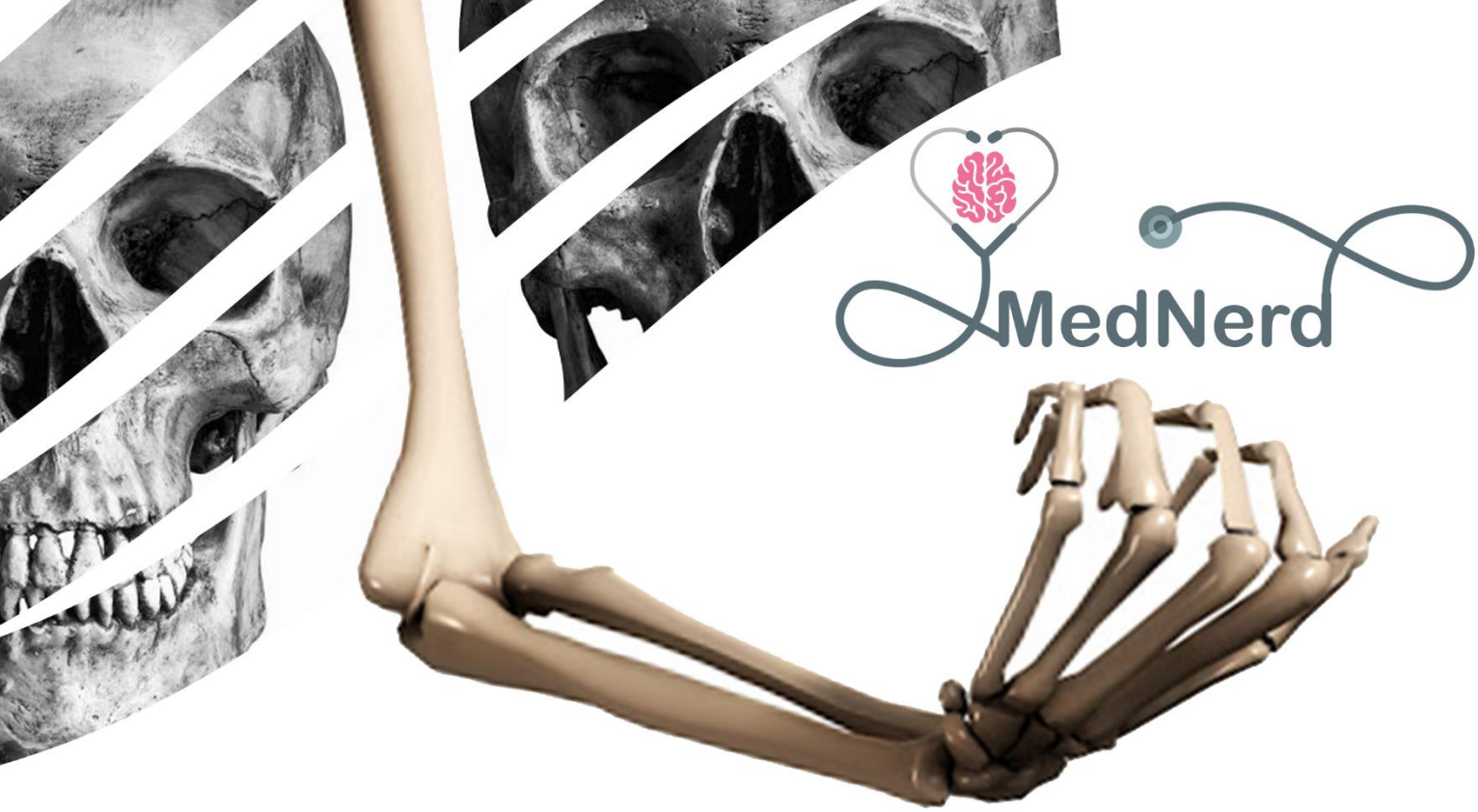

MedNerd

Human Anatomy & Embryology

Lecture: Autonomic NS

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#16

Sympathetic NS

Autonomic nervous system has two parts:

1) **Sympathetic:** fight and flight conditions.
2) **Parasympathetic:** rest and digest conditions.

Introduction:

The sympathetic nervous system (SNS) is one of the three divisions of the autonomic nervous system, the others being the parasympathetic nervous system and the enteric nervous system.

The autonomic nervous system functions to regulate the body's unconscious actions. The sympathetic nervous system's primary process is to stimulate the body's fight or flight response. It is, however, constantly active at a basic level to maintain homeostasis. The sympathetic nervous system is described as being antagonistic to the parasympathetic nervous system which stimulates the body to "feed and breed" and to (then) "rest-and-digest".

-source: Wikipedia

The sympathetic system has two parts:

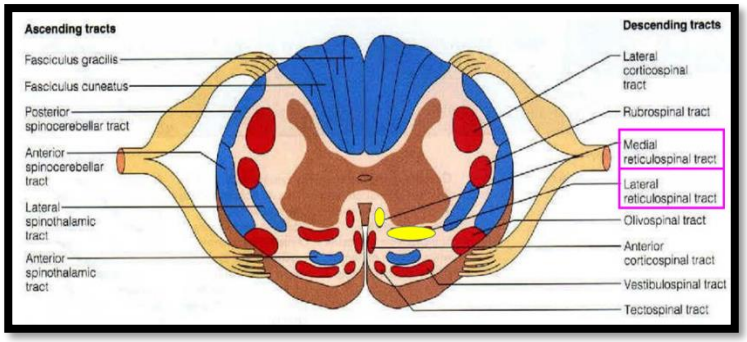
1) **Central part**
2) **Peripheral part**

What is the highest brain center controlling the sympathetic activity? Ans: hypothalamus

- Hypothalamus is influenced by Limbic system + Reticular Formation.
- Limbic system Dealing with afferent endocrine feedback, emotion, motivation, and memory.
- Reticular formation is important in controlling sympathetic NS.
  It contains containing centers for:
  a) Vasopressor + dilator of blood vessel.
  b) cardiac accelerator + decelerators.
  c) respiration.
  - ❖ All these factors affect hypothalamus thus affecting sympathetic NS.

What is the hypothalamus going to do?

it sends descending tract called ***reticulospinal tract*** and this tract is going to spinal cord.



- in the spinal cord there are two reticulospinal tracts:
  1. lateral reticulospinal tract.
  2. medial reticulospinal tract.

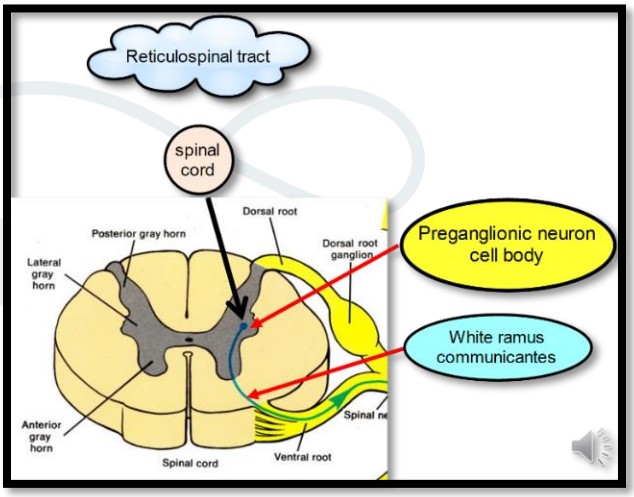
- where do these tracts end? They End in the lateral horn (T1 – L2) of the spinal cord. This area is called **Sympathetic outflow.**

At the end of this point >> the first order neuron is going to end up at the lateral horn containing cell bodies.

Sum: hypothalamus > reticulospinal tract (lateral and medial) > lateral horn.

What else?

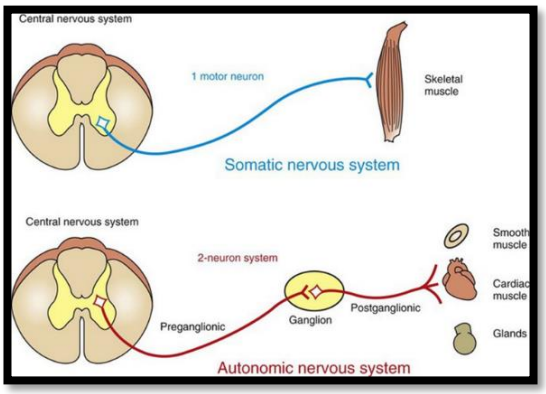
- ✓ The lateral horn has cell bodies of preganglionic nerve (so preganglionic cell body is within central NS) cells are going to send an axon
- ✓ Now we will leave the central part and going to the peripheral part of NS.
- ✓ Axons of these cells will travel ventrally along with ventral root of the spinal nerve.
- ✓ And because these neurons are myelinated, they called white ramus communicans.



the peripheral part of the ANS is made up of two neurons:

1) Preganglionic neuron coming from the lateral horn (in sympathetic NS).
2) Postganglionic neuron sending axons to the affected organ.

-Synapse in the ganglion connects the two neurons.



In contrast to the somatic nervous system:

SINGLE PEREPHERAL NEURON: Here the Ventral horn sends its axons to the effector organs without presence of ganglion.

Pathways of the axons:

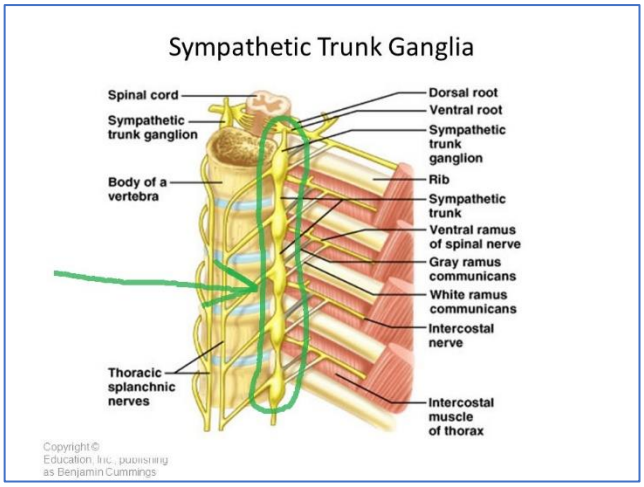
-before we start:

*ramus (plural: rami): an arm or branch or bridge.

*white ramus = myelinated axons (appears white because myelin sheath is made of several layers of plasma membrane [lipid bilayer] of a Schwann cells, so it is fatty=white “)

*gray ramus = unmyelinated axons.

*sympathetic trunk ganglia: vertical chain of interconnected paravertebral ganglia, linked by either white or gray matter. Look at the image:



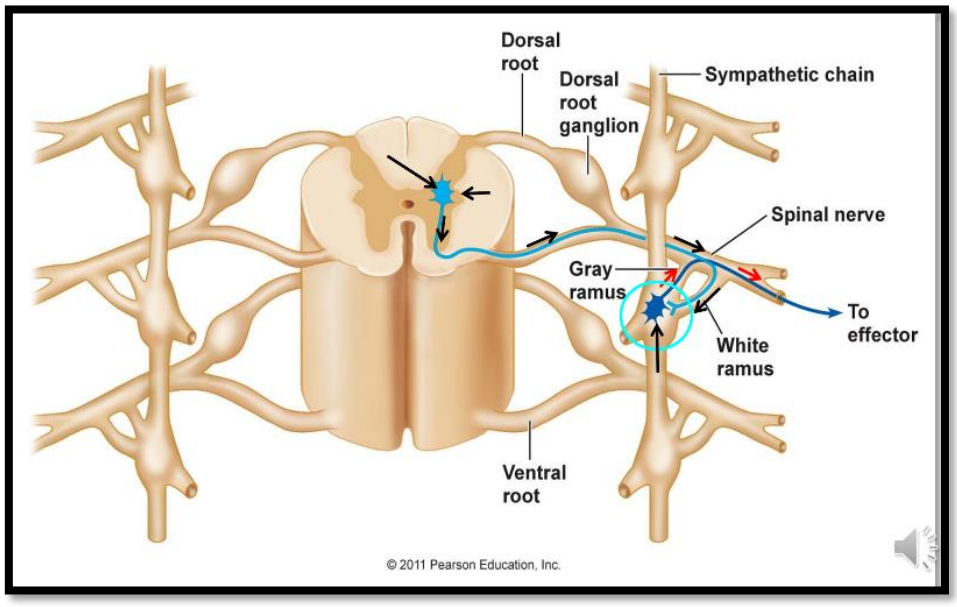
The common way:

- Lateral horn sends myelinated axons called white ramus communicans along with ventral root all the way to the spinal nerve, but here it will leave spinal nerve and go to enter a ganglion called **paravertebral ganglion**, forming a bridge of myelinated axons or, in other words: WHITE RAMUS between paravertebral ganglion and spinal nerve.

- Now, After the entrance of preganglionic white ramus to the paravertebral ganglion, we have possible 3 scenarios to complete the way towards the affected organ:

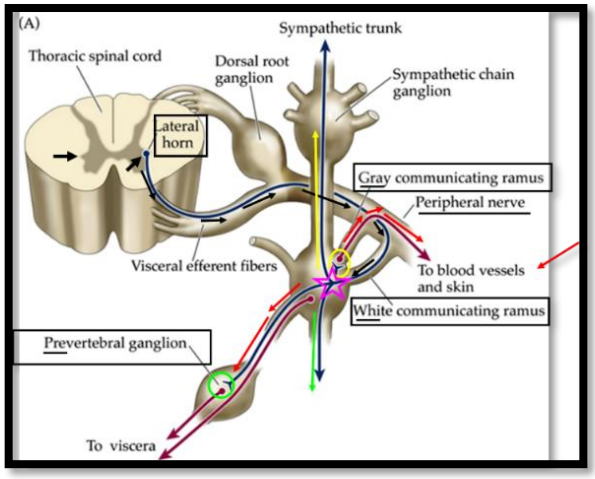
➢ First scenario:

-The preganglionic nerve make a **synapse** (connection) with the postganglionic cell bodies that are within the ganglion (so the postganglionic cell body is outside the central NS, while we saw the preganglionic is inside central NS in the lateral horn of gray matter of spinal cord), then after synapse, we have an unmyelinated bundle of axons coming out from postganglionic nerve exiting the paravertebral ganglion and rejoin spinal nerve forming a bridge of unmyelinated axons or, in other words: GRAY RAMUS between paravertebral ganglion and spinal nerve, which will complete the way along with the spinal nerve to the desired organ.



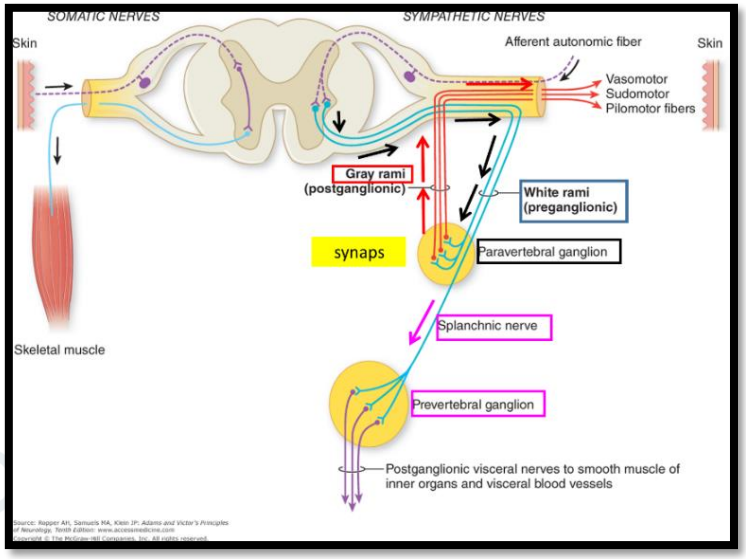
➢ Second scenario:

- After reaching the paravertebral ganglion, white ramus will NOT SYNAPSE and keep going <u>up</u> to the paravertebral ganglion just above the original one, or <u>down</u> to the one just below the original, then it synapses there. (or may go further up or down).



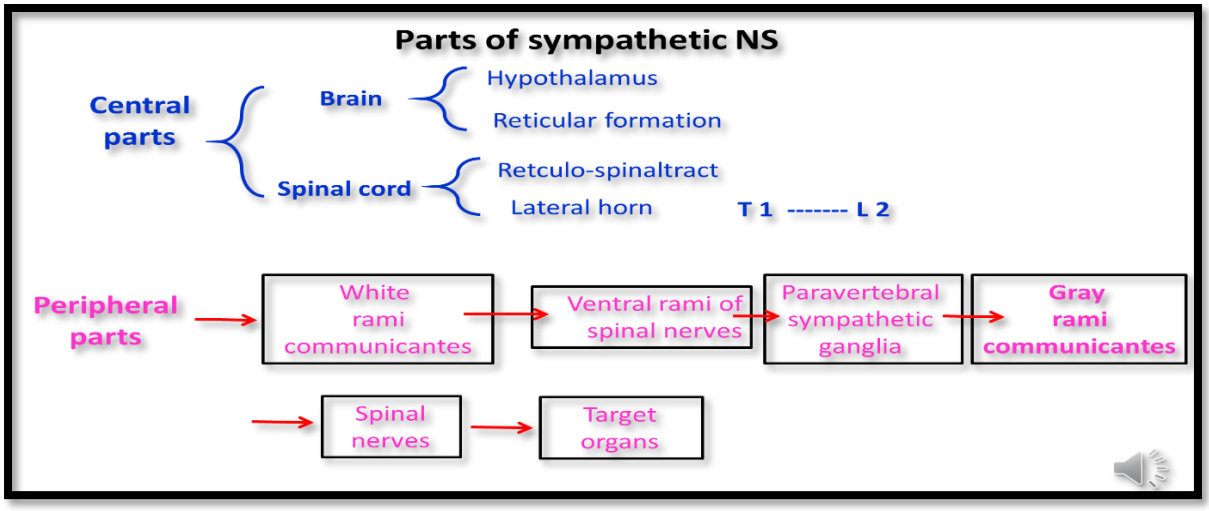
➢ Third scenario:

- White ramus enters the paravertebral ganglia and <u>exit</u> it <u>on its own</u>, without synapse or (ascend or descend) in the sympathetic trunk chain. The relationship between white ramus and the paravertebral ganglia is just passage, it passes without doing any interesting things “).
- So after that where does it go? It goes to the front of vertebral body to another ganglion called **Prevertebral** (not para) ganglion and synapses there.



THIS “insurgent” NERVE IS going to be CALLED: ***SPLANCHNIC NERVE*** حنحكي عنهم هسا

To sum up:

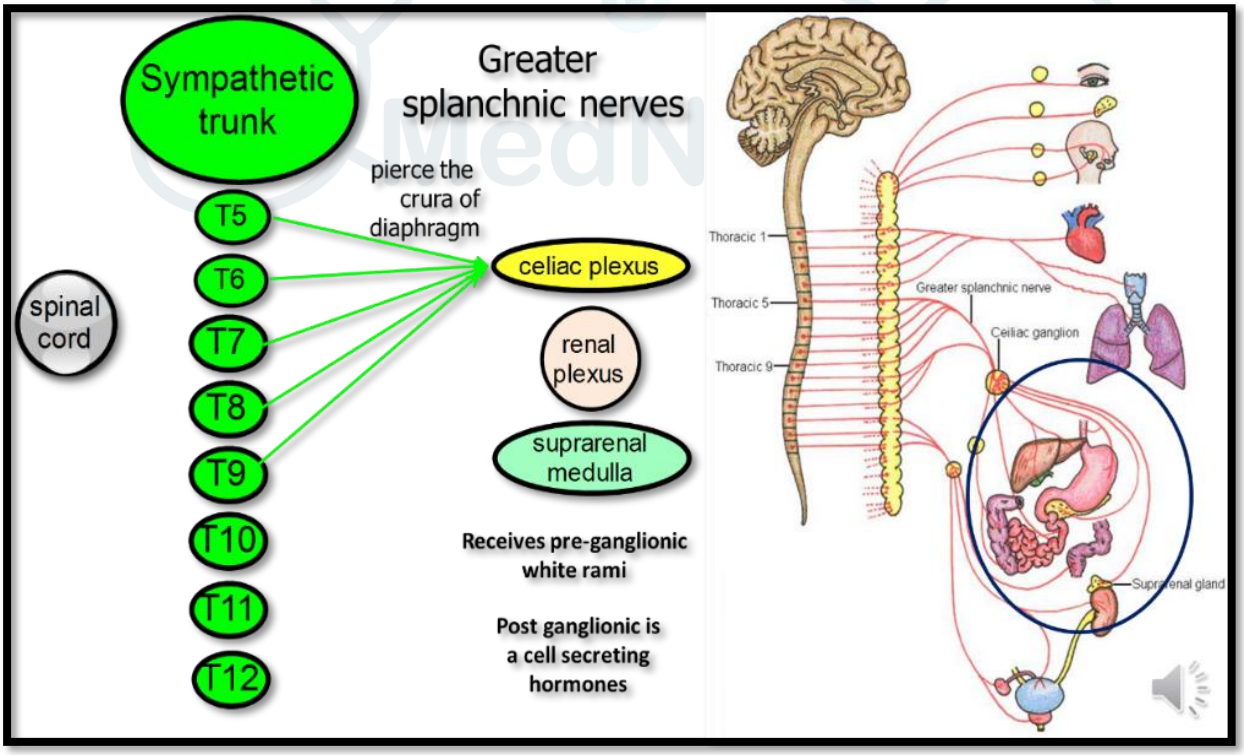


Splanchnic nerves:

-They are 3 groups: Greater, lesser, and least.

- ✓ T5-9 **Greater splanchnic nerve** ends in the celiac ganglia.
- ✓ T10-12 is the **lesser splanchnic nerve** ends to superior mesenteric ganglia.
- ✓ L1,2 the **least splanchnic nerve** ends to the inferior mesenteric ganglia.

- ➢ Greater splanchnic nerves: formed by spinal nerves T5-T9, they pierce the crura of diaphragm and form 3 sympathetic plexuses:
  - **celiac plexus:** around celiac artery, this plexus supplies most parts of the gastrointestinal tract.
  - **renal plexus**: around the renal artery, supplies renal structures (glomerulus, tubules).
  - **suprarenal medulla**: post ganglionic is a cell secreting hormone (adrenal gland cells, secrete Adrenaline and other hormones).
    - these plexuses receive white rami as a pre-ganglionic nerves because they are splanchnic nerves.



Some beautiful info “)

- The lesser splanchnic nerve is going to feed the superior mesenteric ganglion which is supplying the distal part of the large intestine (see figure Red).

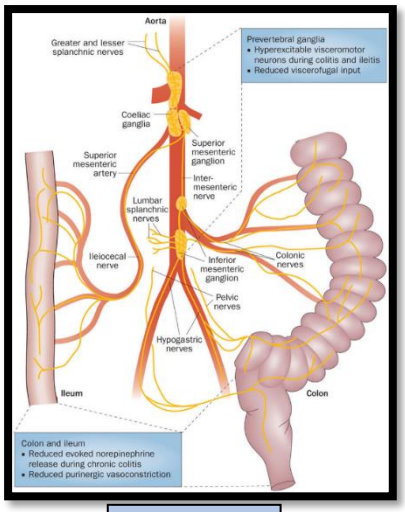


Figure Red

The greater and lesser splanchnic nerve passes through the diaphragm and form the celiac plexus (see Figure Yellow).

The greater and lesser splanchnic nerve they both go to the celiac ganglion tract (see Figure pink).

- The thoracic, abdominal, and pelvic cavities are greatly filled with sympathetic and parasympathetic nerves (autonomic NS) (see figure GREEN).
  - Postsynaptic nerves travels alone in T1-L2 (thoracic + upper lumbar region), but in cervical and lower lumbar, it travels along with blood vessels.

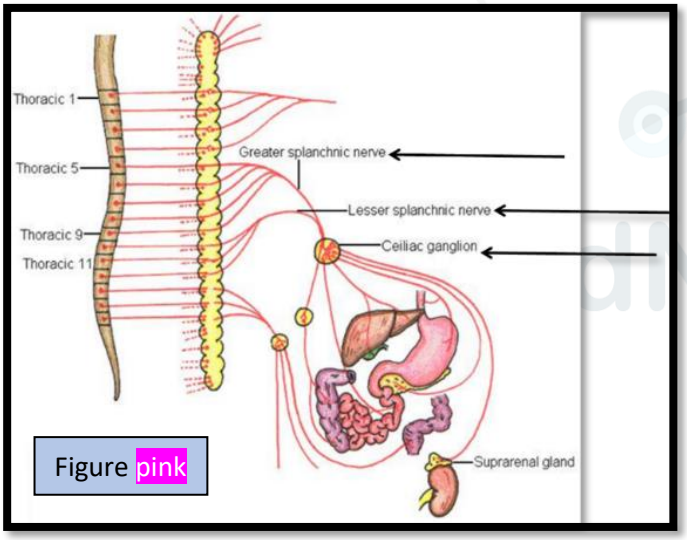


Figure pink

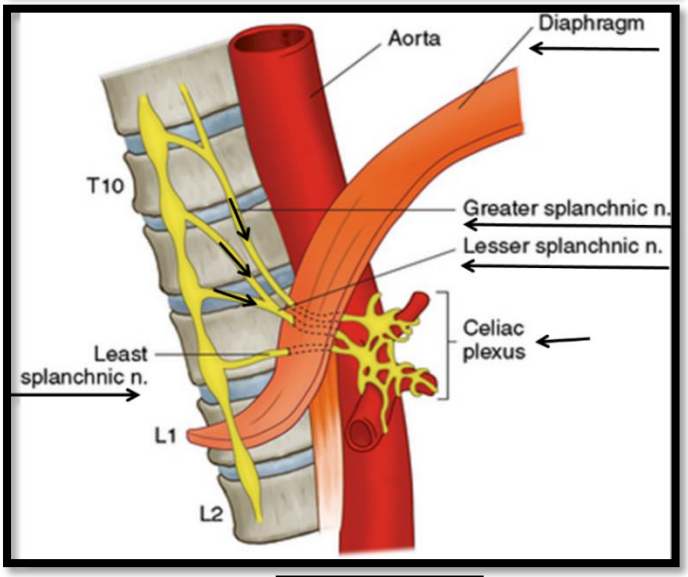


Figure Yellow

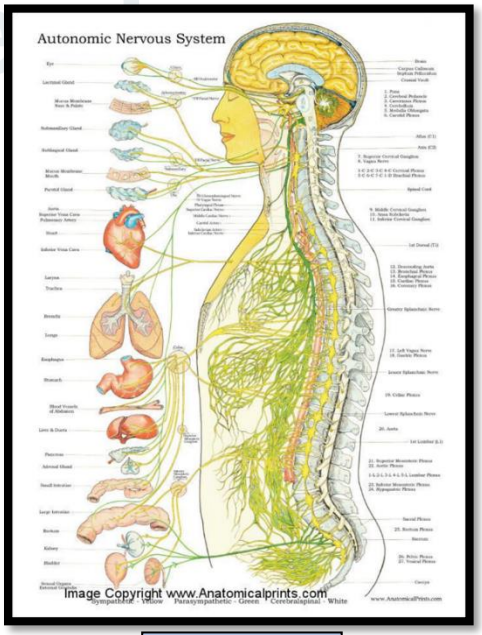


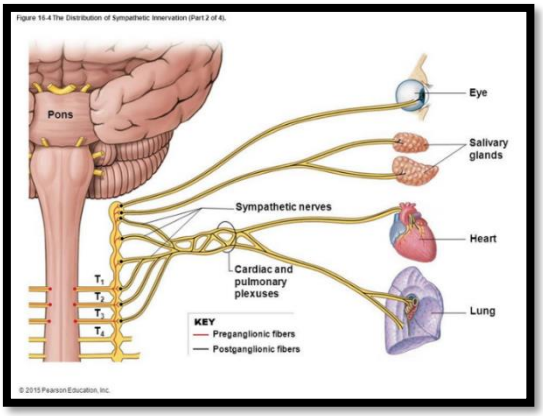
Figure Green

Cervical sympathetic ganglia:

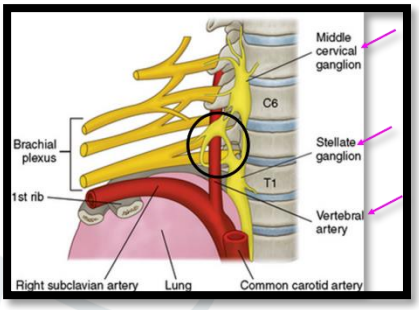
- The three cervical sympathetic ganglia (superior, middle and inferior) are posterior to the carotid sheath.

- The cervical sympathetic ganglia will supply target organs and reach them through blood vessels (nerves run along with blood vessels) and they target the:

I. Eye
II. Salivary glands
III. Heart
IV. Lung



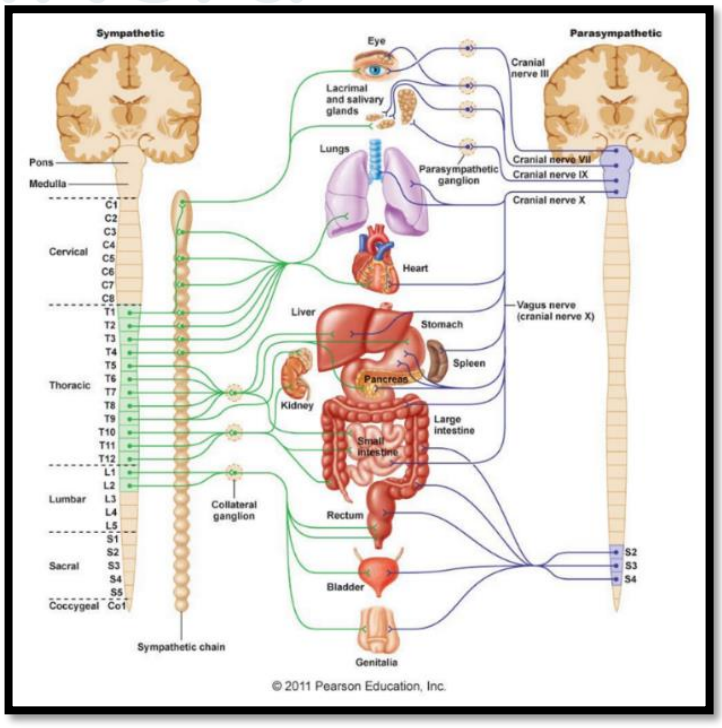
- closer image to the inferior cervical ganglia.
- it has special feature called loop contain the vertebral artery.
- sometimes this loop fuses with T1 sympathetic ganglion.



What are the target organs of sympathetic NS?

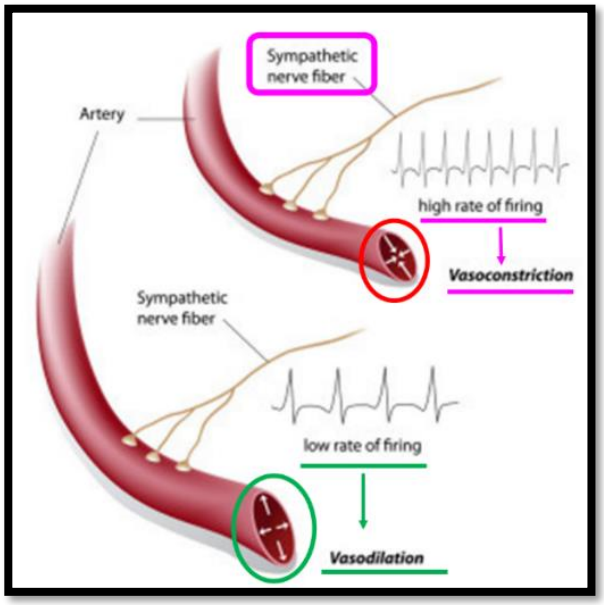
Organs in the midline of the picture:

- Eye
- Lacrimal and salivary gland
- Lung
- Heart
- Liver
- Spleen
- Kidney
- Urinary bladder
- Small and large intestine



❖ One of the targets of sympathetic nerve fibers is the blood vessels:

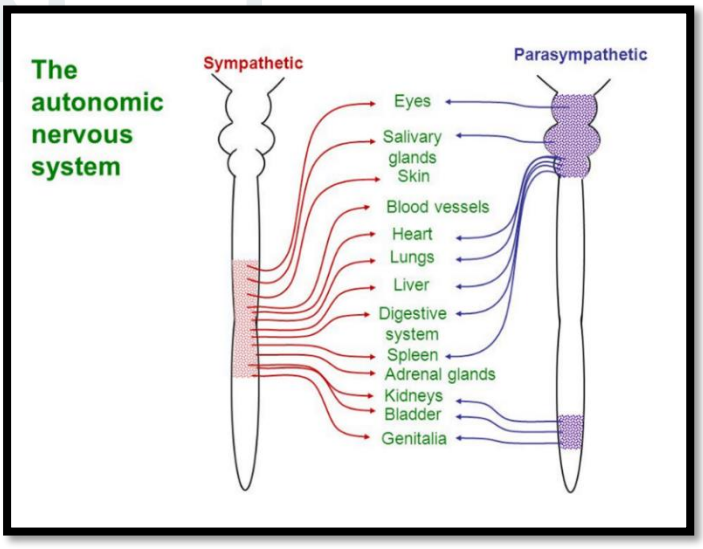
- When there is high rate of firing impulses >> the smooth muscle of the vessel will constrict → <u>vasoconstriction</u> (under the effect of sympathetic NS).
- When there is low rate of firing impulses >> the smooth muscle will relax, and the vessel will become <u>vasodilated</u> (under the effect of parasympathetic NS).
- No Parasympathetic supply to blood vessels.



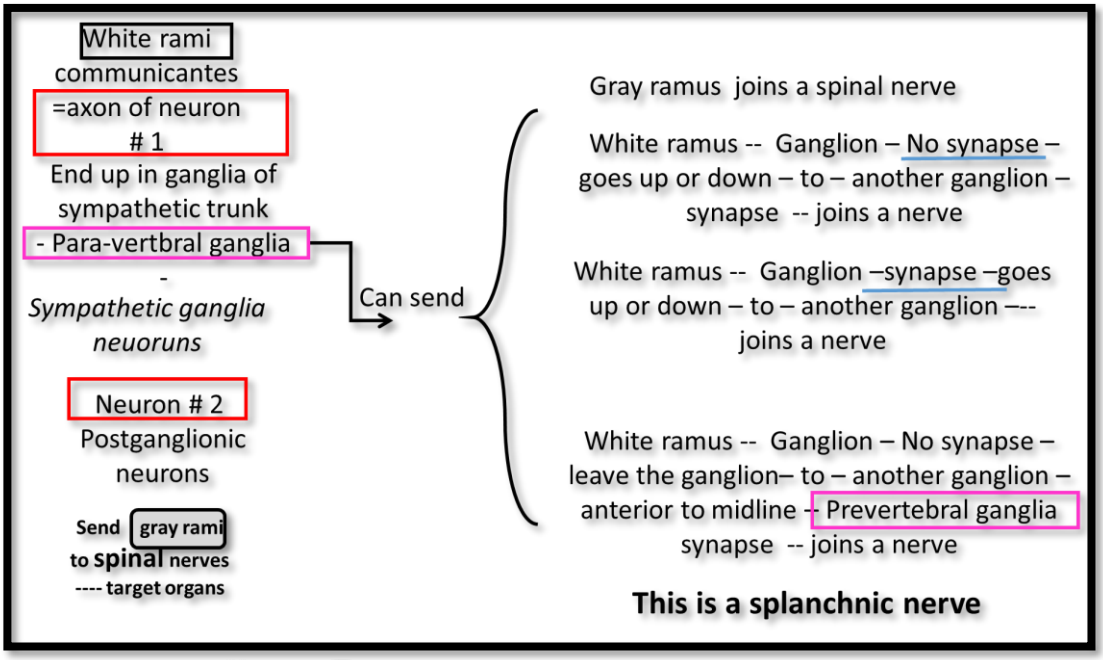
- the difference between sympathetic and parasympathetic:

✓ Sympathetic nerves target the blood vessels and adrenal glands (as final affected organs).

✓ parasympathetic don't target these organs.

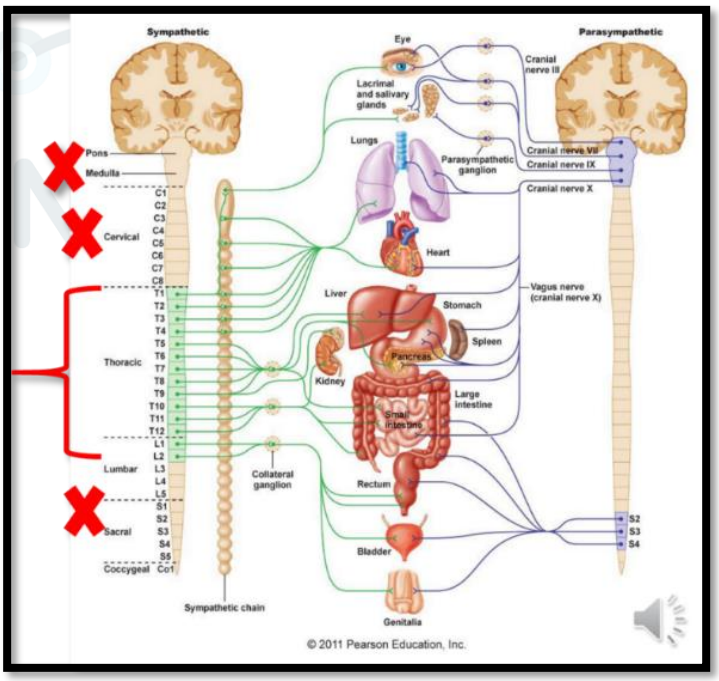


To sum up..



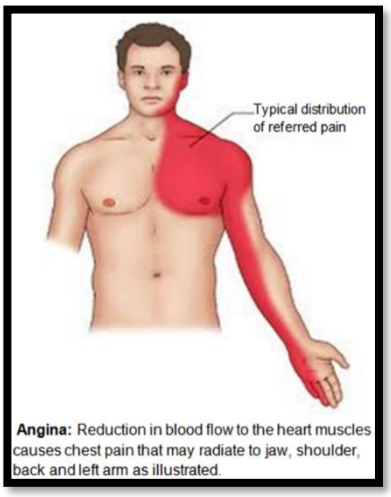
A bunch of questions:

- Do we have sympathetic ganglia in the cervical region? = yes
- Do we have sympathetic ganglia below L2? = yes
- How do they receive their white rami?
  - For the cervical ganglia, it receives from T1-T4.
  - For the lower lumbar ganglia (below L2), it receives from T12-L2.
  -
- Are all ganglia of sympathetic trunk receive white rami = yes
  - From T1 – L2 >> directly.
  - Other regions >> indirectly.



pain of the heart:

- This is the typical distribution of the referred pain of the heart when pain takes place in the heart, in some cases patient feel the pain coming from the red-shadowed area in the figure (afferent part of ANS).
- The ANS have an Afferent or sensory part and Efferent or motor part.



Angina: Reduction in blood flow to the heart muscles causes chest pain that may radiate to jaw, shoulder, back and left arm as illustrated.

The story of pain coming from the heart:

- when Angina (ischemic chest pain) or anoxia of myocardium takes place, the pain is going to be produced, then it's carried by the afferent sympathetic nerve then reach the dorsal root ganglion like somatic sensation.
- pain from skin have the same way through the dorsal root ganglion and they end up in the dorsal horn of the gray matter of the spinal cord.
- Why this heart pain feels like in the skin?
- Depends on the firing impulses:
  If the impulses coming from the heart are too frequent and strong they overflow to the neurons bringing the pain from the pectoral area so the pain will be felt in the skin and the original pain is coming from the heart.

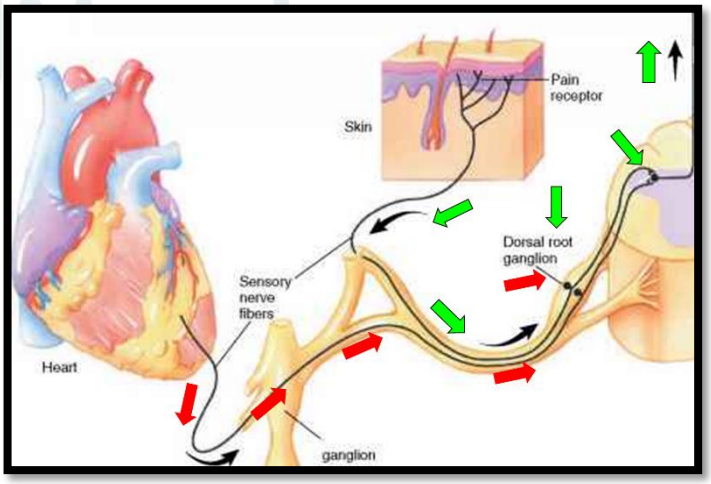
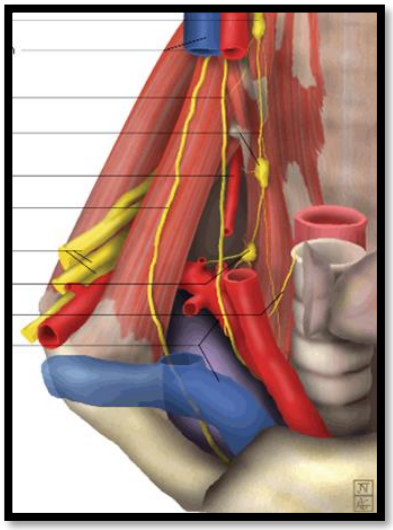


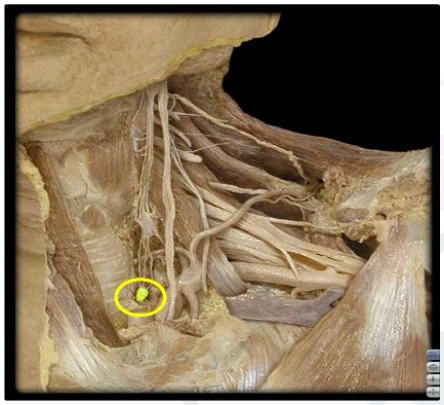
Photo gallery

- image of the 3 cervical sympathetic ganglia:

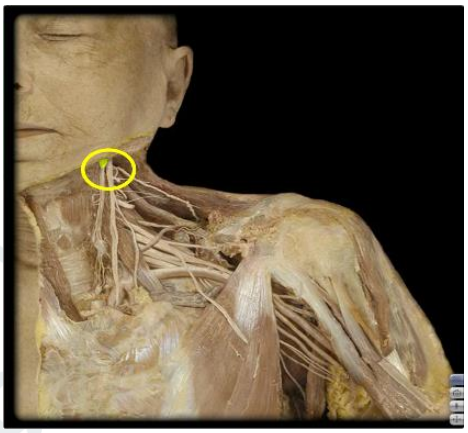
1) superior
2) middle
3) inferior

- they are posterior to the carotid sheath.

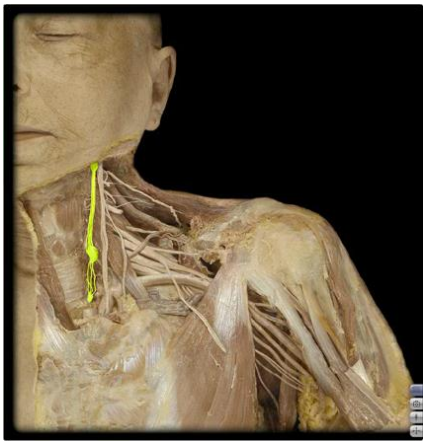




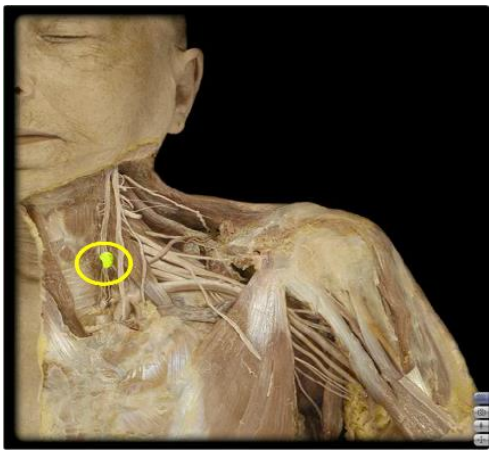
middle cervical ganglion



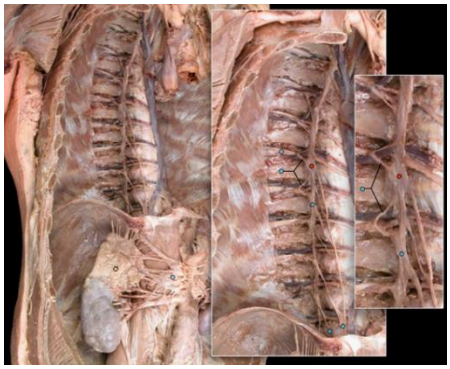
superior cervical ganglion at the upper end of the sympathetic trunk



The cervical part of the sympathetic trunk showing the 3 ganglia and the connection between them.



- Inferior cervical ganglion
- And also called stellate ganglion
- There is distance between these 3 ganglia much longer than the ones of the rest of the sympathetic trunk.



- sympathetic trunk in the thorax

- Here the lateral chest wall has been removed.
- We can see the yellow line is the thoracic part of the sympathetic trunk.

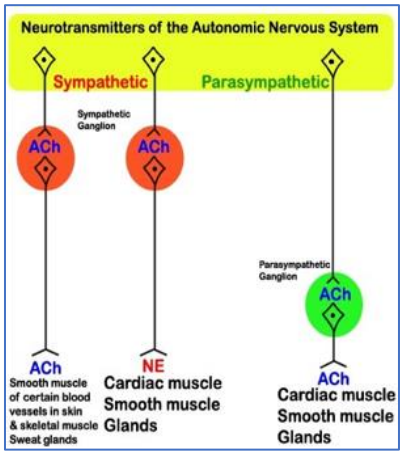
Now, it's the

Parasympathetic NS

- Autonomic nervous system has two parts, sympathetic (earlier lecture) and parasympathetic (this lecture) that exist in balance. (if one increases the other decreases according to the body's need and requirement).
- The parasympathetic system is known as rest and digest, its most dominant when you are relaxed and not using lots of energy (as in heavy exercise) → Heart rate is slow, pupils are constricted.

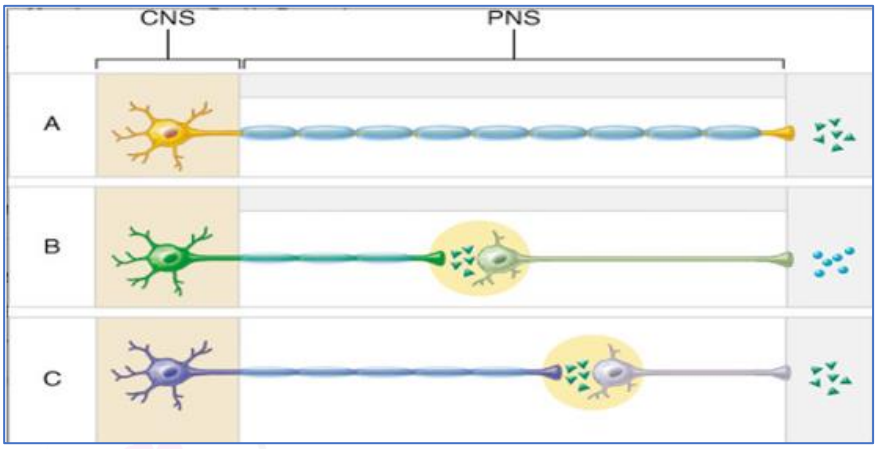
Ganglion comparison: (both are two neuron system/ chain: contain two neurons)

A. **Sympathetic:** short preganglionic and long postganglionic axons.
B. **Parasympathetic:** long preganglionic and short postganglionic axons.
    - Preganglionic neuron of parasympathetic is located in brainstem and (S2, S3, and S4).
    - Post ganglionic neuron of parasympathetic is located near the effector organ (sometimes inside it!).



Parts of the nervous system:

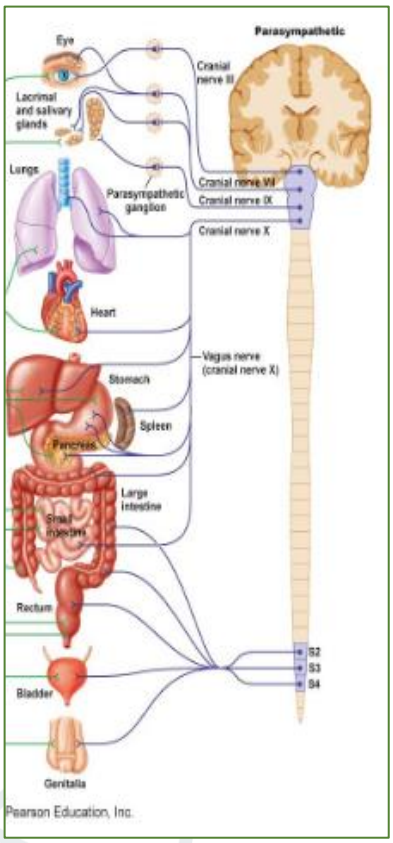
- Somatic: a single neuron directly from CNS to the organ.
- Sympathetic and parasympathetic: 2 neurons:
  preganglionic axon → ganglion → **postganglionic** axon → effector organ



Target organs of parasympathetic system and its effects on them:

- Pupils → constriction.
- Sphincters → relaxation.
- Heart → slower heart rate.
- Glands → secretions increase (watery secretions).
- Smooth muscles → (contraction and stimulation of GI smooth muscles, and bronchi's smooth muscles also contract leading to a worse asthma at night when the parasympathetic is more dominant).

Origin of preganglionic neurons of the parasympathetic system: Craniosacral



From the Brainstem: four nerves (Cranial outflow):

- *Oculomotor (III):*
  - Has a parasympathetic nucleus (**Edinger Westphal**) located in the midbrain of brain stem → the preganglionic neuron/axon travels to reach the ciliary ganglion in the orbit → the post ganglionic neuron/axon supplies the iris.
- *Facial (VII): (2 nuclei)*
  - Superior salivatory nucleus (motor) → Preganglionic travels to reach Submandibular ganglion → postganglionic that supply the sublingual salivary gland and submandibular salivary gland.
  - Lacrimatory nucleus → Preganglionic fibers to the pterygopalatine ganglion → Postganglionic fibers that supplies lacrimal gland and nasal gland.
- *Glossopharyngeal (IX):*
  - Inferior salivatory nucleus → Preganglionic fibers to the Otic (spell is correct) ganglion → Postganglionic to parotid gland.
- *Vagus (X): (most widely distributed cranial nerve):*
  - Dorsal nucleus of Vagus → supply multiple organs of thorax and abdomen and form plexuses such as:
    1- Renal plexus.
    2- Pulmonary plexus.
    3- cardiac plexus: parasympathetics to the heart characterized by having plexuses and are located around the arch of aorta:
       A. Superficial cardiac plexus.
       B. Deep cardiac plexus.

    4+5- Myenteric and mucosal plexuses in the intestine.

    6- hypogastric plexus for other abdominal organs.

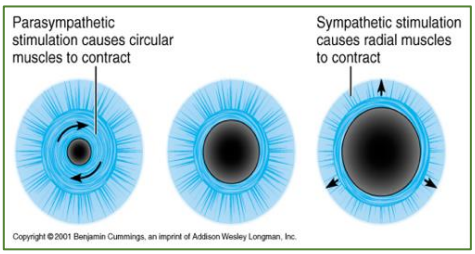
Sacral outflow (S2, S3, S4):

- preganglionic fibers go through spinal nerves → ganglion in the wall of the pelvic organs.

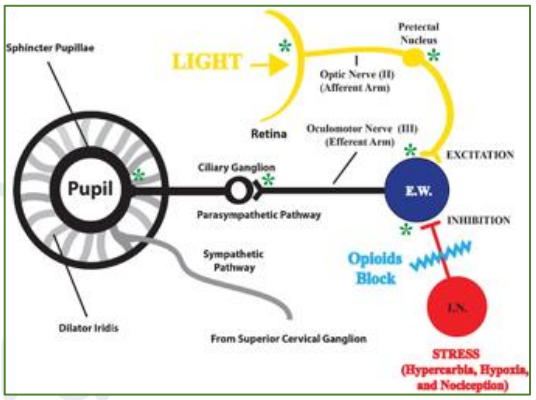
Visceral afferent: (sensory)

- Brings pain from internal organs such as heart, stomach, and intestine → send pain impulses through autonomic afferents → reaches spinal cord through spinal nerves → overflow of impulses from afferent parasympathetic (if very high firing rate it will come over to somatic tract) → ascending tract takes the impulses to the brain.

Effect on pupil:



- Light hits the retina → optic nerve pick up impulses send a branch that attach to the pretectal nucleus → sends a branch to Edinger Westphal (parasympathetic nucleus of oculomotor nerve)→ from it, extends the preganglionic neuron to the ciliary ganglion present in the orbit →postganglionic neuron → constriction of the pupil.



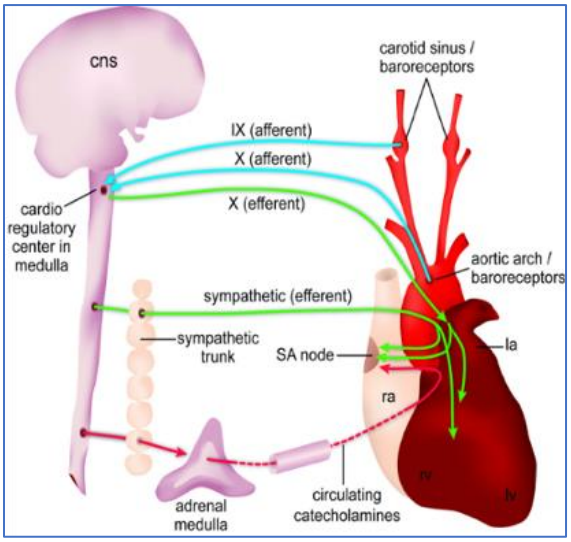
- There is a sympathetic part that joins this pathway, and it comes from the superior cervical ganglion.

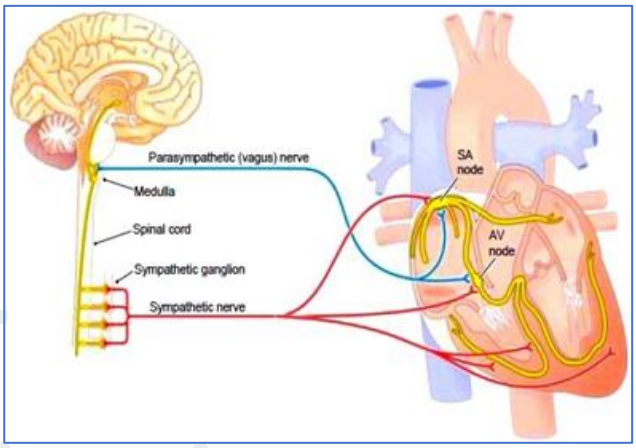
- Parasympathetic → circular muscles to contract → constriction of pupil.

- Sympathetic → Radial muscles to contract → dilation of pupil.

Heart and autonomic nervous system:

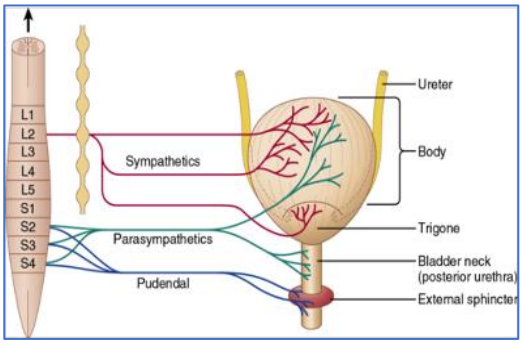
- Carotid sinus (has baroreceptors) come through the afferents of the glossopharyngeal nerve (sensation).
- 2 Parasympathetic plexuses controlling the heart: superficial cardiac plexus + deep cardiac plexus.
- Aortic arch baroreceptors come through the vagus afferent nerve (sensation) (sends pain from heart to vagus nucleus).
- Vagus send efferent motor fibers to the heart (SA and AV nodes).
- Sympathetic effect is on SA and AV nodes.
- Hormones of adrenal gland (stimulated by ANS) also affect the heart.





Urinary bladder and autonomic nervus system:

- Sympathetic part comes from L2 and supply muscular wall of urinary bladder and to supply to the base of urinary bladder where it has internal sphincter (trigone).
- Parasympathetic comes from S2, S3, and S4 → to supply muscular wall (increase excitability and increase contraction) and supply also the internal sphincter.
- Lastly: Pudendal nerve supply external urinary sphincter.



End of the lecture 😉

"DON'T YOU EVER LET SOMEBODY TELL YOU THAT YOU CAN'T DO SOMETHING"