Systemic Module
CNSII

“Anatomy”

Autonomic Nervous System

Dr. Ayman Alzubi

Faculty of Medicine, Yarmouk University

Nervous System

Remember !!!

- Two main divisions of Nervous system:
  - **Central Nervous System (CNS).**
  - **Peripheral Nervous System (PNS).**

- **CNS:** Composed of the **brain** and **spinal cord** -- Serve as the main control centers for all body activities.

- **PNS:** Composed of the **cranial nerves** and **spinal nerves** **--** Serve as linkage between the CNS and the body.

Nervous System

- PNS consists of :
  - **Sensory (afferent) nerves.**
  - **Motor (efferent) nerves.**
- The sensory nerves send nerve impulse from the body to the CNS
- Impulse reaches brain and is integrated (control center).
- The motor nerves send the reaction commands from the CNS to the effector organs.

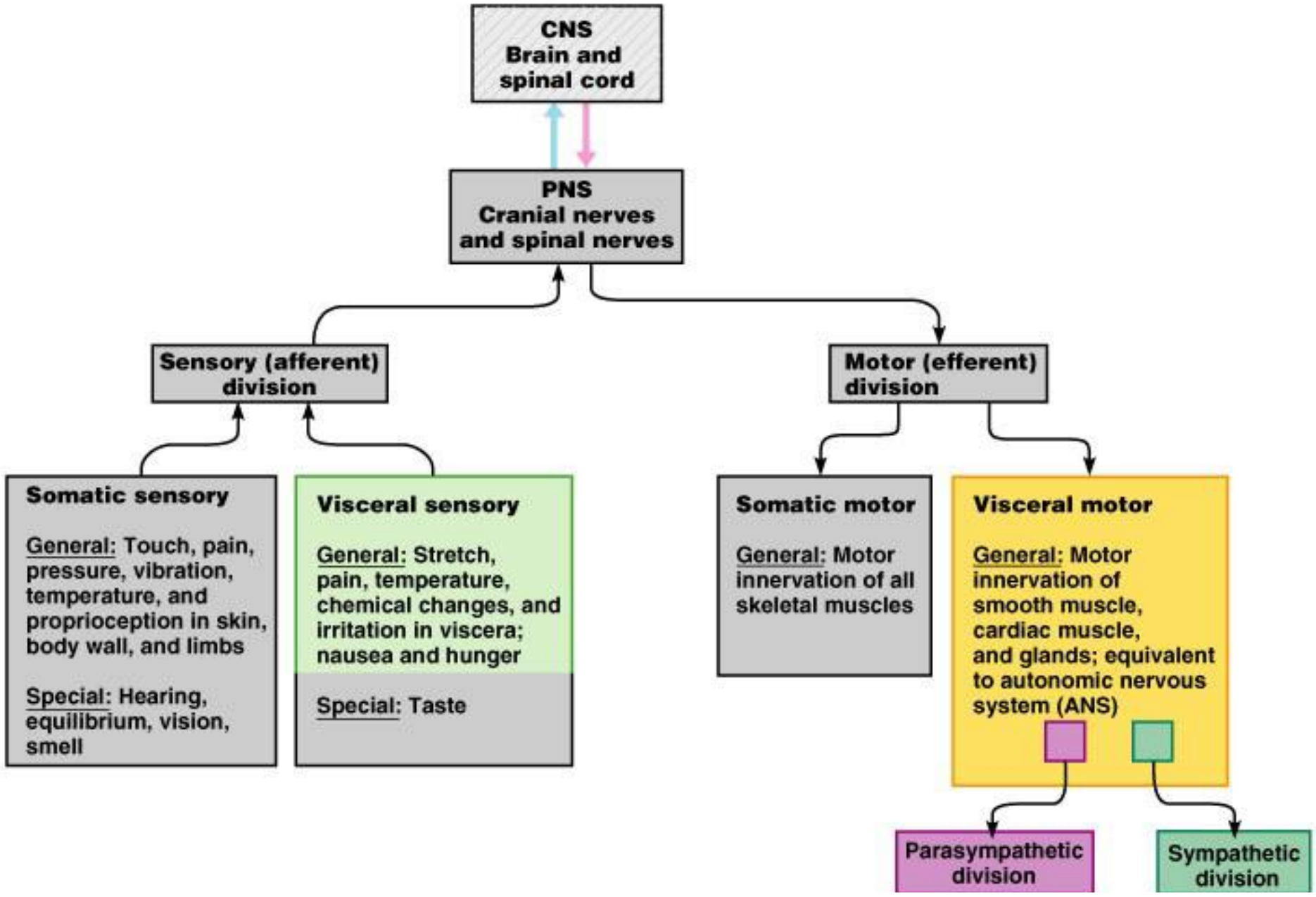
Nervous System

- Motor nerves (or motor output) are functionally divided into:

1. **The somatic nervous system** (**SNS**) which regulates the voluntary contraction of the skeletal muscles.

2. **The autonomic nervous system** (**ANS**) which regulates the involuntary control of smooth, cardiac muscles and glands.

Organization of Nervous System

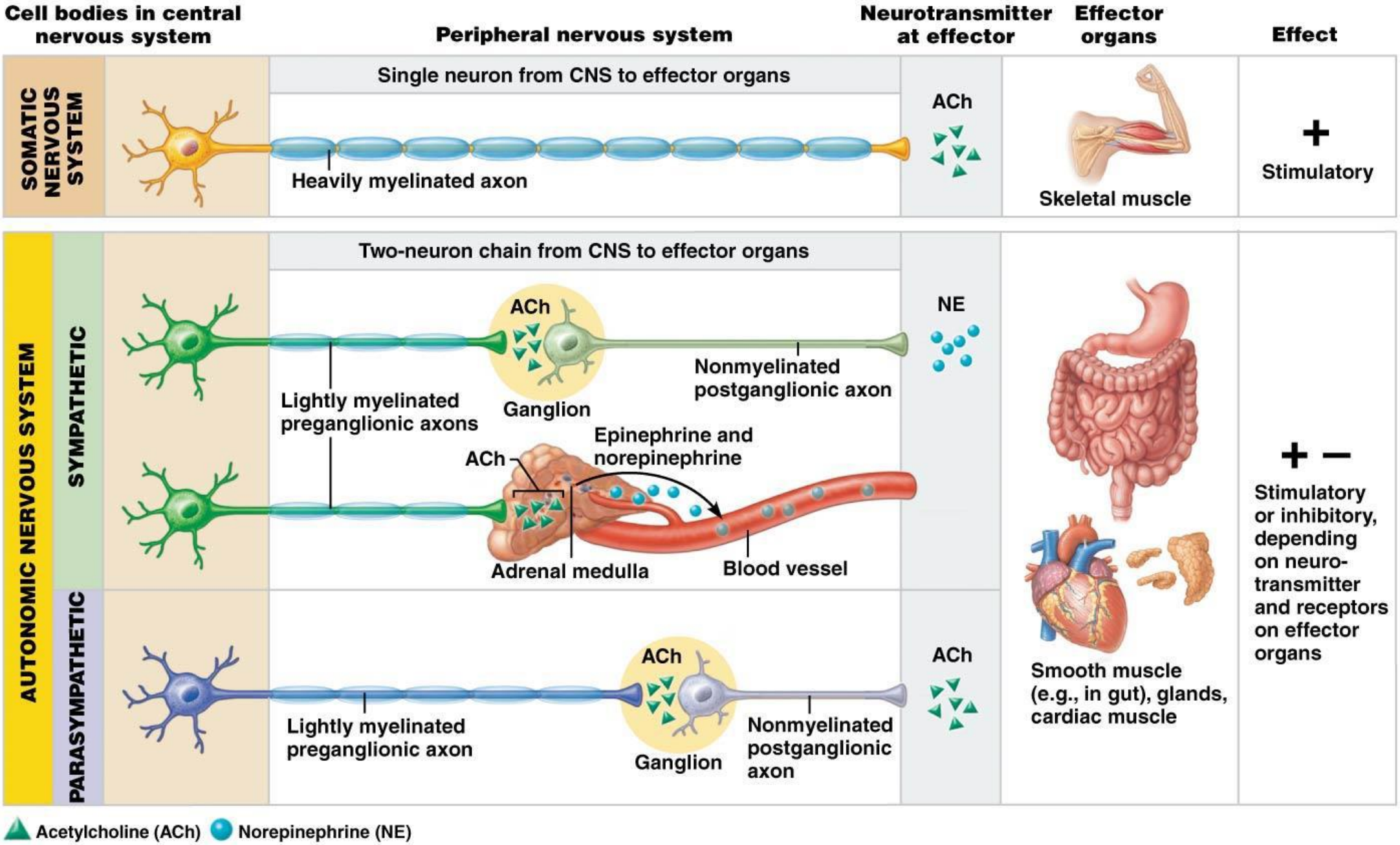


SNS vs ANS

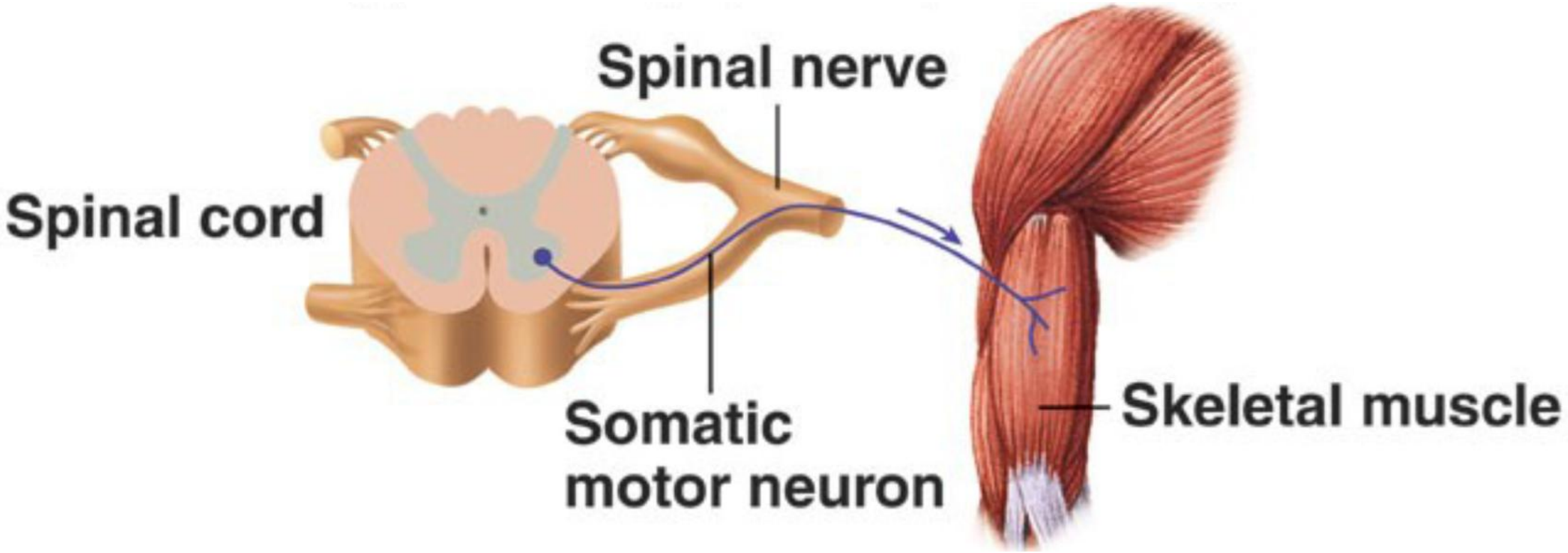
- **Somatic Nervous System (SNS)**
  - Innervates *skeletal muscles*
  - Voluntary control from cerebral cortex
  - Direct synapse with target organ
  - Excitatory

- **Autonomic Nervous System (ANS)**
  - Innervates *smooth muscle , cardiac muscle and glands*
  - Involuntary control from hypothalamus limited control from cerebral cortex.
  - Two neurons chain (preganglionic and postganglionic neurons)
  - Excitatory and Inhibitory

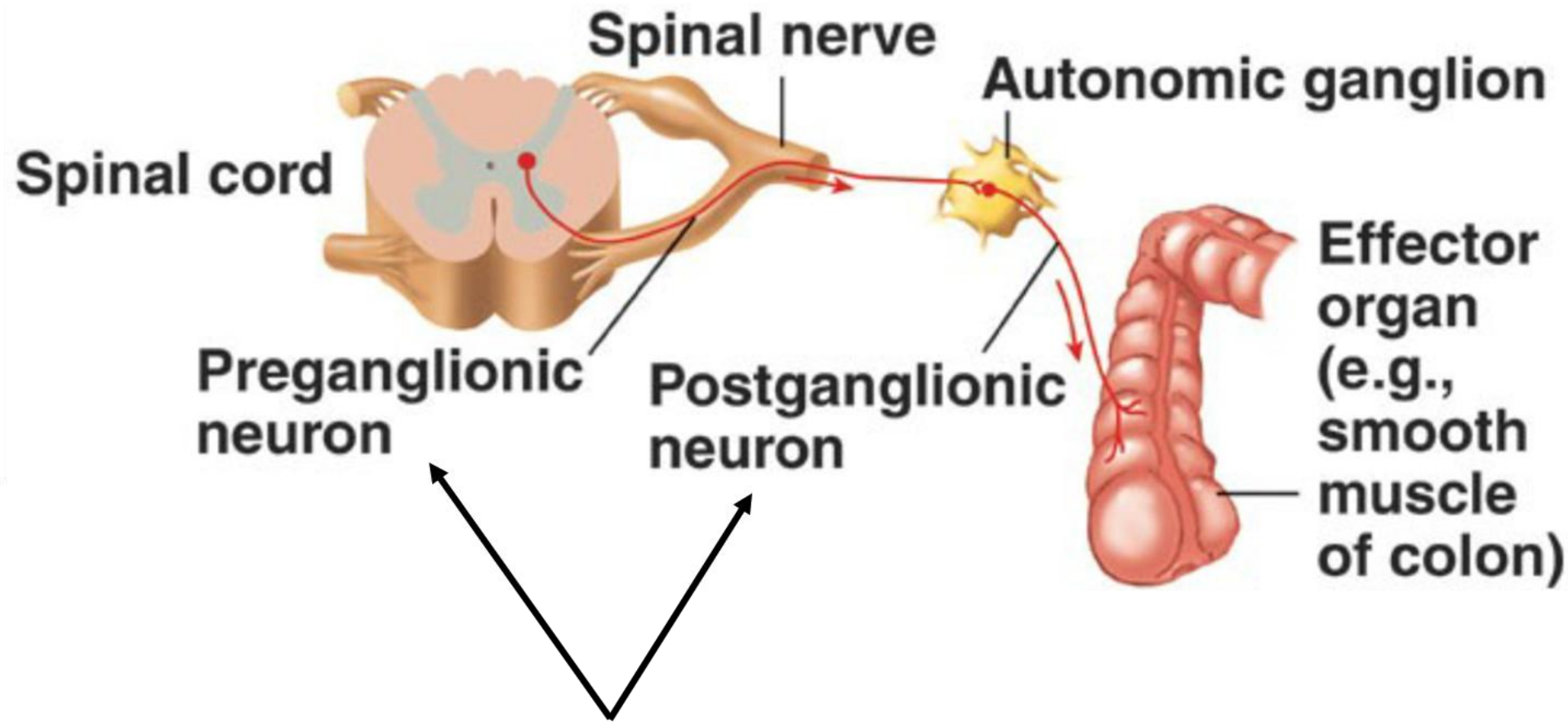
Comparison of Somatic and Autonomic Systems



Somatic Motor Action- Somatic Nervous System



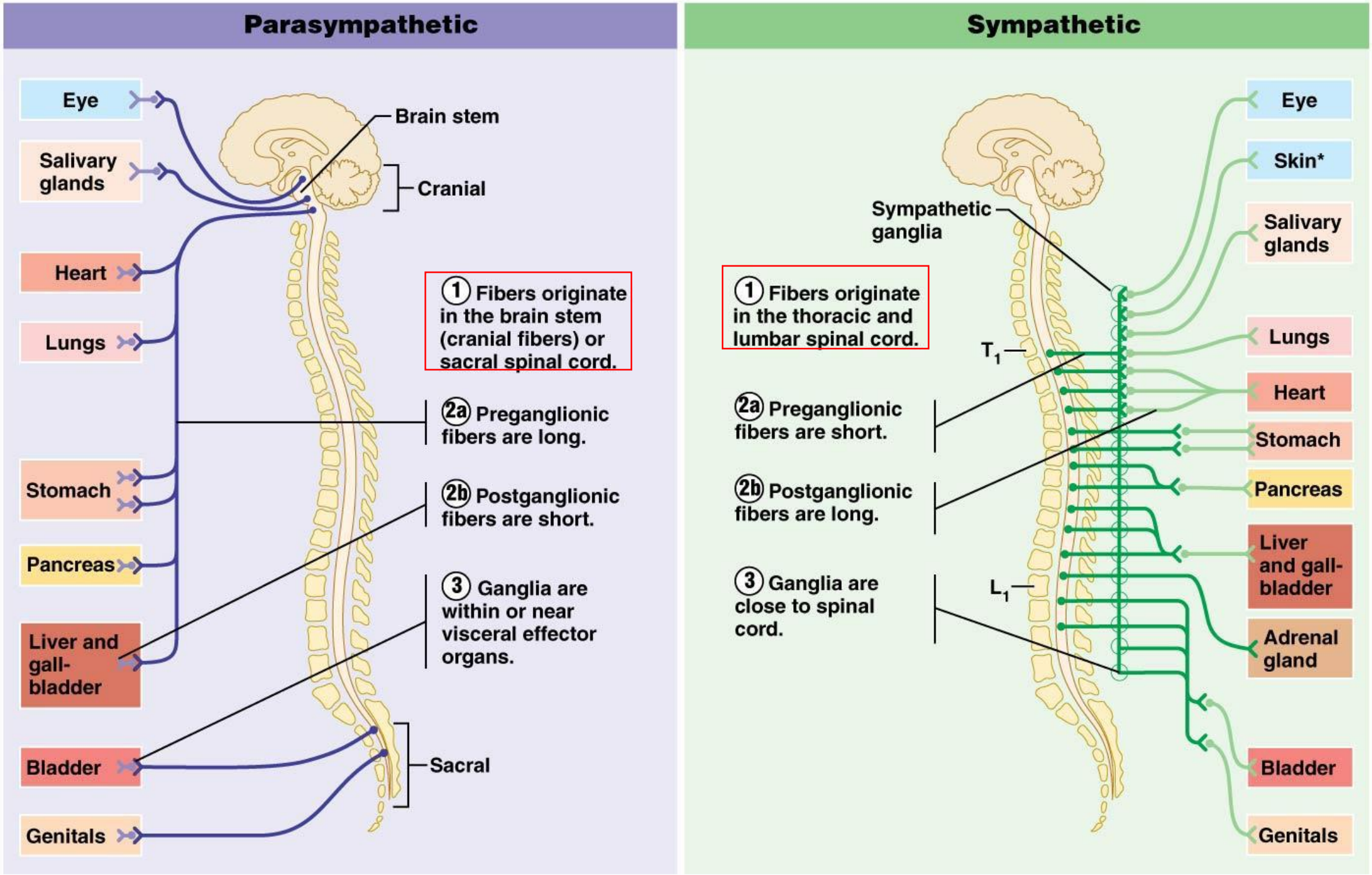
Autonomic Motor Action- Autonomic Nervous System



Chain of two motor neurons

Divisions of Autonomic Nervous System

- The ANS can be divided into:
  - **Sympathetic division**
  - **Parasympathetic division**
- In general:
  - **The sympathetic division stimulate activities of the effector organs** (except digestive organs).
  - **The parasympathetic division inhibit activities of the effector organs** (except digestive organs).


Parasympathetic
Eye
Salivary glands
Heart
Lungs
Stomach
Pancreas
Liver and gall-bladder
Bladder
Genitals
Brain stem
Cranial
Sacral
1 Fibers originate in the brain stem (cranial fibers) or sacral spinal cord.
2a Preganglionic fibers are long.
2b Postganglionic fibers are short.
3 Ganglia are within or near visceral effector organs.
Sympathetic
Sympathetic ganglia
1 Fibers originate in the thoracic and lumbar spinal cord.
T1
2a Preganglionic fibers are short.
2b Postganglionic fibers are long.
3 Ganglia are close to spinal cord.
L1
Eye
Skin*
Salivary glands
Lungs
Heart
Stomach
Pancreas
Liver and gall-bladder
Adrenal gland
Bladder
Genitals

Sympathetic Division

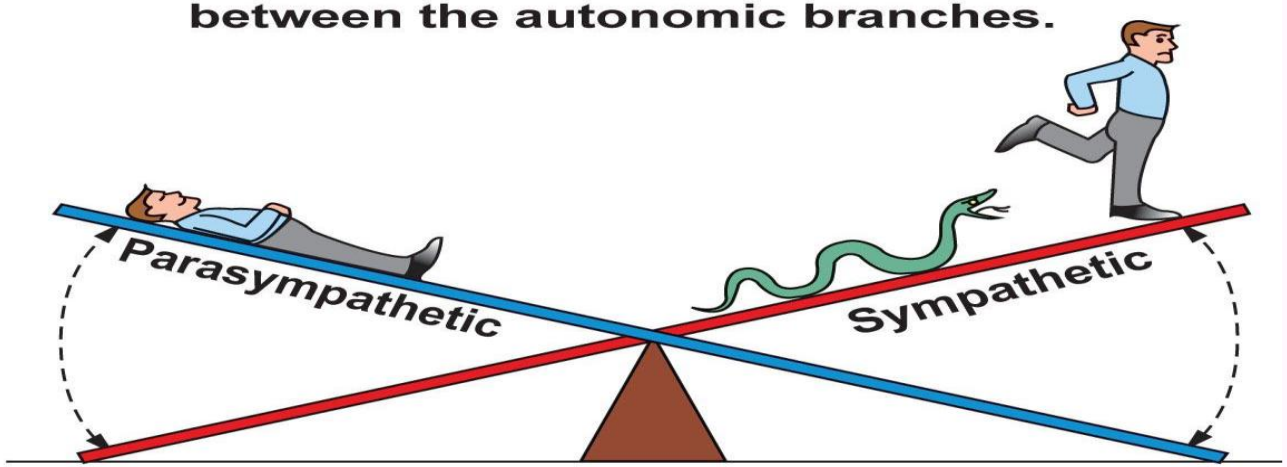
Sympathetic Division

- The entire sympathetic nervous system is activated in ***stressful or emergency situations*** – ***fight or flight response***

- When stimulated:
  - Release of large quantities of epinephrine from the adrenal gland.
  - Increases the heart rate and cardiac output
  - Bronchial dilation and increase in respiration
  - Skeletal muscle vasodilation
  - Gastrointestinal vasoconstriction
  - Pupillary dilation, bronchial dilation

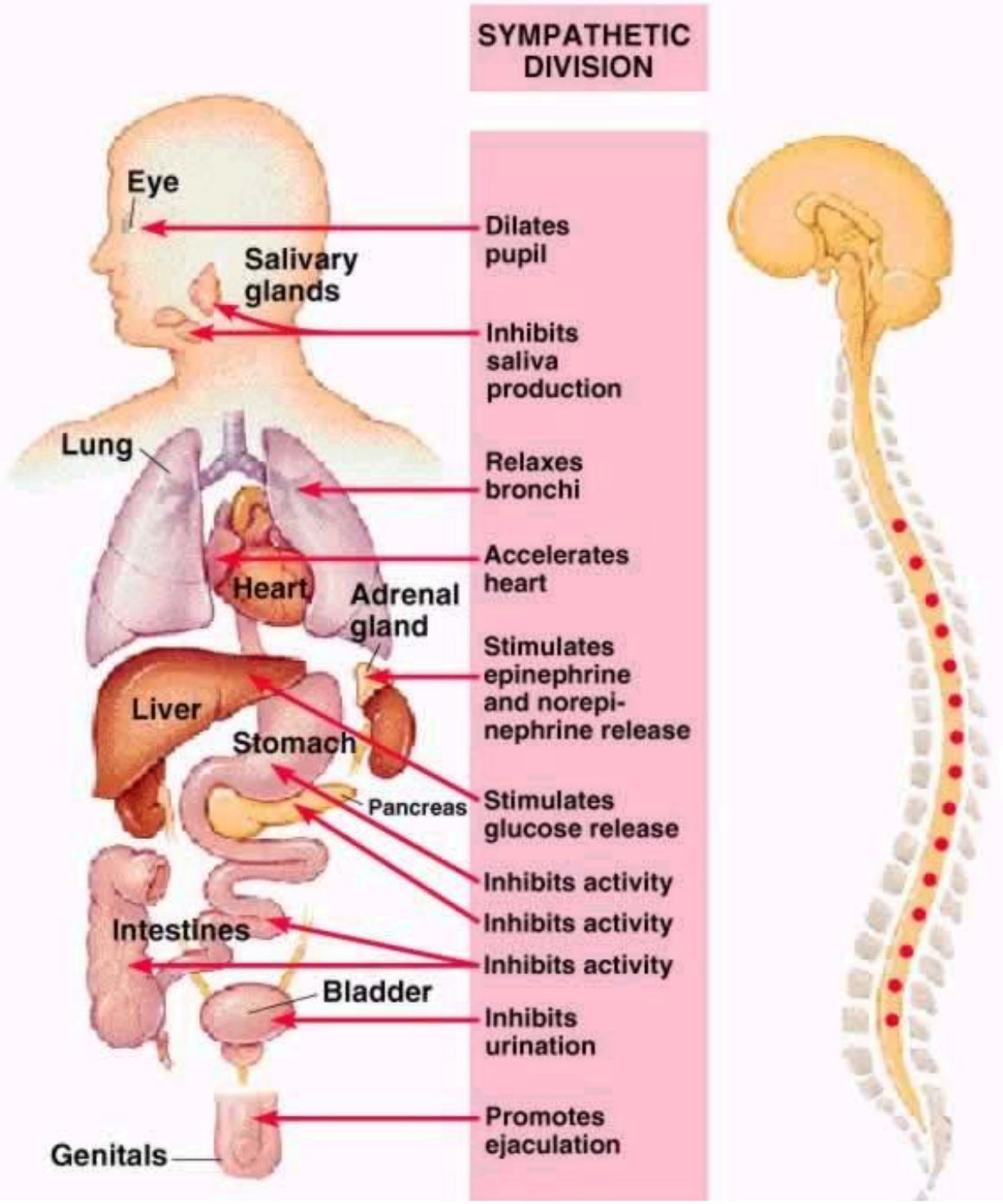
➢ ***The overall effect is to prepare the individual for imminent danger or stressful situation.***

Homeostasis is a dynamic balance between the autonomic branches.



Rest-and-digest: Parasympathetic activity dominates.

Fight-or-flight: Sympathetic activ dominates.



Sympathetic Division

- The cell bodies of the preganglionic neurons are in thoracic and lumbar segments of the spinal cord specifically at **T1 - L2** .

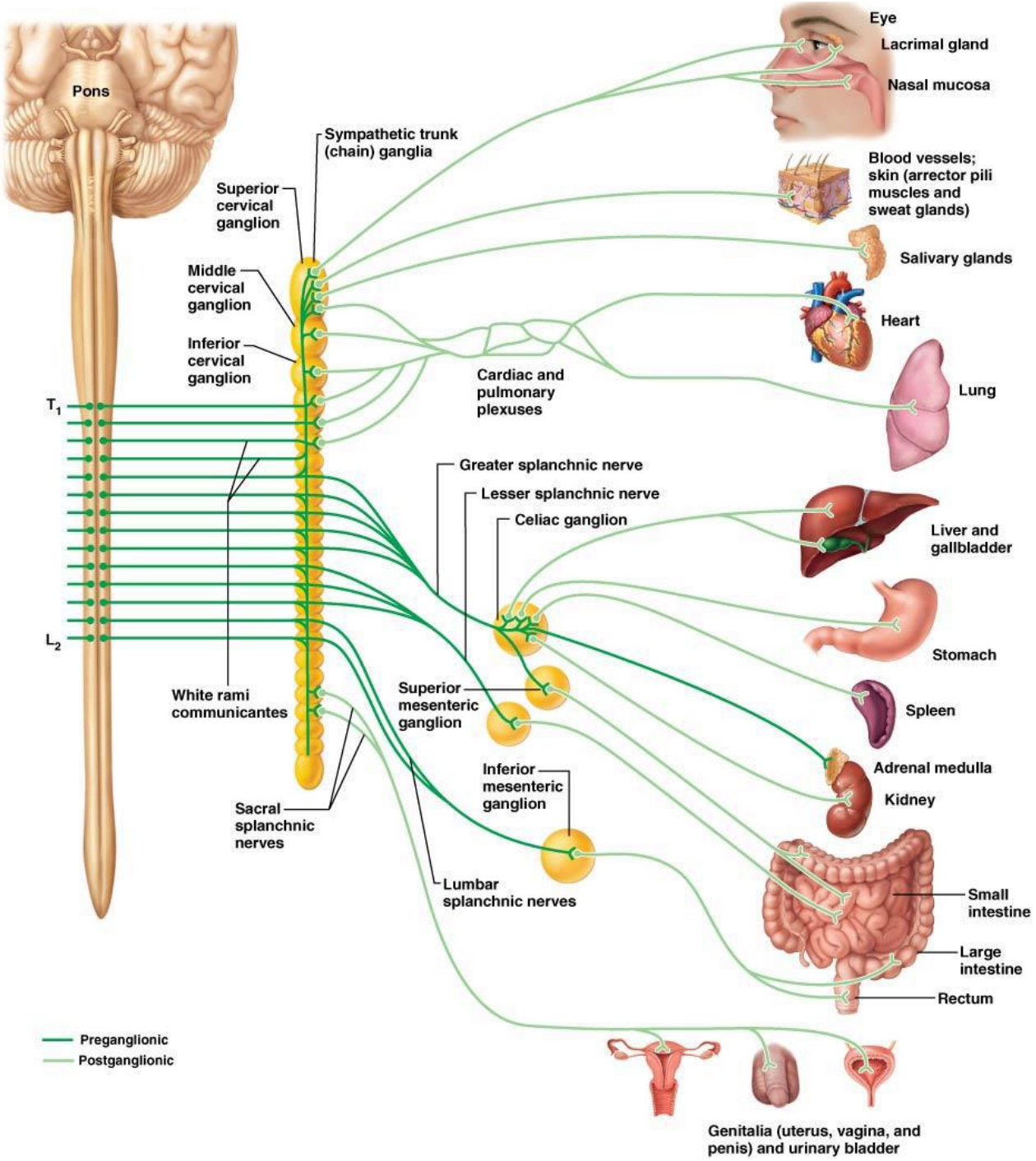
- ***Short preganglionic neurons***; ***Long postganglionic neurons***. The ganglia for the sympathetic division are located just outside the spinal cord on both sides of it (***Paravertebral*** *and* ***Prevertebral ganglia***).

- Postganglionic fibers are distributed throughout the body (innervates internal organ and skin)

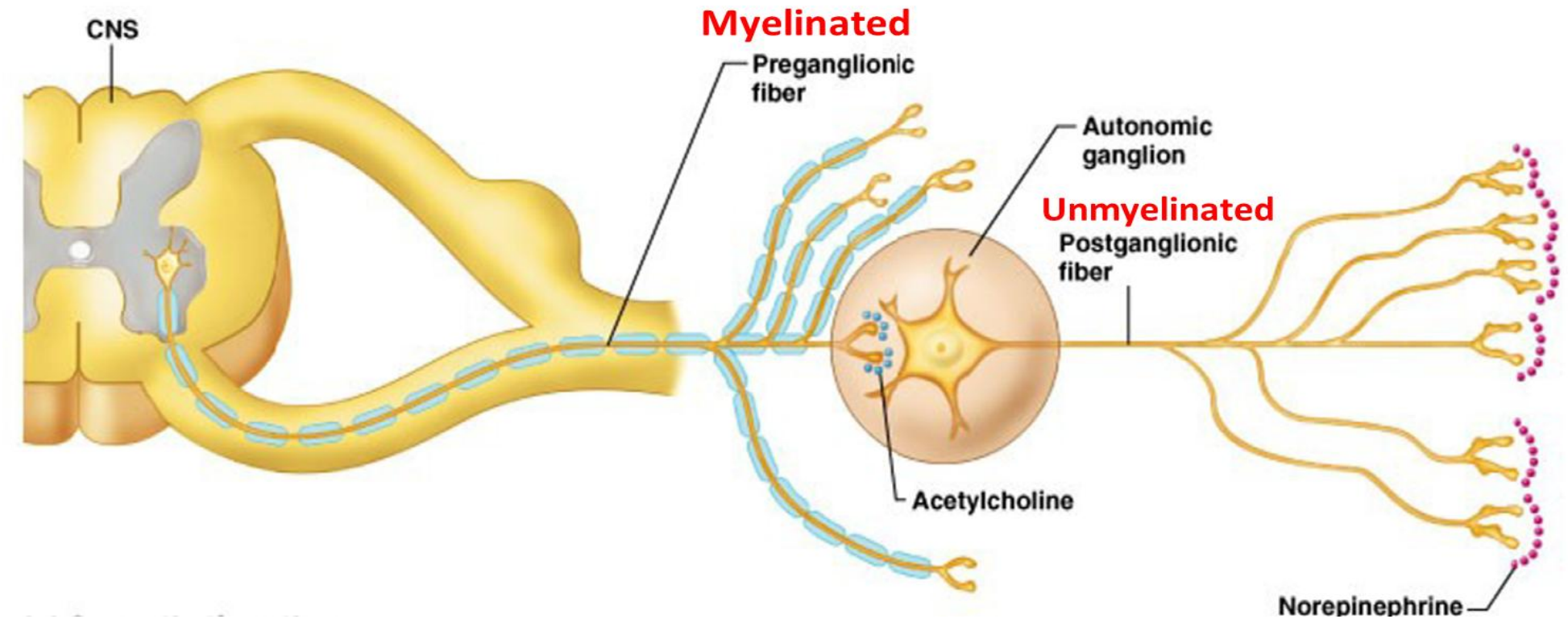
- Preganglionic neurons secrete **Ach** onto nicotinic receptors**.**

- Postganglionic neurons secrete **NE** onto α or β receptors**.**

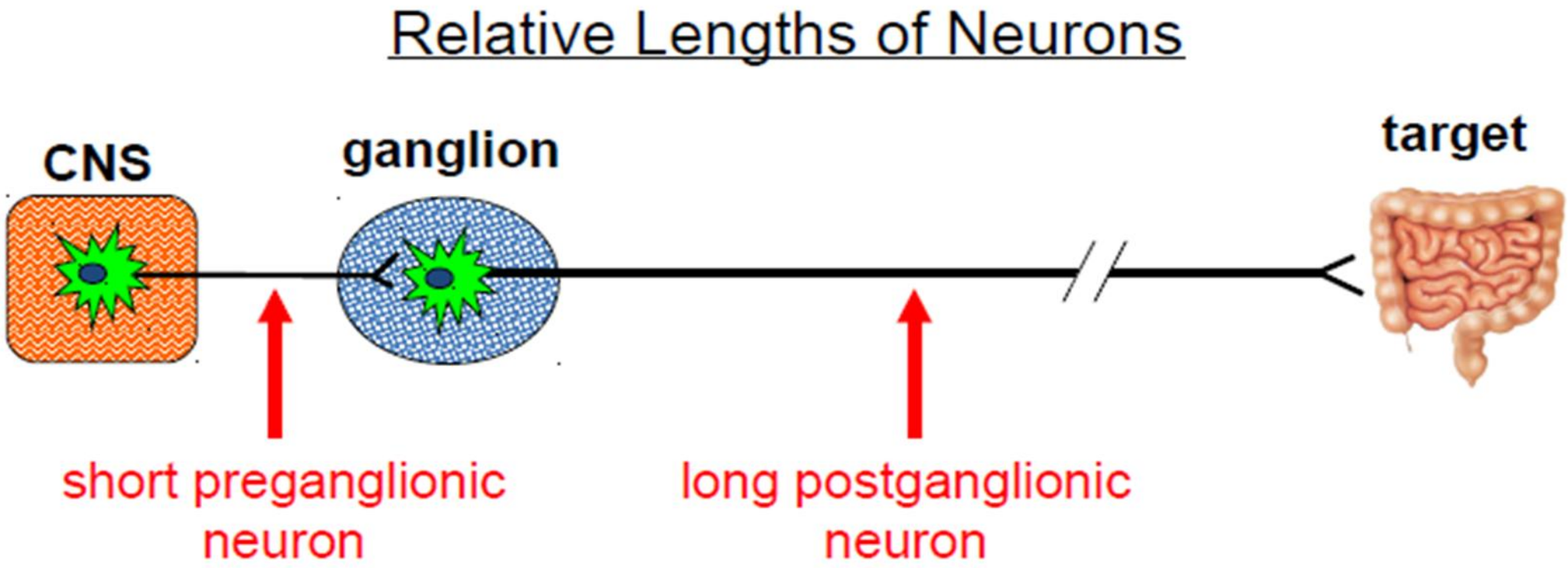
Sympathetic Division



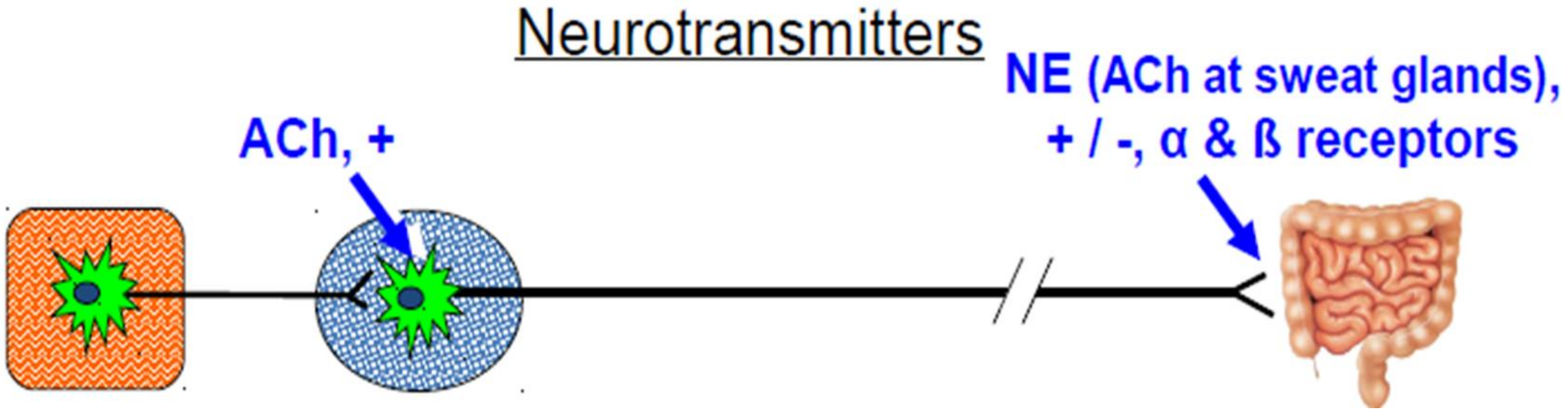
Sympathetic Pathway



Sympathetic Pathway



Sympathetic Pathway

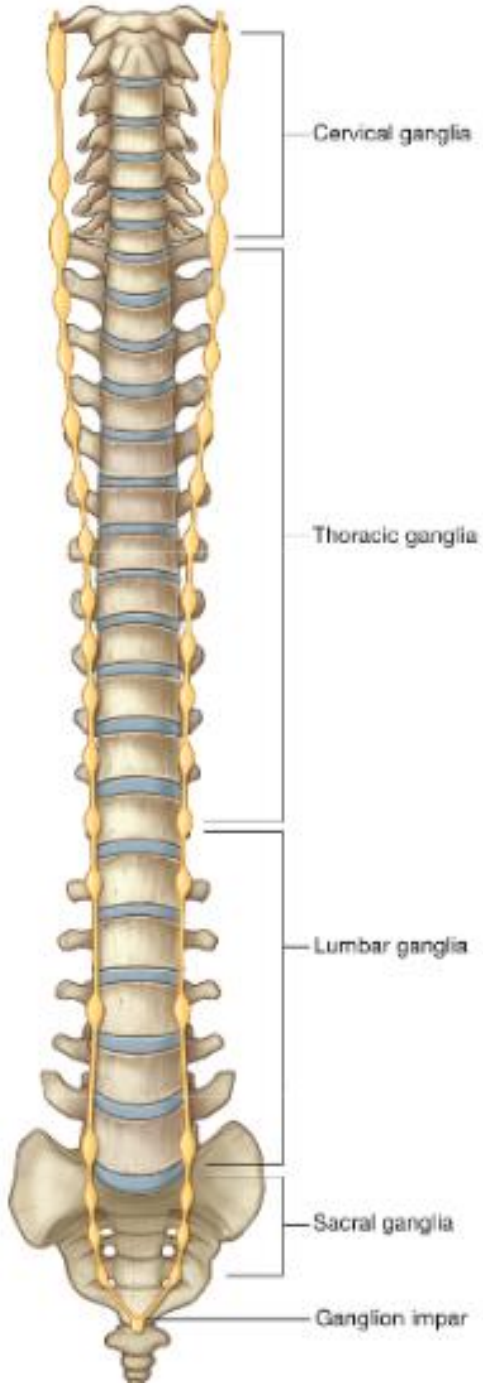


Sympathetic Trunk and Paravertebral Ganglia

- The sympathetic trunks are two parallel nerve cords extending on either side of the vertebral column from the base of the skull to the coccyx.

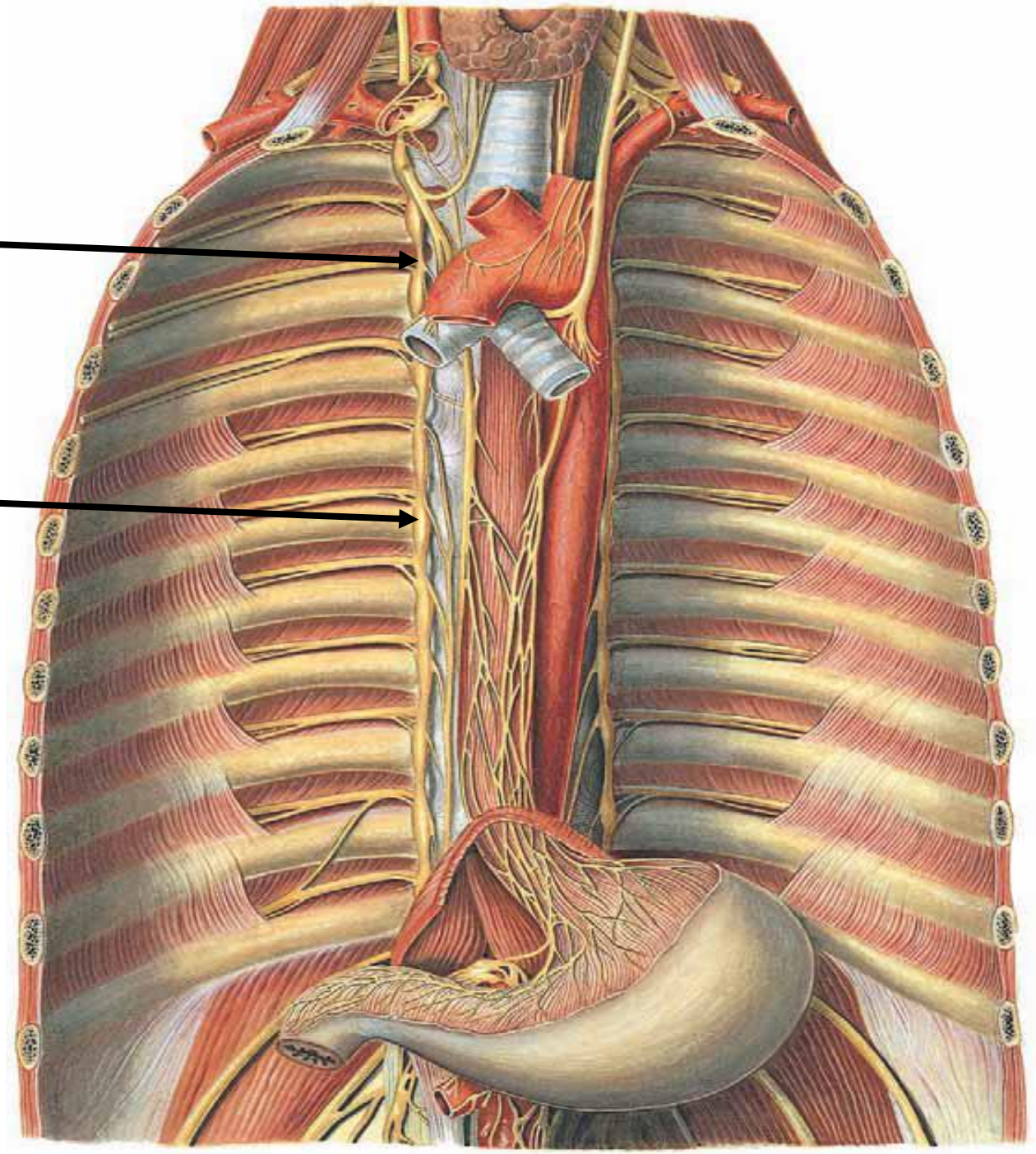
- Contain sympathetic ganglia called **paravertebral ganglia**:
  - 3 in the cervical region
  - 11 or 12 in the thoracic region
  - 4 in the lumbar region
  - 4 or 5 in the sacral region

- The two sympathetic trunks come together anterior to the coccyx to form the **ganglion impar.**

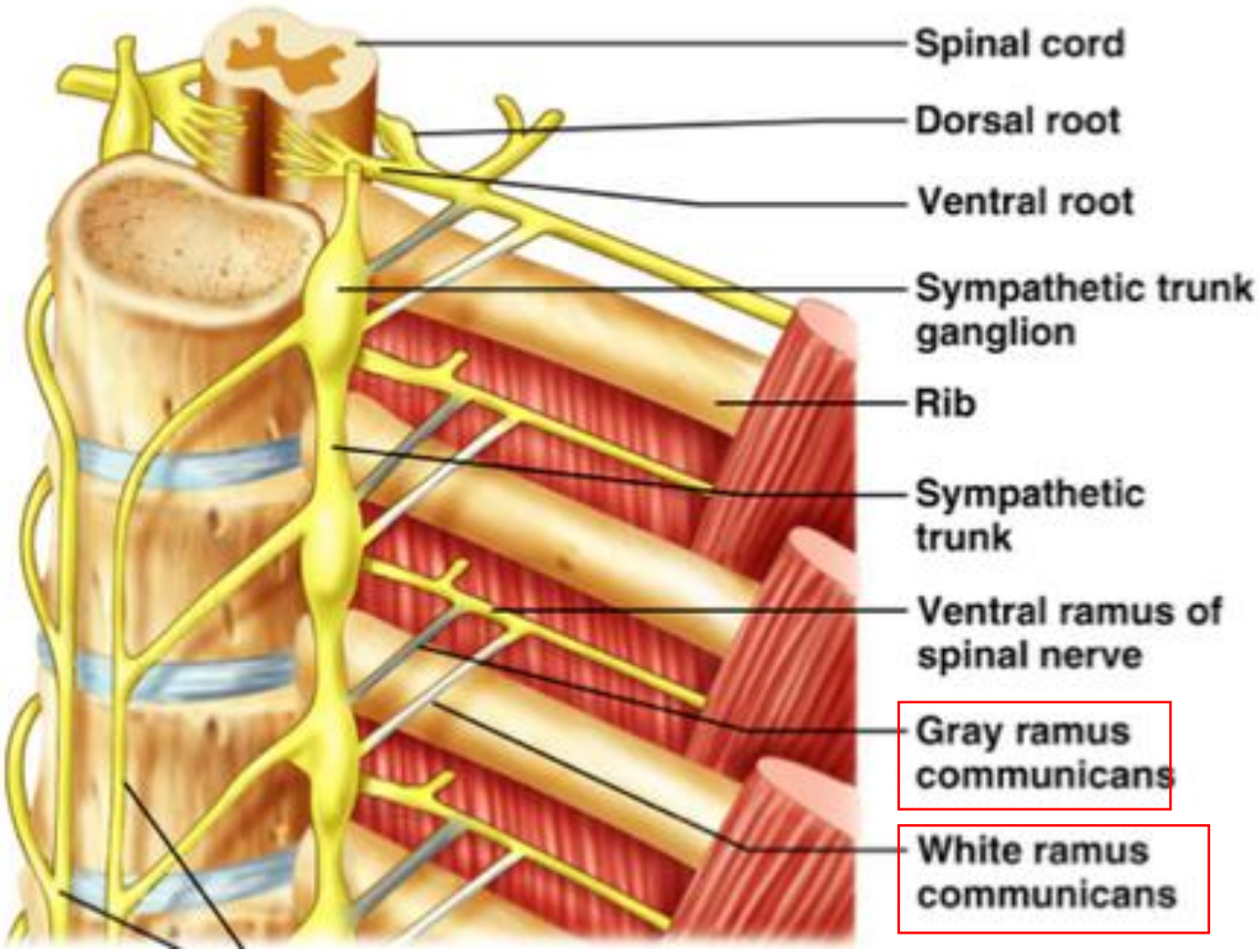


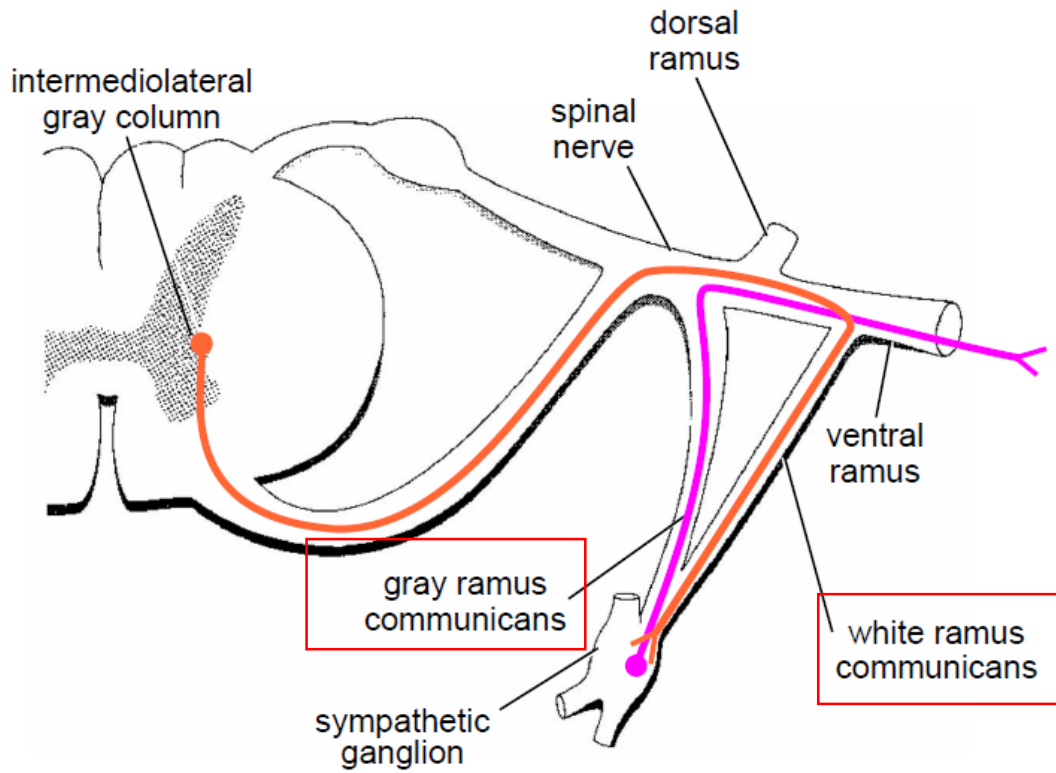
Sympathetic trunk

Thoracic paravertebral ganglia,
Sympathetic trunk



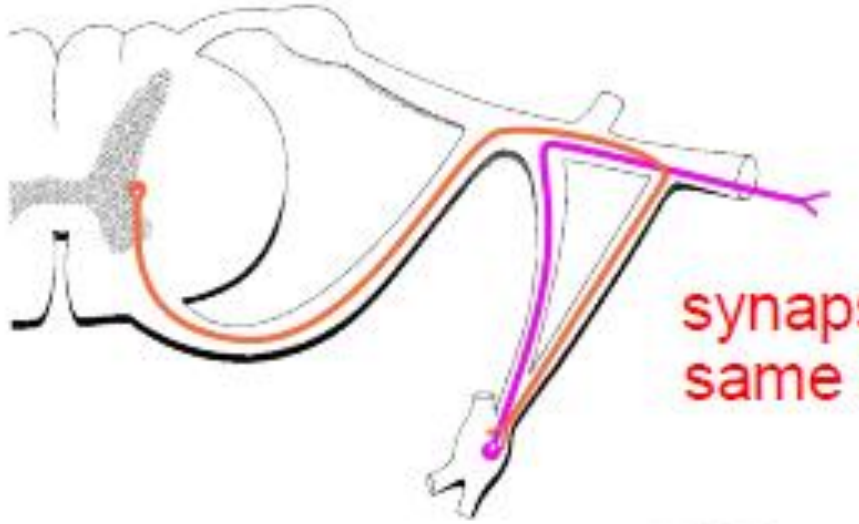
Sympathetic Trunk Ganglia



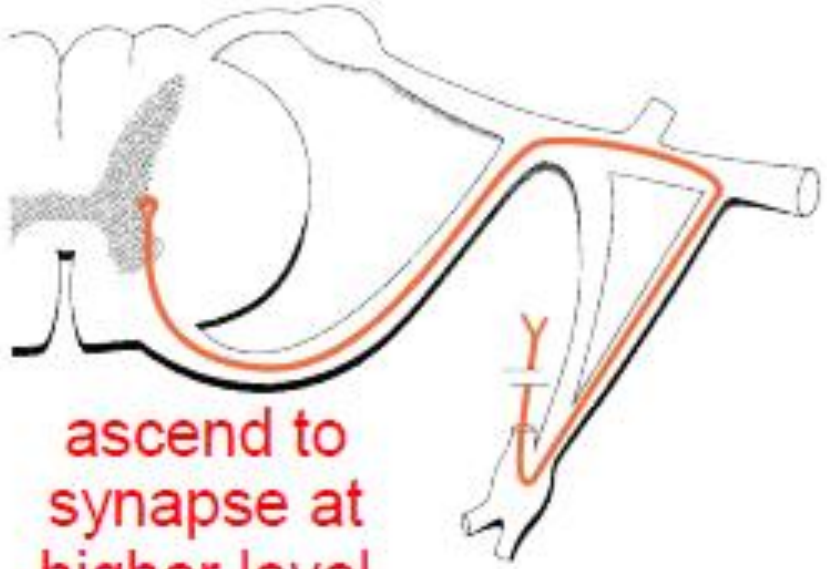


Options of preganglionic axons in sympathetic trunk

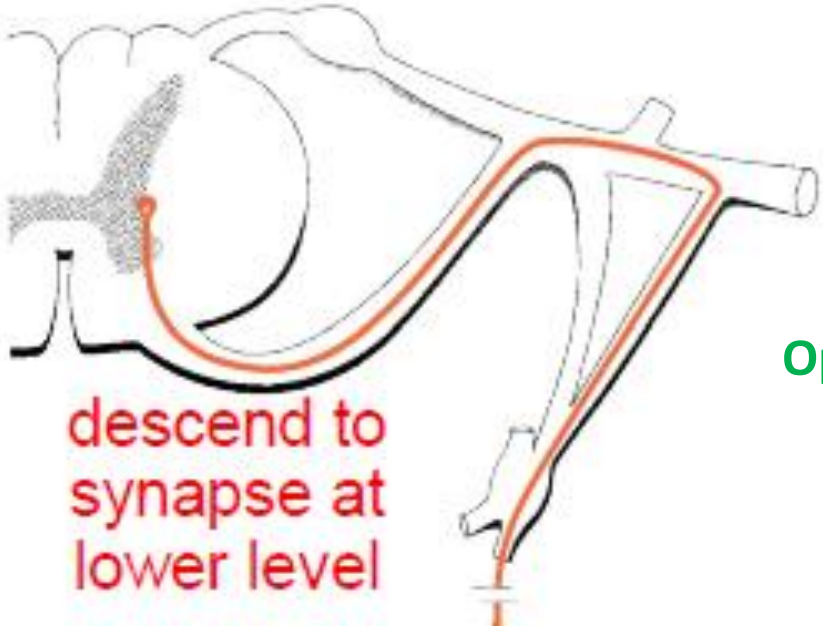
Option 1



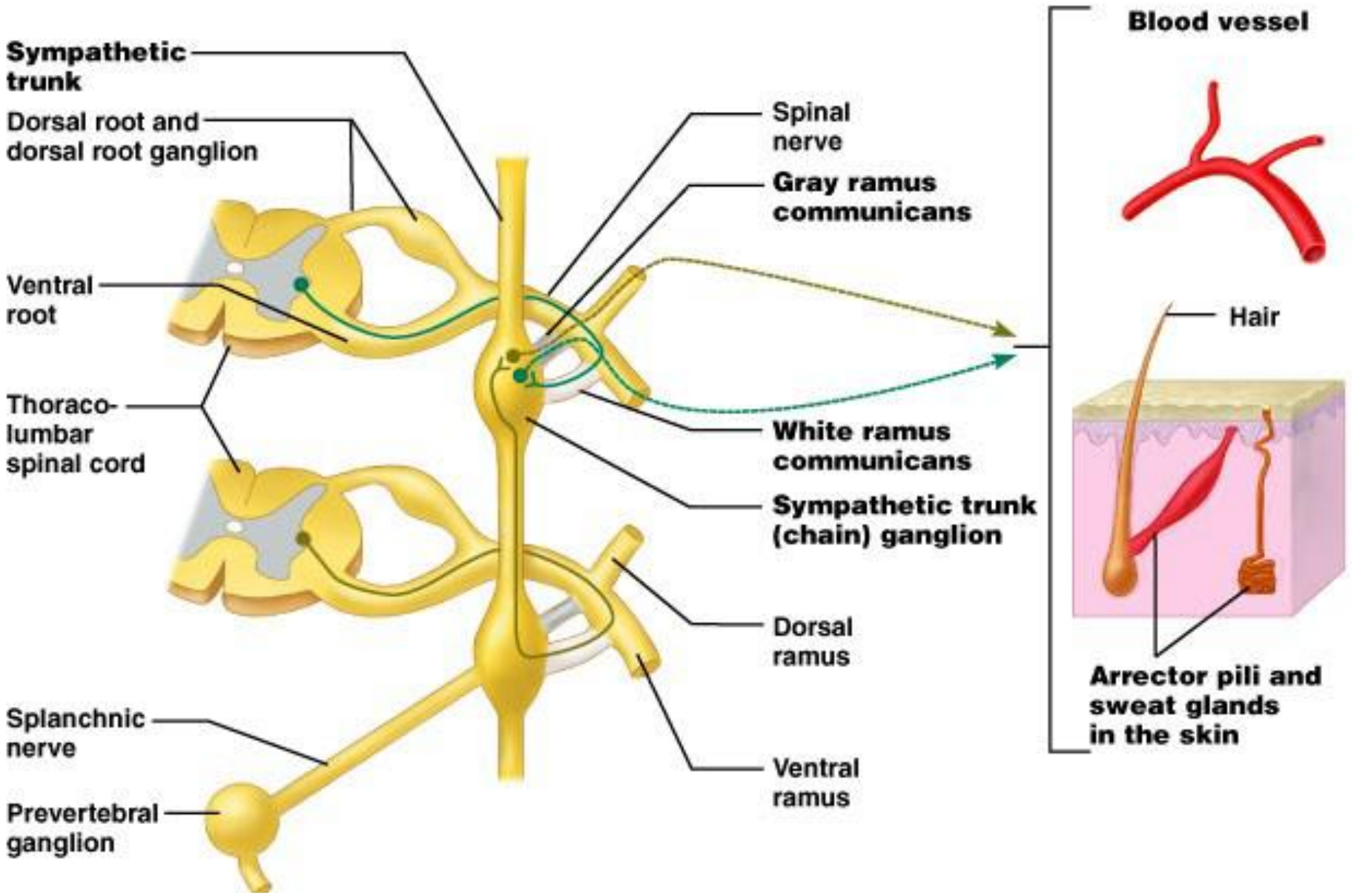
Option 2



Option 3



Synapse in sympathetic trunk at same level or different level



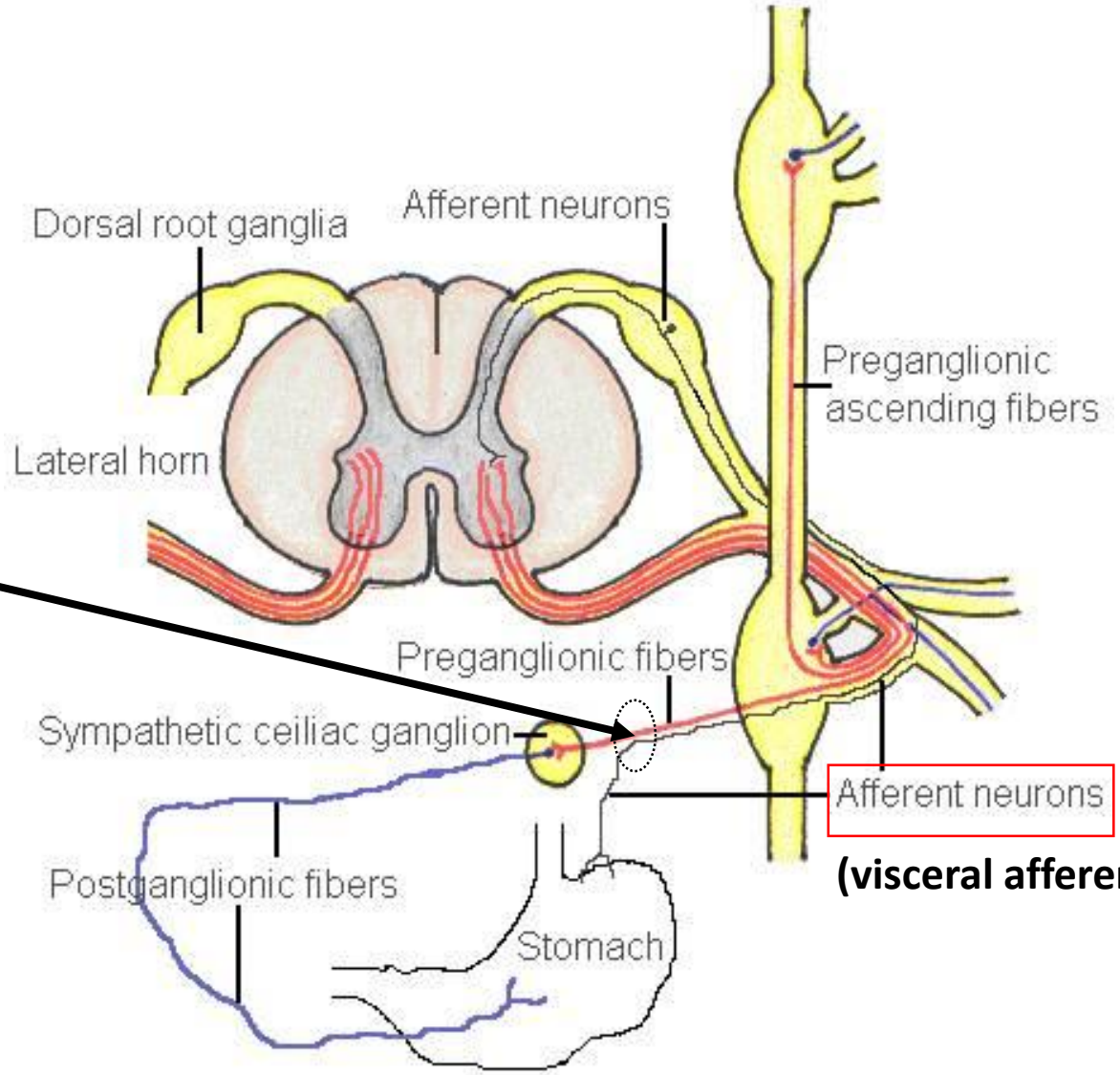
Prevertebral (Preaortic) Ganglia

- Some preganglionic fibers leave the sympathetic trunk without making synapses.

- These preganglionics form the **splanchnic nerves** and reach the **prevertebral ganglia** that are located anterior to abdominal aorta, in plexuses surrounding its major branches.

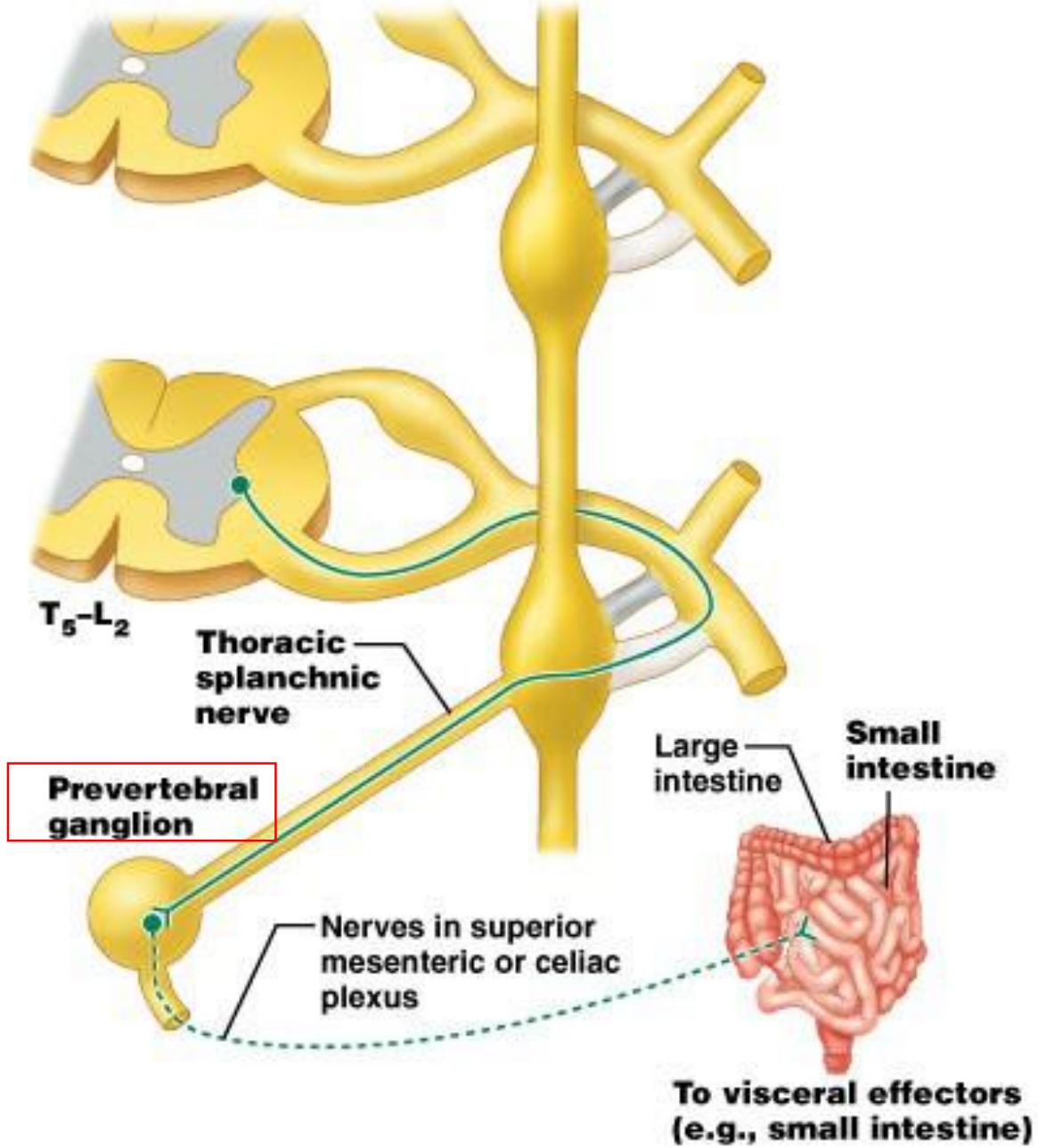
- The postganglionic follow arteries to **abdominopelvic organs.**

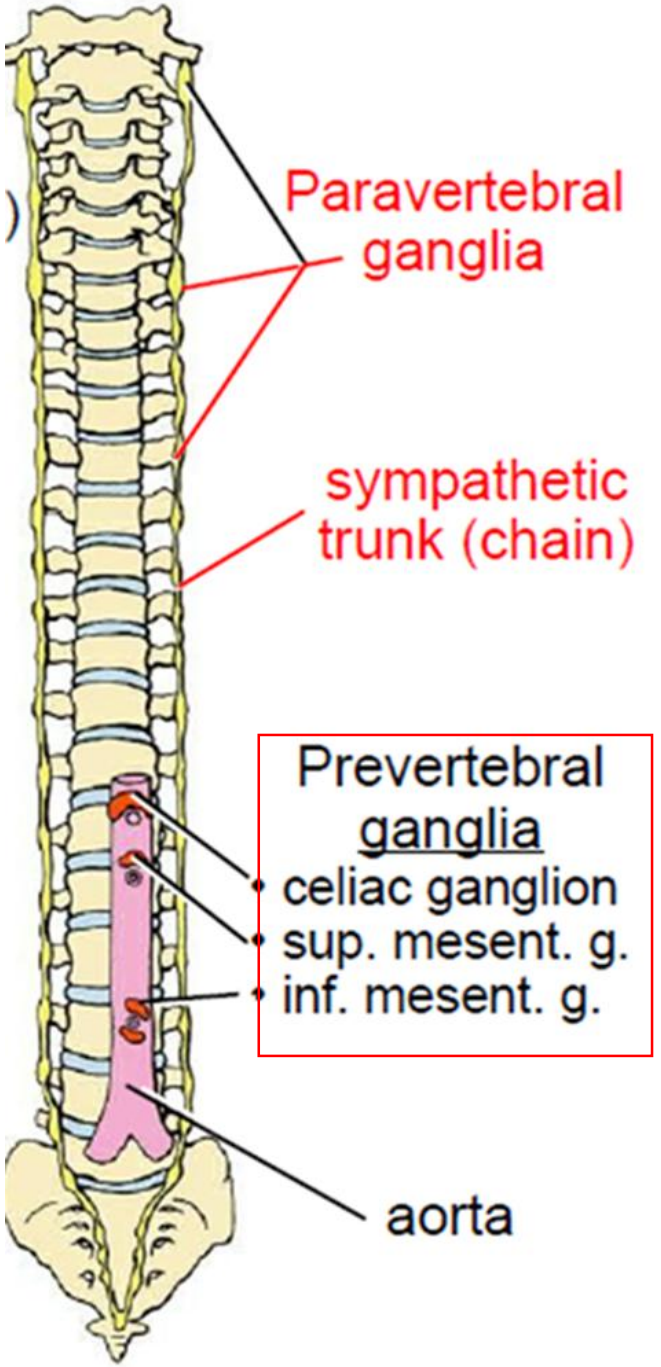
Splanchnic nerve



Option 4

(visceral afferent fibers)


T_5–L_2
Thoracic splanchnic nerve
Prevertebral ganglion
Large intestine
Small intestine
Nerves in superior mesenteric or celiac plexus
To visceral effectors (e.g., small intestine)


Paravertebral ganglia
sympathetic trunk (chain)
Prevertebral ganglia
celiac ganglion
sup. mesent. g.
inf. mesent. g.
aorta

Sympathetic Splanchnic Nerves

Abdominopelvic splanchnic nn.

Thoracic splanchnic nerve

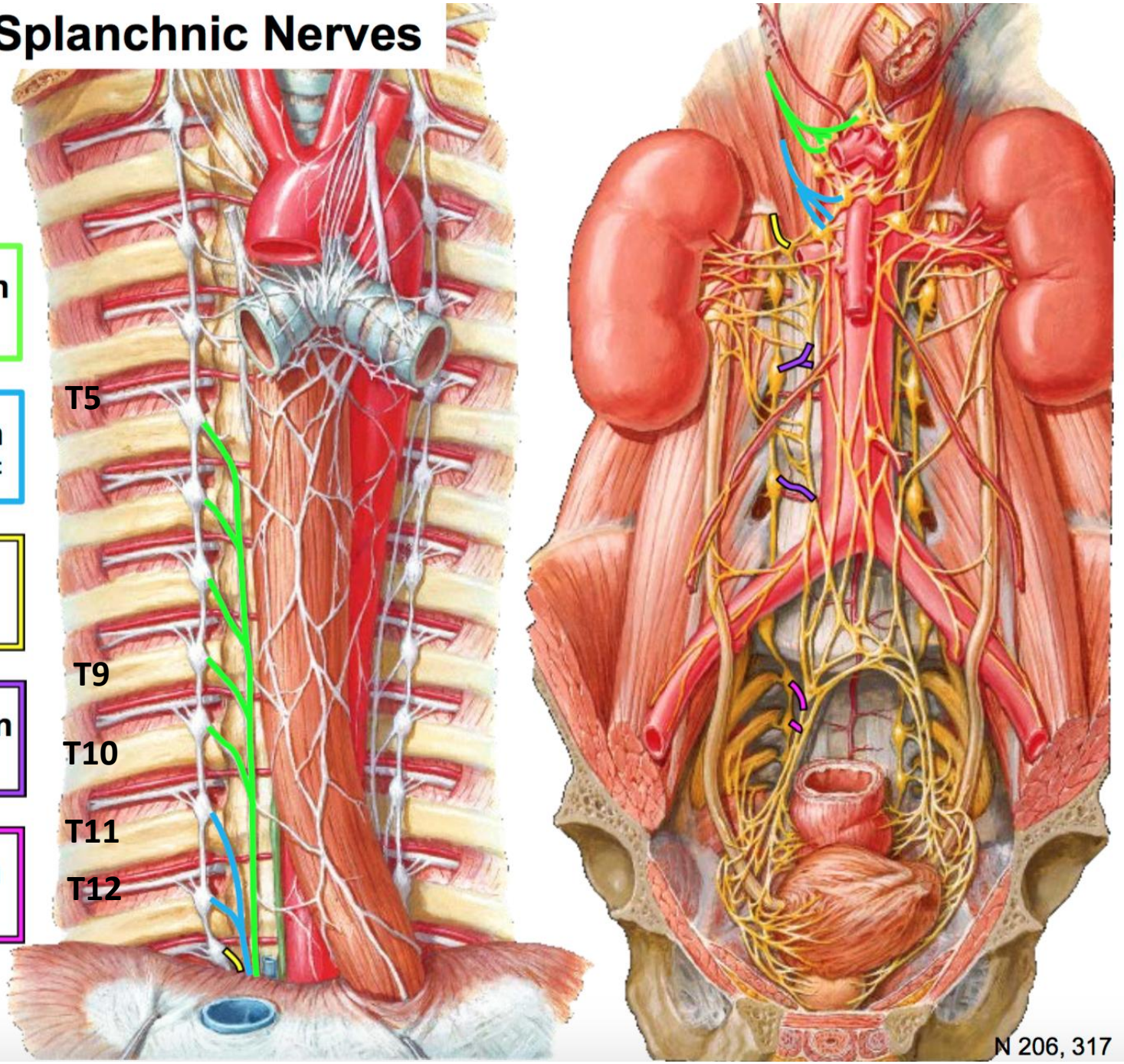
Greater splanchnic n
T5-T9 spinal cord segment

Lesser splanchnic n
T10-T11 spinal cord segment

Least splanchnic n
T12 spinal cord segment

Lumbar splanchnic n
L1-L2 spinal cord segment

Sacral splanchnic n
L1-L2 spinal cord segment

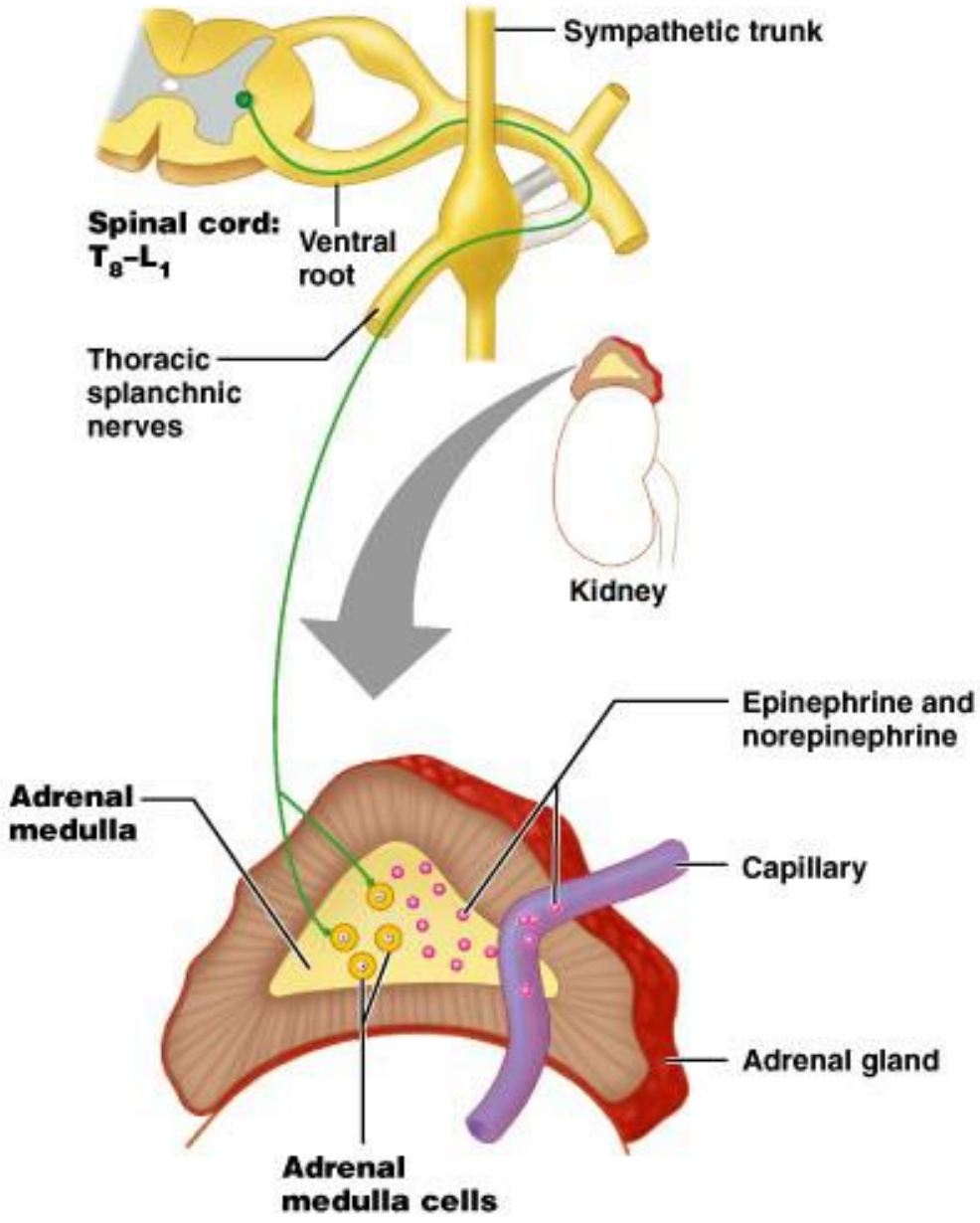


N 206, 317

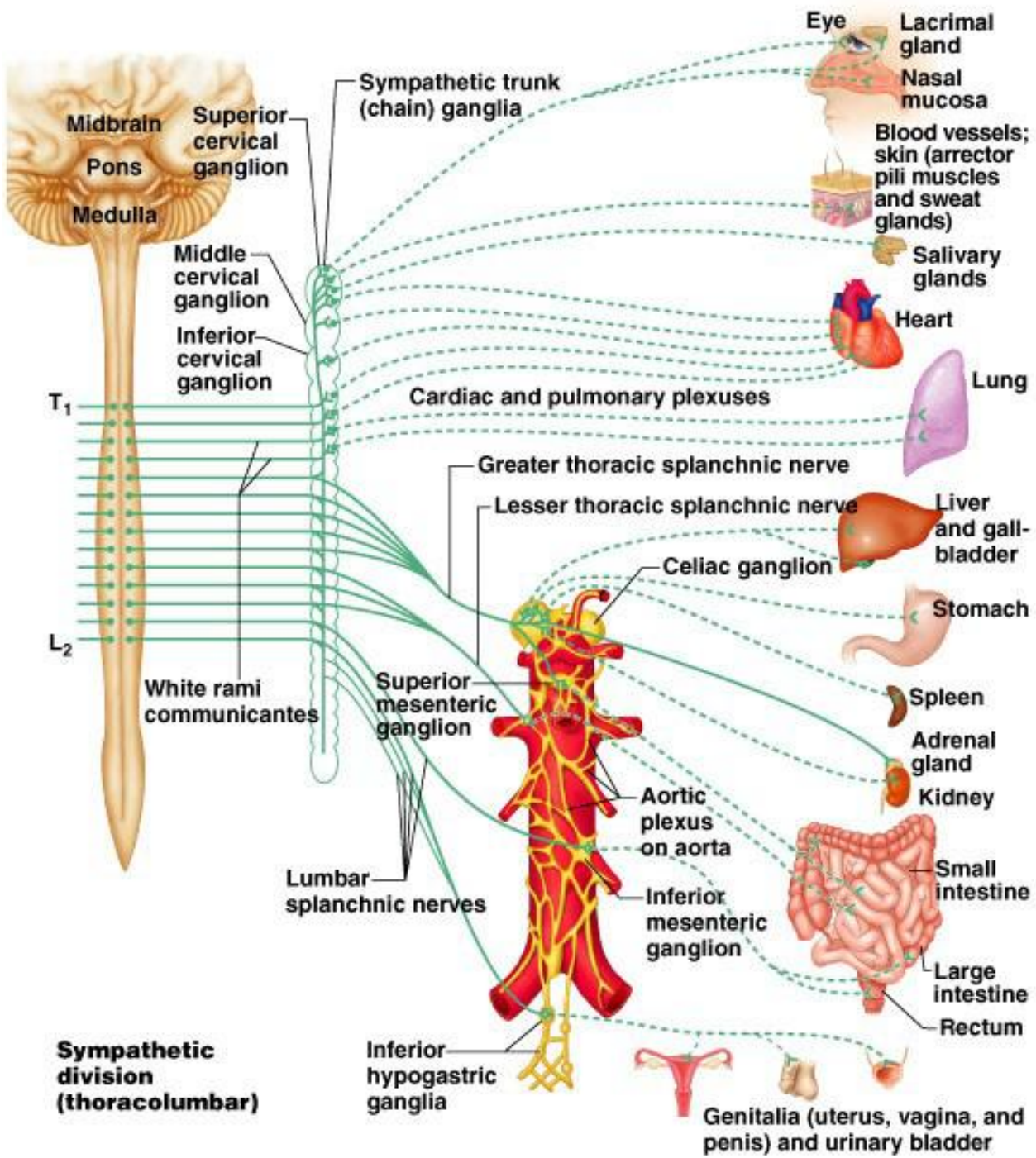
Adrenal gland is exception

- Adrenal medulla (inside part) is a major organ of the sympathetic nervous system

- Preganglionics synapse on adrenal medulla cells – can cause body-wide release of epinephrine (adrenaline) and norepinephrine in an extreme emergency (adrenaline “rush” or surge)



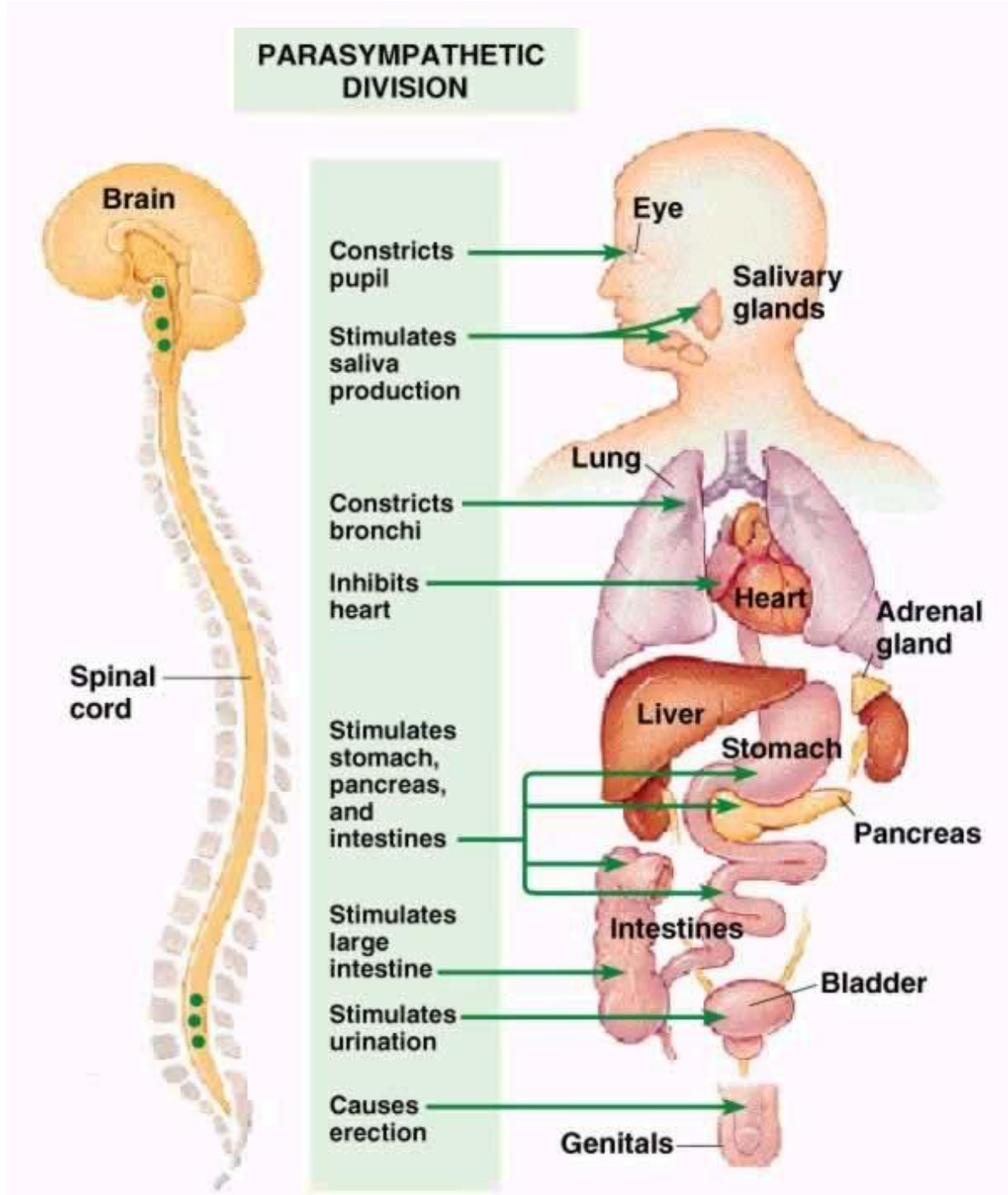
Sympathetic Division



Parasympathetic Division

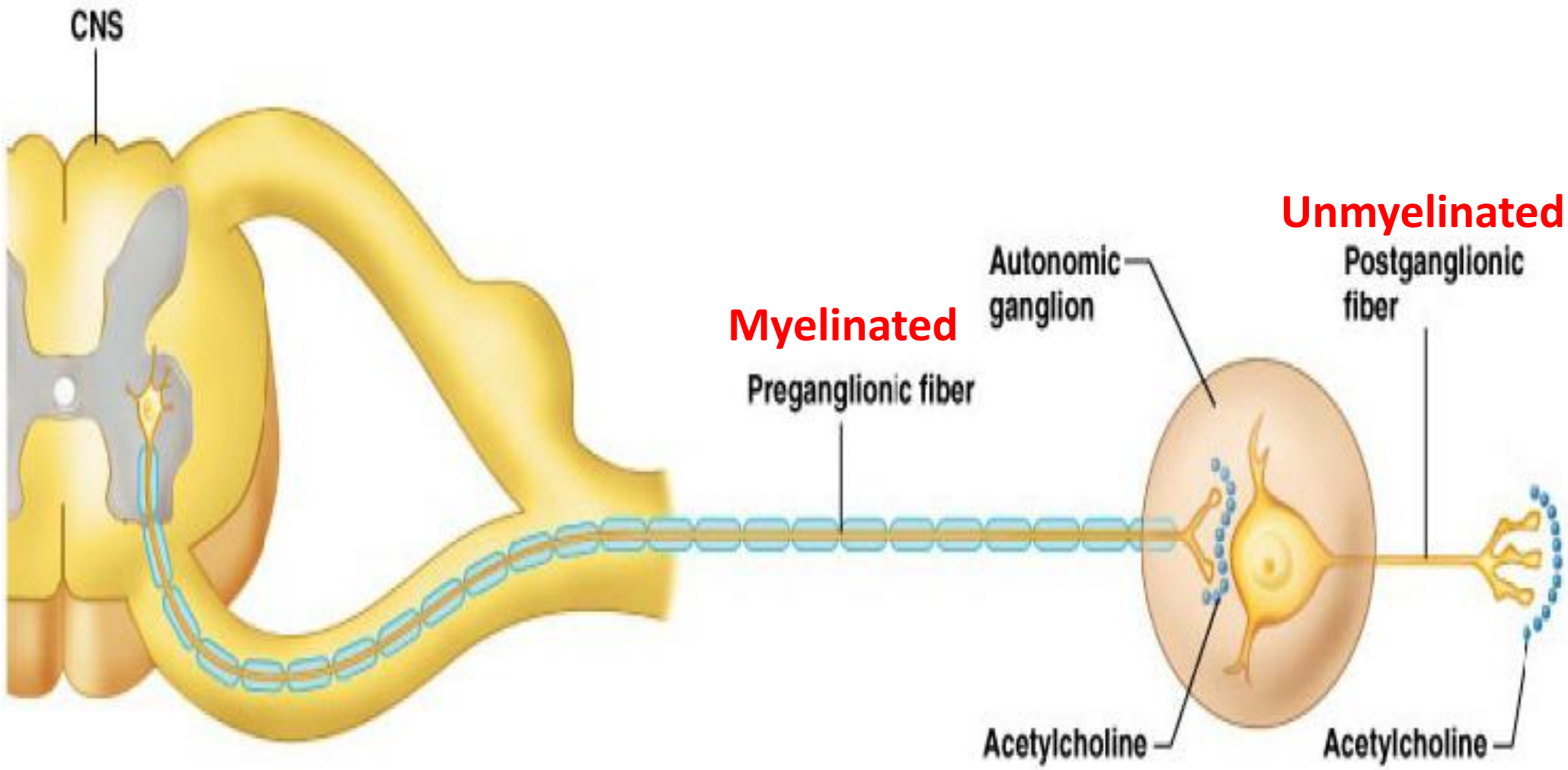
Parasympathetic Division

- The parasympathetic nervous system is activated during ***ordinary situations - rest and digest response***
- When stimulated: Increase digestive secretions and reduce the heart rate …….
- The cell bodies of the preganglionic neurons are in **the brainstem** and in the **sacral spinal segments $S_2 – S_4$.**


PARASYMPATHETIC DIVISION
Brain
Spinal cord
Constricts pupil
Stimulates saliva production
Constricts bronchi
Inhibits heart
Stimulates stomach, pancreas, and intestines
Stimulates large intestine
Stimulates urination
Causes erection
Eye
Salivary glands
Lung
Heart
Adrenal gland
Liver
Stomach
Pancreas
Intestines
Bladder
Genitals

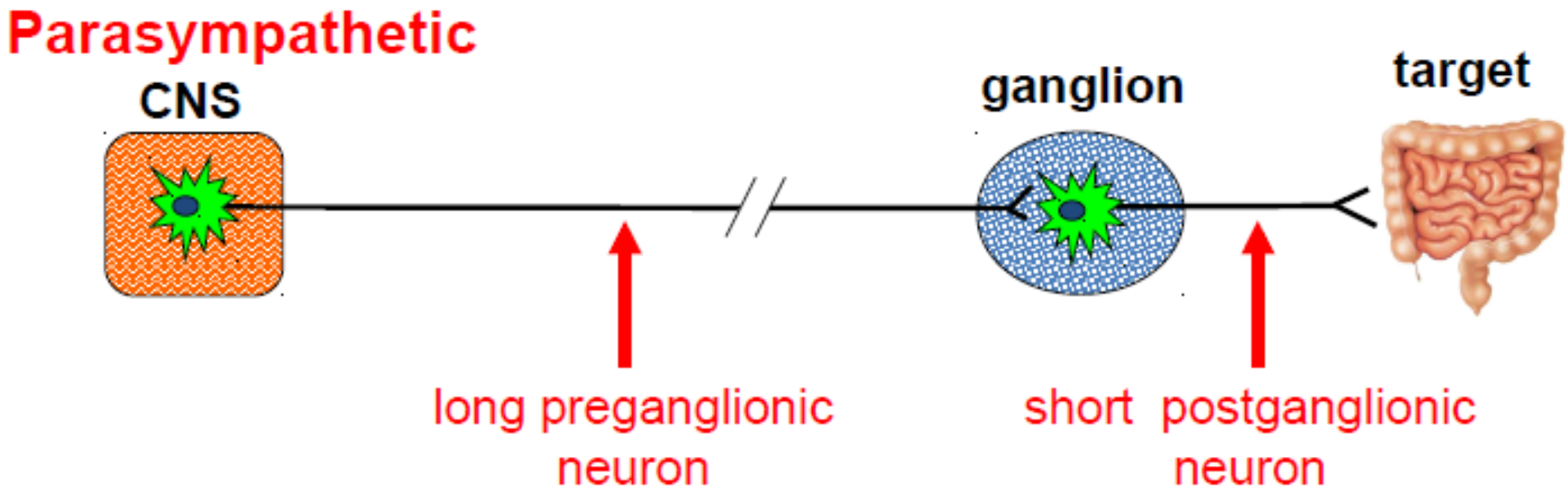
Parasympathetic Division

- ***Long preganglionic neurons***; ***Short postganglionic neurons***; The ganglia for the parasympathetic division are located near or in the organs they connect with.
- ONLY Innervates internal organ (not skin)
- Preganglionic neurons secrete **Ach** onto nicotinic receptors.
- Postganglionic neurons secrete **Ach** onto muscarinic receptors.

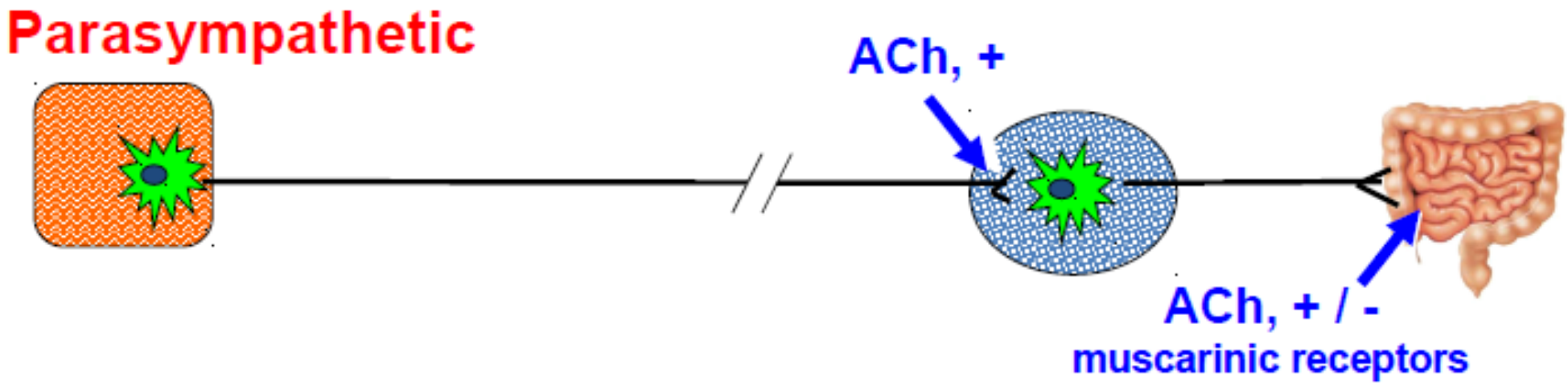


Parasympathetic Pathway

Relative Lengths of Neurons



Neurotransmitters



Parasympathetic Pathways

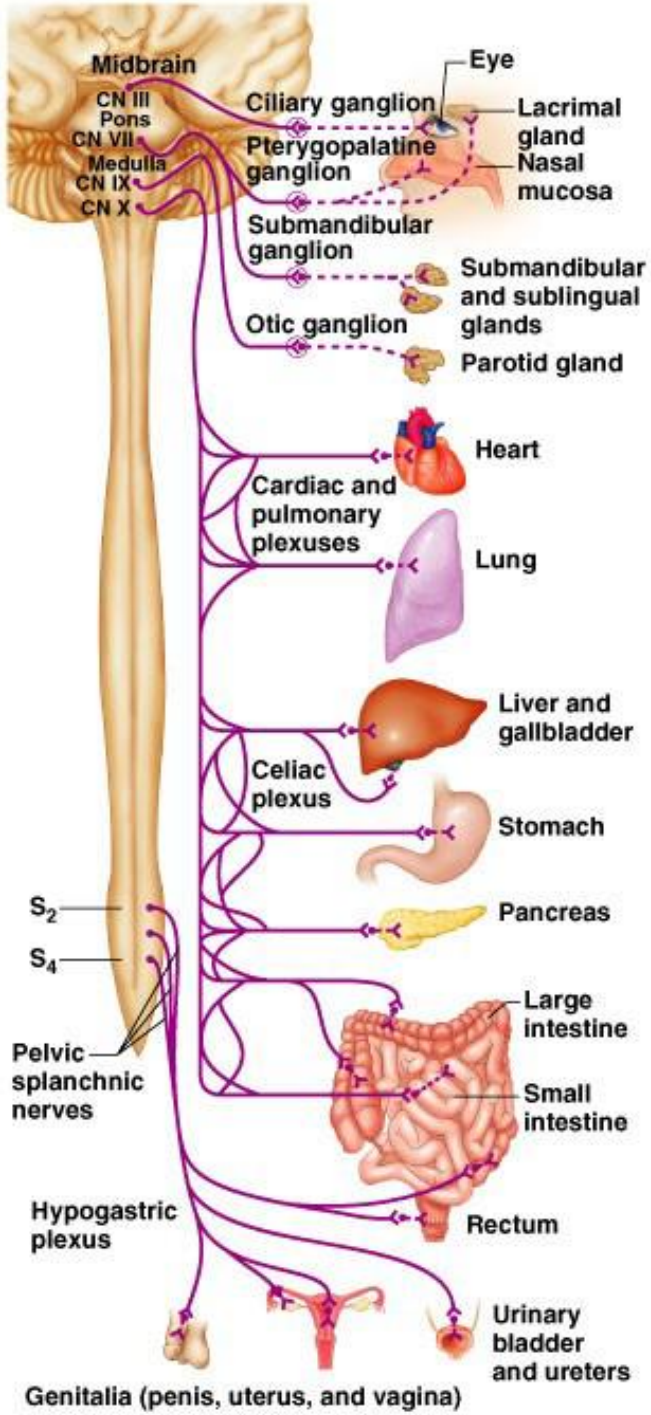
Cranial Outflow

- Cell bodies of preganglionic fibers located in cranial nerve nuclei in the **brain stem.**

- Preganglionic fibers run via:

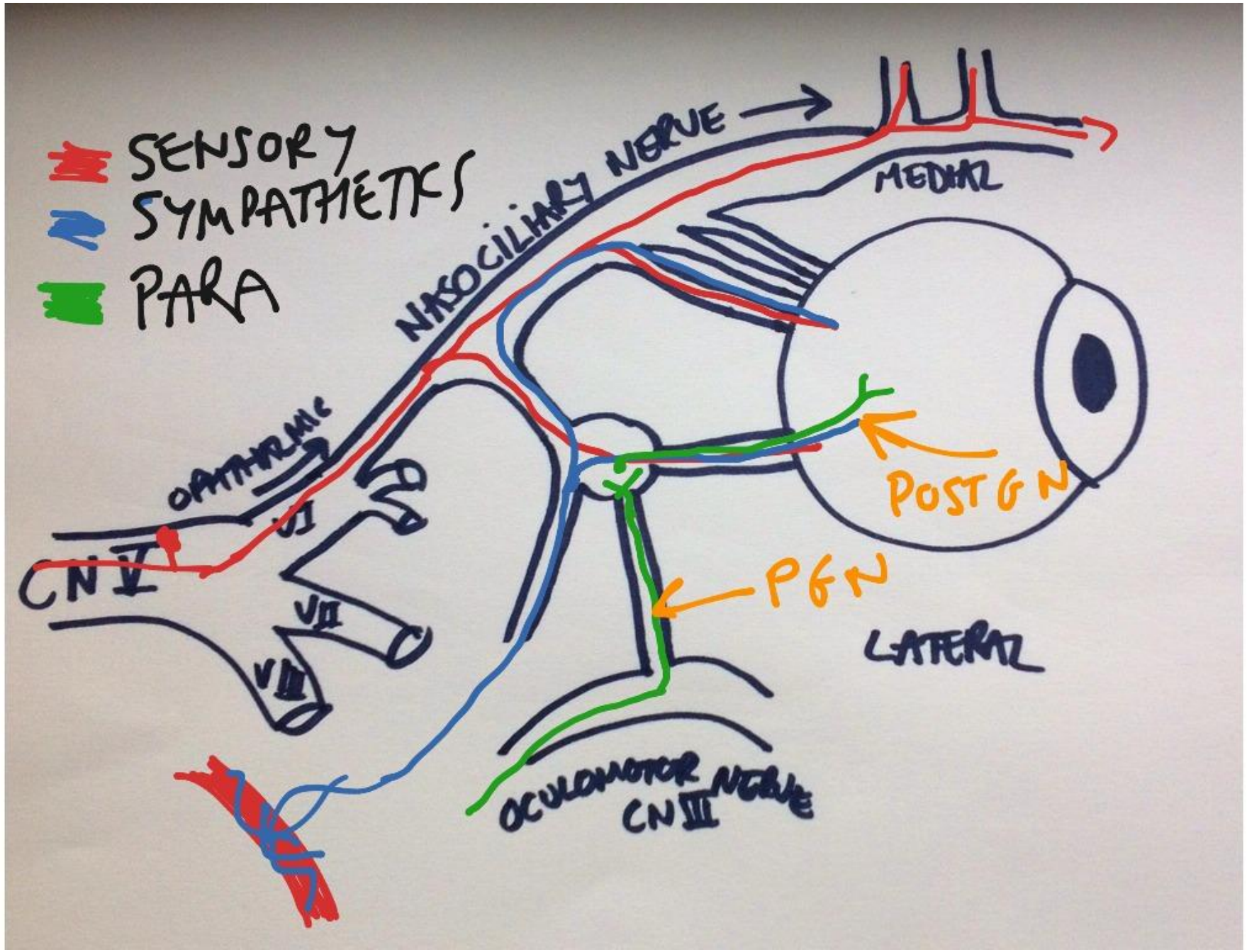
  - **3rd Cranial Nerve (Oculomotor)**
  - **7th Cranial Nerve (Facial)**
  - **9th Cranial Nerve (Glossopharyngeal)**
  - **10th Cranial Nerve (Vagus)**

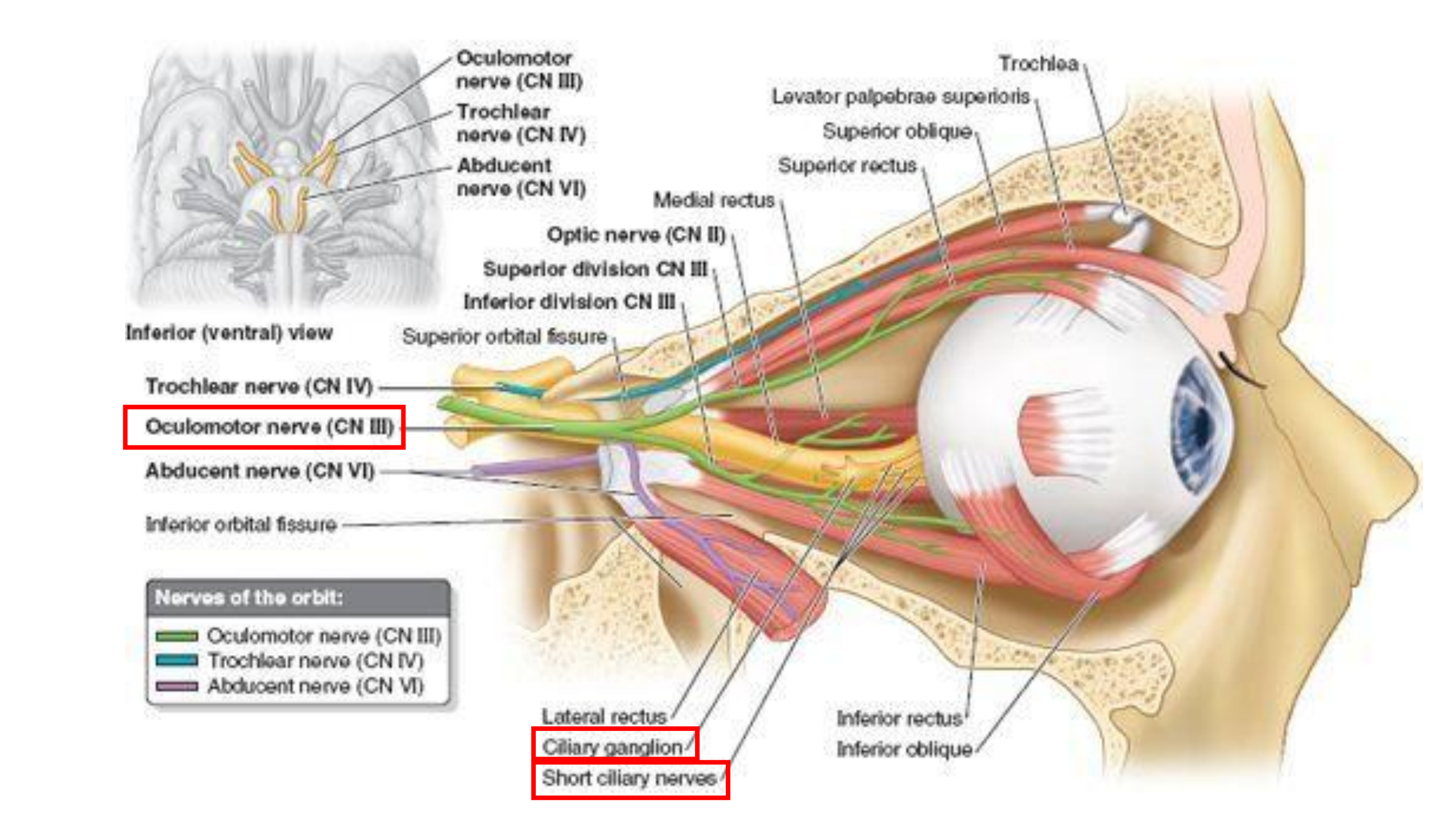
Parasympathetic Division



CN III: Oculomotor Nerve

- **Origin:** **Edinger-Westphal nucleus** at midbrain.
- **Course:**
  - Preganglionic from E-W nucleus run via oculomotor to relay in the **Ciliary Ganglion**.
  - Postganglionic axons run in the ***short ciliary nerves*** and innervate two eye muscles, ***pupillary constrictor muscle*** (constrictor of the pupil) and ***ciliary muscle*** (changes the shape of the lens in the eye).
- Its stimulation leads to miosis, accommodation to neat vision.


SENSORY
SYMPATHETICS
PARA
NASOCILIARY NERVE
MEDIAL
OPHTHALMIC
V1
CN V
VII
VIII
POST G N
PGN
LATERAL
OCULOMOTOR NERVE
CN III


Oculomotor nerve (CN III)
Trochlear nerve (CN IV)
Abducent nerve (CN VI)
Inferior (ventral) view
Trochlea
Levator palpebrae superioris
Superior oblique
Superior rectus
Medial rectus
Optic nerve (CN II)
Superior division CN III
Inferior division CN III
Superior orbital fissure
Trochlear nerve (CN IV)
Oculomotor nerve (CN III)
Abducent nerve (CN VI)
Inferior orbital fissure
Nerves of the orbit:
Oculomotor nerve (CN III)
Trochlear nerve (CN IV)
Abducent nerve (CN VI)
Lateral rectus
Ciliary ganglion
Short ciliary nerves
Inferior rectus
Inferior oblique

CN VII: Facial Nerve

- **Origin:** The **superior salivatory nucleus** which is a part of facial nucleus in the lower part of pons.

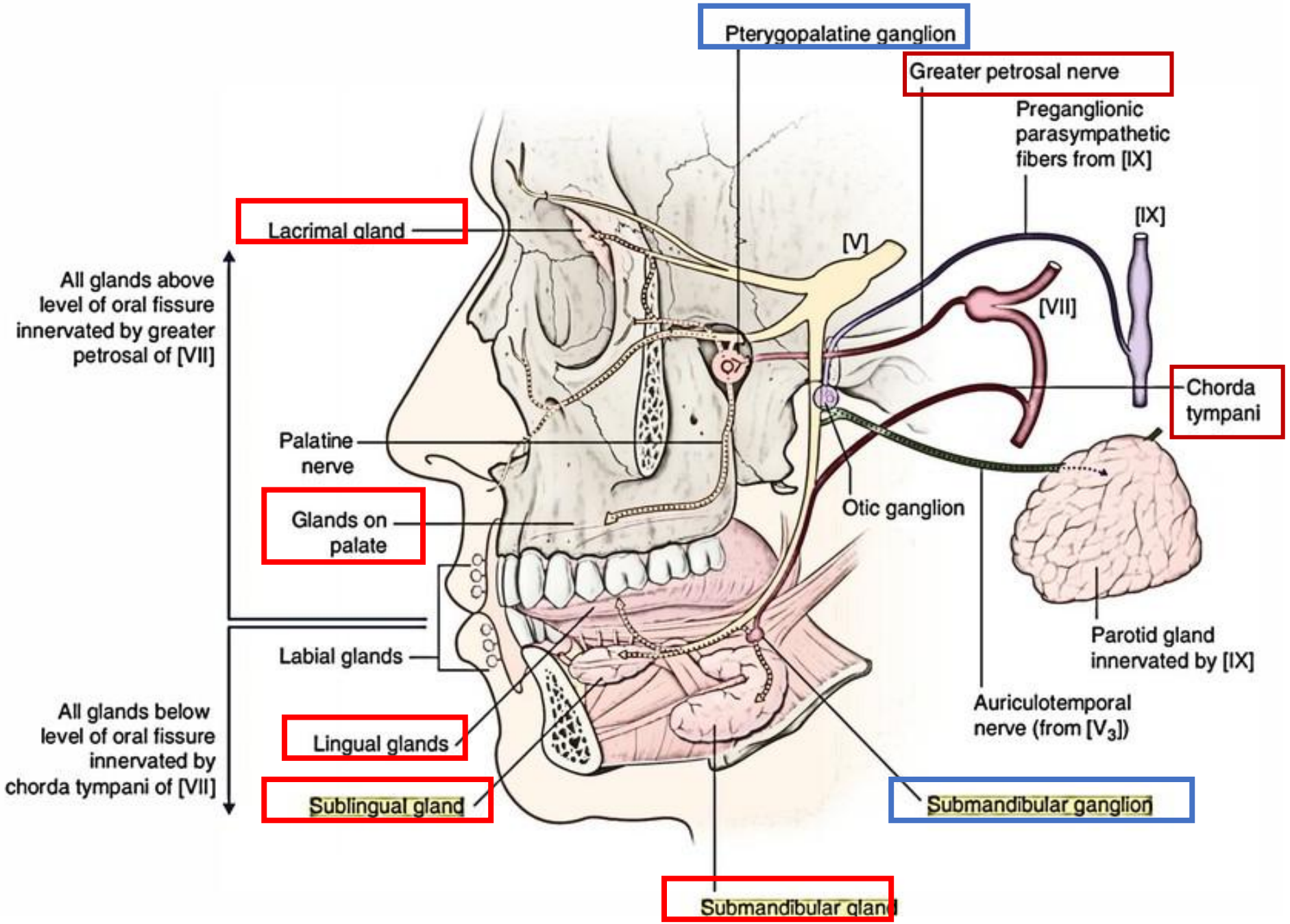
- **Course:** Preganglionic fibers from the superior salivatory, run via:

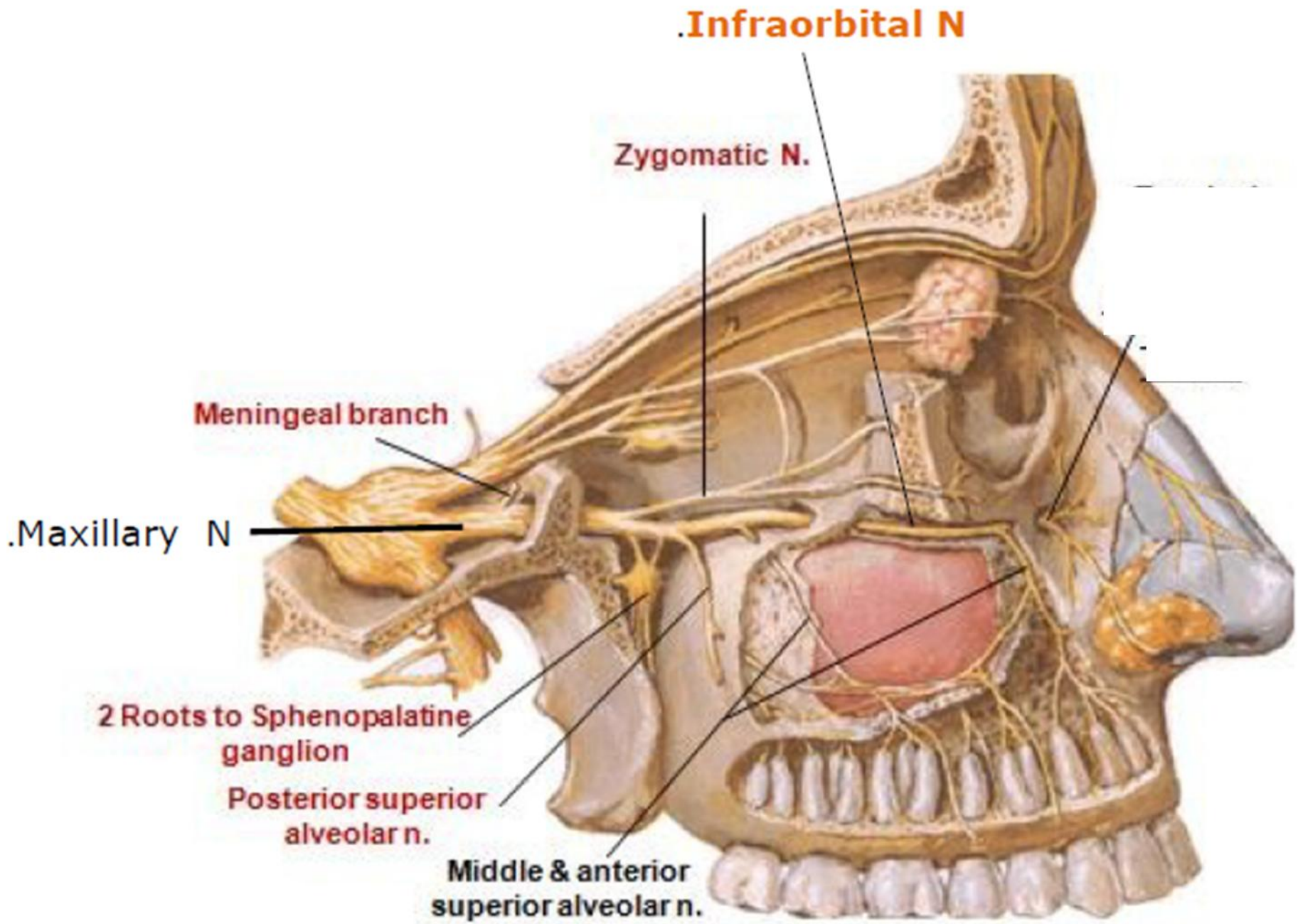
  1. ***Chorda tympani*** (facial nerve) and ***lingual nerve*** (mandibular nerve), and relay in **Submandibular Ganglion.**

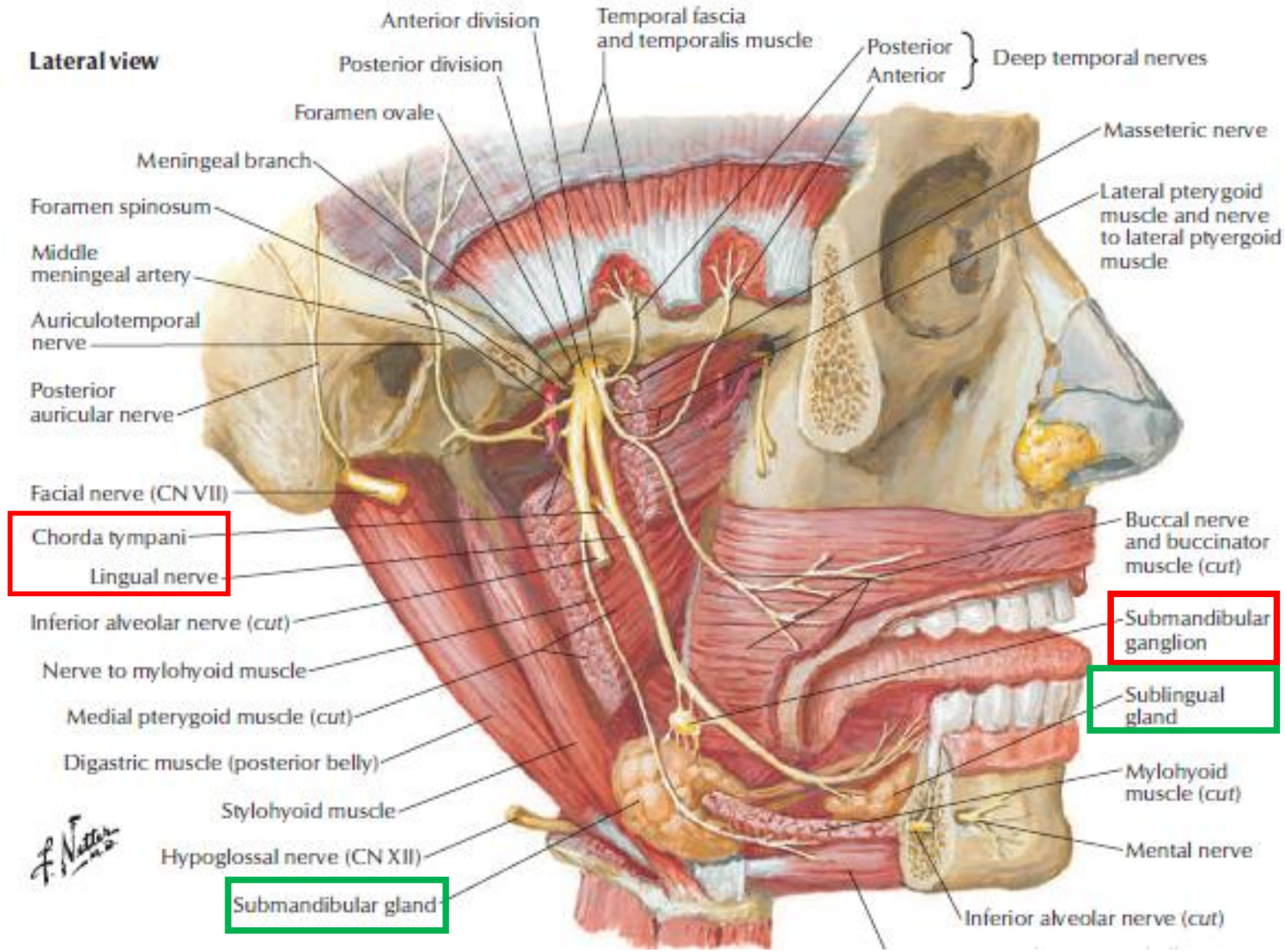
     - Postganglionic nerve arises from submandibular ganglion supply *submandibular and sublingual salivary glands and lingual glands*

  2. ***Greater petrosal nerve*** (facial nerve) and relay in **Pterygopalatine Ganglion.**

     - Postganglionic nerve arises from pterygopalatine ganglion supply *Lacrimal glands and the glands of the soft palate and nasopharynx.*


Pterygopalatine ganglion
Greater petrosal nerve
Preganglionic parasympathetic fibers from [IX]
[IX]
[V]
[VII]
Lacrimal gland
All glands above level of oral fissure innervated by greater petrosal of [VII]
Chorda tympani
Palatine nerve
Glands on palate
Otic ganglion
Parotid gland innervated by [IX]
Labial glands
Auriculotemporal nerve (from [V3])
All glands below level of oral fissure innervated by chorda tympani of [VII]
Lingual glands
Sublingual gland
Submandibular ganglion
Submandibular gland


.Infraorbital N
Zygomatic N.
Meningeal branch
.Maxillary N
2 Roots to Sphenopalatine ganglion
Posterior superior alveolar n.
Middle & anterior superior alveolar n.


Lateral view
Anterior division
Posterior division
Temporal fascia and temporalis muscle
Posterior
Anterior
Deep temporal nerves
Foramen ovale
Meningeal branch
Masseteric nerve
Foramen spinosum
Lateral pterygoid muscle and nerve to lateral ptyergoid muscle
Middle meningeal artery
Auriculotemporal nerve
Posterior auricular nerve
Facial nerve (CN VII)
Chorda tympani
Lingual nerve
Buccal nerve and buccinator muscle (cut)
Submandibular ganglion
Inferior alveolar nerve (cut)
Sublingual gland
Nerve to mylohyoid muscle
Medial pterygoid muscle (cut)
Digastric muscle (posterior belly)
Mylohyoid muscle (cut)
Stylohyoid muscle
Hypoglossal nerve (CN XII)
Mental nerve
Submandibular gland
Inferior alveolar nerve (cut)

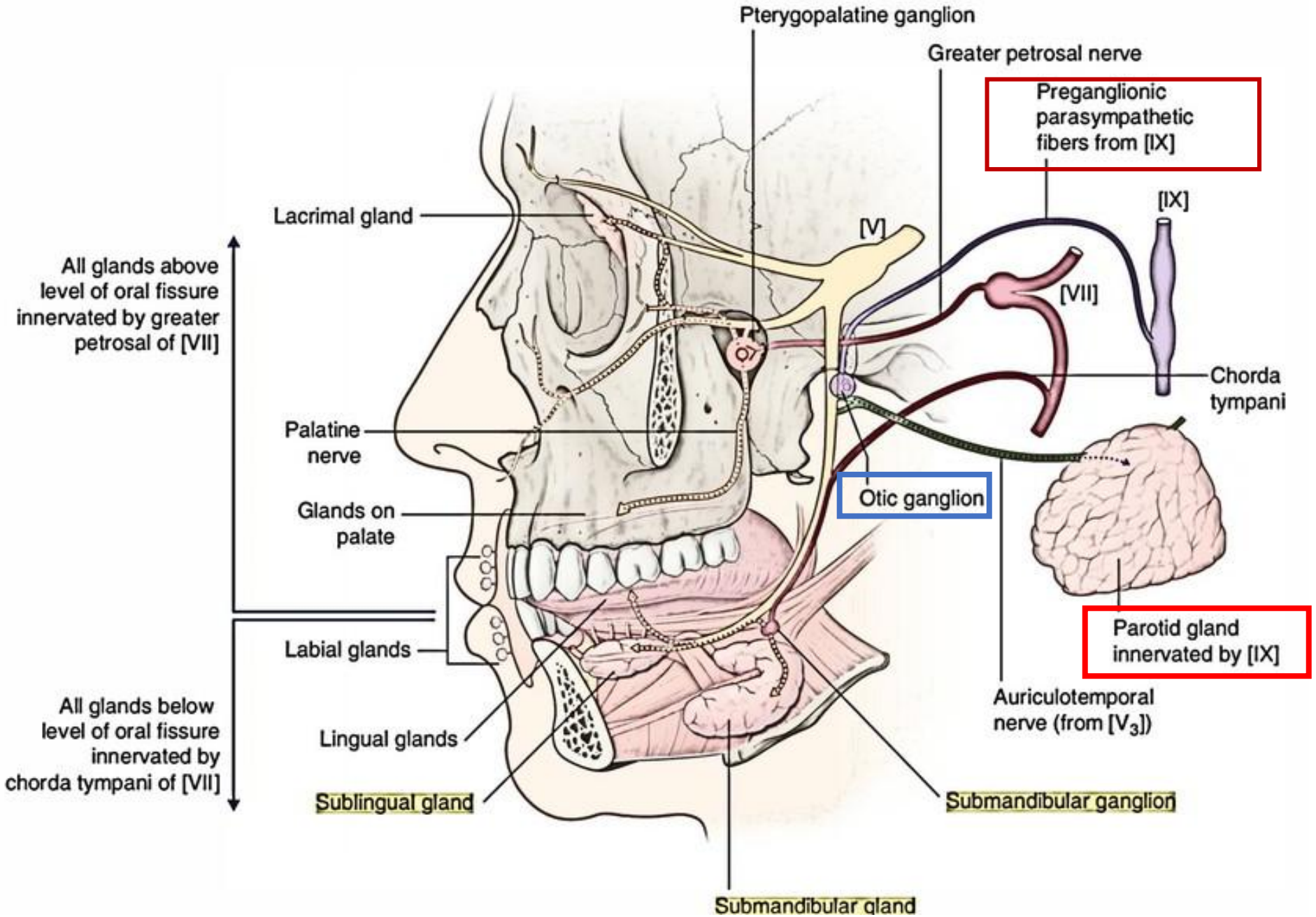
CN IX: Glossopharyngeal Nerve

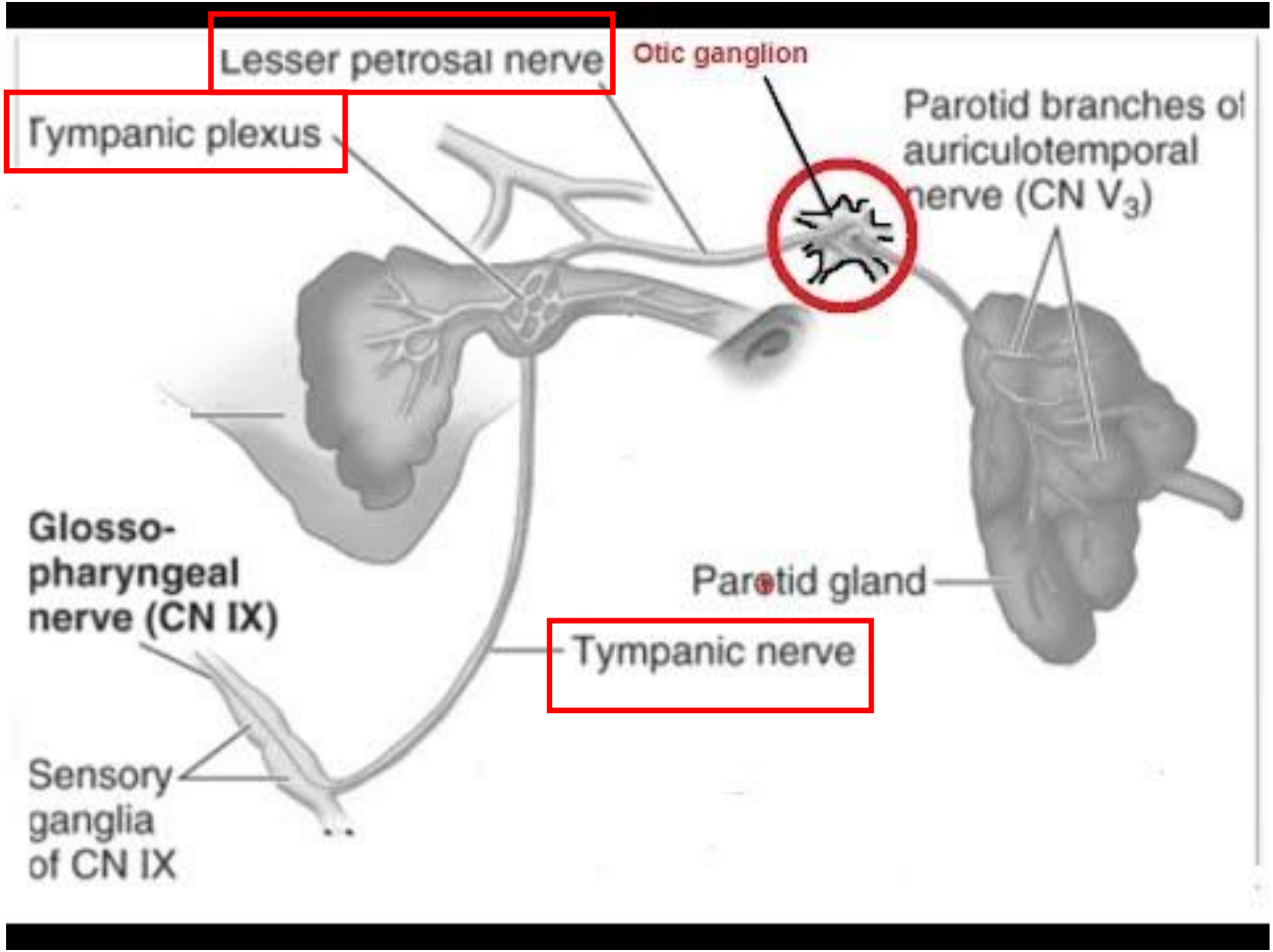
- **Origin**: The preganglionic fibers originate in the **inferior salivatory nucleus** of the glossopharyngeal nerve.

- **Course:**

  - The preganglionic fibers run via ***tympanic branch*** and then pass via the ***tympanic plexus*** and the ***lesser petrosal nerve*** to the **Otic Ganglion.**

  - Postganglionic nerve fibers arise from otic ganglion run via ***auriculotemporal nerve*** and supply the ***parotid salivary gland.***


Pterygopalatine ganglion
Greater petrosal nerve
Preganglionic parasympathetic fibers from [IX]
[IX]
[V]
[VII]
Lacrimal gland
All glands above level of oral fissure innervated by greater petrosal of [VII]
Chorda tympani
Palatine nerve
Otic ganglion
Glands on palate
Parotid gland innervated by [IX]
Labial glands
Auriculotemporal nerve (from [V3])
All glands below level of oral fissure innervated by chorda tympani of [VII]
Lingual glands
Sublingual gland
Submandibular ganglion
Submandibular gland


Lesser petrosal nerve
Otic ganglion
Tympanic plexus
Parotid branches of auriculotemporal nerve (CN V3)
Glosso-pharyngeal nerve (CN IX)
Parotid gland
Tympanic nerve
Sensory ganglia of CN IX

CN X: Vagus Nerve

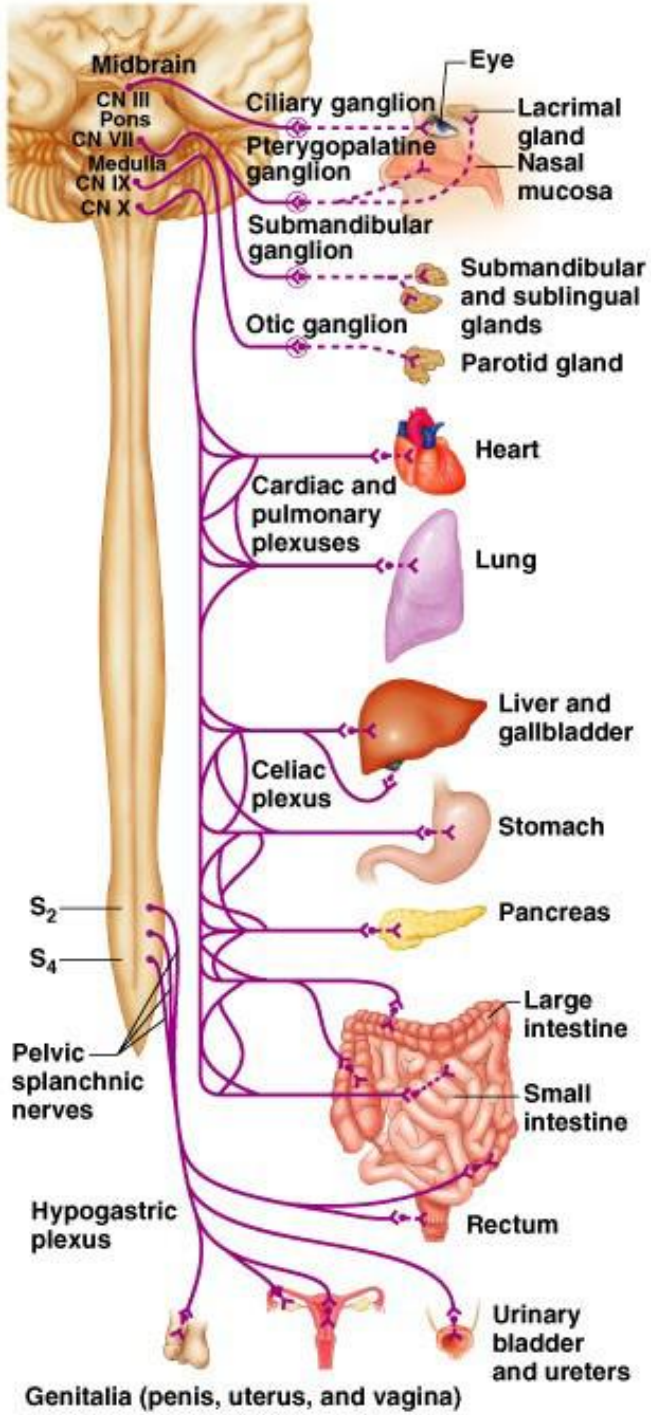
- **Origin:** The preganglionic fibers originate in the **Dorsal vagus nucleus** in medulla oblongata

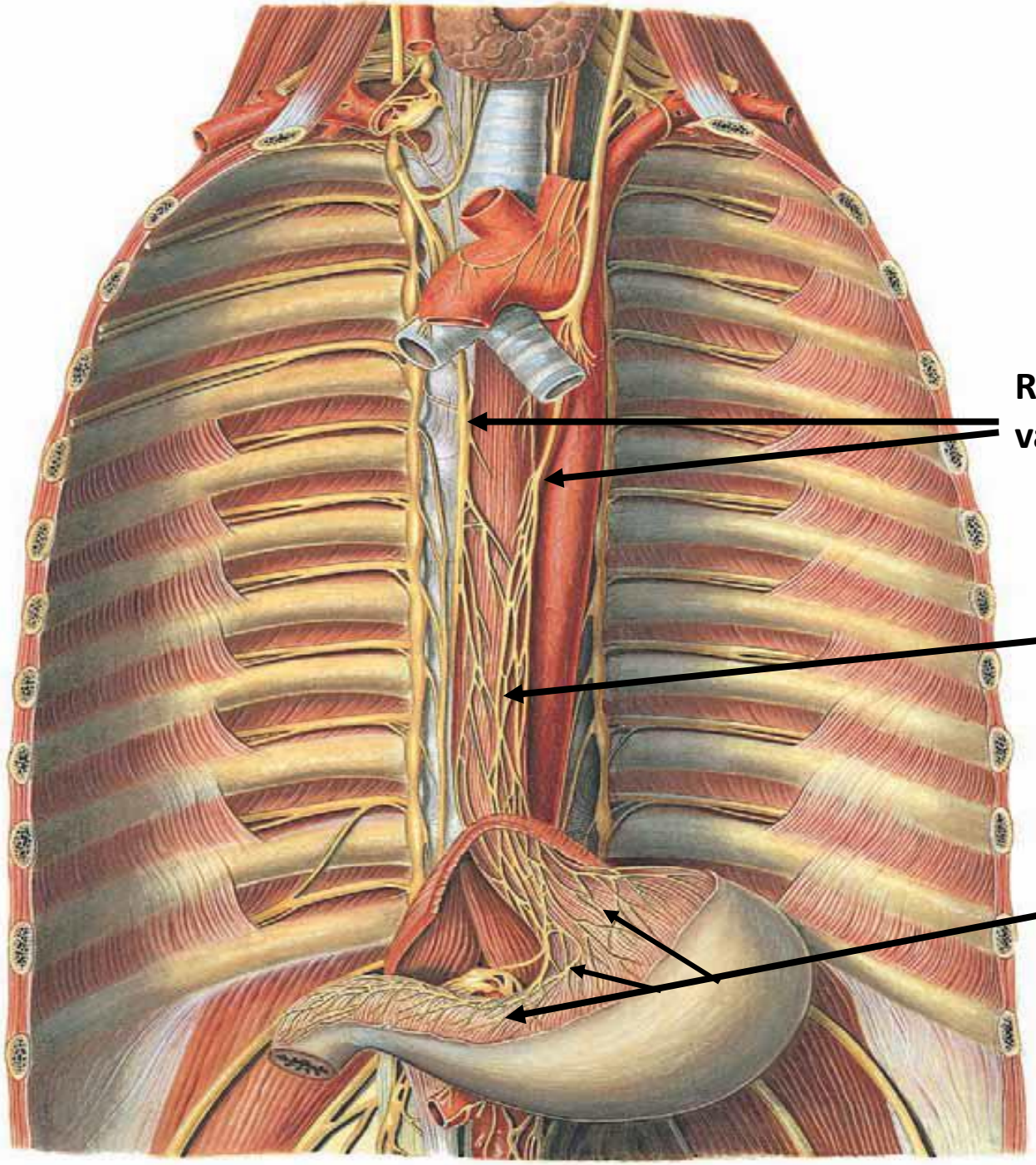
- **Course:**

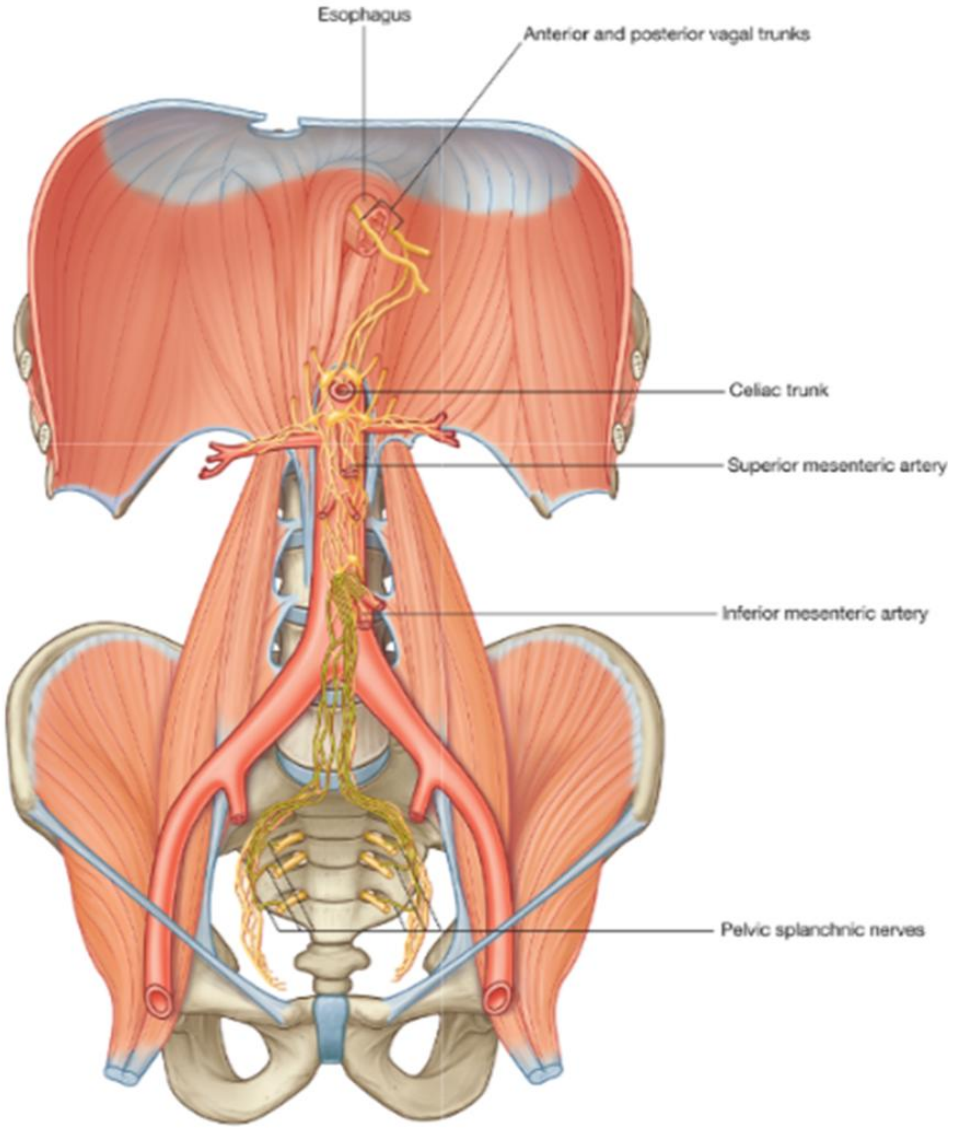
  - The preganglionic fibers run via the vagus nerve the **terminal ganglia.**

  - Postganglionic nerve fibers arise from the terminal ganglia and supply the thoracic *(heart and lungs)* and abdominal viscera *(Digestive organs).*

Parasympathetic Pathways




Right and left vagus nerves
Esophageal plexus
Anterior gast plexus


Esophagus
Anterior and posterior vagal trunks
Celiac trunk
Superior mesenteric artery
Inferior mesenteric artery
Pelvic splanchnic nerves

Parasympathetic Pathways

Sacral Outflow

- **Origin:** Preganglionic nerve fibers arise from the **lateral horn cells of the 2nd, 3rd and 4th sacral segments.**

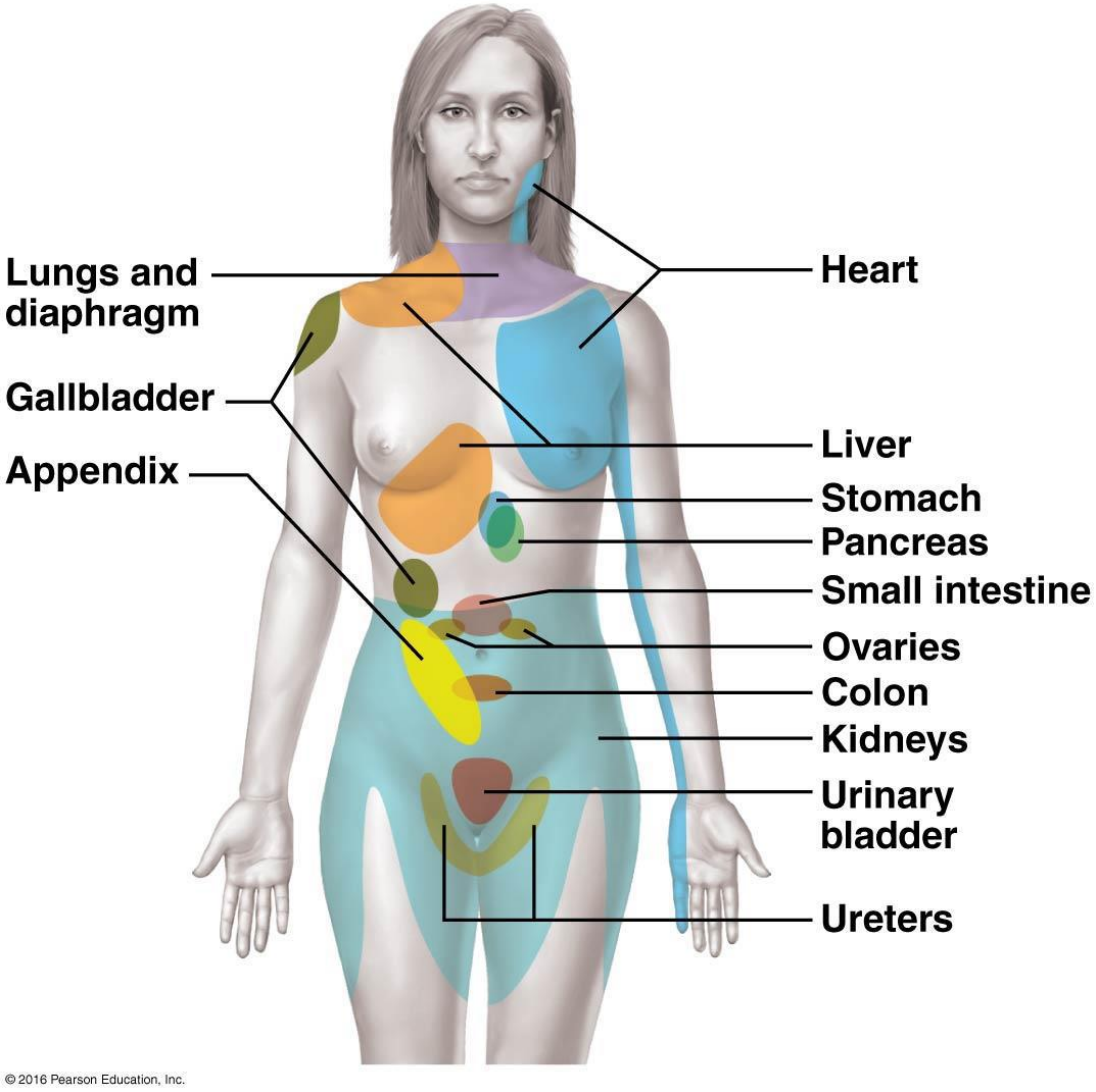
- **Course:** These preganglionic passes form the ***pelvic nerves*** which relay in the **terminal ganglia**, where the postganglionic nerve fibers emerge and supply the *descending colon and rectum, urinary bladder, seminal vesicles, prostate, and erectile tissue*.

Visceral Sensory Neurons

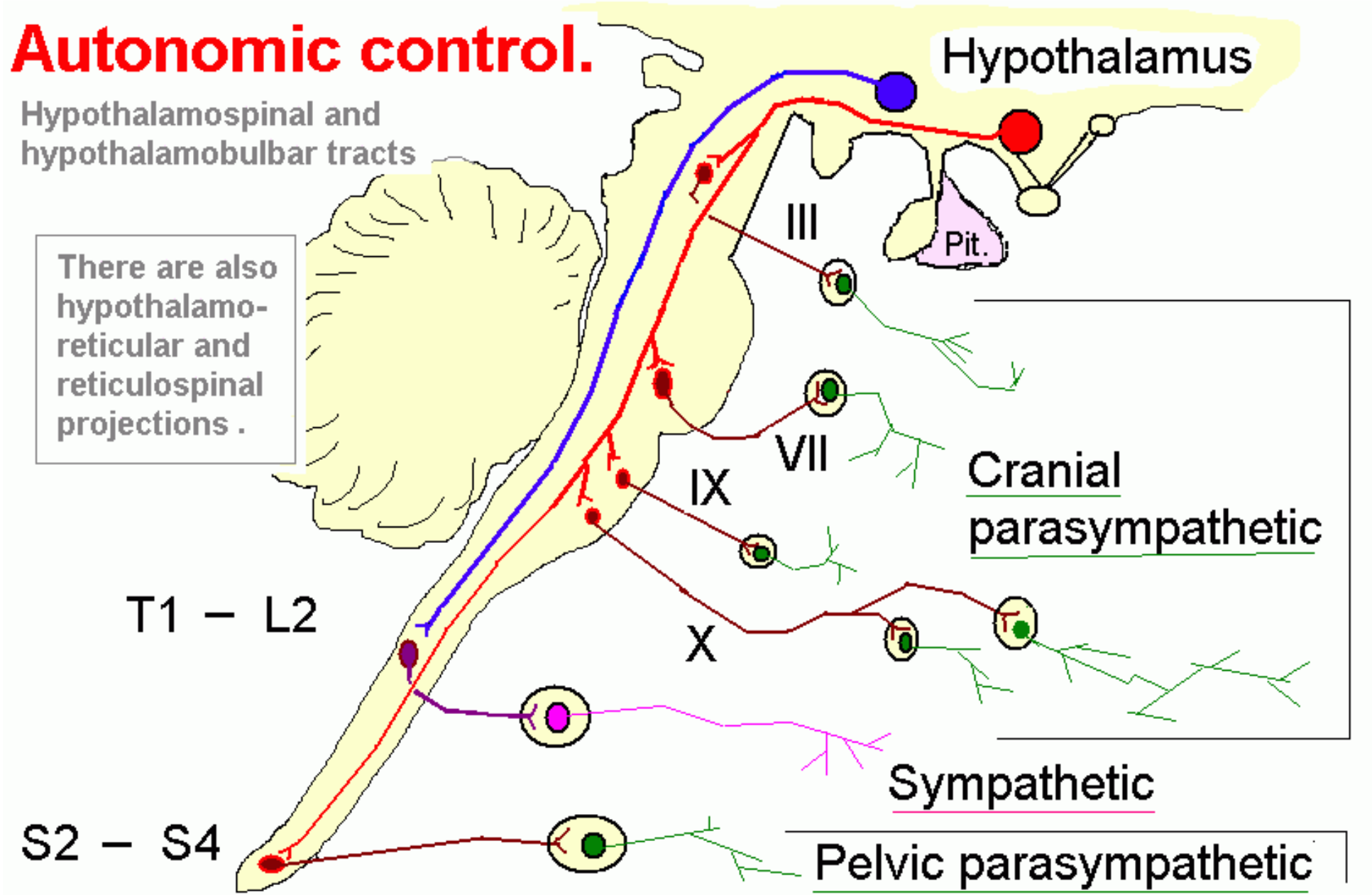
- Monitor temperature, pain, irritation, chemical changes and stretch in the visceral organs.
  - Brain interprets as hunger, fullness, pain, nausea,
- Receptors widely scattered – localization poor (e.g. which part is giving you the gas pain?)
- Visceral sensory fibers run within autonomic nerves, especially vagus and sympathetic nerves
  - Sympathetic nerves carry most pain fibers from visceral organs of body trunk
- **Simplified pathway**: ***sensory neurons*** to ***spinothalamic tract*** to ***thalamus*** to ***cerebral cortex***

Referred Pain: Important to Know

- Pain in visceral organs is often perceived to be somatic in origin.
- This may be due to the fact that visceral pain afferents travel along the same pathways as somatic pain fibers.



Control of ANS



Thank You

Ayman.alzubi@yu.edu.jo