Khalleedd✅

Lecture:

Autonomic Nervous System

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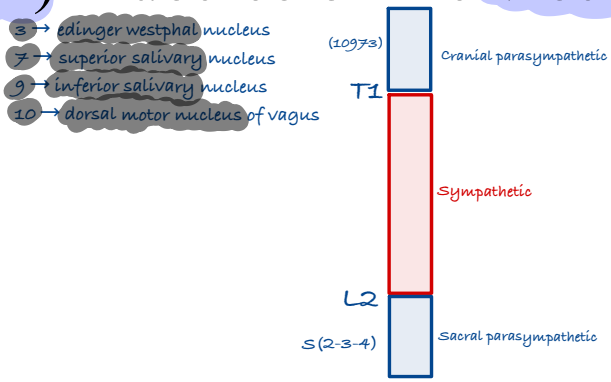
Anatomy of the Autonomic Nervous System
(Involuntary Nervous System or Visceral Nervous System)

- **Definition:** it is the involuntary nervous system which **supplies:**
  - ✓ Unstriated (smooth) muscles of the viscera and blood vessels.
  - ✓ Cardiac muscles.
  - ✓ Glands.



- **Structures of the Autonomic Nervous System:**

Called like this cause it dilate the pupil

✓ Sympathetic nervous system (Thoraco-lumbar) T1-L2 and some source L3

"Fight or Flight".

Called like this cause it constrict the pupil

✓ Parasympathetic nervous system (Cranio-sacral)

"Rest and Digest".

It called para because it dispersed around the sympathetic above and below

Parts of the Autonomic Nervous System

1. **Central part:** consists of autonomic nuclei in the brain stem, thalamus, hypothalamus, insula and intermediolateral nuclei of the spinal cord.

T1 to L2 → sympathetic
S2S3S4 → parasympathetic
Nuclei of cranial nerves

Located in the lateral horn of spinal cord at the level of T1 to L2 (somatic motor of chest muscles) لانه الجزء الأمامي محجوز بسبب وجود ال intrmediolateral nuclei إضافة بين الانتيريور واليوستيريور وسميناه ال horn فراحت عملت

While para sympethetic nervous system in sacral part located in anterior horn cells cause it empty and has no somatic motor of chest muscle

2. **Peripheral part:** consists of:
   - Peripheral Sympathetic nervous system (SNS).
   - Peripheral Parasympathetic nervous system (PSNS).

The Origin of the Autonomic Nervous System

1. **The origin of the sympathetic nervous system (Thoraco-lumbar nervous system):**

   Consists of fibers which arise from the 12 thoracic and upper 2 lumbar segments (Thoraco-lumbar part) and reach the sympathetic chain by **the white rami.**

   In lateral horn cells of spinal cord of this grea
   وحكينا قبل ليه ماخدة الجزء الجانبي

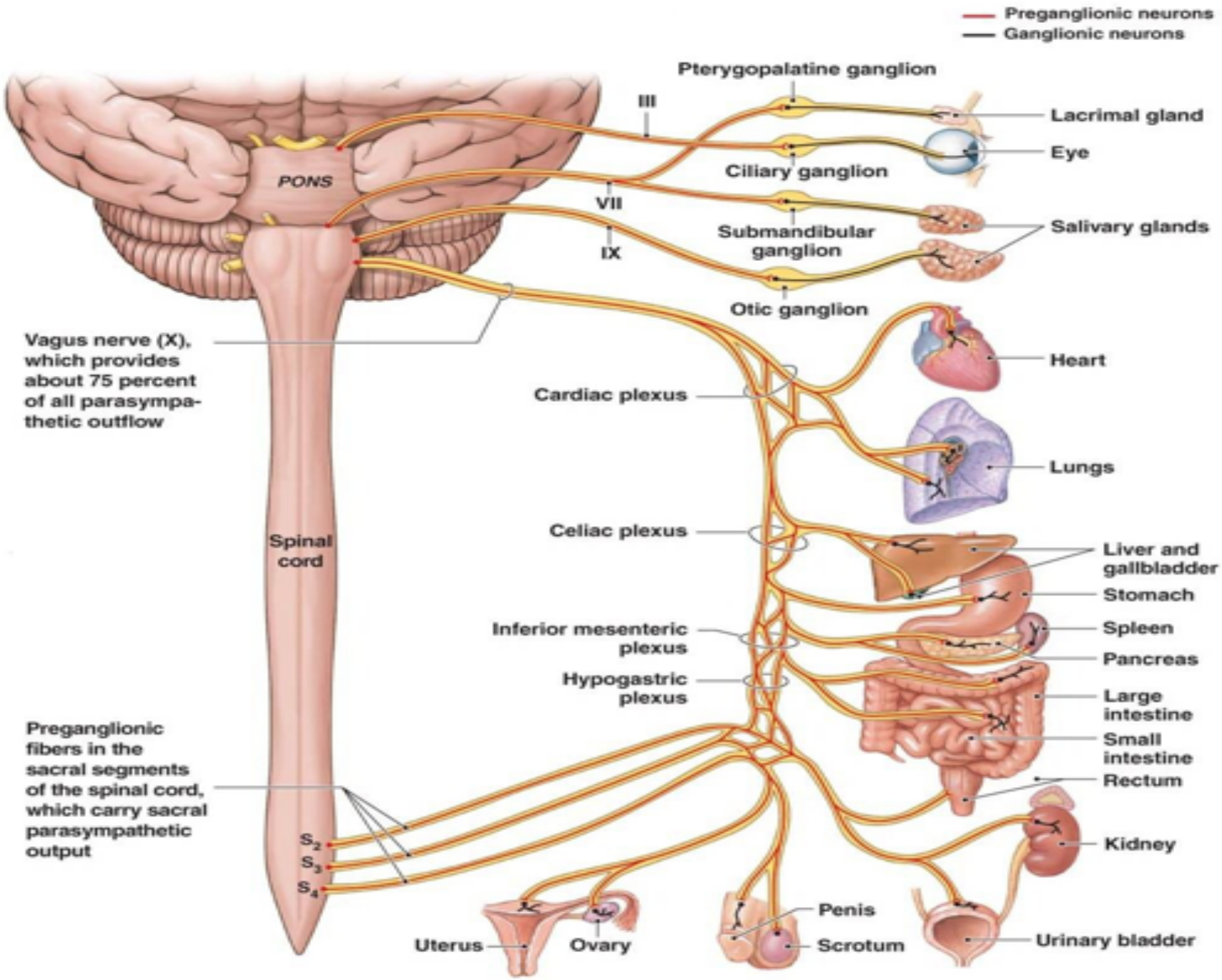
2. **The Origin of the parasympathetic nervous system (Cranio-spinal nervous system):**

   Sacral

   a. The cranial part: consists of fibers which pass in four cranial nerves (3, 7, 9 & 10 cranial nerves)=**10973.**

   Oculomotor Facial Glossopharyngeal Vagus

   b. The sacral part: consists of fibers which arise from **the S2, S3, and S4** segments of the spinal cord.


Preganglionic neurons
Ganglionic neurons
Pterygopalatine ganglion
III
Lacrimal gland
Eye
Ciliary ganglion
PONS
VII
Submandibular ganglion
Salivary glands
IX
Otic ganglion
Vagus nerve (X), which provides about 75 percent of all parasympathetic outflow
Heart
Cardiac plexus
Lungs
Celiac plexus
Spinal cord
Liver and gallbladder
Stomach
Inferior mesenteric plexus
Spleen
Pancreas
Hypogastric plexus
Large intestine
Small intestine
Preganglionic fibers in the sacral segments of the spinal cord, which carry sacral parasympathetic output
Rectum
Kidney
S_2
S_3
S_4
Penis
Uterus
Ovary
Scrotum
Urinary bladder

The Peripheral Autonomic Nervous System

- Most of the visceral structures are supplied by two systems (receive sympathetic and parasympathetic nerves).

Work as stimulator in heart
inhibitor in GIT

Work as stimulator to peristalsis and modulation and defecation reflexes in GIT
And inhibitory to heart

- **The SNS supplies:**

Like arrector pilli muscle
responsible for pulling hair upright

Cause vasoconstriction

1. Skin of the body (its arterioles, sweat glands).
2. Blood vessels of the limbs (its smooth muscles).

Of B.Vs

3. Deep viscera.

- **The PSNS supplies the deep viscera only.**
- Each of the two systems consists of two order neurons.

One in CNS and one in PNS

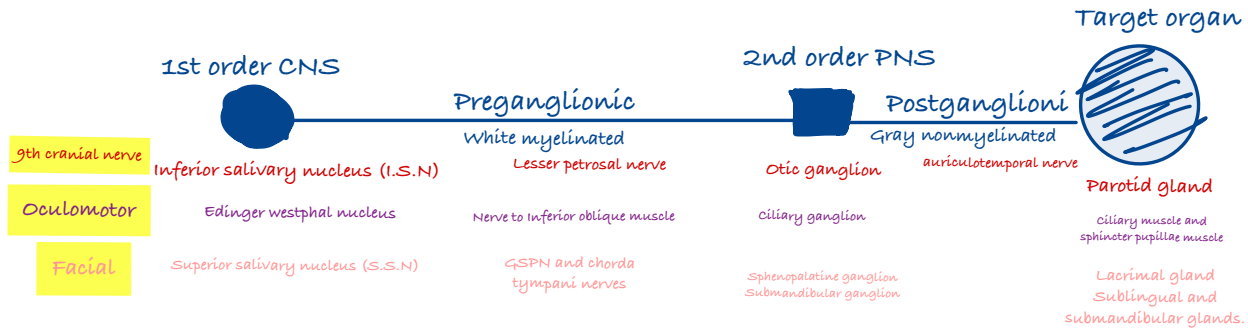
Each of the two systems consists of two order neurons.

One in CNS and one in PNS

ناخد مثال الدكتور ونطبق عليه الفكرة ،وانا حضيف اشياء عشان تربطوا الكلام

Dr example is glossopharangeal nerve

- The 2nd order might be either sympathetic or parasympathetic



A.T nerve is a branch of post division of mandibular nerve and give sensation to the parotid and complete to skin

وحناخدهم بالتفصيل دونت ووري كل وحدة وشو القيرست اوردروشو البري غانغليونك نيرف تاعها وشو السكند اوردروشو البوست غانغليونك نيرف تاعها والى اخرهاي القصة

The 1st order might be:

1. nuclei of parasympathetic cranial nerves
2. Intromediolateral nuclei of sympathetic from T1-L2 located in lateral horn cells
3. Para sympathetic nuclei located in anterior horn cells of S(2-3-4)

In PSNS the ganglia is terminal so close to the target organ and so the preganglionic is longe axon while the postganglionic is short axon

1. First Order Neurone

- **It is formed by:**
  1. The nerve cells of certain nuclei in the brain stem.
  2. Lateral horn cells (intermediolateral nuclei) of T1 -L2 and Anterior AHCs of S2-S4 of the spinal cord

وعارفين ليش الي عند ال T1-L2 ليش بيكون لاتيرال
والي من S2-S4 ليش بيكون من الانتيريور

- The axons of these cells carry stimuli to the autonomic ganglia **(called preganglionic fibers which are white or myelinated).** Between the 1st order neuron in CNS and the 2nd order neuron in PNS

2. Second Order Neurone

- It is formed by the nerve cells in **the sympathetic and parasympathetic ganglia.**
- The axons of these cells carry stimuli to the viscera **(called postganglionic fibers which are gray or non-myelinated).** Between the 2nd order and target organ

Types of Autonomic Ganglia

To differentiate between the PSNS and SNS we should know that in para the preganglionic fibers is long and post is short while in sympathetic the preganglionic is very short and the postganglionic is long

They are present outside the CNS and may be:

1. **Paravertebral ganglia (Sympathetic):** as sympathetic trunk (chain).

بتوقع انو الفايبرز تكون البوست غانغليا تكون طويلة عبال م توصل للتارجت اورجان وبرضو بتوقع انها تكون بعيدة عنه كتير

Close to spinal cord

2. **Collateral ganglia (Peripheral or Sympathetic):** as celiac, superior mesenteric and inferior mesenteric ganglia.

In abdominal cavity

3. **Terminal ganglia (Parasympathetic):** they are present on the walls of the viscera.

بتوقع انو الفايبرز تعون البوست غانغليا تكون قصيرة ف بالتالي حتكون الغانغليا قريبة من التارجت اورجان

Close to the target organ

Notice that:

1. The sympathetic preganglionic fibers are **short,** while the postganglionic fibers are **long.**

2. The parasympathetic preganglionic fibers are **long,** while the postganglionic fibers are **short.**

3. **The preganglionic fibers** are white or **myelinated.**

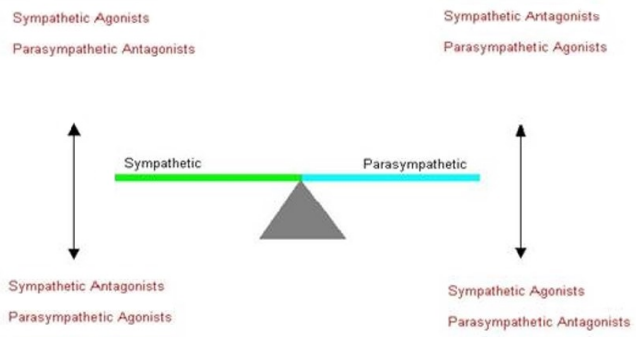
4. **The postganglionic fibers** are gray or **non-myelinated.**

How are the Visceral Structures Supplied by Autonomic (Motor) Fibers?

The autonomic supply to the visceral structures in two points:

Like the example about heart and GIT system

1. Most of the visceral structures have two nerve supply: **one sympathetic and one parasympathetic.** One of these nerves acts **"stimulator"** while the other acts **"inhibitor".**
2. **Each of sympathetic and parasympathetic NS is formed of two neurons:**
   a. The body of the first neuron is found in the CNS and its axon is called **a preganglionic fiber.** The body of the second neuron is found in the PNS and its axon is called **a postganglionic fiber.**



Transmitters of the Autonomic Nervous System

1. The preganglionic transmitter:

For sympathetic and parasympathetic preganglionic transmitter is **Acetylcholine.**

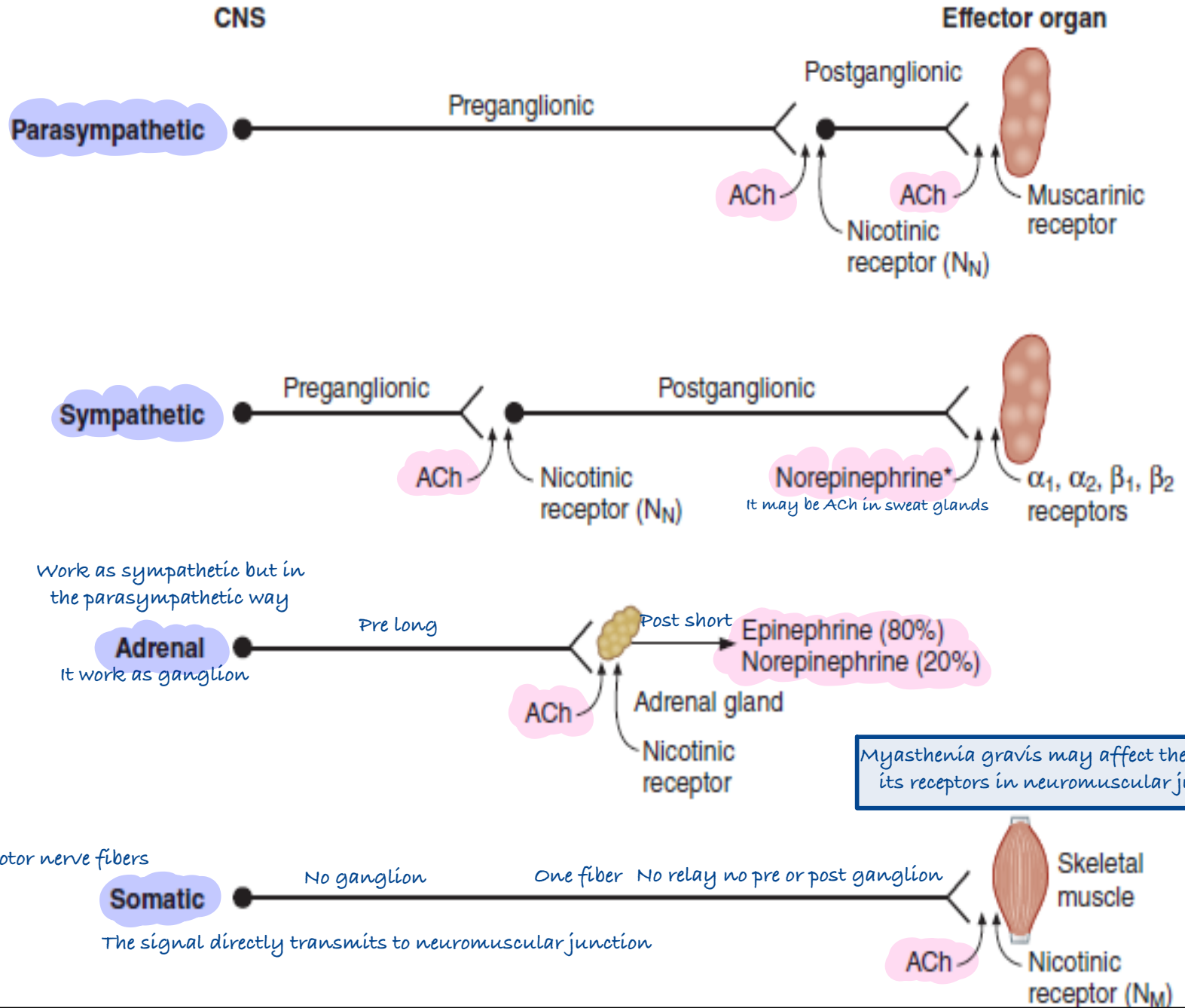
2. The postganglionic transmitter:

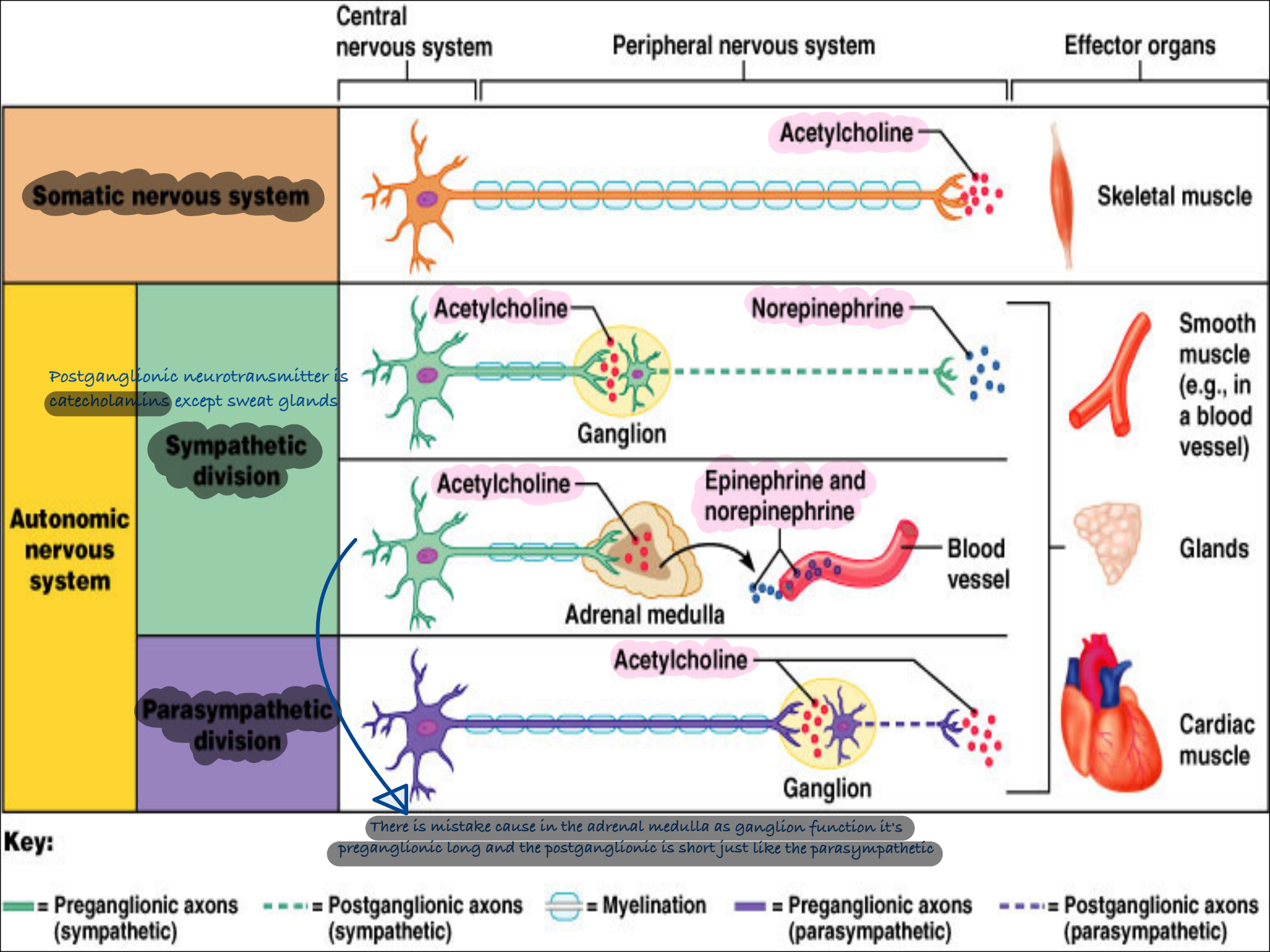
A. All postganglionic fibers of the parasympathetic are **Acetylcholine.**

B. The majority of sympathetic postganglionic fibers are **Epinephrine and/or Norepinephrine.** Catechalamins

C. The few which are known to be **Acetylcholine** (for the sweat glands). Exception

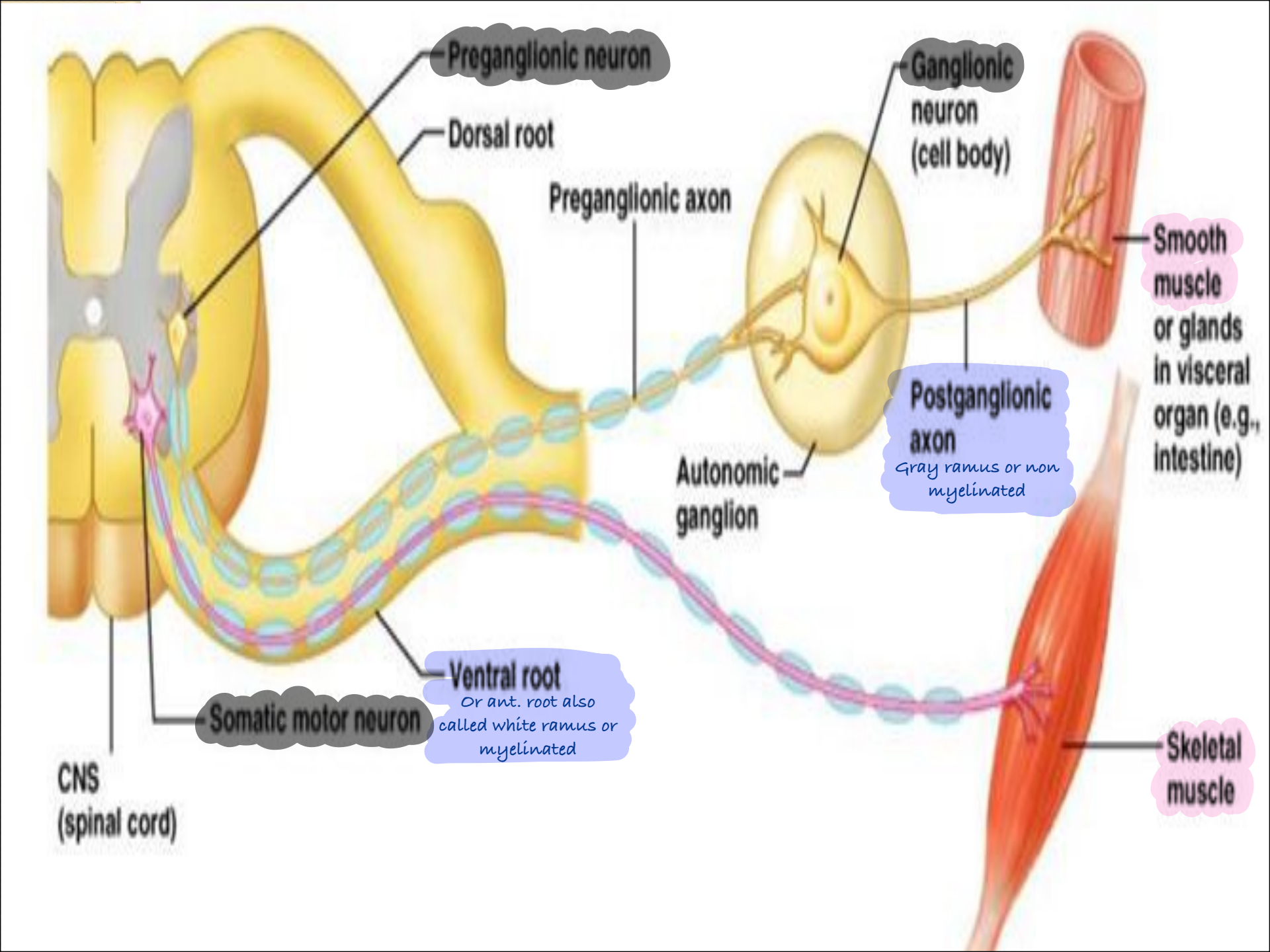
In Horner syndrome the sympathetic fibres is damaged and it cause anhidrosis and that a prove that the sweat gland is responsible for this function


CNS
Effector organ
Parasympathetic
Preganglionic
Postganglionic
ACh
Nicotinic receptor (N_N)
ACh
Muscarinic receptor
Sympathetic
Preganglionic
Postganglionic
ACh
Nicotinic receptor (N_N)
Norepinephrine*
It may be ACh in sweat glands
α_1, α_2, β_1, β_2 receptors
Work as sympathetic but in the parasympathetic way
Adrenal
It work as ganglion
Pre long
Post short
Epinephrine (80%)
Norepinephrine (20%)
ACh
Adrenal gland
Nicotinic receptor
Myasthenia gravis may affect the ACh and its receptors in neuromuscular junction
Called motor nerve fibers
Somatic
No ganglion
One fiber No relay no pre or post ganglion
Skeletal muscle
The signal directly transmits to neuromuscular junction
ACh
Nicotinic receptor (N_M)


Central nervous system
Peripheral nervous system
Effector organs
Somatic nervous system
Acetylcholine
Skeletal muscle
Autonomic nervous system
Sympathetic division
Acetylcholine
Norepinephrine
Ganglion
Smooth muscle (e.g., in a blood vessel)
Acetylcholine
Epinephrine and norepinephrine
Blood vessel
Adrenal medulla
Glands
Parasympathetic division
Acetylcholine
Ganglion
Cardiac muscle
Postganglionic neurotransmitter is catecholamins except sweat glands
There is mistake cause in the adrenal medulla as ganglion function it's preganglionic long and the postganglionic is short just like the parasympathetic
Key:
= Preganglionic axons (sympathetic)
= Postganglionic axons (sympathetic)
= Myelination
= Preganglionic axons (parasympathetic)
= Postganglionic axons (parasympathetic)

Comparison of Autonomic and Somatic Nervous System

Somatic	Autonomic
Conscious or voluntary regulation	Functions without conscious awareness (involuntary)
Fibers do not synapse after they leave the CNS (single neuron from CNS to effector organ). And work without relay in ganglia.	Fibers synapse once at a ganglion after they leave the CNS (two-neuron chain). Motor control.
Innervates skeletal muscle fibers, always stimulatory Its neurotransmitter is ACh	Innervates smooth muscle, cardiac muscle, and glands; either stimulates or inhibits


Preganglionic neuron
Dorsal root
Preganglionic axon
Ganglionic neuron (cell body)
Smooth muscle or glands in visceral organ (e.g., intestine)
Postganglionic axon
Gray ramus or non myelinated
Autonomic ganglion
Ventral root
Or ant. root also called white ramus or myelinated
Somatic motor neuron
CNS (spinal cord)
Skeletal muscle

Comparison of Autonomic and Somatic Motor Systems

Done ✅

Cell bodies in central nervous system	Peripheral nervous system	Neurotransmitter at effector	Effector organs	Effect
SOMATIC NERVOUS SYSTEM	Single neuron from CNS to effector organs; Heavily myelinated axon	ACh	Skeletal muscle	+ Stimulatory
AUTONOMIC NERVOUS SYSTEM — SYMPATHETIC	Two-neuron chain from CNS to effector organs; Lightly myelinated preganglionic axons; ACh; Ganglion; Unmyelinated postganglionic axon; Epinephrine and norepinephrine; Adrenal medulla; Blood vessel	NE	Smooth muscle (e.g., in gut), glands, cardiac muscle	+ – Stimulatory or inhibitory, depending on neuro-transmitter and receptors on effector organs
AUTONOMIC NERVOUS SYSTEM — PARASYMPATHETIC	Lightly myelinated preganglionic axon; ACh; Ganglion; Unmyelinated postganglionic axon	ACh		

Organization of the Autonomic Nervous System

Characteristic	Sympathetic	Parasympathetic	Somatic*
Origin of preganglionic nerve	Nuclei of spinal cord segments T1–T12; L1–L3 (thoracolumbar)	Nuclei of cranial nerves III, VII, IX, and X; spinal cord segments S2–S4 (craniosacral)	
Length of preganglionic nerve axon	Short	Long	
Neurotransmitter in ganglion	ACh	ACh	
Receptor type in ganglion	Nicotinic	Nicotinic	
Length of postganglionic nerve axon	Long	Short	
Effector organs	Smooth and cardiac muscle; glands	Smooth and cardiac muscle; glands	Skeletal muscle
Neurotransmitter in effector organs	Norepinephrine (except sweat glands, which use ACh)	ACh	ACh (synapse is neuromuscular junction)
Receptor types in effector organs	α_1, α_2, β_1, and β_2	Muscarinic	Nicotinic

Done ✅

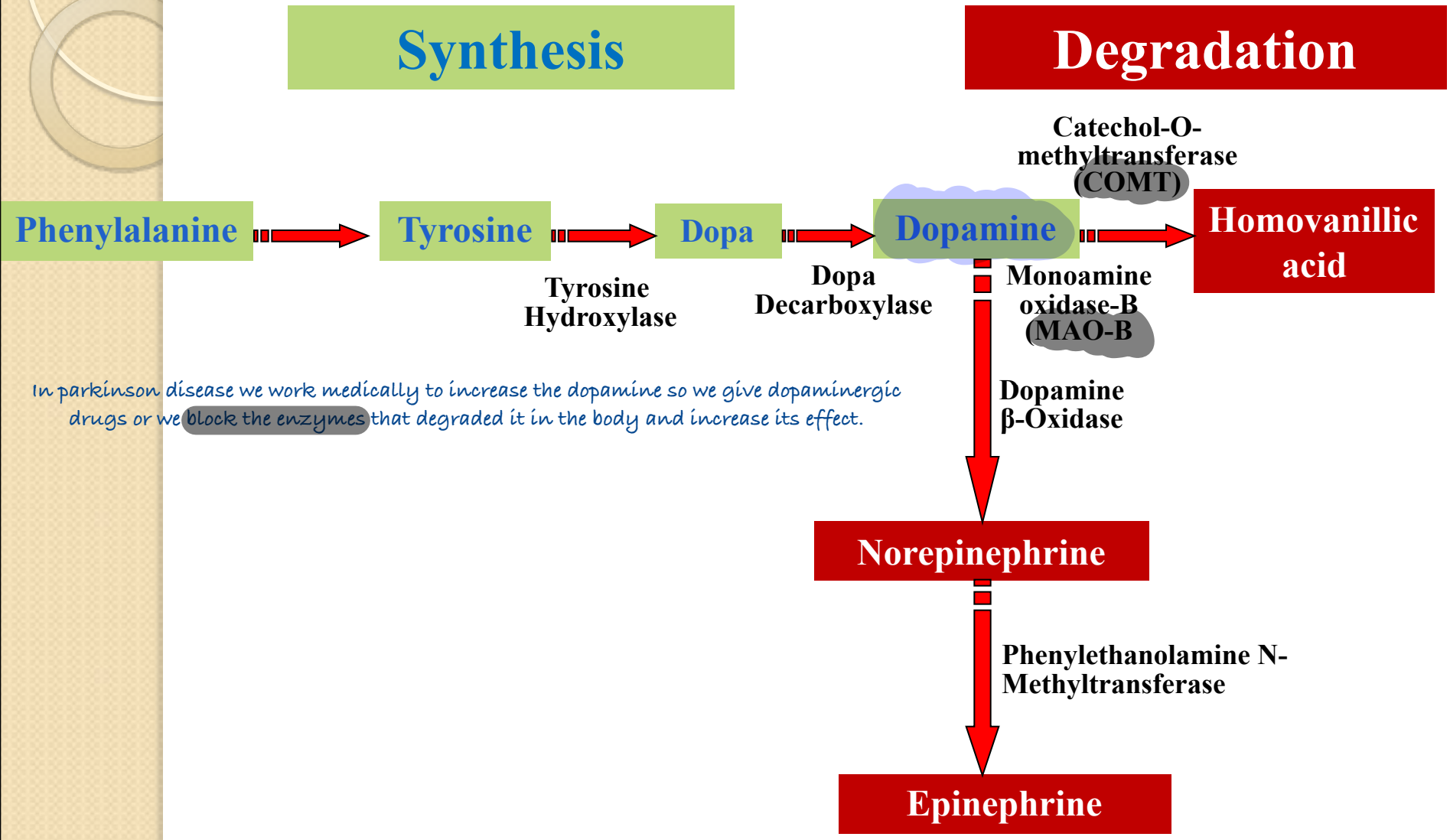
Neurotransmission at adrenergic Neurons

- **The process involves five steps:**

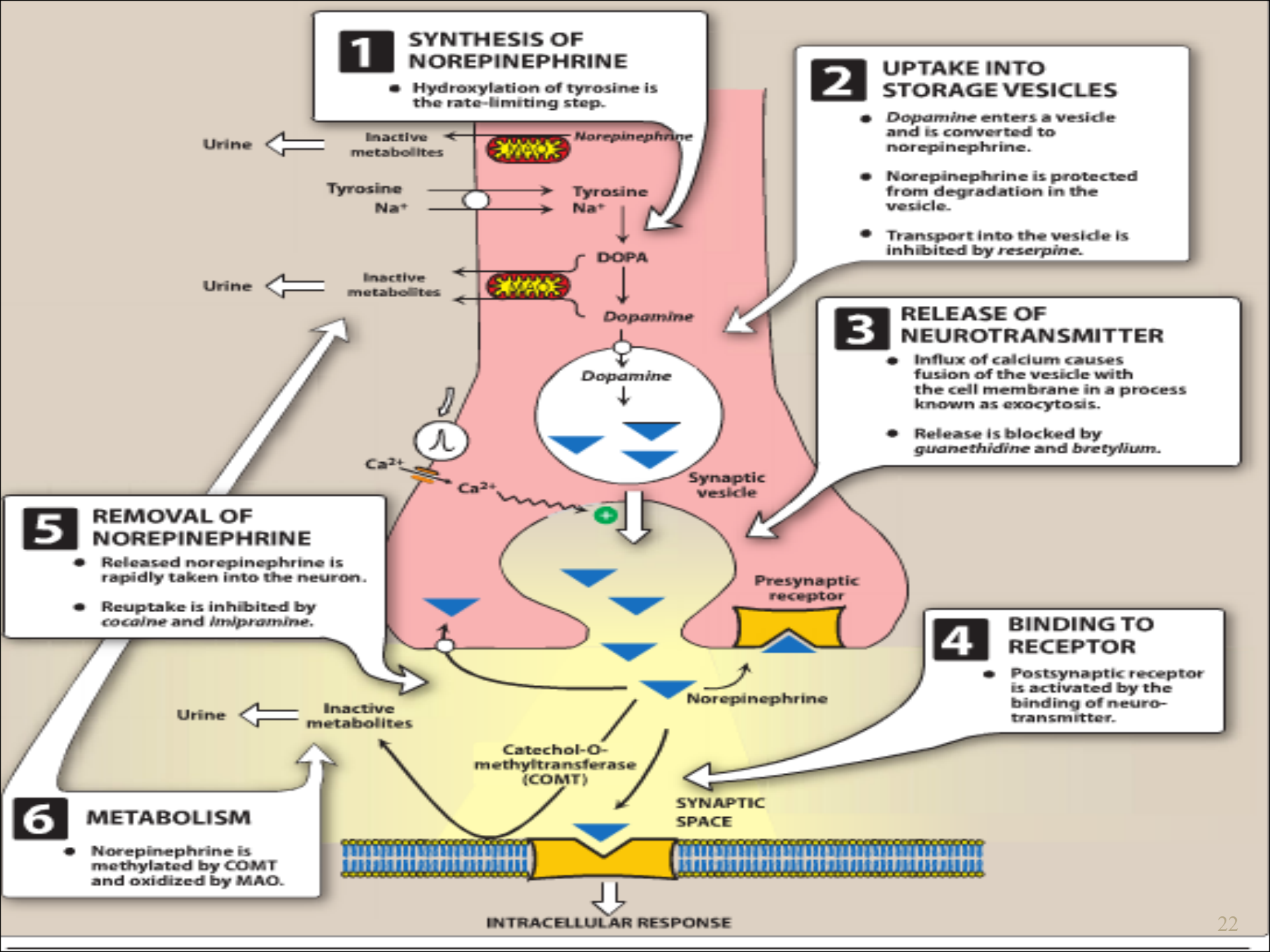
1. Synthesis.
2. Storage.
3. Release.
4. Receptor binding.
5. Removal of the neurotransmitter .

The BBB protect these transmitters from escape out of the CNS

Pathway of Dopamine Metabolism



In parkinson disease we work medically to increase the dopamine so we give dopaminergic drugs or we block the enzymes that degraded it in the body and increase its effect.


1 SYNTHESIS OF NOREPINEPHRINE
Hydroxylation of tyrosine is the rate-limiting step.
2 UPTAKE INTO STORAGE VESICLES
Dopamine enters a vesicle and is converted to norepinephrine.
Norepinephrine is protected from degradation in the vesicle.
Transport into the vesicle is inhibited by reserpine.
3 RELEASE OF NEUROTRANSMITTER
Influx of calcium causes fusion of the vesicle with the cell membrane in a process known as exocytosis.
Release is blocked by guanethidine and bretylium.
4 BINDING TO RECEPTOR
Postsynaptic receptor is activated by the binding of neuro-transmitter.
5 REMOVAL OF NOREPINEPHRINE
Released norepinephrine is rapidly taken into the neuron.
Reuptake is inhibited by cocaine and imipramine.
6 METABOLISM
Norepinephrine is methylated by COMT and oxidized by MAO.
Urine
Inactive metabolites
MAO
Norepinephrine
Tyrosine
Na+
DOPA
Dopamine
Ca2+
Synaptic vesicle
Presynaptic receptor
Catechol-O-methyltransferase (COMT)
SYNAPTIC SPACE
INTRACELLULAR RESPONSE

Catecholamines

- Catecholamines are sympathomimetic amines that contain the 3,4-dihydroxybenzene group such as:

Produced by adrenal gland increase b.p so if Pheochromocytoma a tumor in adrenal medulla it will remarkably increase the catecholamines so it will cause vaso constriction and cause high blood pressure

1. Epinephrine.
2. Norepinephrine.
3. Isoproterenol.
4. Dopamine. The precursor

Receptor Types in the ANS

1. Adrenergic receptors (adrenoreceptors): Related to sympathetic

a. Alpha Receptors: are subdivided into two types:

- **Alpha "α_1" Receptors:** are located on vascular smooth muscle of the skin, the gastrointestinal sphincters, bladder sphincters, and the radial "dilator" muscle of the iris.
  - ✓ **Effect:** produce **excitation** (e.g., contraction or constriction).
- **Alpha "α_2" Receptors:** are located on walls of GIT , and wall of bladder.
  - ✓ **Effect:** often produce inhibition effect or relaxation.

Sympathetic decrease the peristalsis of GIT and cause relaxation of urinary bladder and prevent both micturation and defecation

Alpha 1 receptors

Vasoconstriction

Mydriasis

Dilated pupil

Increased closure of internal sphincter of the bladder

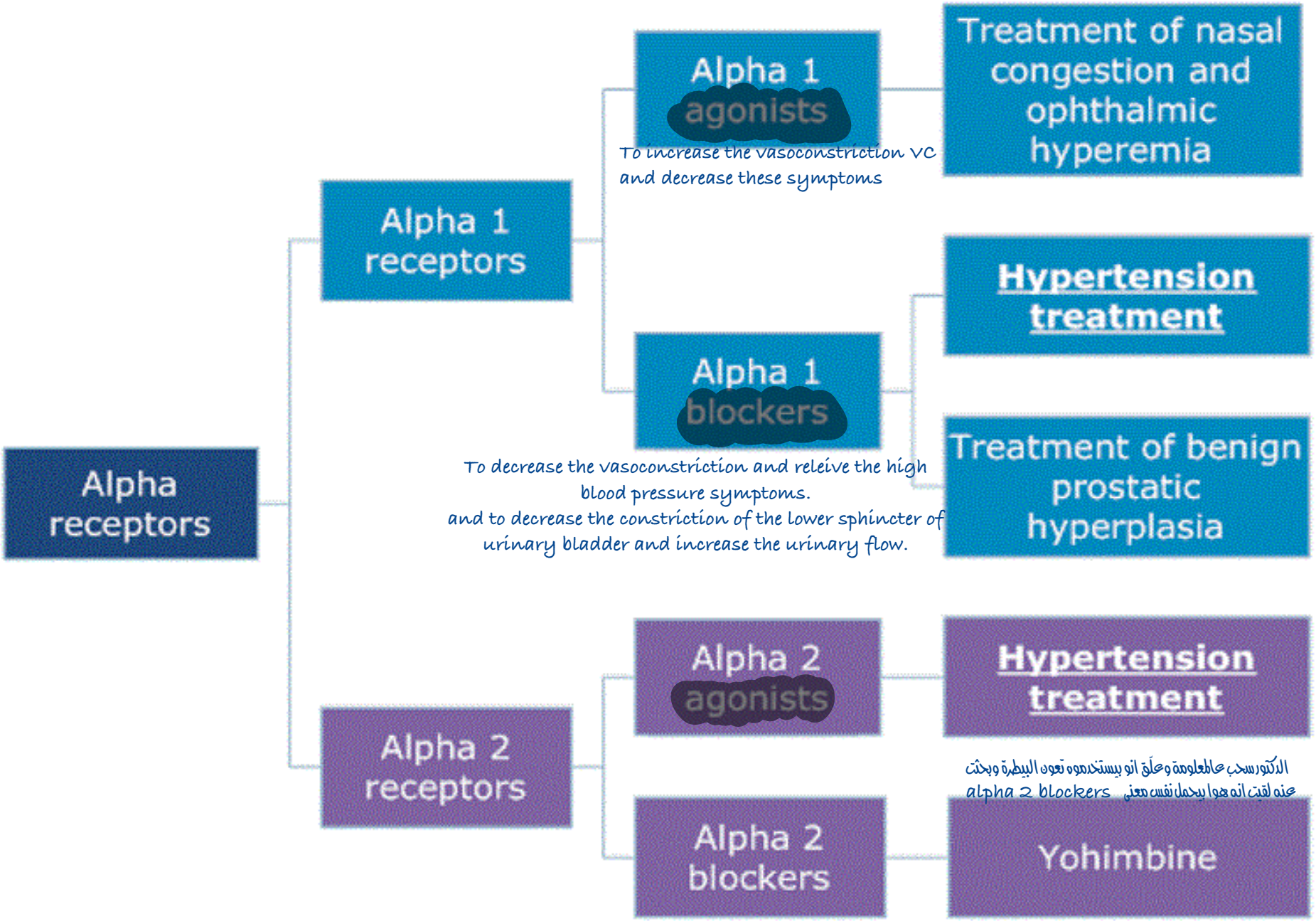
Increased peripheral resistance

Increased blood pressure

So if we gonna give drugs to HTN and decrease blood pressure we should block (antagonist) the alpha 1 receptor

And in renal (urinary bladder) we if we need to increase the urinary flow and decrease the incontenence we should block alpha 1 receptor

Drugs Affecting Alpha Receptors



b. Beta Receptors: are subdivided into three types:

- **Beta "b_1" Receptors:** are located in the sinoatrial (SA) node, atrioventricular (AV) node, and ventricular muscle of the heart.
  - ✓ **Effect:** produce **excitation** (e.g., increased heart rate, increased conduction velocity, increased contractility).

If we wanna treat symptoms of heart failure and weakness of the muscle of the heart we will give beta 1 agonists drugs Chronotropic and inotropic

- **Beta b_2 Receptors:** are located on vascular smooth muscle of skeletal muscle, bronchial smooth muscle, and in the walls of the GIT and bladder.

So if we wanna relief symptoms of respiratory problems like asthma or COPD we will give beta 2 agonists drugs.

  - ✓ **Effect:** produce **relaxation** (e.g., dilation of vascular smooth muscle, dilation of bronchioles, relaxation of the bladder wall).
- **Beta b_3 Receptors:** are located in the fat cells.
  - ✓ **Effect:** Play important role with b1 receptors in lipolysis.

β–1 receptors

Heart

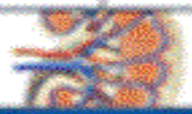
Tachycardia

Increased the heartbeat

Increased chronotropy and inotropy

Increased the contractility

Increased AV-node conduction velocity



Renal juxtaglomerular cells

RAAS system

Increased renin release

So it will cause HTN

β–2 receptors

Bronchial smooth muscle

Beta 2 agonists

Is we give sympathomemitic we will treat symptoms of asthma

Bronchodilation

Uterine muscle

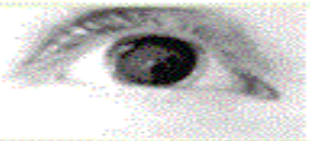
In women presenting preterm contractions that may cause preterm delivery of the fetus they use medications to relax the uterus like beta 2 agonists

Uterine relaxation (tocolysis)

β–2 receptors

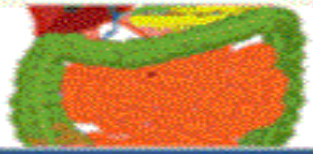
Bladder detrusor muscle

Relaxation



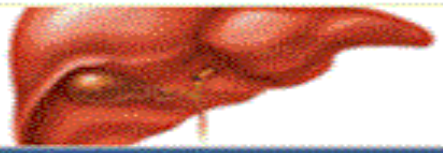
Eye ciliar muscle

Relaxation



GI tract

Decreased motility



Liver

Increased glucose metabolism, lipolysis

Mainly work in beta 3

Smooth muscle

Vascular smooth muscle

Relaxation

2. Cholinergic Receptors (cholinoreceptors)

Related to parasympathetic

preganglionic sympathetic or parasympathetic

a. **Nicotinic receptors:** are located in the **autonomic ganglia** (NN) of the sympathetic and parasympathetic nervous systems, at the **neuromuscular junction** (NM).

- ✓ **Effect:** produce usually **excitation** postsynaptic potential.

Parasympathetic only

b. **Muscarinic receptors:** are located in the **heart** (M2), **smooth muscle** (M3), and **glands** (M3).

- ✓ Are **inhibitory** **in the heart** (e.g., decreased heart rate, decreased conduction velocity in AV node).
- ✓ Are **excitatory** **in smooth muscle** and **glands** (e.g., increased GI motility, increased secretion).

The enzyme that responsible for degradation of ACh is cholenstrase
So if we block the enzyme we are using cholinergic drugs that provide its function

- ✓ Are activated by **ACh and muscarine.**

Anticholinergic

- ✓ Are blocked by **atropine.**

Pyridostigmine block the cholenstrase enzyme

أول اشي ال NM junction، على سيرة انه المرض بيأثر على السكيليتال مسلز وبس كيف بدنا نميز اذا كانت المشكلة بالنيرف نفسه ولا بال pupil is intact والدليل التاني انه سأل أهلها smooth muscle وهاي ما بتتأثر بالمرض هادة منطقي لانه هادة ف هي دليل، nerve problem لانها ما بتتغير خلال اليوم وبتضلها ع نفس حالها كيف وضعها خلال اليوم حكو انه بيتغير بالمسا وهاد دليل انو مش

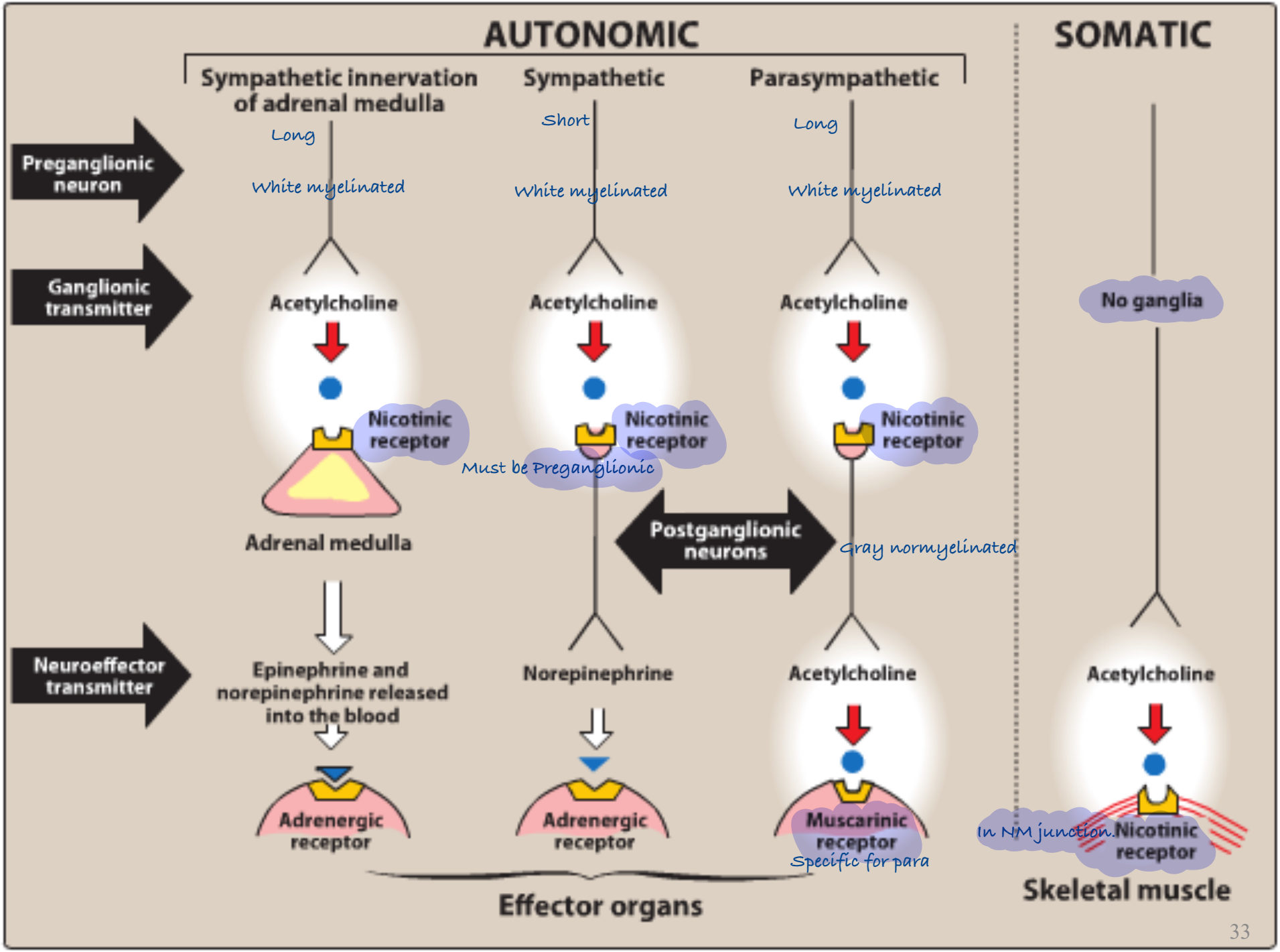
In cases of myasthenia graves (adisease affect the skeletal muscle only the problem is in neuromuscular junction) decrease the transmission of the signal from nerve endings to muscle fibers.
We give pyridostigmine a member of cholinergic drugs

Its ganglionic fibers looks like the PSNS
Pre long + Post short

Adrenal Medulla

Follow the SNS

- Is a specialized ganglion of the sympathetic nervous system.
- Preganglionic fibers synapse directly on **chromaffin cells** in the adrenal medulla.
- The chromaffin cells secrete **Epinephrine (80%)** and **norepinephrine (20%)** into the circulation.
- Tumor of chromaffin cells
  Pheochromocytoma: is a tumor of the adrenal medulla that secretes excessive amounts of catecholamines.


AUTONOMIC
SOMATIC
Sympathetic innervation of adrenal medulla
Sympathetic
Parasympathetic
Preganglionic neuron
Long
Short
Long
White myelinated
White myelinated
White myelinated
Ganglionic transmitter
Acetylcholine
Acetylcholine
Acetylcholine
No ganglia
Nicotinic receptor
Nicotinic receptor
Nicotinic receptor
Must be Preganglionic
Adrenal medulla
Postganglionic neurons
Gray normyelinated
Neuroeffector transmitter
Epinephrine and norepinephrine released into the blood
Norepinephrine
Acetylcholine
Acetylcholine
Adrenergic receptor
Adrenergic receptor
Muscarinic receptor
Specific for para
In NM junction
Nicotinic receptor
Effector organs
Skeletal muscle

Autonomic Centers in the Brain Stem & Hypothalamus

1. Medulla oblongata:

- Vasomotor center.
- Respiratory center.
- Swallowing, coughing, and vomiting centers.

3. Midbrain:

- Micturition center.

4. Hypothalamus:

- Temperature regulation center.
- Thirst and hunger regulatory centers.

Effect of the Autonomic Nervous System on Organ Systems

Done ✅

Organ	Sympathetic Action	Sympathetic Receptor	Parasympathetic Action	Parasympathetic Receptor
Heart	↑ heart rate ↑ contractility ↑ AV node conduction	β_1 β_1 β_1	↓ heart rate ↓ contractility (atria) ↓ AV node conduction	M_2 M_2 M_2
Vascular smooth muscle	Constricts blood vessels in skin; splanchnic Dilates blood vessels in skeletal muscle	α_1 β_2	— —	
Gastrointestinal tract	↓ motility Constricts sphincters	α_2, β_2 α_1	↑ motility Relaxes sphincters	M_3 M_3
Bronchioles	Dilates bronchiolar smooth muscle	β_2	Constricts bronchiolar smooth muscle	M_3
Male sex organs	Ejaculation	α	Erection	M
Bladder	Relaxes bladder wall Constricts sphincter	β_2 α_1	Contracts bladder wall Relaxes sphincter	M_3 M_3
Sweat glands	↑ sweating	M (sympathetic cholinergic)	—	
Eye Radial muscle, iris Circular sphincter muscle, iris Ciliary muscle	 Dilates pupil (mydriasis) — Dilates (far vision)	 α_1 β	 — Constricts pupil (miosis) Contracts (near vision)	 M M
Kidney	↑ renin secretion	β_1	—	
Fat cells	↑ lipolysis	β_1	—	

α_1	Reflect the "flight or fight" RX. • Vasoconstriction of blood vessels (control of B.P.). • Inhibit motility in the gut by contracting sphincter muscles and relaxing non – sphincter tissue. • Mobilize energy by breaking down liver glycogen to glucose.
α_2	• Found in presynaptic membranes. • Provide feedback control of neurotransmitter secretion (inhibit Ca++ influx, decrease neurotransmitter release)(autoreceptor negative feedback).
β_1	• Well known for their effects in the heart • increase heart rate and force of contraction • Induce muscle relaxation in the gut.
β_2	• Induce bronchodilation. • Induce smooth muscle relaxation in the gut. • Induce conversion of glycogen to glucose. • Stimulate secretion of insulin from pancreas.
M	• Decrease heart activity. (M2) • Increase motility in G.I. tract. (M1, M3) • Depolarization of smooth muscle fibers, (M3) • Hyperpolarization of cardiac muscle fibers. (M2)

Drugs Affecting Adrenergic and Cholinergic System

Taking in the account the receptor effect

Alpha 1 excitatory
Alpha 2 inhibitory
Beta 1 excitatory to heart
Beta 2 bronchodilation
Beta 3 lipolysis

1. **Sympathomimetics Drugs:** (Agonists) stimulation of adrenergic receptor.
2. **Sympatholytic Drugs:** (Antagonists) block the action of the neurotransmitters at the adrenergic receptors.
3. **Cholinergic "Anticholinesterase" Drugs:** (They degrade the enzyme that degrade the ACh) stimulation the cholinergic receptors.
4. **Anticholinergic Drugs:** block cholinergic receptors. (Atropine)

The Parasympathetic Ganglia in the Head and Neck

There are four parasympathetic ganglia in the head and neck:

①+②+③ contain sympathetic, parasympathetic and sensory fibers
④ contain sympathetic, parasympathetic and motor fibers

1. Ciliary ganglion. Follow the oculomotor nerve
2. Submandibular ganglion. Follow the facial nerve by chorda tympani nerve
3. Sphenopalatine (pterygopalatine) ganglion.
   Follow the facial nerve by GSPN → greater superficial petrosal nerve
4. Otic ganglion. Follow the glossopharyngeal nerve

While vagus has many ganglia in respiratory system, heart and abdomen.

These ganglions are parasympathetic and the only fibers that relay is the para while the other sympathetic or motor or sensory just pass from it to reach the affected organ.

1st order neuron is Edenger westphal nucleus

Ciliary Ganglion

- **Type:** it is a small parasympathetic ganglion (1-2 mm in diameter).
- **Site:** in the posterior part of the orbit.
- **Roots Entering the Ciliary Ganglion:**
  1. **Sensory root:** branch from nasociliary nerve (branch of ophthalmic nerve).
     1st branch of trigeminal nerve
  2. **Sympathetic root:** from the sympathetic plexus around the ICA.
  3. **Parasympathetic root:** from nerve to inferior oblique muscle (branch of oculomotor nerve).

Edenger westphal nucleus give oculomotor nerve then inf. division nerve to inf. Oblique muscle

Branches of the Ciliary Ganglion

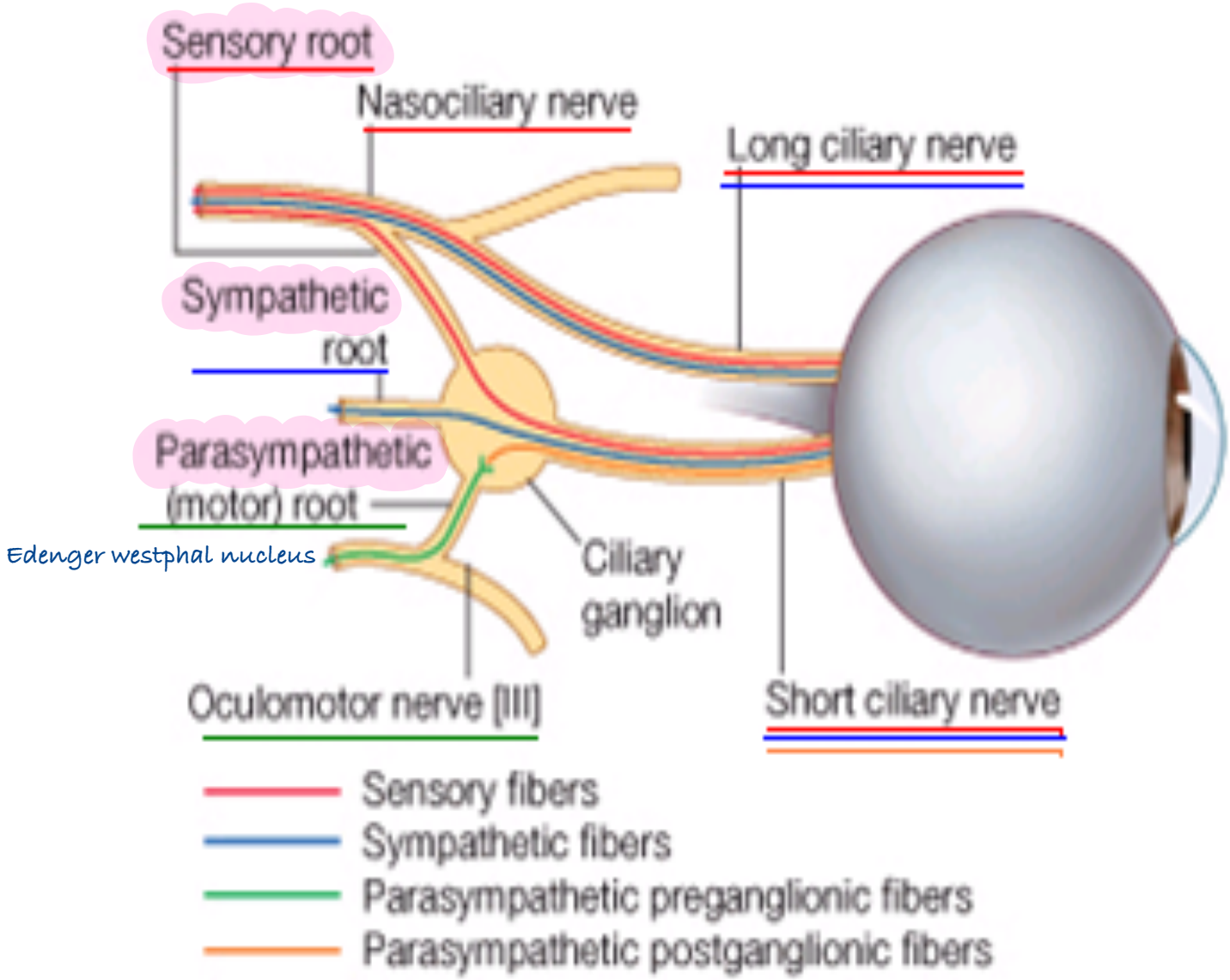
The ciliary ganglion has **8-10 short ciliary nerves** which pierce the sclera around optic nerve.

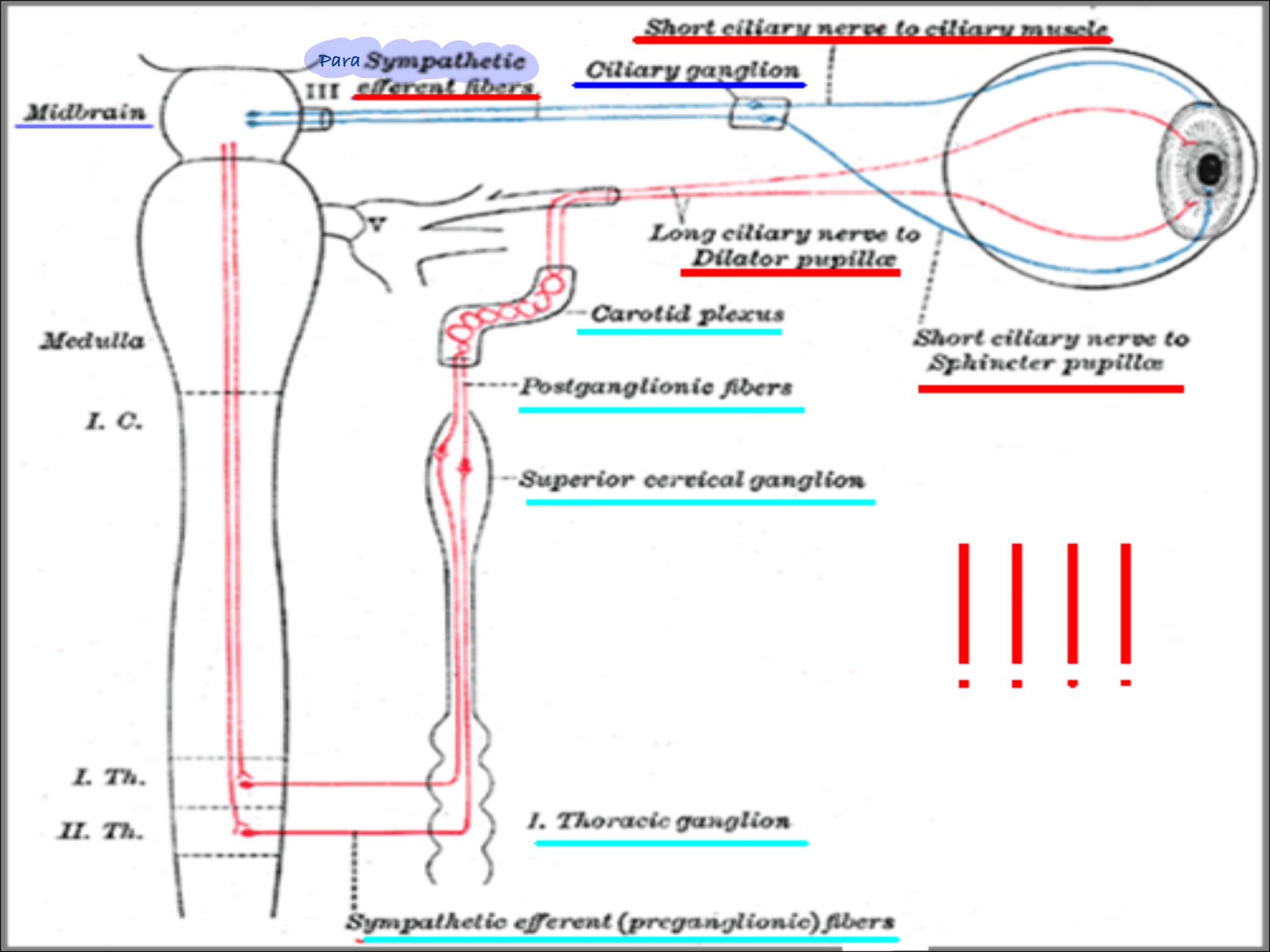
They contain:

1. **Sympathetic fibers:** to the blood vessels of the eye.
2. **Sensory fibers:** to the cornea and iris.
3. **Parasympathetic fibers:** to the supply the sphincter pupillae (for light reflex) and ciliary muscle (for accommodation).

Direct and indirect

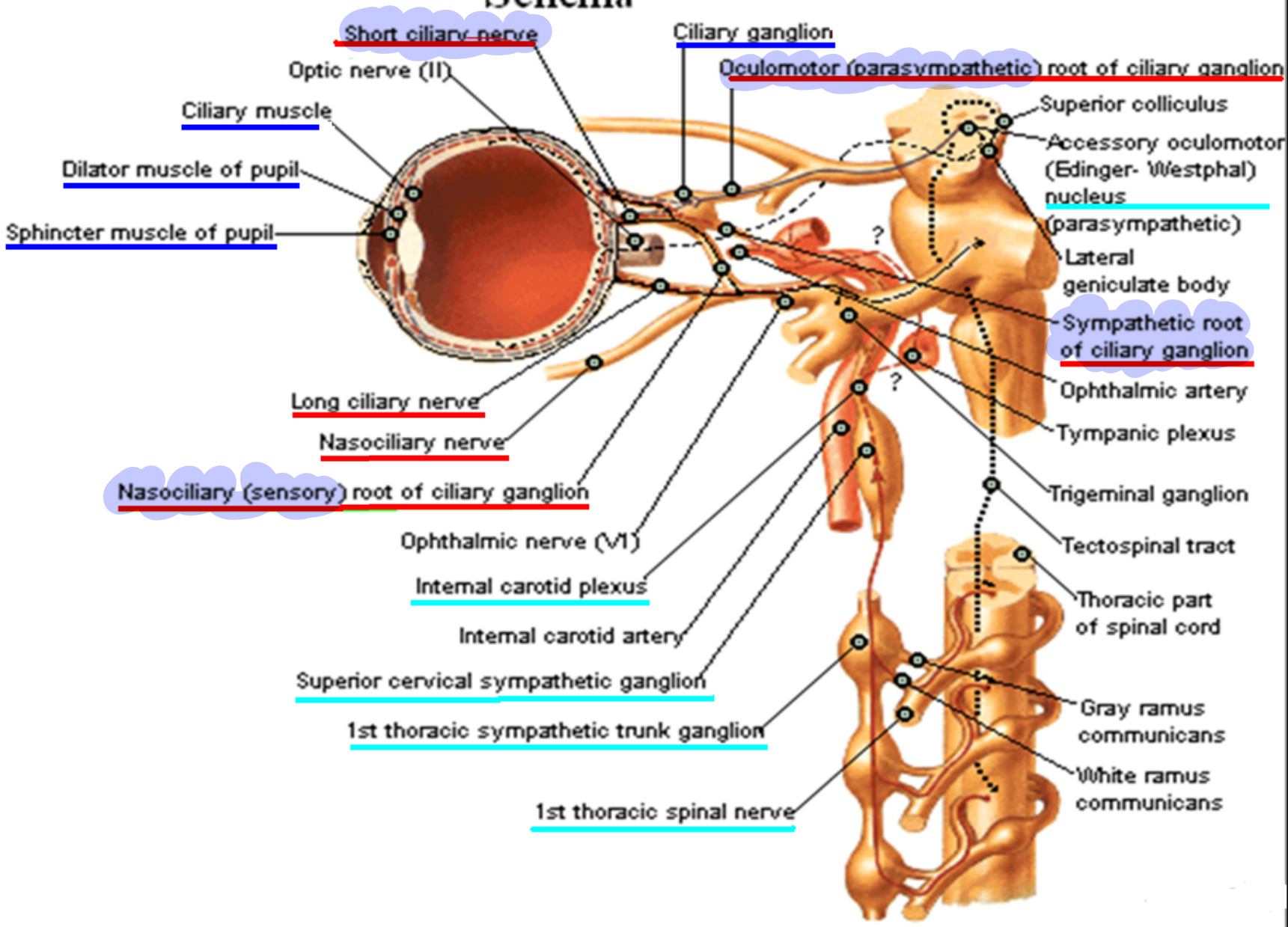
Accommodation reflex to adduction both eyes when object is close to the eye


Sensory root
Nasociliary nerve
Long ciliary nerve
Sympathetic root
Parasympathetic (motor) root
Edenger westphal nucleus
Ciliary ganglion
Oculomotor nerve [III]
Short ciliary nerve
Sensory fibers
Sympathetic fibers
Parasympathetic preganglionic fibers
Parasympathetic postganglionic fibers


Short ciliary nerve to ciliary muscle
Para Sympathetic
III efferent fibers
Ciliary ganglion
Midbrain
V
Long ciliary nerve to
Dilator pupillæ
Carotid plexus
Medulla
Short ciliary nerve to
Sphincter pupillæ
Postganglionic fibers
I. C.
Superior cervical ganglion
!!!!
I. Th.
II. Th.
I. Thoracic ganglion
Sympathetic efferent (preganglionic) fibers

Ciliary Ganglion

Schema



1st order neuron is superior salivary nucleus

Submandibular Ganglion

- **Type:** it is a small parasympathetic ganglion (2-3 mm in diameter).
- **Site:** it lies in the submandibular region on the upper part of hyoglossus muscle.
- **Roots Entering the Submandibular Ganglion:**

Chorda tympani and lingual nerve supply the ant. 2/3 sensory to the tongue

1. **Parasympathetic root:** arising from the chorda tympani nerve (Branch of facial nerve).
2. **Sympathetic root:** arising from the sympathetic plexus around facial artery. Or external carotid artery
3. **Sensory root:** from lingual nerve (branch of mandibular nerve). 3rd branch of trigeminal V3

Branches of the Submandibular Ganglion

1. **Several small branches (mixed: parasympathetic + sympathetic + sensory fibers)** pass directly from the ganglion to supply **the submandibular salivary gland.**
2. **Similar branches** join the lingual nerve to reach **the sublingual salivary gland.**

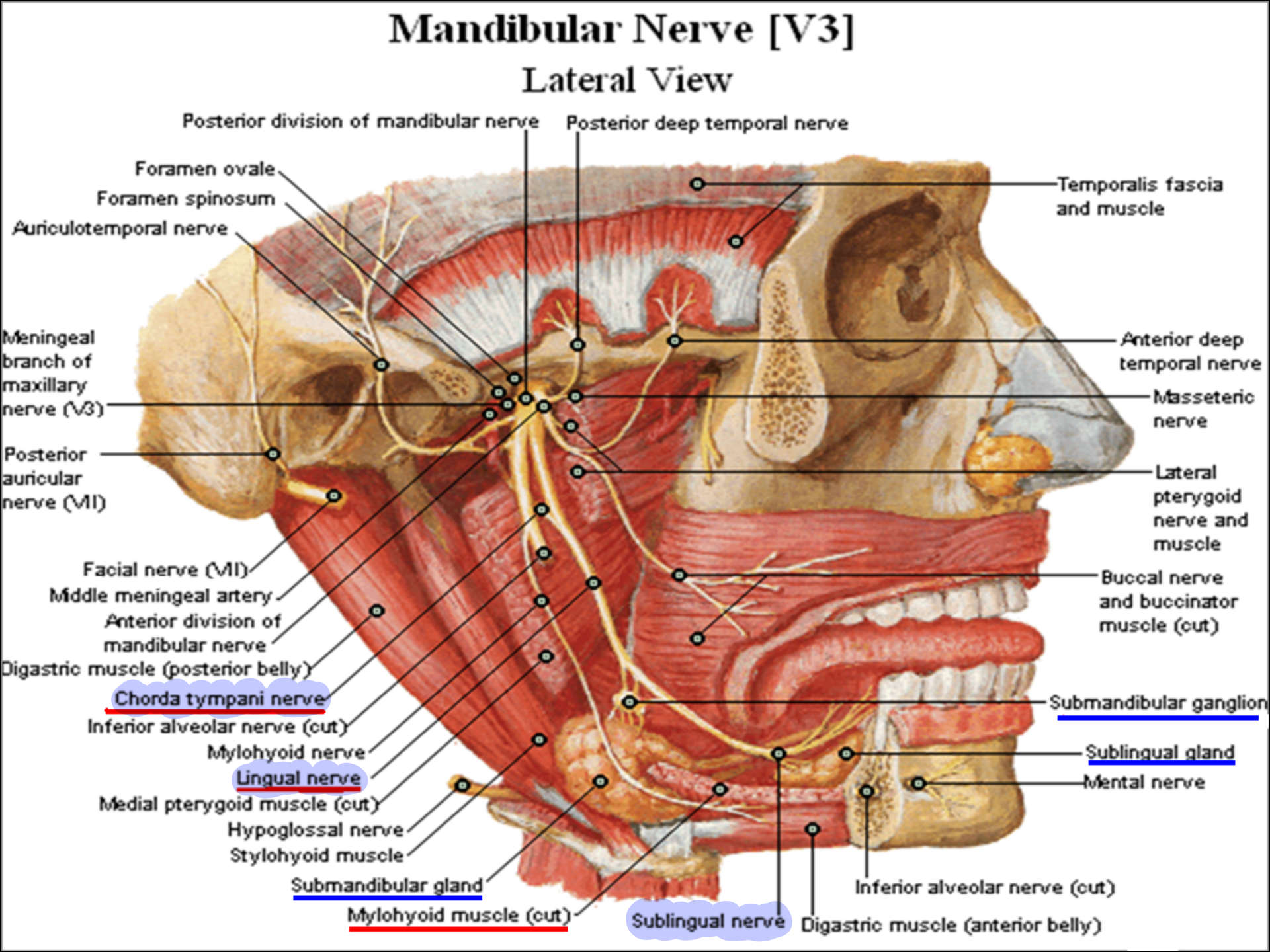
The sublingual nerve carry mixed fibers to the sublingual salivary gland.

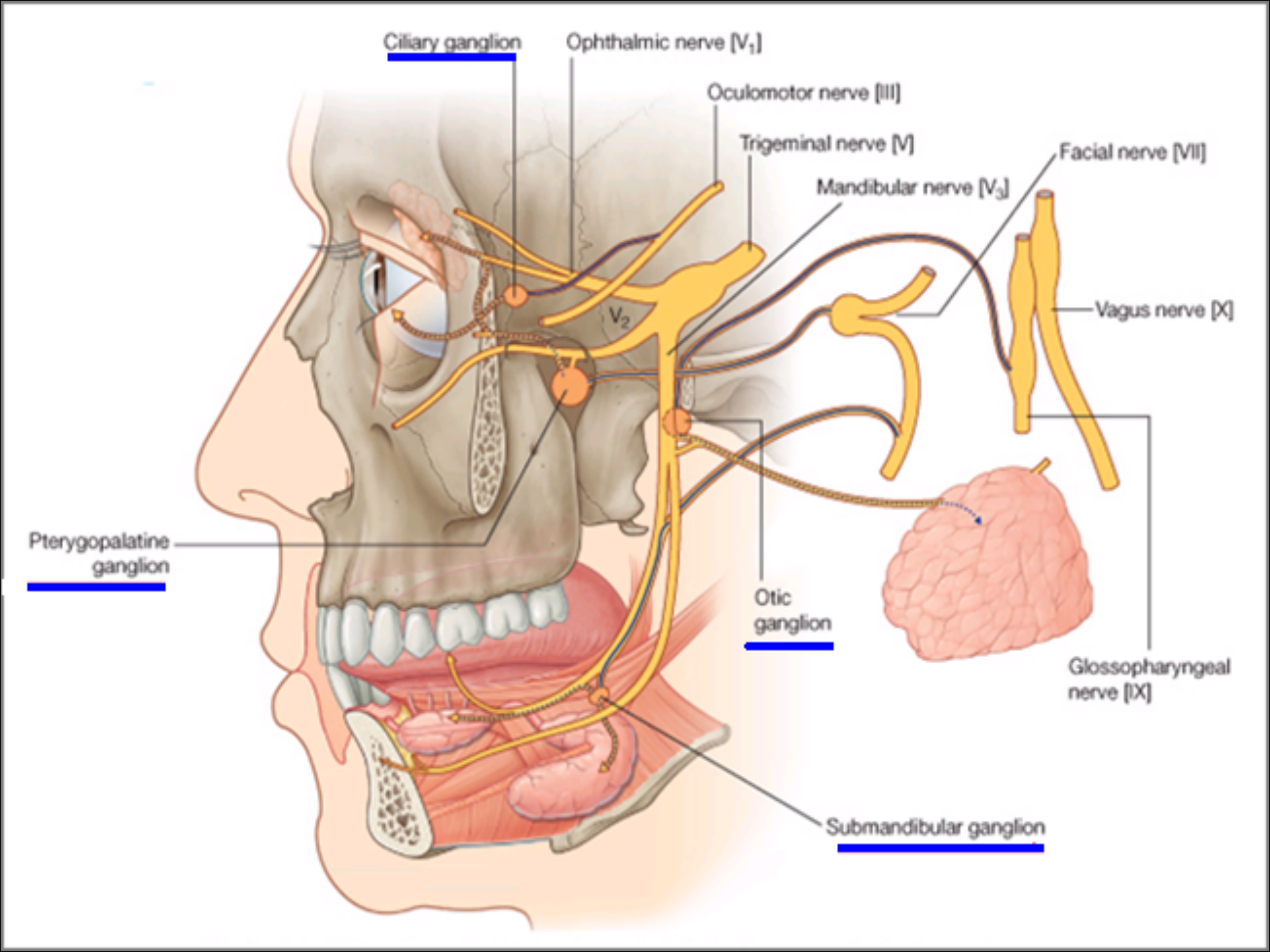
Sensory to receptors of submandibular or sublingual glands
Para secretomotor function
Sympathetic for blood vessels

Note: all the sympathetic fibers reach these parasympathetic ganglia are postganglionic because the came out from cervical sympathetic ganglion and do the relay function there.

Mandibular Nerve [V3]

Lateral View

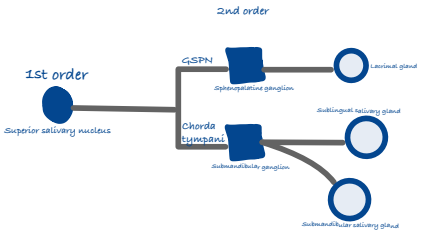


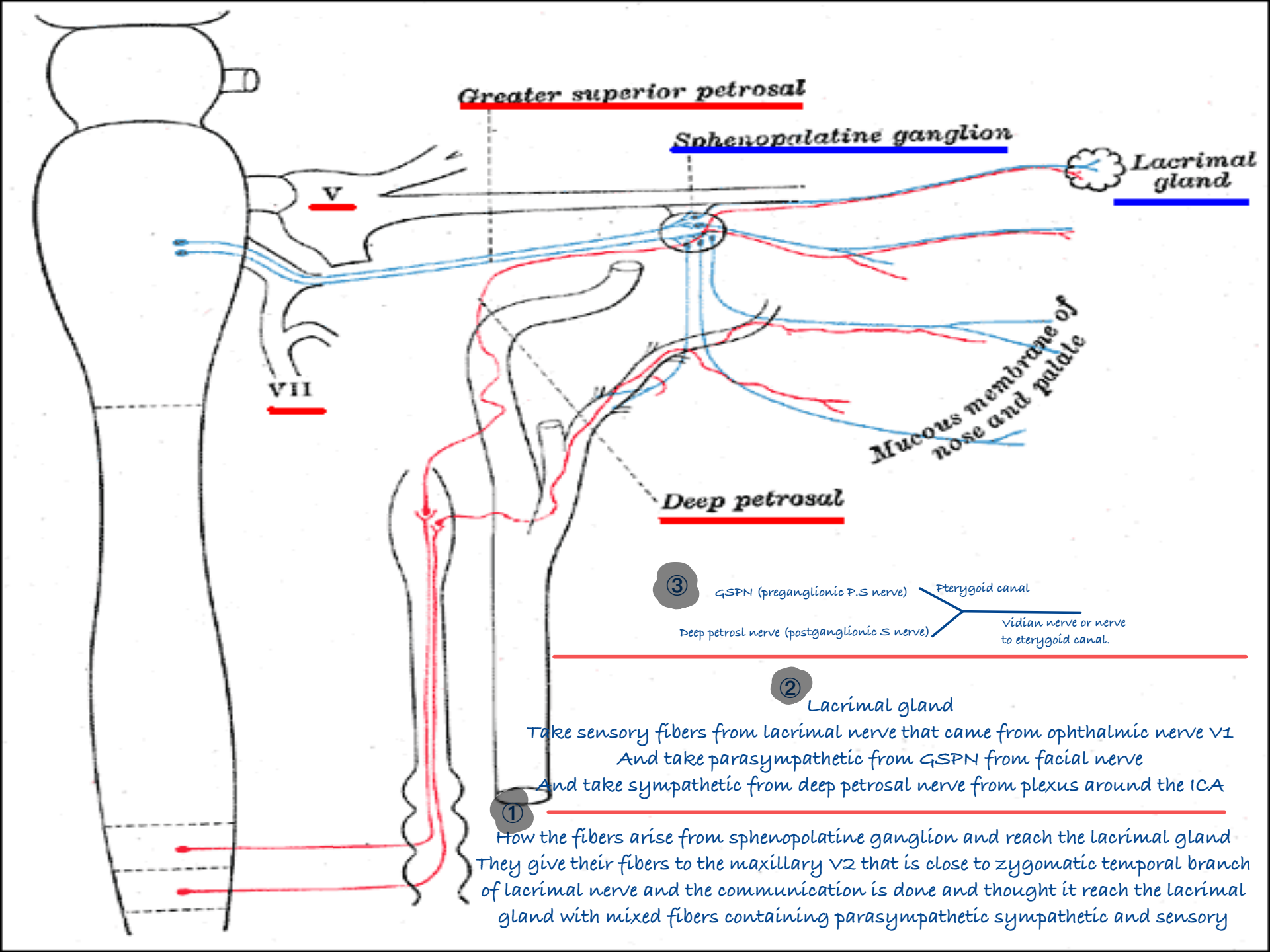

Ciliary ganglion
Ophthalmic nerve [V1]
Oculomotor nerve [III]
Trigeminal nerve [V]
Facial nerve [VII]
Mandibular nerve [V3]
V2
Vagus nerve [X]
Pterygopalatine ganglion
Otic ganglion
Glossopharyngeal nerve [IX]
Submandibular ganglion

Sphenopalatine (Pterygopalatine) Ganglion

- **Type:** it is the largest parasympathetic ganglion (4-5 mm in diameter).
- **Site:** it lies in the pterygopalatine fossa.
- **Roots Entering the Sphenopalatine Ganglion:**
  1. **Sensory root:** two sensory branches arising from the maxillary nerve. (2nd branch of trigeminal nerve, V3)
  2. **Sympathetic root:** the deep petrosal nerve from sympathetic plexus around the ICA.
  3. **Parasympathetic root:** the greater petrosal nerve (branch of facial nerve). (GSPN)

The 1st order neuron » superior salivary nucleus give facial nerve then it give 2 chorda tympani and GSPN





③ GSPN (preganglionic P.S nerve) → Pterygoid canal

Deep petrosl nerve (postganglionic S nerve) → Vidian nerve or nerve to eterygoid canal.

② Lacrimal gland

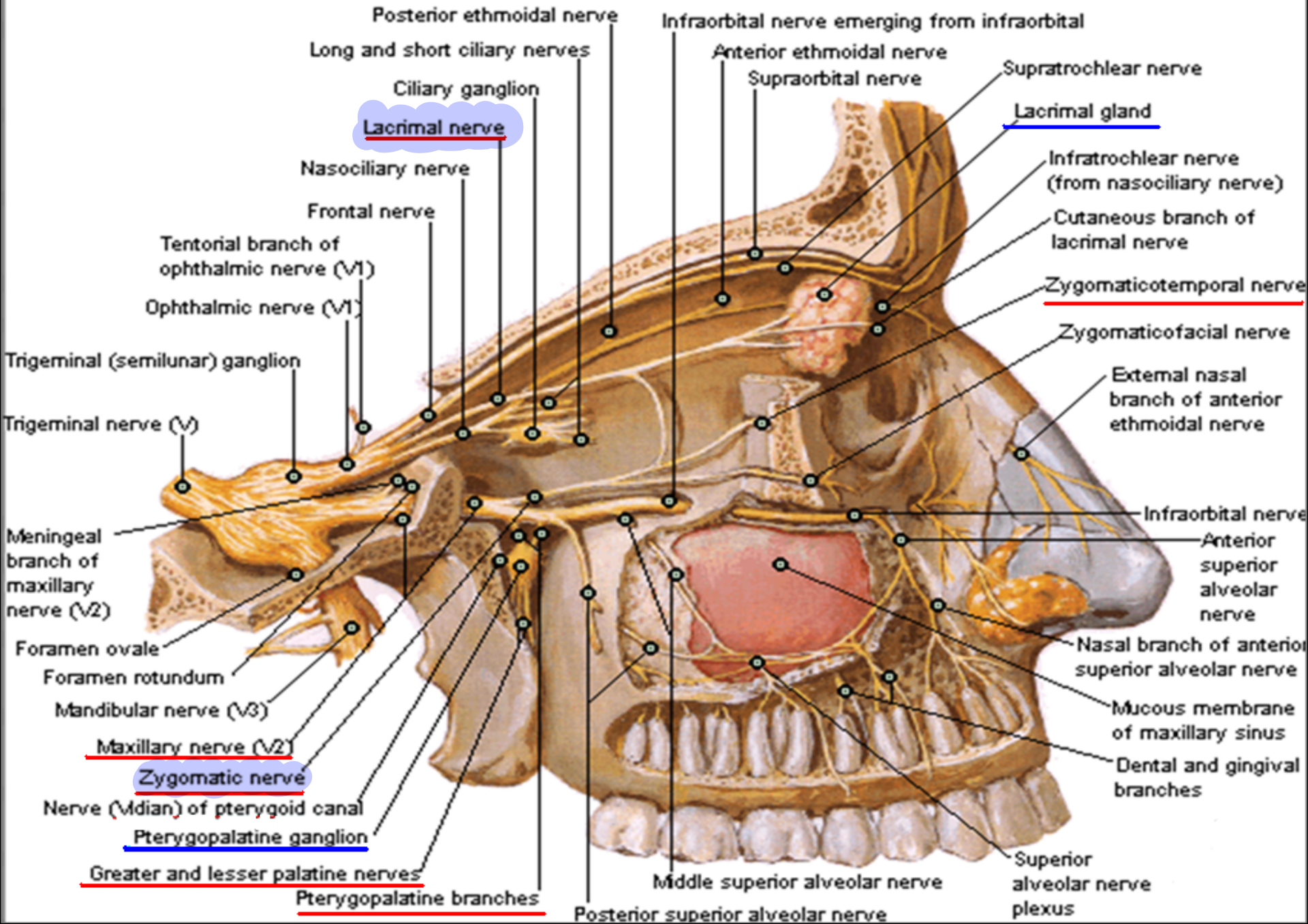
Take sensory fibers from lacrimal nerve that came from ophthalmic nerve V1
And take parasympathetic from GSPN from facial nerve
And take sympathetic from deep petrosal nerve from plexus around the ICA

① How the fibers arise from sphenopolatine ganglion and reach the lacrimal gland
They give their fibers to the maxillary V2 that is close to zygomatic temporal branch of lacrimal nerve and the communication is done and thought it reach the lacrimal gland with mixed fibers containing parasympathetic sympathetic and sensory

Branches of the Sphenopalatine Ganglion

1. **Orbital branches:** enter the orbit through the inferior orbital fissure. They supply the orbital periosteum and the mucous membrane of the sphenoid air sinus. Another fibers pass with the zygomaticotemporal nerve to the orbit, where they branch off to join the lacrimal nerve to supplies lacrimal gland.
2. **Pharyngeal branch:** to supply the mucous membrane of the nasopharynx.
3. **Greater palatine nerve:** to supply the mucous membrane of the hard palate and part of the nose.
4. **Lesser palatine nerve:** to supply the mucous membrane of the soft palate and the palatine tonsil.
5. **Short sphenopalatine nerve:** to supply the mucous membrane of the upper part of the lateral wall of the nose and nasal septum.
6. **Long sphenopalatine nerve:** to supply the mucous membrane of the anterior part of the hard palate.

Ophthalmic and Maxillary Nerves



1st order is inferior salivary nucleus

Otic Ganglion

The parotid gland take sensation not through otic ganglion and by auriculotemporal nerve → And A.T nerve the sensory for parotid gland complete to reach skin

- **Type:** it is a small parasympathetic ganglion.
- **Site:** in the infratemporal fossa just below foramen ovale.
- **Roots Entering the Otic Ganglion:**

Not sensory

1. **Motor root:** arising from nerve to medial pterygoid muscle (branch of the main trunk of mandibular nerve).

3rd branch of trigeminal V3

2. **Parasympathetic root:** formed by lesser superficial petrosal nerve (branch of glossopharyngeal nerve).

And came from inf. Salivary nucleus

3. **Sympathetic root:** from the plexus around middle meningeal artery (from the plexus around ECA).

Middle meningual came from maxillary artery

Branches of the Otic Ganglion

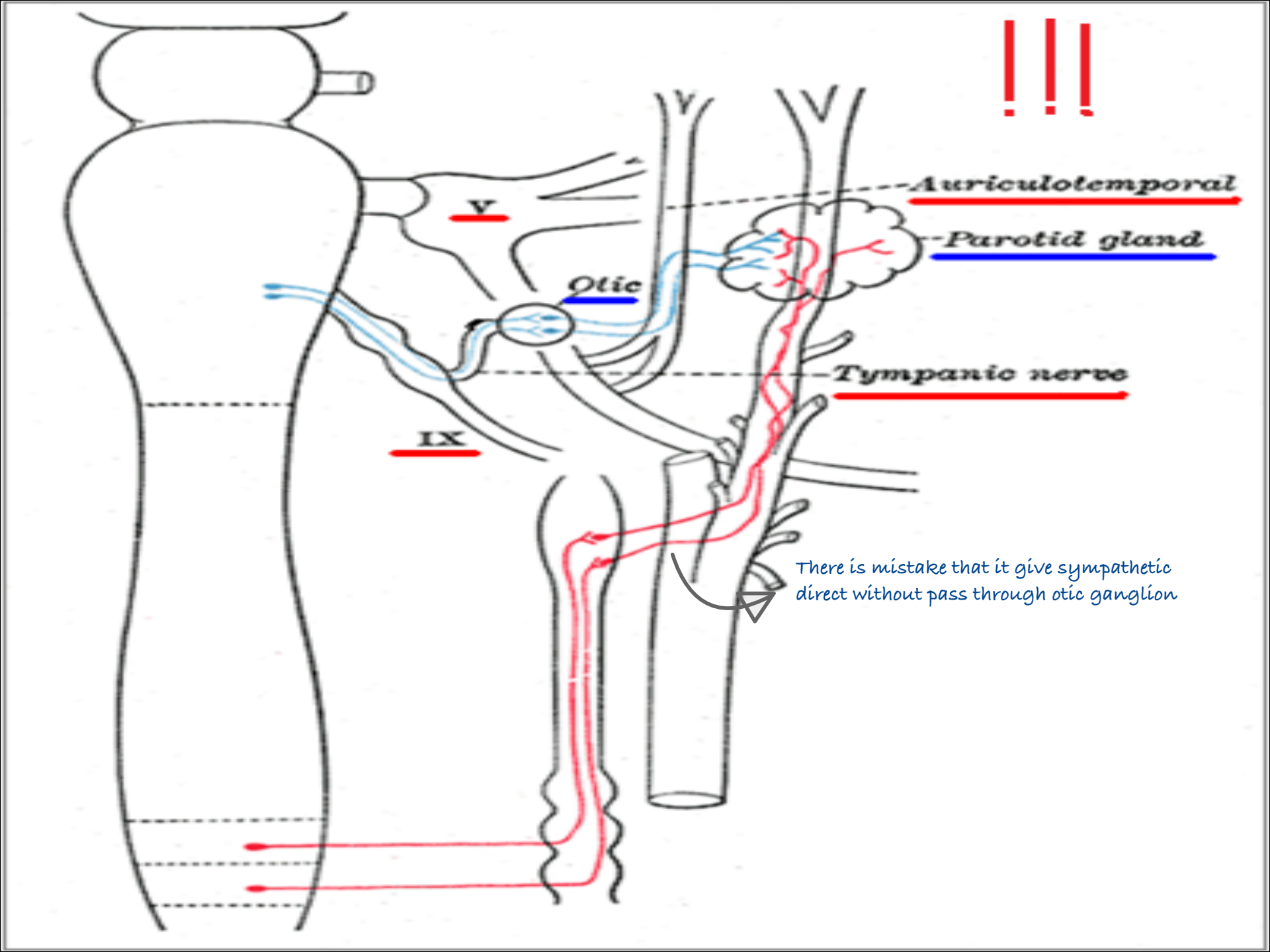
Because we are talking about gland no need to motor and movement

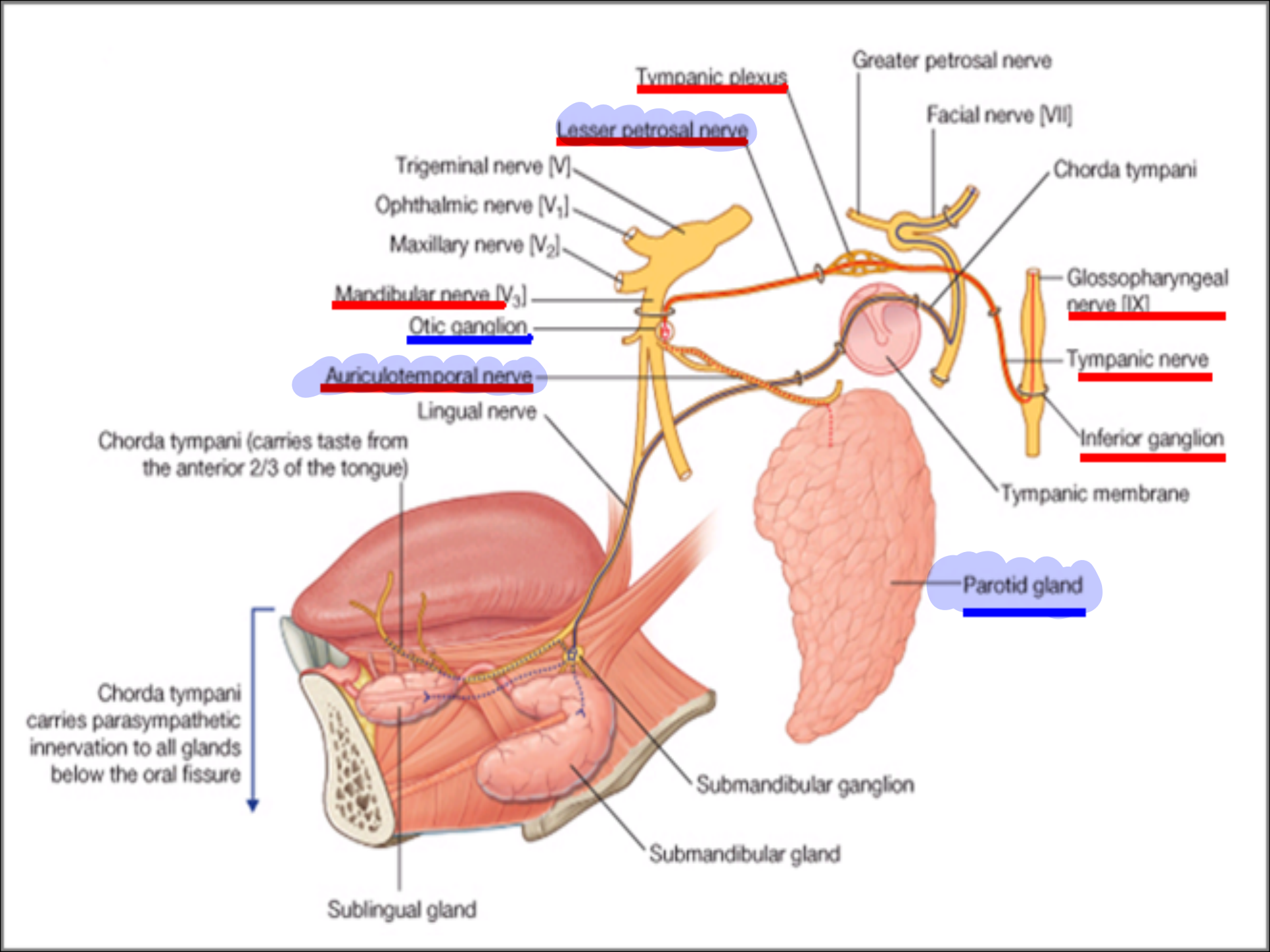
So the motor goes to

1. **Motor branch:** to tensor palati muscle and another branch to tensor tympani muscle.

Take motor fibers from nerve to medial pterygoid muscle

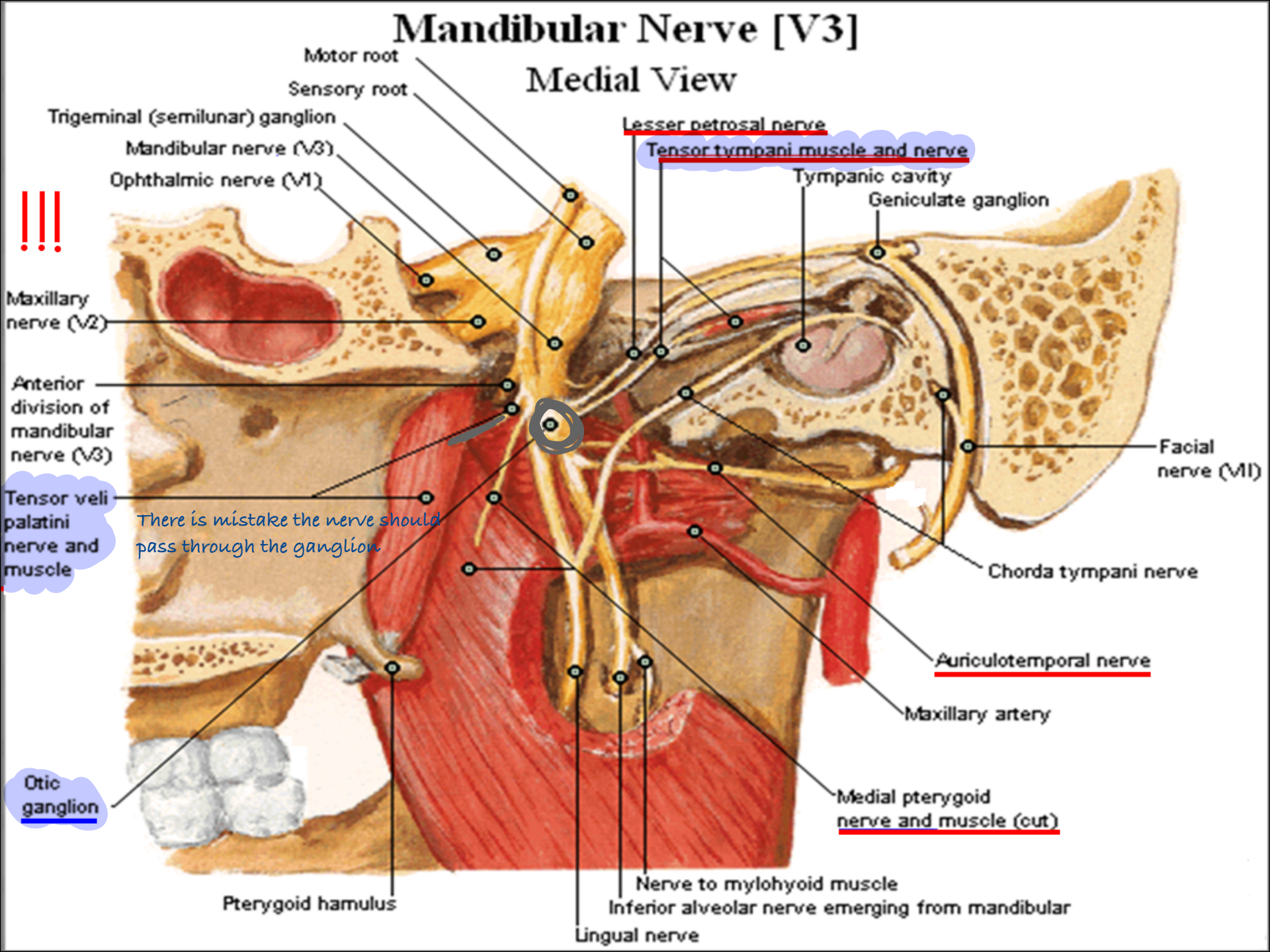
2. **A communicating branch:** to auriculotemporal nerve, this branch is formed of:
    a. **Sympathetic fibers:** to supply the blood vessels of parotid gland.
    b. **Parasympathetic fibers:** secretomotor to parotid gland.


!!!
V
V
Auriculotemporal
Parotid gland
Otic
Tympanic nerve
IX
There is mistake that it give sympathetic
direct without pass through otic ganglion


Tympanic plexus
Greater petrosal nerve
Lesser petrosal nerve
Facial nerve [VII]
Trigeminal nerve [V]
Chorda tympani
Ophthalmic nerve [V1]
Maxillary nerve [V2]
Glossopharyngeal nerve [IX]
Mandibular nerve [V3]
Otic ganglion
Tympanic nerve
Auriculotemporal nerve
Lingual nerve
Inferior ganglion
Chorda tympani (carries taste from the anterior 2/3 of the tongue)
Tympanic membrane
Parotid gland
Chorda tympani carries parasympathetic innervation to all glands below the oral fissure
Submandibular ganglion
Submandibular gland
Sublingual gland

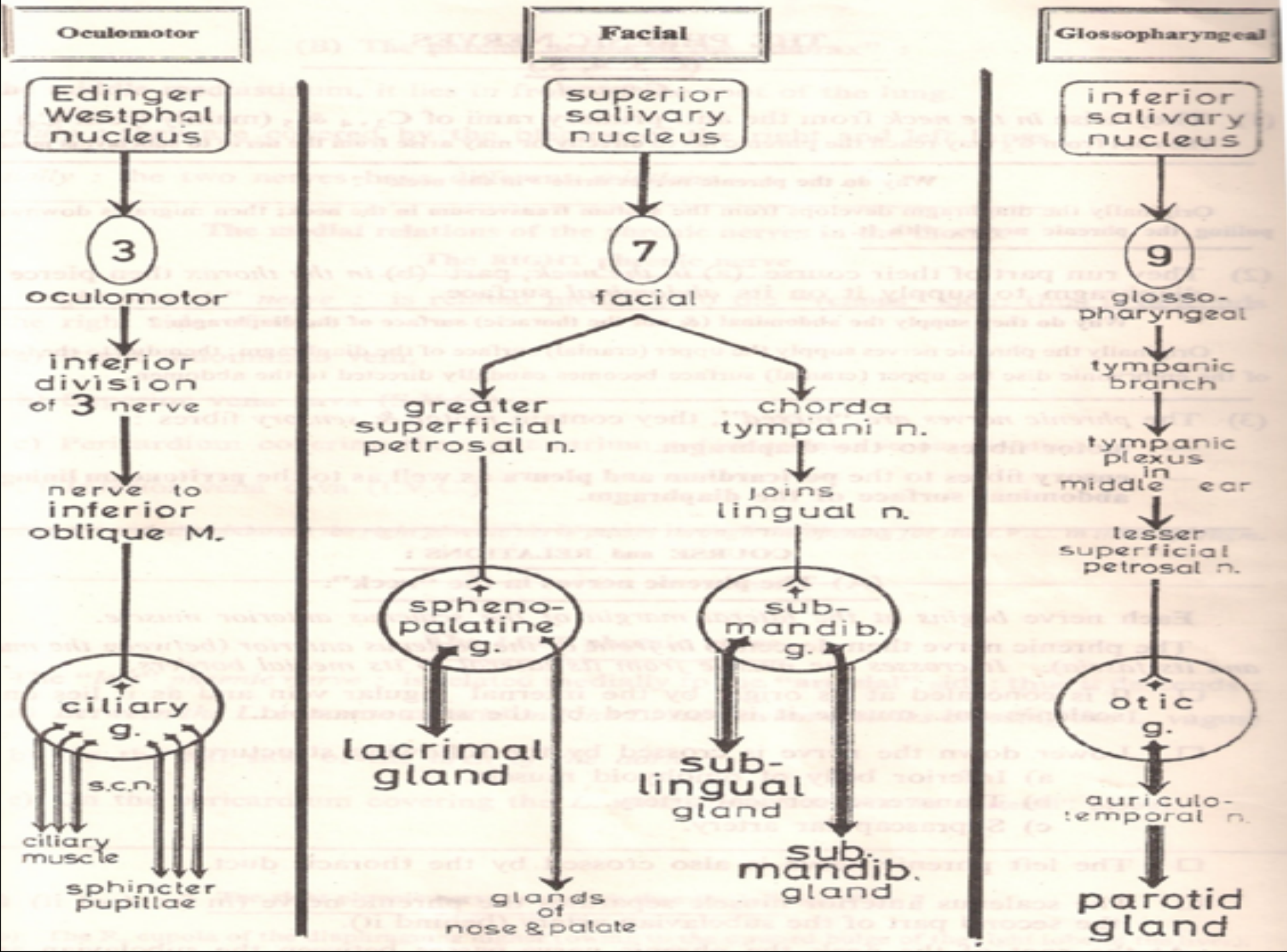
Mandibular Nerve [V3]

Medial View



The Parasympathetic Ganglia in the Head and Neck

Ganglion (2nd order PNS)	Nucleus (1st order CNS)	Parasympathetic root	Sensory or motor root	Sympathetic root	Organs supplied
Ciliary	Edinger-Westphal	Oculomotor nerve (Nerve to if. Oblique m.)	Nasociliary (From V1 Ophthalmic)	Nasociliary nerve from internal carotid plexus	Sphincter pupillae and ciliary muscles
Sphenopalatine	Superior salivary	Greater superficial petrosal nerve from VII nerve (Facial)	Maxillary (V2)	Deep petrosal nerve from internal carotid plexus	Lacrimal glands; glands of nose, palate, mouth and pharynx
Submandibular	Superior salivary	Chorda tympani nerve from VII nerve	Lingual	Plexus around facial artery	Submandibular and sublingual glands
Otic	Inferior salivary	Lesser superficial petrosal nerve from IX nerve (Glossopharyangeal)	Mandibular "Motor" (Medial pterygoid muscle)	Plexus around middle meningeal artery	Parotid gland
Many ganglion in the different organs	Dorsal motor nucleus of vagus	Vagus nerve	Many nerves	Many plexus	Heart, Respiratory system, Abd. viscera (2 the junction between proximal 2/3 of transverse colon.)


Oculomotor
Edinger Westphal nucleus
3
oculomotor
inferior division of 3 nerve
nerve to inferior oblique M.
ciliary g.
s.c.n.
ciliary muscle
sphincter pupillae
Facial
superior salivary nucleus
7
facial
greater superficial petrosal n.
chorda tympani n.
joins lingual n.
spheno-palatine g.
sub-mandib. g.
lacrimal gland
sub-lingual gland
sub. mandib. gland
glands of nose & palate
Glossopharyngeal
inferior salivary nucleus
9
glosso-pharyngeal
tympanic branch
tympanic plexus in middle ear
lesser superficial petrosal n.
otic g.
auriculo-temporal n.
parotid gland

The Sympathetic Nervous System

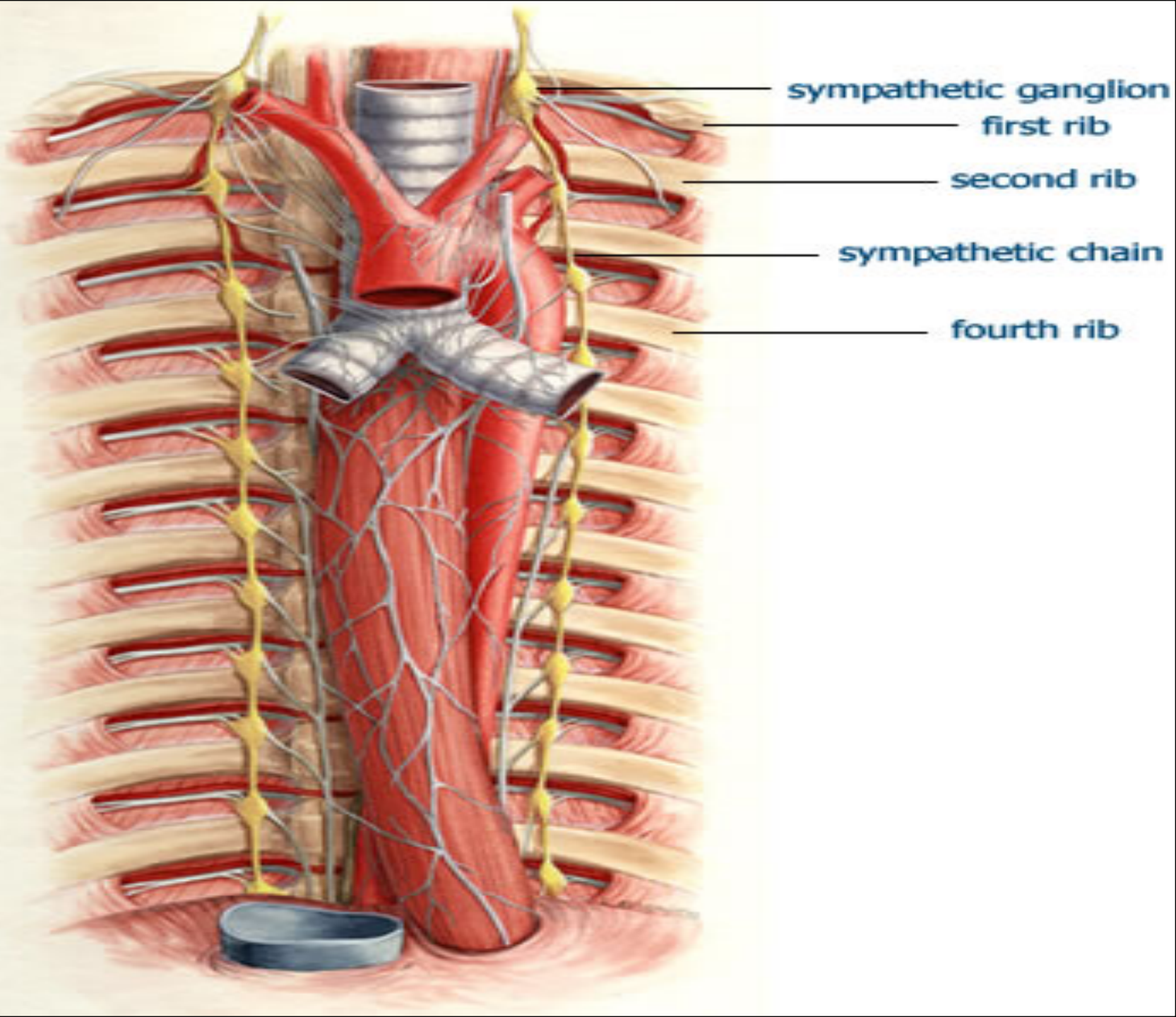
- **Cells of Origin:** The sympathetic NS formed by the cells of the intermediolateral nuclei of the lateral horn of **T1-L2** segments of the spinal cord **(Thoraco-lumbar part)** and reach the sympathetic chain by the white rami (right and left).
- Sympathetic cells may also be found in **C8 segments of the spinal cord.**

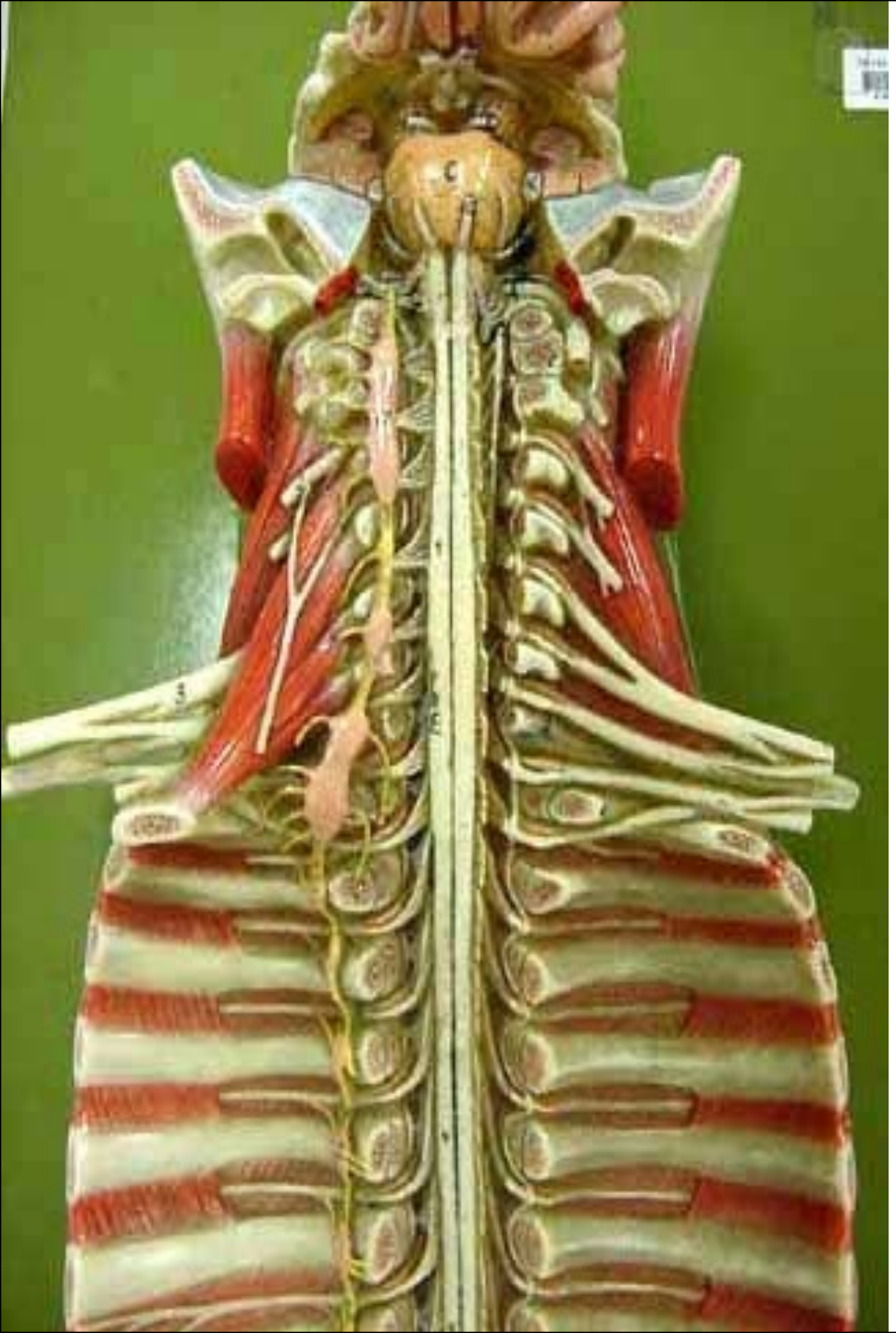
The Sympathetic Ganglia

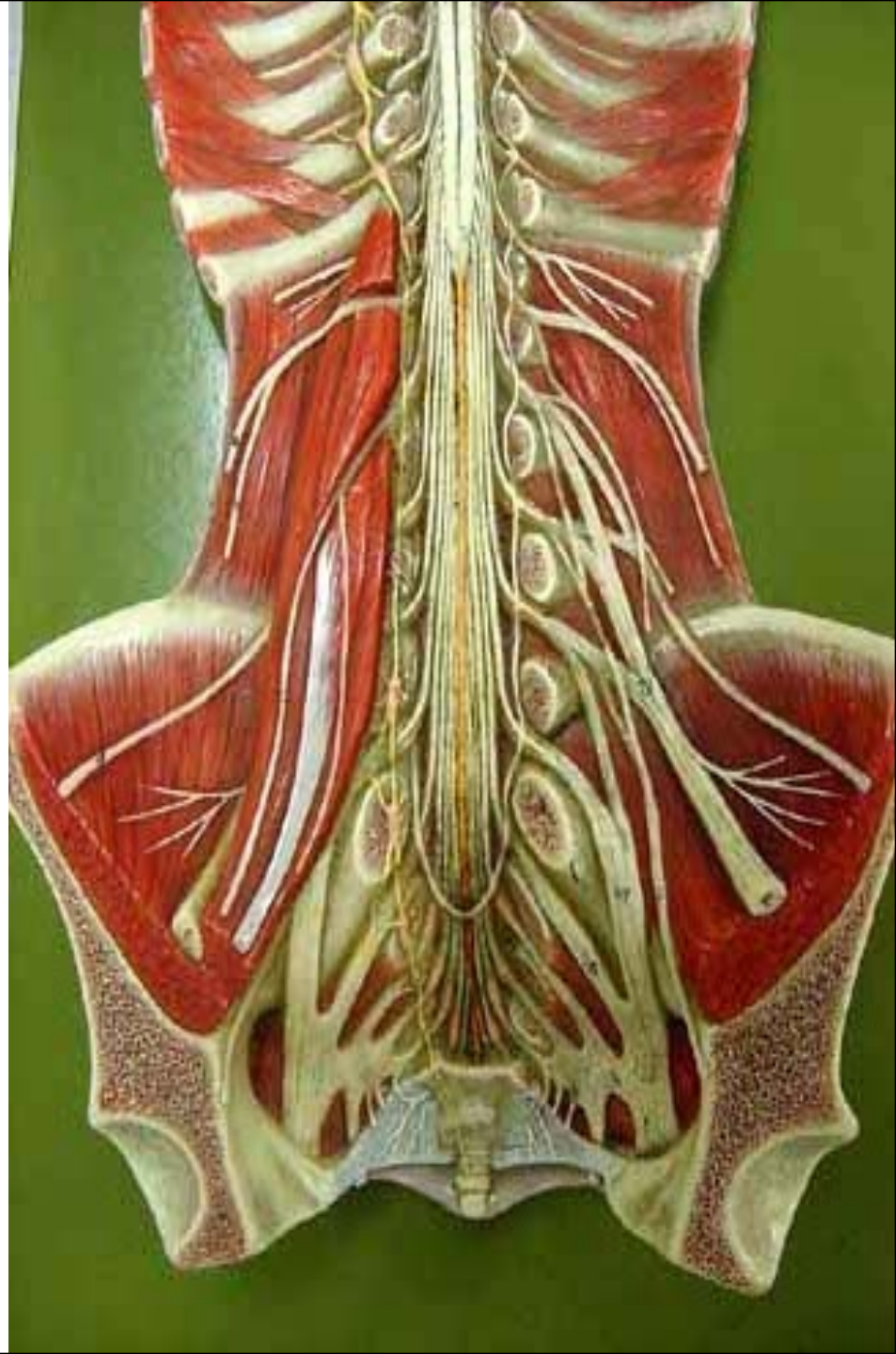
1. **Paravertebral Ganglia:** which formed the sympathetic chain or trunk.
   - ❖ There are two sympathetic chains (right and left) on each side of the vertebral column.
   - ❖ Each chain extends from the level of the **first cervical vertebra** (above) to front of **the coccyx** (below) where two chains unite to form a single coccygeal ganglion **(impar ganglion).**
   - ❖ It formed of 22-23 ganglia on each side.
2. **Collateral or Peripheral Ganglia:** these are ganglia that surround some large arteries: **celiac, superior and inferior mesenteric ganglia.**

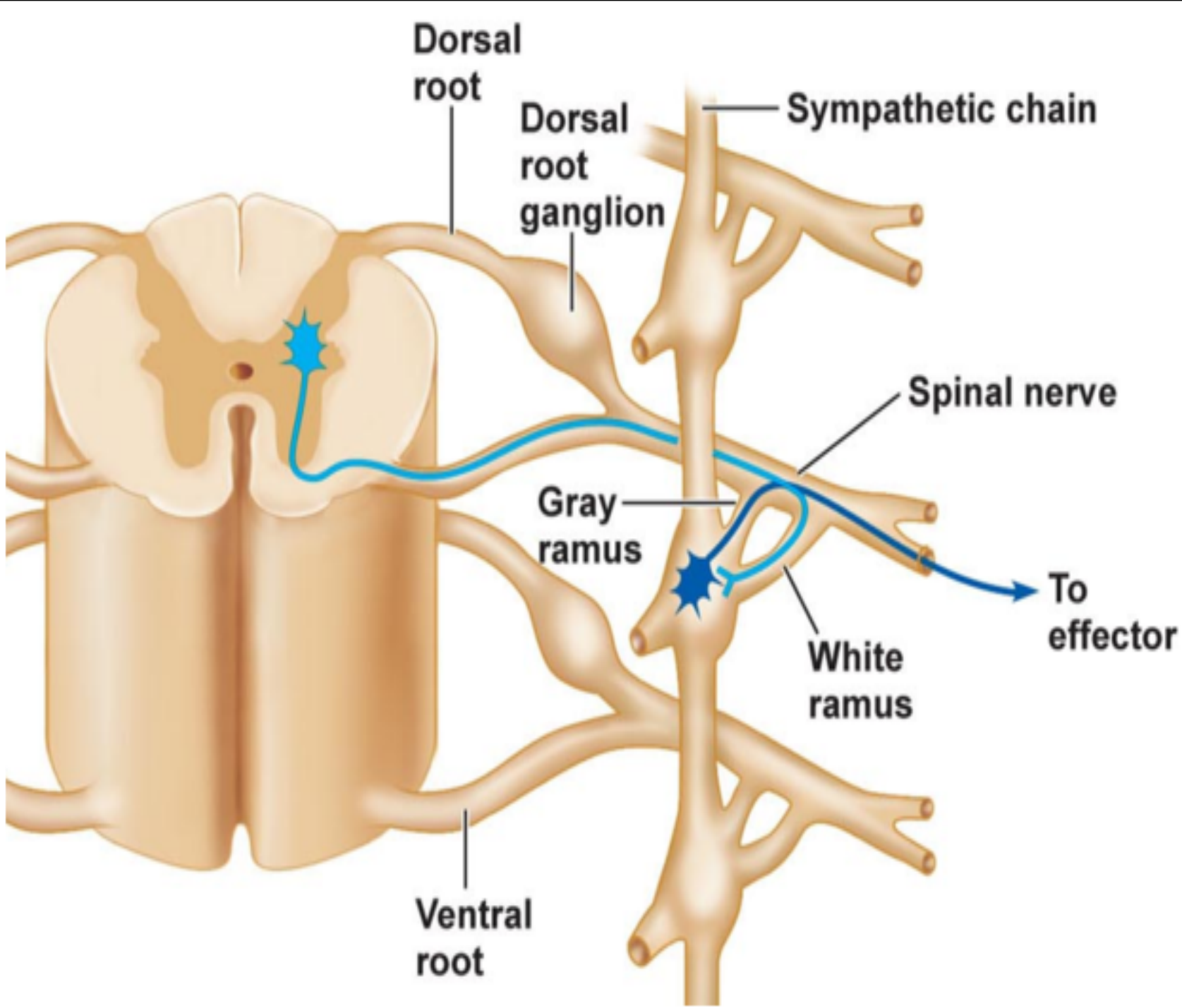
How Many Sympathetic Ganglia are Found in the Sympathetic Chains?

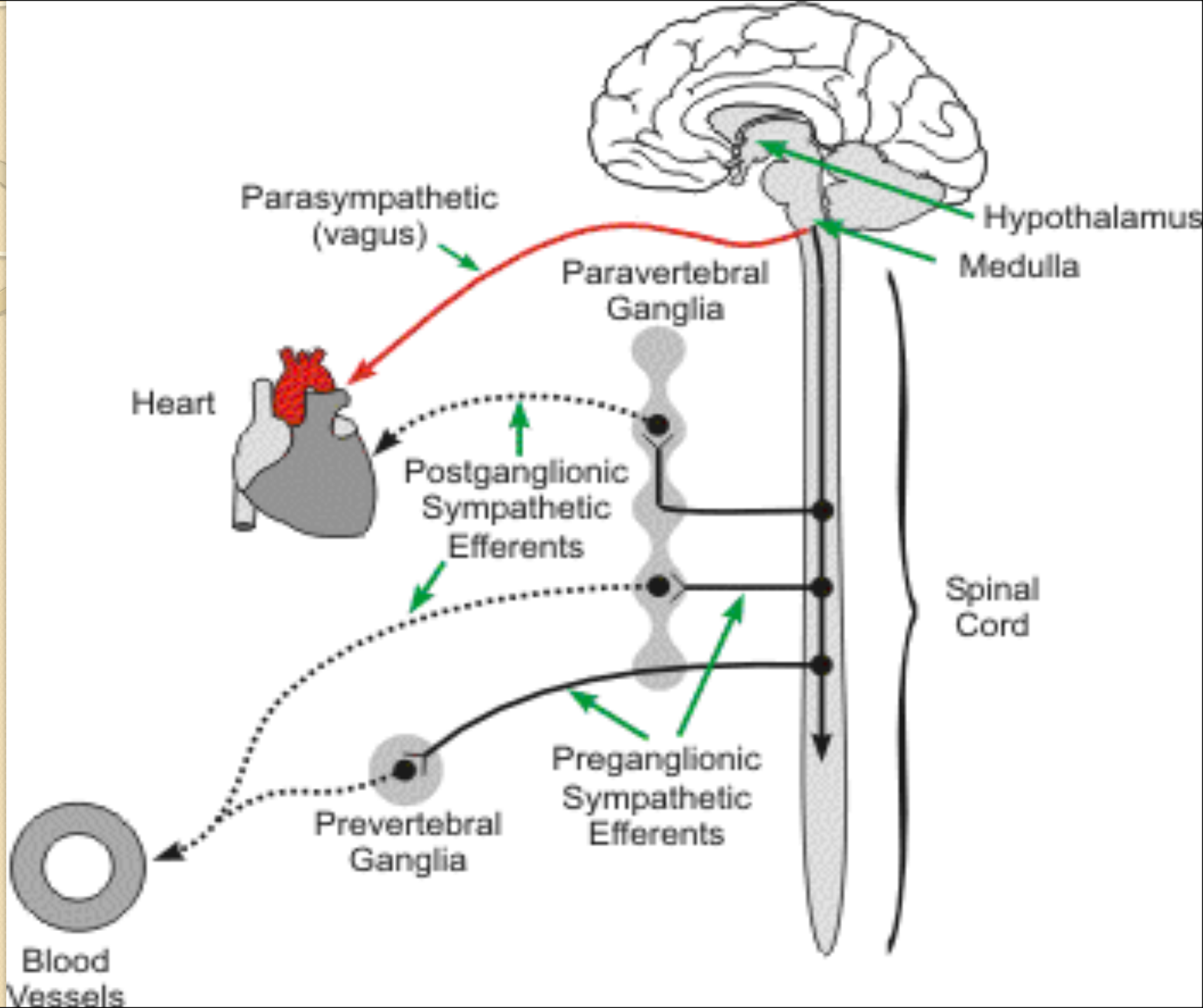
1. **Cervical ganglia:** 3 pairs.
2. **Thoracic ganglia:** 10-12 pairs.
3. **Lumbar ganglia:** 4-5 pairs.
4. **Sacral ganglia:** 4-5 pairs.
1. **Coccygeal ganglion:** one fused together (impar ganglion).

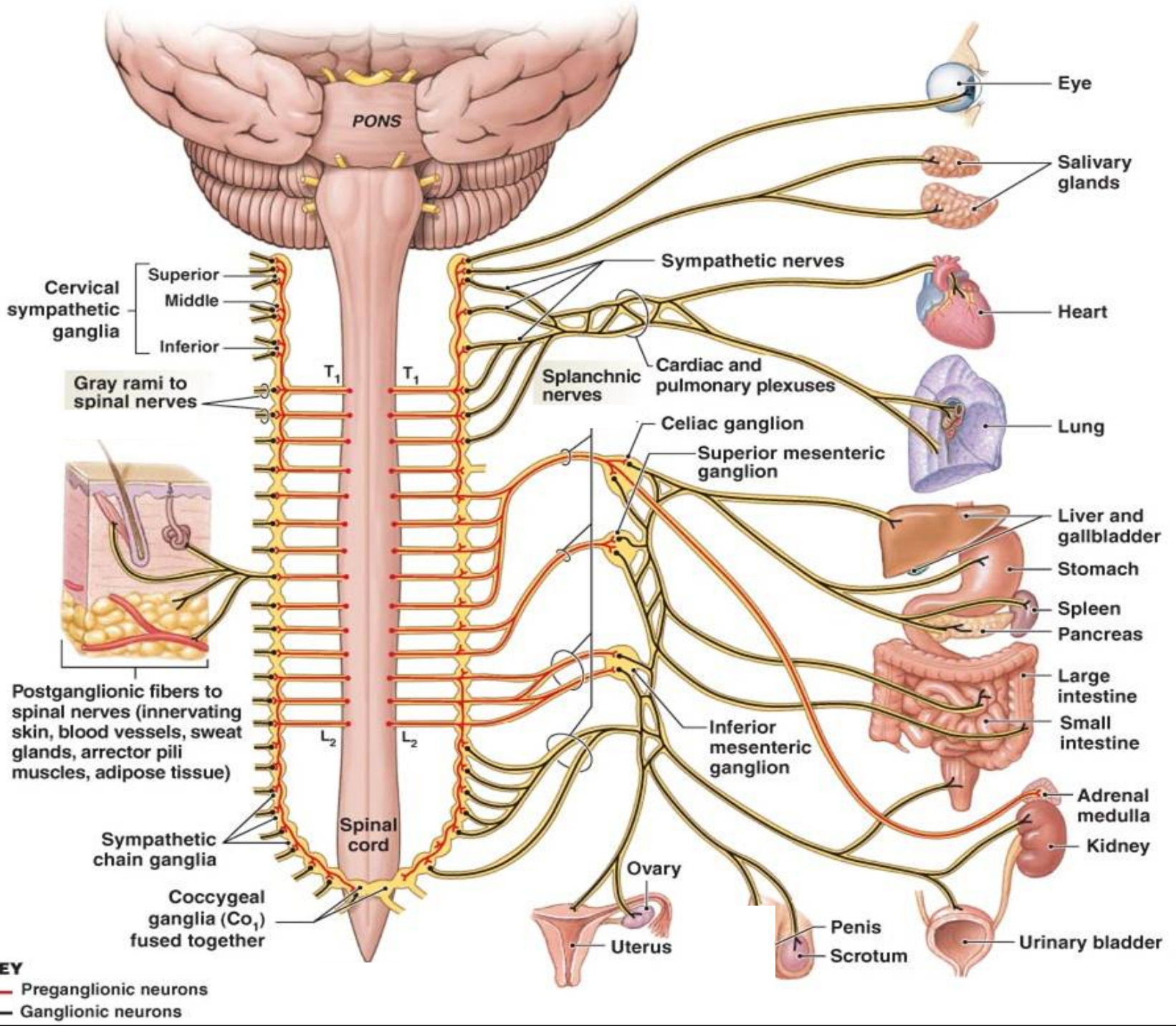

sympathetic ganglion
first rib
second rib
sympathetic chain
fourth rib






Dorsal root
Dorsal root ganglion
Sympathetic chain
Spinal nerve
Gray ramus
White ramus
To effector
Ventral root


Parasympathetic
(vagus)
Hypothalamus
Medulla
Paravertebral
Ganglia
Heart
Postganglionic
Sympathetic
Efferents
Spinal
Cord
Preganglionic
Sympathetic
Efferents
Prevertebral
Ganglia
Blood
Vessels


PONS
Eye
Salivary glands
Sympathetic nerves
Heart
Cervical sympathetic ganglia
Superior
Middle
Inferior
Gray rami to spinal nerves
T1
T1
Splanchnic nerves
Cardiac and pulmonary plexuses
Lung
Celiac ganglion
Superior mesenteric ganglion
Liver and gallbladder
Stomach
Spleen
Pancreas
Large intestine
Small intestine
Inferior mesenteric ganglion
Adrenal medulla
Kidney
Postganglionic fibers to spinal nerves (innervating skin, blood vessels, sweat glands, arrector pili muscles, adipose tissue)
L2
L2
Spinal cord
Sympathetic chain ganglia
Coccygeal ganglia (Co1) fused together
Ovary
Uterus
Penis
Scrotum
Urinary bladder
KEY
Preganglionic neurons
Ganglionic neurons

The Cervical Part of the Sympathetic Chain

Site: It lies behind the common, external, and internal carotid arteries, outside carotid sheath and medial to the vagus nerve.

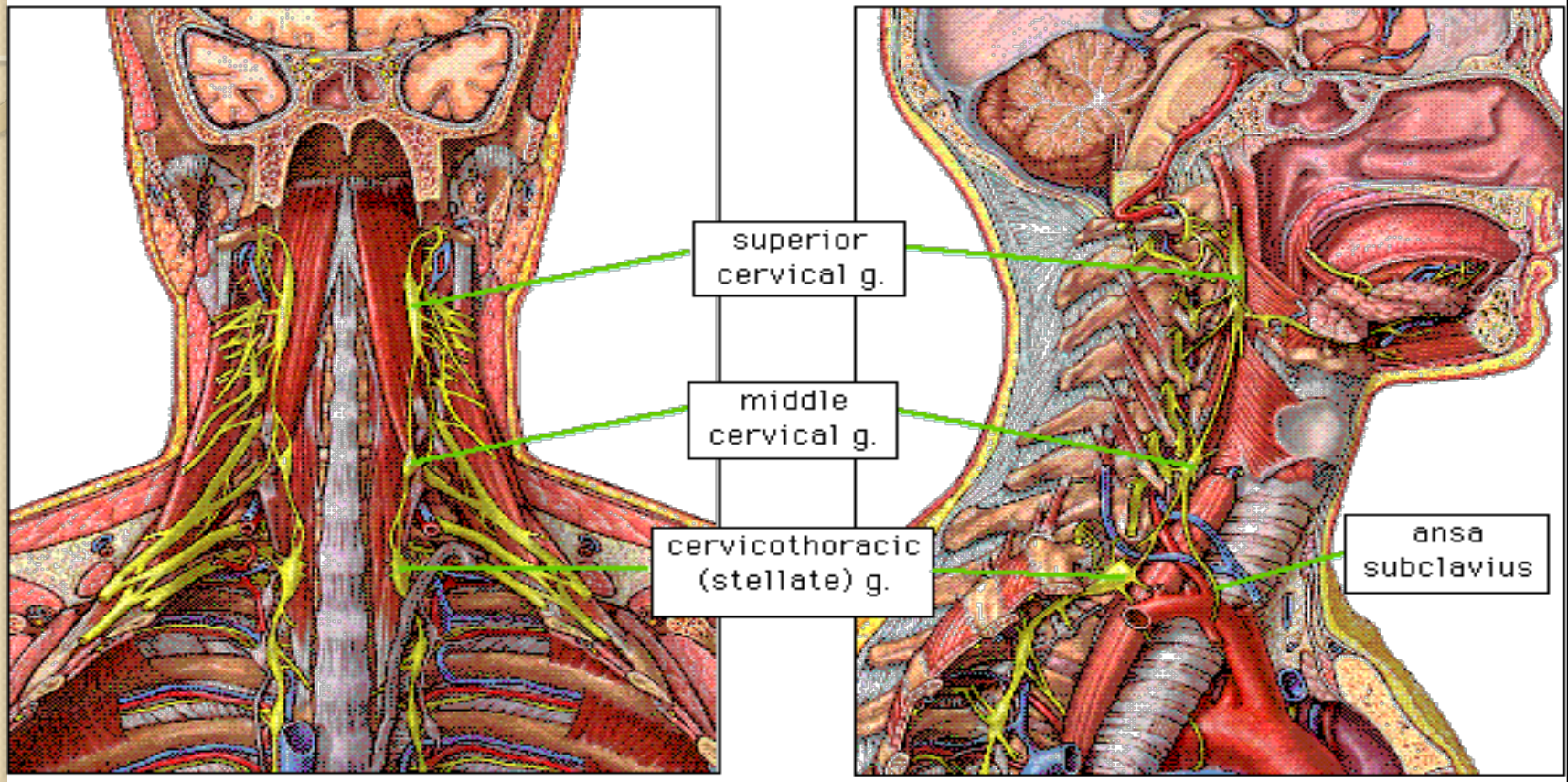
It has:

1. **Preganglionic fibers:** from upper thoracic segments (T1-T4) until the three cervical ganglion.
2. **Postganglionic fibers:** leave these ganglia, to the cervical nerves, cranial nerves and large vessels.

The Cervical Sympathetic Ganglion

There are three cervical sympathetic ganglion:

1. Superior cervical sympathetic ganglion.
2. Middle cervical sympathetic ganglion.
3. Inferior cervical sympathetic ganglion.

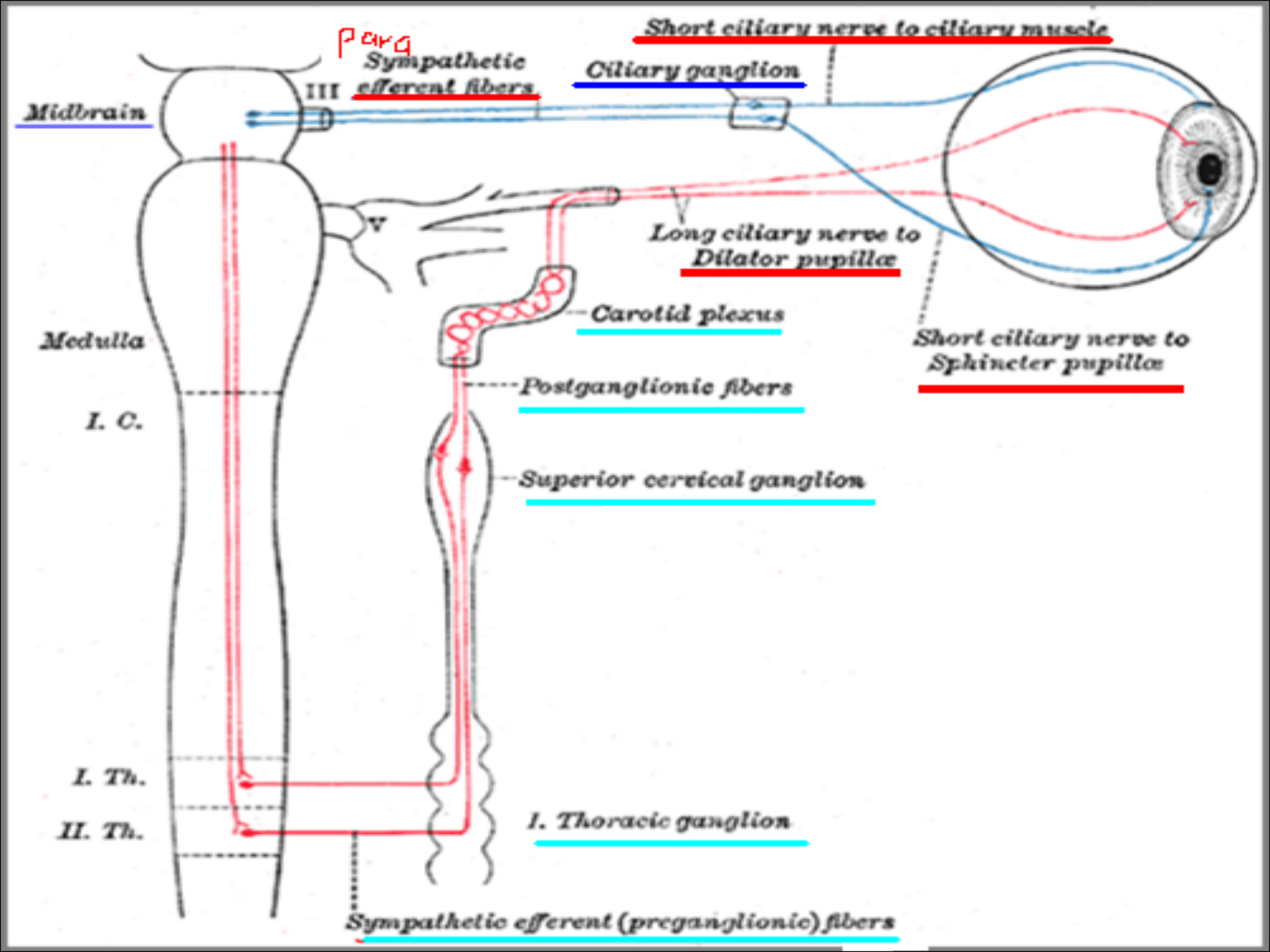

superior cervical g.
middle cervical g.
cervicothoracic (stellate) g.
ansa subclavius

Destruction of the Superior Cervical Sympathetic Ganglion

- This removes all the sympathetic fibers that reach face and neck and produces **Horner's syndrome:**
  1. Myosis.
  2. Partial ptosis.
  3. Anhydrosis.
  4. Enophthalamus.

Sympathetic Supply of the Pupil

Pathway: Fibers start from hypothalamus, descends through the brain stem and cervical part of the spinal cord to the lateral horn cells of C8 – T2 segment → preganglionic fibers → sympathetic chain → relay in the superior cervical sympathetic ganglion. The postganglionic fibers pass with carotid plexus (around ICA) → long ciliary nerve → dilator pupillae muscle.


Short ciliary nerve to ciliary muscle
Sympathetic efferent fibers
Ciliary ganglion
III
Midbrain
V
Long ciliary nerve to Dilator pupillæ
Carotid plexus
Medulla
Short ciliary nerve to Sphincter pupillæ
Postganglionic fibers
I. C.
Superior cervical ganglion
I. Th.
II. Th.
I. Thoracic ganglion
Sympathetic efferent (preganglionic) fibers

Innervation of the Urinary Bladder and Rectum

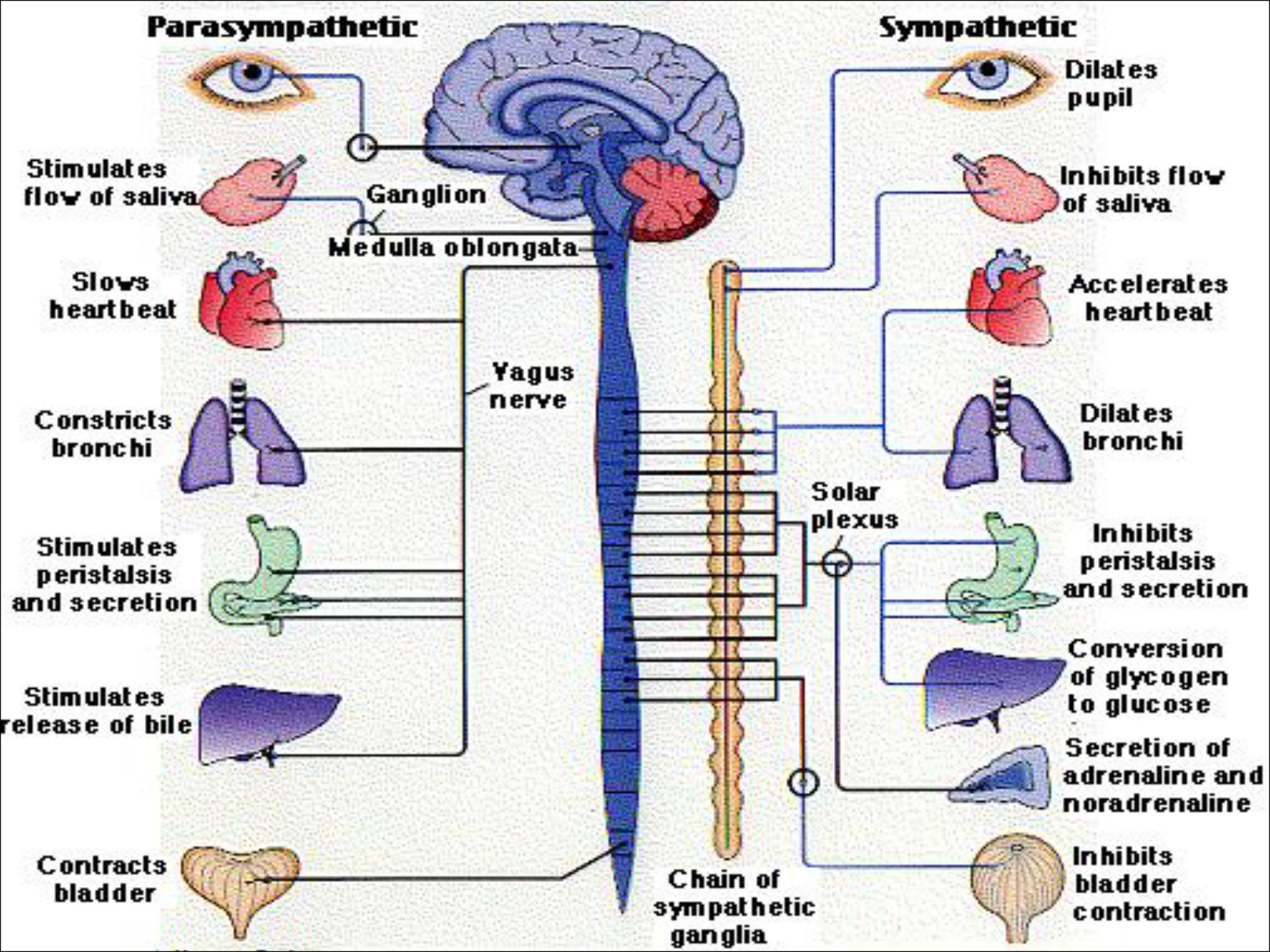
They receive 3 types of nerves:

1. **Somatic innervation (Pudendal nerve):** supplies the striated muscles of the external sphincter of the urethra and rectum.
2. **Sympathetic nerves:** branches from the pelvic plexuses. They supply the blood vessels of the urinary bladder and rectum.
3. **Parasympathetic nerves:** branches from S2, S3 & S4 segments of the spinal cord → pass in S2, S3 & S4 → pelvic plexuses. **They supply:**
    - The muscles of the walls of urinary bladder and rectum **(contraction).**
    - Inhibitory fibers to the internal sphincter of the urinary bladder and rectum **(relaxation).**

Effects of Autonomic Nervous System on Organs and Body

Organ	Sympathetic action	Parasympathetic action
Eye:		
•Pupil	- Dilates	- Constricts
•Ciliary muscle	- Relaxes	- Contracts
Glands:		
•Lacrimal & nasopharyngeal glands	- Reduces secretion	- Increase secretion
•Salivary glands	- Vasoconstriction	- Increase secretion
Heart	- Heart rate & muscle contraction increased	- Heart rate & muscle contraction decreased
Lung:		
•Bronchial muscle	- Dilates bronchi	- Constricts bronchi
•Bronchial arteries	- Constricts	- Dilates
GIT:		
•Muscle in walls	- Decreases peristalsis	- Increases peristalsis
•Muscle in sphincters	- Contracts	- Relaxes
•Glands	- Reduce secretion	- Increases secretion
Kidney	- Decreased urine secretion	- Increased urine secretion
Urinary bladder:		
•Bladder wall	- Relaxes	- Contracts
•Sphincter	- Contracts	- Relaxes

Organ	Sympathetic action	Parasympathetic action
• Gall bladder	- Relaxation	-Contraction
•Liver	- Increased conversion of glycogen to glucose	- Stimulate release of bile
• Pancreas	- Inhibition of insulin and glucagon secretion	- Stimulation of insulin and glucagon secretion
• Male sex organs	- Ejaculation	- Erection
Pineal gland	- Increase melatonin synthesis and secretion	-
Skin: • Sweat glands • Pilomotor muscle	 - Increases secretion - Contraction	 - -
• Platelet	Increase aggregation	-
• lypolisis	- Increase	-
• Renin secretion	- Increase	-
• Mast cells: histamine	- Decrease	-


Parasympathetic
Sympathetic
Dilates pupil
Stimulates flow of saliva
Ganglion
Medulla oblongata
Inhibits flow of saliva
Slows heartbeat
Accelerates heartbeat
Vagus nerve
Constricts bronchi
Dilates bronchi
Solar plexus
Stimulates peristalsis and secretion
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Stimulates release of bile
Secretion of adrenaline and noradrenaline
Contracts bladder
Chain of sympathetic ganglia
Inhibits bladder contraction

Thank You