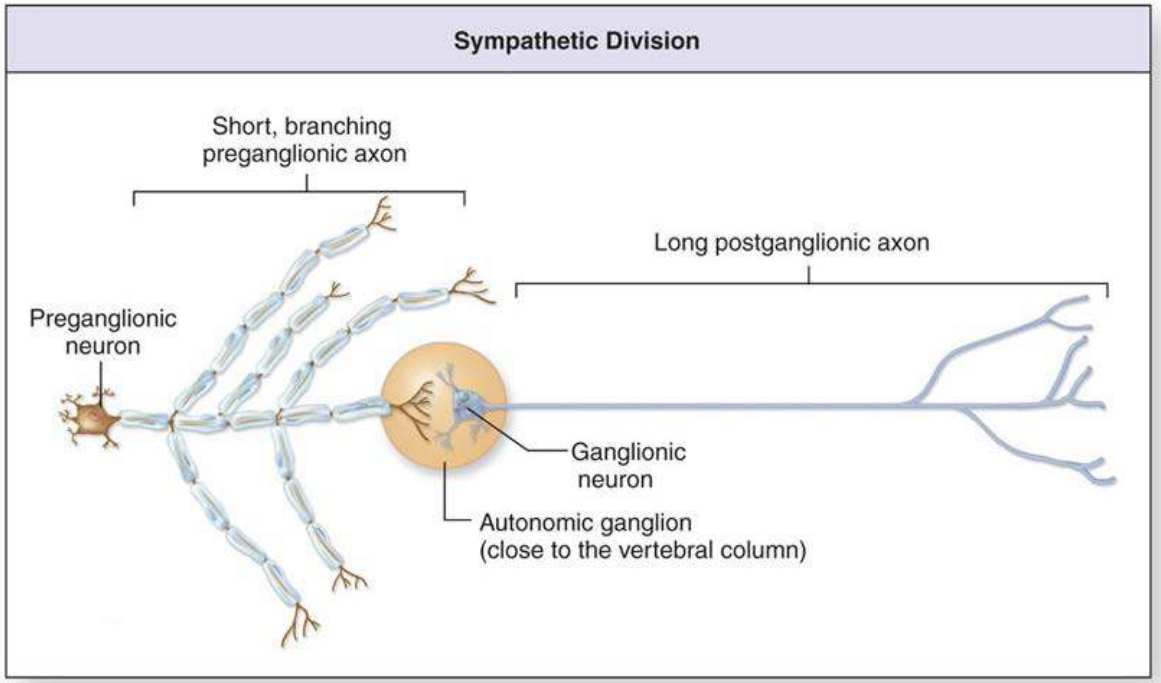


Different types of ganglia

- **Sympathetic**
  - Sympathetic trunk ganglia
  - Prevertebral ganglia
    - Found in the abdomen
    - Include Celiac, superior and inferior mesenteric ganglia
- **Parasympathetic**
  - Intramural or terminal ganglion

Anatomic Differences Between Parasympathetic and Sympathetic Neurons





Comparison of Sympathetic and Parasympathetic Divisions

Feature	Parasympathetic Division	Sympathetic Division
Function	Conserves energy and replenishes energy stores; maintains homeostasis; "rest-and-digest" division	Prepares body to cope with emergencies and intensive muscle activity; "fight-or-flight" division
Location of Preganglionic Neuron Cell Bodies	Brainstem and lateral gray matter in S2–S4 segments of spinal cord	Lateral horns in T1–L2 segments of spinal cord
Location of Ganglionic Neuron Cell Bodies	Terminal or intramural ganglion	Sympathetic trunk ganglion or prevertebral ganglion
Divergence of Axons	Few (1 axon innervates < 4 ganglionic cell bodies)	Extensive (1 axon innervates > 20 ganglionic cell bodies)
Length of Preganglionic Axon	Long	Short
Length of Postganglionic Axon	Short	Long
Location of Ganglia	Terminal ganglia located close to the target organ; intramural ganglia located within wall of the target organ	Sympathetic trunk (paravertebral) ganglia located on either side of vertebral column; prevertebral (collateral) ganglia located anterior to vertebral column and descending aorta
Rami Communicantes	None	White rami attach to T1–L2 spinal nerves; gray rami attach to *all* spinal nerves

Postganglionic neurons

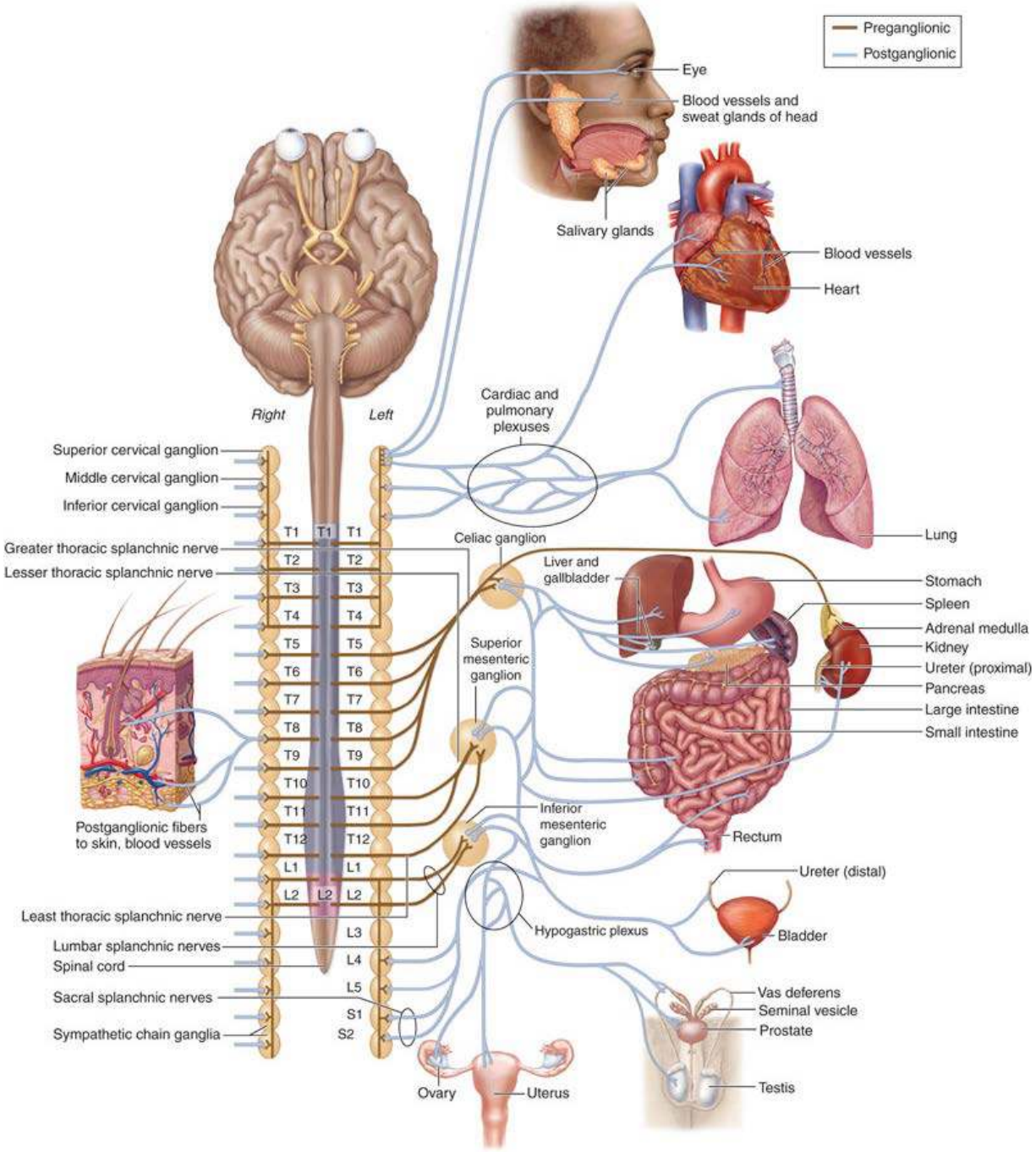
- Sympathetic system
  - One presynaptic neuron can diverge onto many postganglionic neurons
  - Many organs can be affected at once
  - May extend to adrenal medullae
- Parasympathetic system
  - Many postsynaptic neurons can converge on a single effector
  - Effect can be localized to a single effector

The Sympathetic Division of the Autonomic Nervous System

Sympathetic Division

- Also termed ***thoracolumbar division*** because preganglionic neuron cell bodies are housed in **lateral horn** of the spinal cord between first thoracic (T1) and second lumbar (L2) spinal segments.
- Preganglionic axons travel with somatic motor neuron axons to exit the spinal cord and enter the anterior roots and then the T1-L2 spinal nerves.

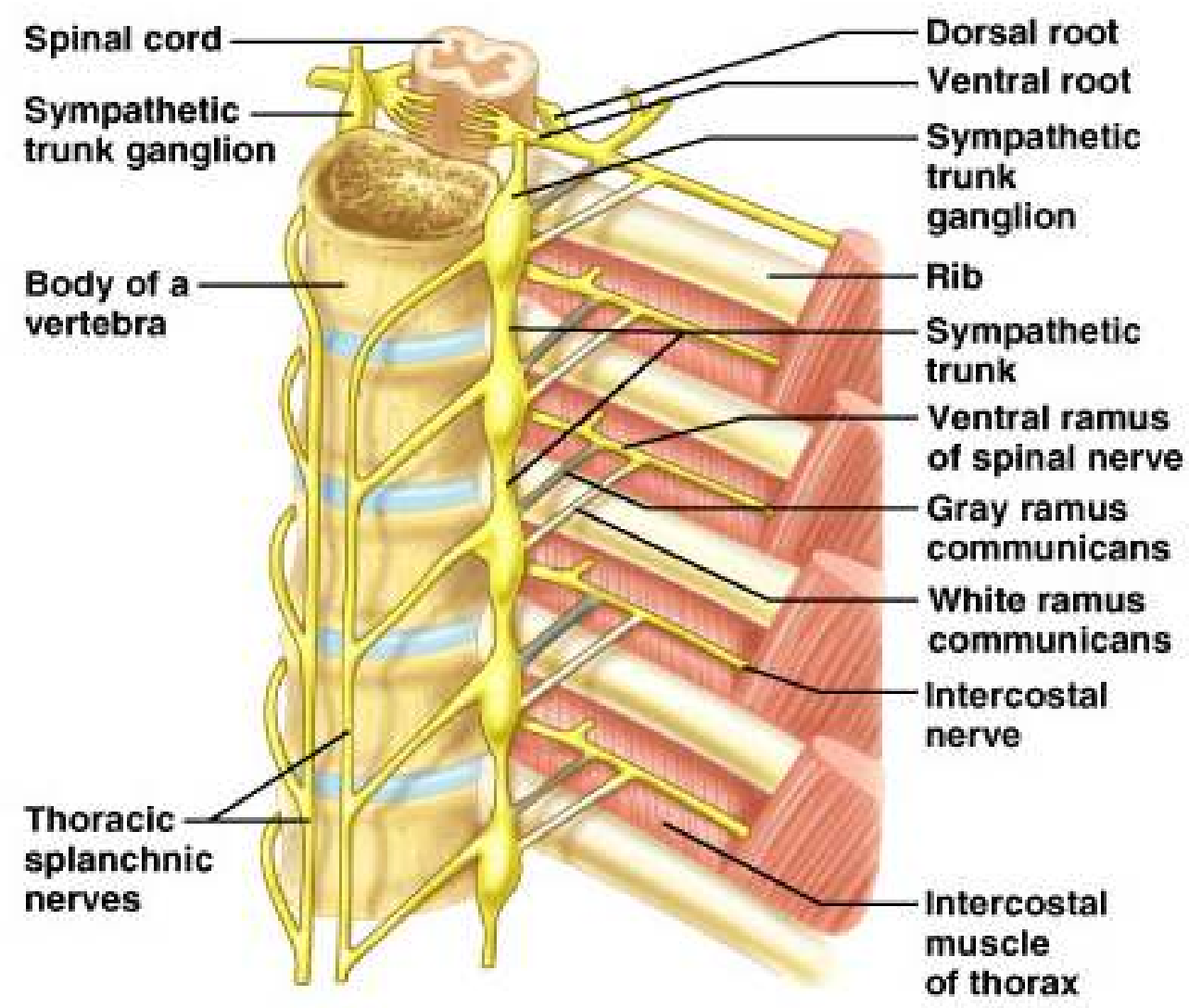
Overview of Sympathetic Pathways



Right and Left Sympathetic Trunks

- Sympathetic trunks are located anterior to spinal nerves and immediately lateral to vertebral column.
- ***Sympathetic trunk ganglia (paravertebral or chain ganglia)*** house sympathetic ganglionic neuron cell bodies. Approximately one sympathetic ganglion is associated with each spinal nerve.
- Cervical portion of each sympathetic trunk is partitioned into three ganglia: the superior, middle and inferior ganglia.

Sympathetic Trunk Ganglia



Rami Communicantes

- Connect sympathetic trunk to each spinal nerve.
- Preganglionic sympathetic axons of T1-L2 spinal nerves are carried by ***white rami communicantes*** (or ***white rami***).
- Postganglionic sympathetic axons are carried from the sympathetic trunk to the spinal nerve by ***gray rami communicantes*** (or ***gray rami***).

Rami Communicantes

- Gray rami connect to all spinal nerves including cervical, sacral and coccygeal spinal nerves.
- Preganglionic axons of white rami are myelinated
- Postganglionic axons of gray rami are unmyelinated.

Splanchnic Nerves

- Composed of preganglionic sympathetic axons that pass through the sympathetic trunk ganglion without synapsing in the trunk.
- Run anteriorly from sympathetic trunk to prevertebral ganglia, where they synapse with postganglionic neurons.

Splanchnic Nerves (Contd.)

- These include:
  - *Greater thoracic splanchnic nerves*: T5-T9.
  - *Lesser thoracic splanchnic nerves*: T10-T11.
  - *Least thoracic splanchnic nerves*: T12.
  - *Lumbar splanchnic nerves*: L1 and L2.
  - *Sacral splanchnic nerves*: Sacral sympathetic ganglia.

Prevertebral (or Collateral) Ganglia

- Splanchnic nerves typically terminate in ***prevertebral ganglia***.
- Prevertebral Ganglia are unpaired and immediately anterior to the vertebral column on the anterolateral surface of the aorta in the abdominopelvic cavity.

Prevertebral (or Collateral) Ganglia

- Ganglia typically cluster around the major abdominal arteries and are named for the arteries.
- Sympathetic postganglionic axons extend away from the ganglionic neuron cell bodies in the ganglia and innervate many of the abdominal organs.

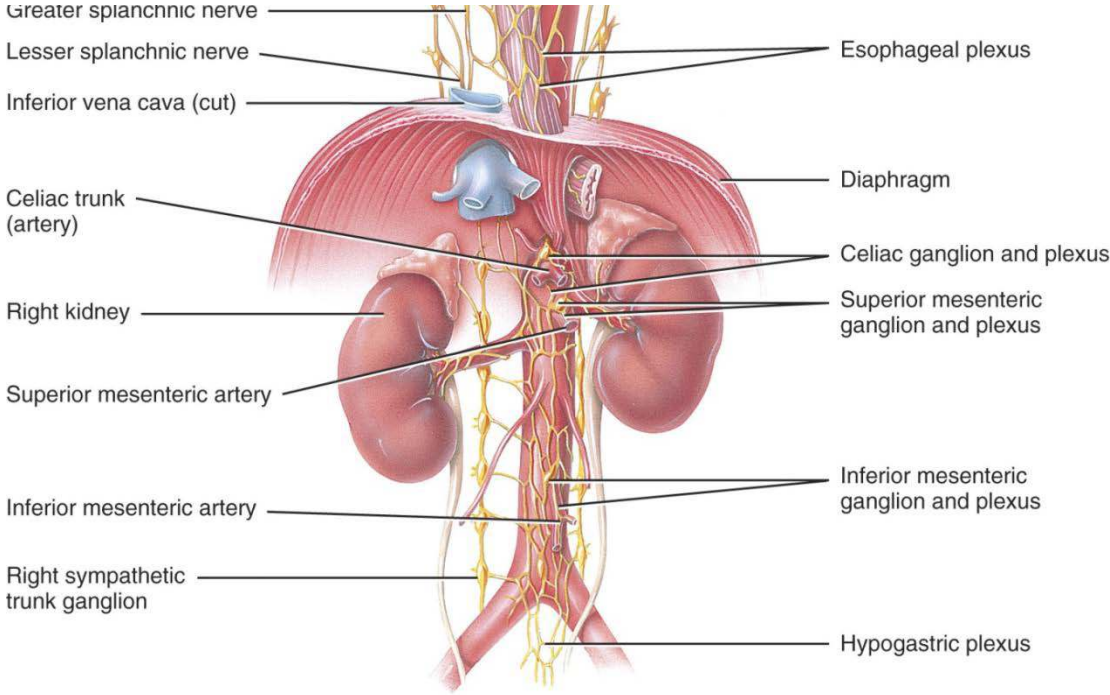
Prevertebral Ganglia

Prevertebral ganglia include:

i. Celiac ganglion

ii. Superior mesenteric ganglion

iii. Inferior mesenteric ganglion



Celiac Ganglion

- Location--adjacent to origin of celiac artery.
- Preganglion axons--greater thoracic splanchnic nerves (T5-T9 segment of spinal cord).
- Postganglionic axons--innervate stomach, spleen, liver, gallbladder, proximal duodenum, part of pancreas.

Superior Mesenteric Ganglion

- Location--adjacent to origin of superior mesenteric artery.
- Preganglionic axons--lesser and least thoracic splanchnic nerves (T10-T12 segment of spinal cord).
- Postganglionic axons--innervate distal duodenum, part of pancreas, remainder of small intestine, proximal large intestine, kidneys, proximal part of ureters.

Inferior Mesenteric Ganglion

- Location--adjacent to the origin of the inferior mesenteric artery.
- Preganglionic axons--lumbar splanchnic nerves (L1-L2 segment of spinal cord).
- Postganglionic axons--innervate the distal colon (from the splenic flexure down), rectum, urinary bladder, distal ureter, and most of reproductive organs.

Sympathetic Pathways

- All preganglionic neurons originate in lateral gray horns of T1-L2 regions of the spinal cord.
- Preganglionic axons travel with T1-L2 spinal nerves.
- Preganglionic axons immediately leave spinal nerve and travel through white rami to enter sympathetic trunk.

Sympathetic Pathways

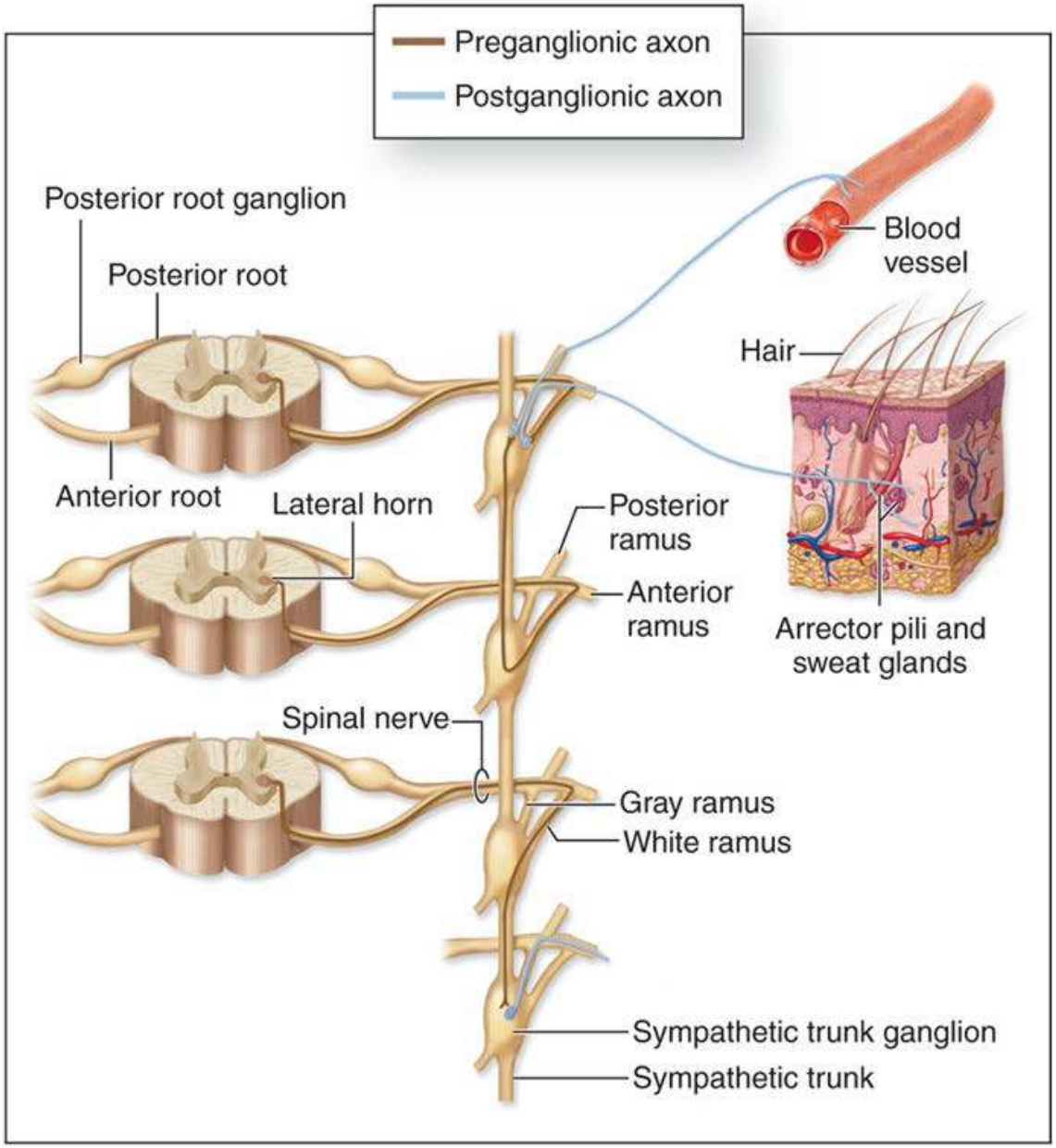
Once inside the sympathetic trunk, preganglionic axons may remain at the level of entry or travel superiorly or inferiorly within the sympathetic trunk.

Axons exit sympathetic trunk ganglia by:

1. **spinal nerve pathway**
2. **postganglionic sympathetic nerve pathway**
3. **splanchnic nerve pathway**
4. **adrenal medulla pathway**

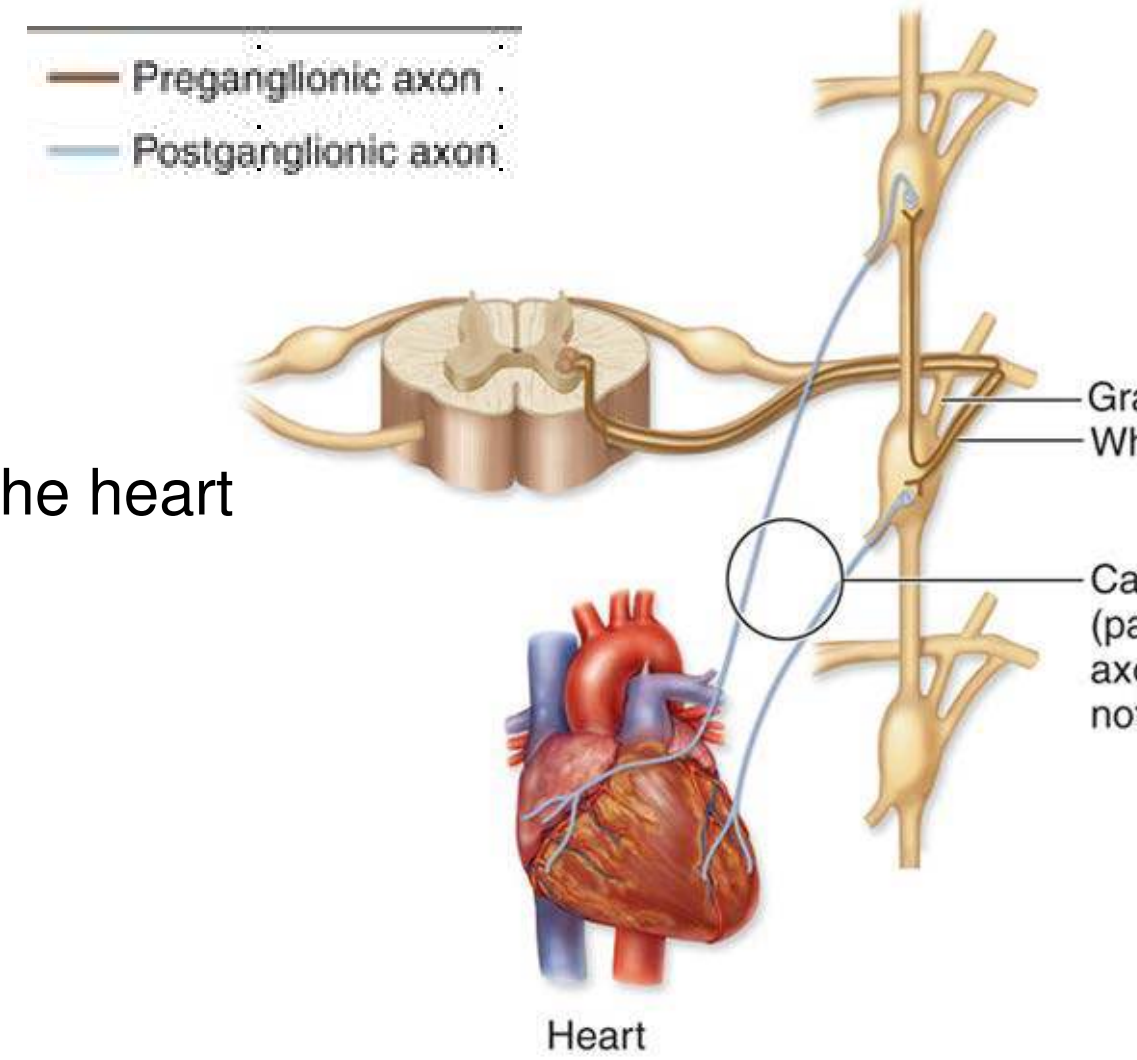
Spinal Nerve Pathway

This is how the blood Vessels and the skin glands are supplied

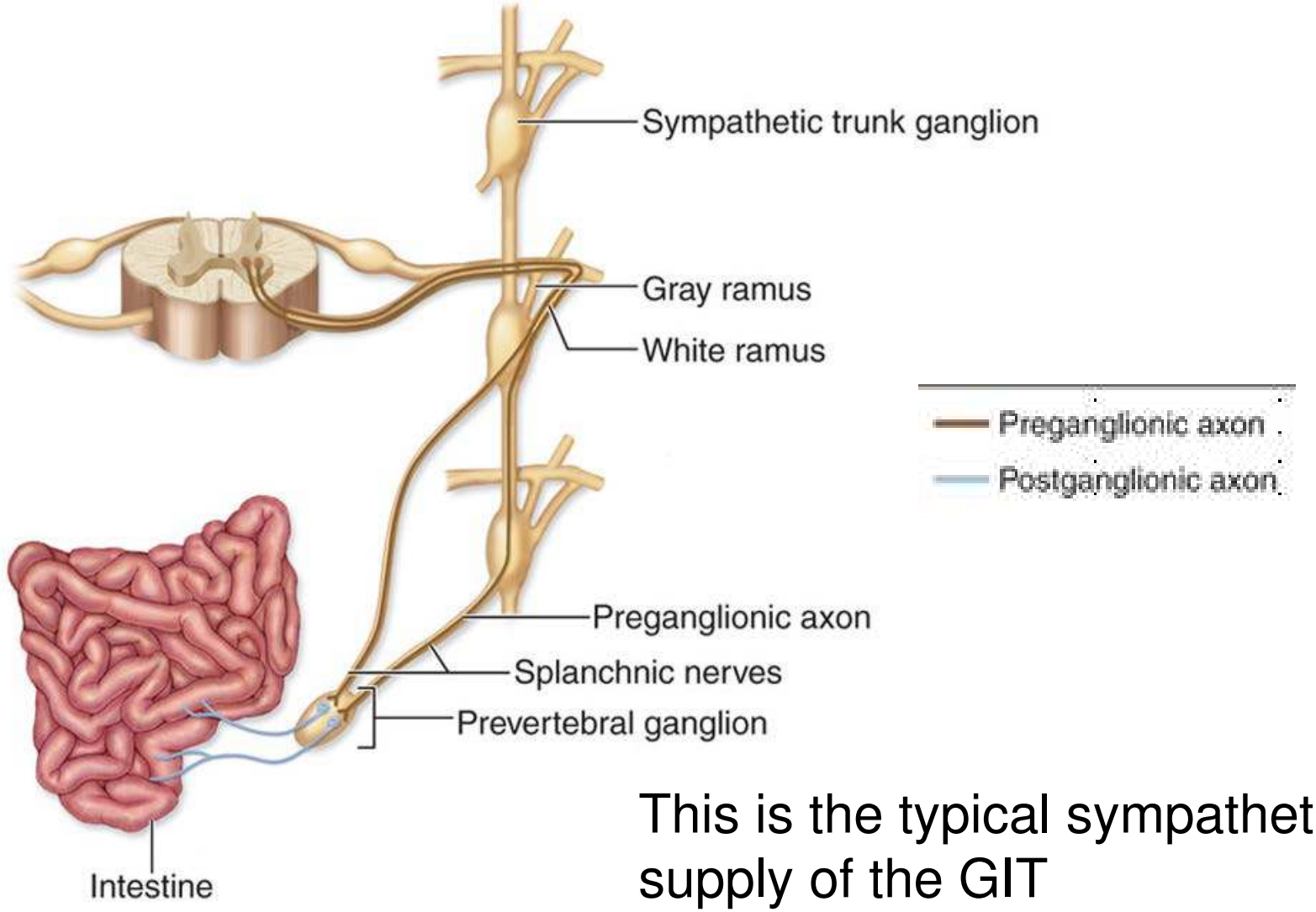


Postganglionic Sympathetic Nerve Pathway

This is how the heart is supplied



Splanchnic Nerve Pathway



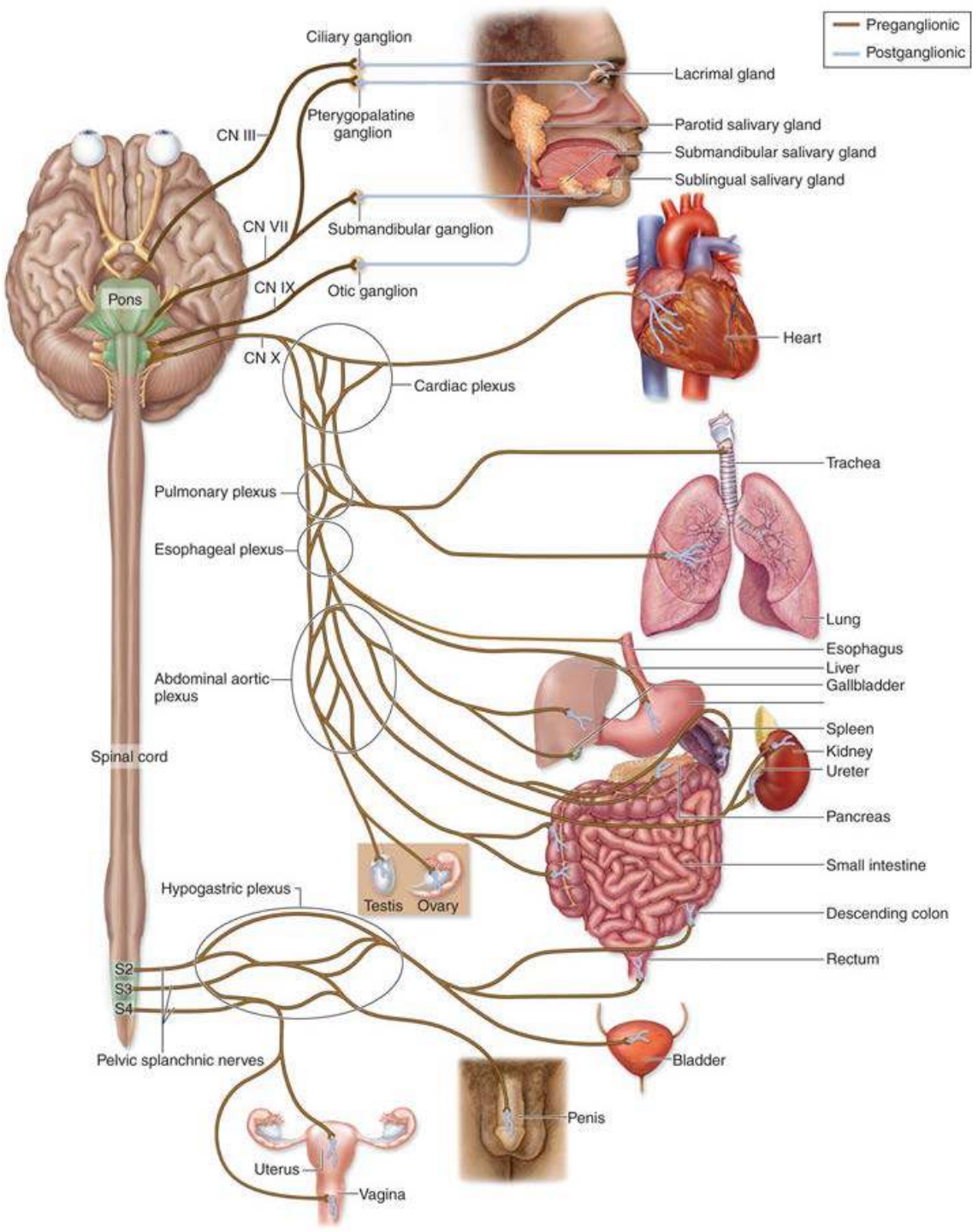
This is the typical sympathetic supply of the GIT

The Parasympathetic Division

The Parasympathetic Division

- **Cranial outflow**
  - Comes from the brain
  - Innervates organs of the head, neck, thorax, and abdomen
- **Sacral outflow**
  - Supplies remaining abdominal and pelvic organs not supplied by the cranial outflow (vagus nerve)

Overview of Parasympathetic Pathways



Cranial Outflow

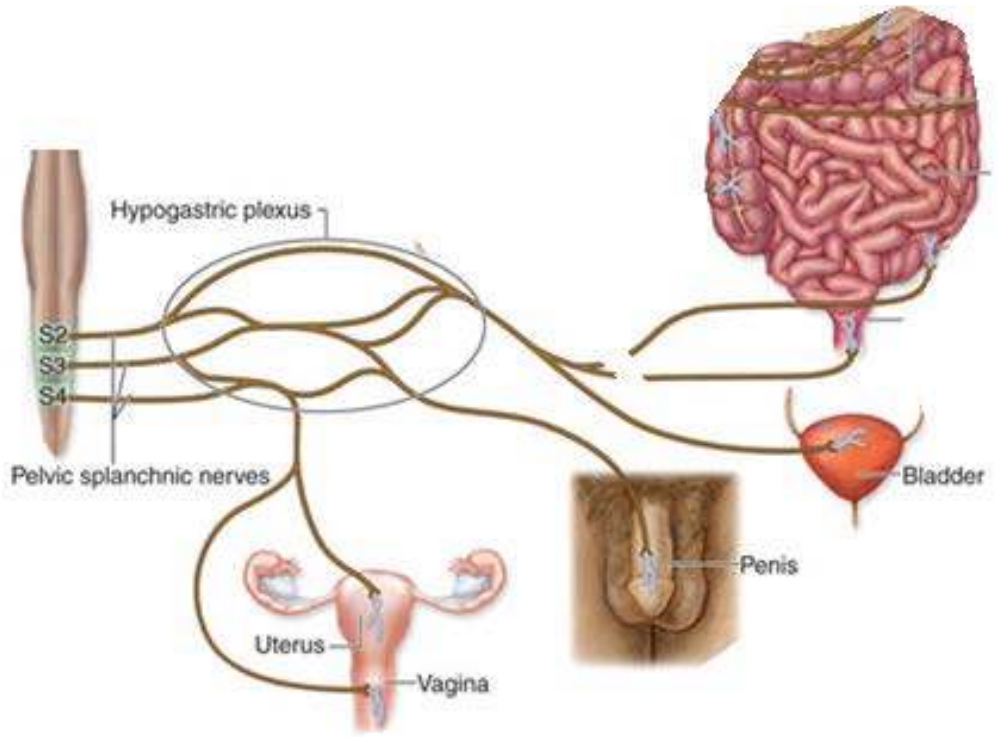
- Preganglionic fibers run via:
  - Oculomotor nerve (III)
  - Facial nerve (VII)
  - Glossopharyngeal nerve (IX)
  - Vagus nerve (X)
- Cell bodies located in cranial nerve nuclei in the brain stem

Outflow via the Vagus Nerve (X)

- Fibers innervate visceral organs of the thorax and most of the abdomen
- Stimulates - digestion, reduction in heart rate and blood pressure
- Preganglionic cell bodies
  - Located in dorsal motor nucleus in the medulla
- Ganglionic neurons
  - Confined within the walls of organs being innervated

Parasympathetic Nervous System: Sacral Outflow

- Emerges from S_2-S_4
- Innervates organs of the pelvis and lower abdomen
- Preganglionic cell bodies located in lateral grey region of spinal cord
- Form pelvic splanchnic nerves



Spinal Sacral Nerves

- Preganglionic neuron cell bodies are housed within lateral gray regions of S2-S4 spinal cord segments.
- Preganglionic axons branch to form pelvic splanchnic nerves which contribute to the superior and inferior hypogastric plexus.
- Preganglionic fibers also project to ganglionic neurons within terminal or intramural ganglia of large intestine (from splenic flexure downward), rectum, reproductive organs, urinary bladder, and distal ureter.

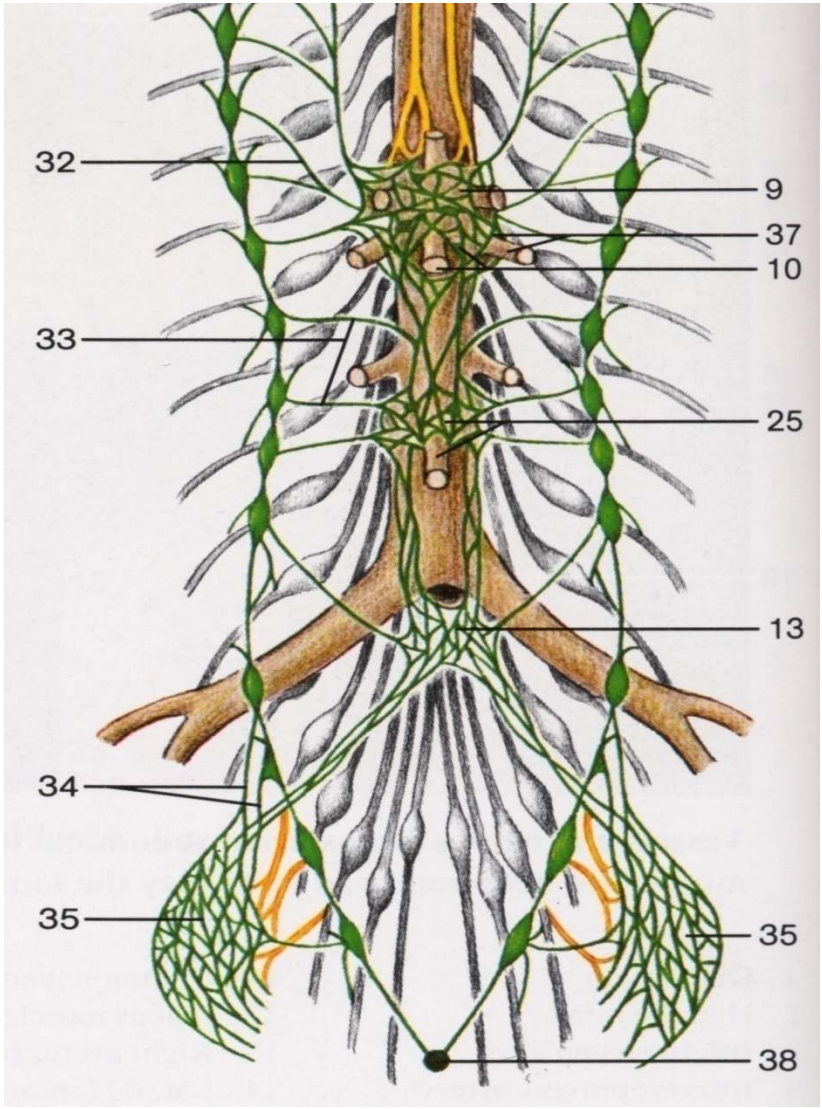
Dual Innervation

- Many visceral effectors have ***dual innervation*** with innervation by postganglionic axons from both sympathetic and parasympathetic divisions.
- The actions of the divisions usually oppose each other (antagonistic effects).

Scheme of Autonomic Fibers and Ganglia

Key

9. Celiac trunk and ganglion
10. Superior mesenteric artery and ganglion
13. Superior hypogastric plexus and ganglion
32. Lesser splanchnic nerve
33. Lumbar splanchnic nerves
34. Sacral splanchnic nerves
35. Inferior hypogastric ganglion and plexus
37. Aorticorenal plexus and renal artery
38. Ganglion impar



Innervation of Abdominal Organs

Peritoneum

- Parietal Peritoneum
  - Somatic nerves from spinal nerves
- Visceral Peritoneum
  - Nerves from autonomics; sensitivity is similar to viscera

Bowel Innervation

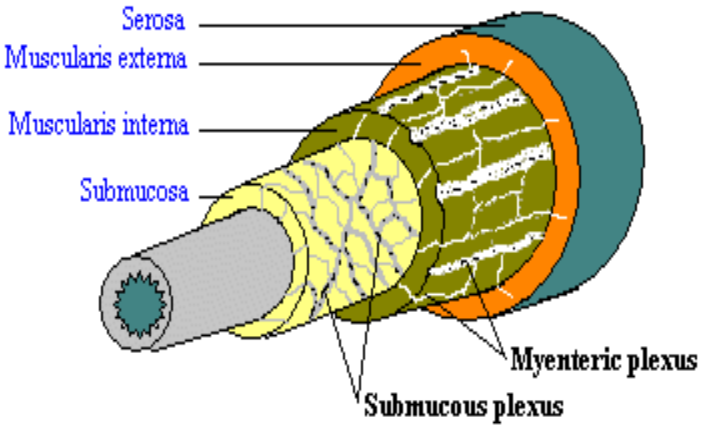
- **Neural controls**
  - **Extrinsic (3)**
    1) Sympathetic
    2) Parasympathetic
    3) Somatic
  - **Intrinsic (2)**
    1) Myenteric plexus
    2) Submucosal plexus

Innervation of Viscera organs

- Viscera organs are normally not sensitive to painful stimuli
  - Burn and crush not felt
  - Stretch, over distension, traction are felt as pain
  - Spasm, ischemia and inflammation are also felt as pain

Intrinsic nervous system

- Submucosal (Meissner) plexus
- Myenteric (Auerbach) plexus
- Regulate segment-to-segment movement of the gastrointestinal (GI) tract
- May be considered a 3rd part of the ANS



Intrinsic Nervous System

- **Myenteric plexus (Auerbach)**
  - Located between the longitudinal and circular layers of muscle in the tunica muscularis
  - Controls tonic and rhythmic contractions
  - Exerts control primarily over digestive track motility
- **Submucosal plexus (Meissner)**
  - Buried in the submucosa
  - Senses the environment within the lumen
  - Regulates GI blood flow
  - Controls epithelial cell function (local intestinal secretion and absorption)
  - May be sparse or missing in some parts of GI tract
- Partially controlled by autonomic nervous system

Intrinsic Nervous System

- **3 types of neurons in enteric system**
  1. **Sensory neurons**
     - Chemoreceptors sensitive to acid, glucose and amino acids
     - Sensory receptors in muscle respond to stretch and tension
  2. **Motor neurons**
     - Control GI motility and secretion
  3. **Interneurons**
     - Largely responsible for integrating information from sensory neurons and providing it to motor neurons

Intrinsic Nervous System

- **Enteric neurotransmitters**
  - Acetylcholine
    - Excitatory
      - Stimulate smooth muscle contraction
      - Increase intestinal secretions,
      - Release of enteric hormones
      - Dilation of blood vessels
  - Norepinephrine
    - Inhibitory
- **Functions autonomously**
  - but normal digestive function requires communication between the intrinsic system and CNS

The End.

- **Question?**
- **PLEASE JOIN THE FORUM AT WWW.OLUWADIYA.COM TO ASK QUESTIONS**