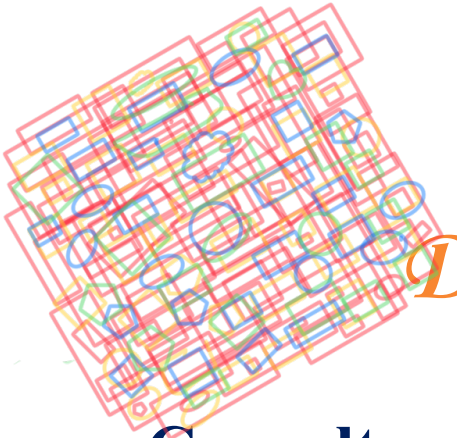
Lecture:

Autonomic Nervous System



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الرجاء تحويل الجوال إلى وضع الصامت
مع الشكر

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:**
  - ✔ Sympathetic nervous system (Thoraco-lumbar) "Fight or Flight".
  - ✔ Parasympathetic nervous system (Cranio-sacral) "Rest and Digest".

Parts of the Autonomic Nervous System

↳ has 2 order neuron.

[PS nucleus: cranial part]
CN3 → EWN
CN7 → SSN
CN9 → ISN
CN 10 → DMN of vagus
most important

in the CNS — first order neuron of ANS

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

↗ nuclei of the cranial nerves [10973]

2. **Peripheral part:** consists of: fibers and ganglia

in the PNS

- Peripheral Sympathetic nervous system (SNS).
- Peripheral Parasympathetic nervous system (PSNS).

* the first order neuron of the sympathetic → intermediolateral nuclei in the lateral horn cell [T_1-L_2]

→ fiber leave the 1st order neuron as preganglionic fiber to [Symp. or Parasymp. ganglia] 2nd order neuron
to reach the 2nd order neuron...
[white matter] preganglionic + myelinated
Axon of 1st order neuron
↙ 1st and 2nd order neurons

The Origin of the Autonomic Nervous System

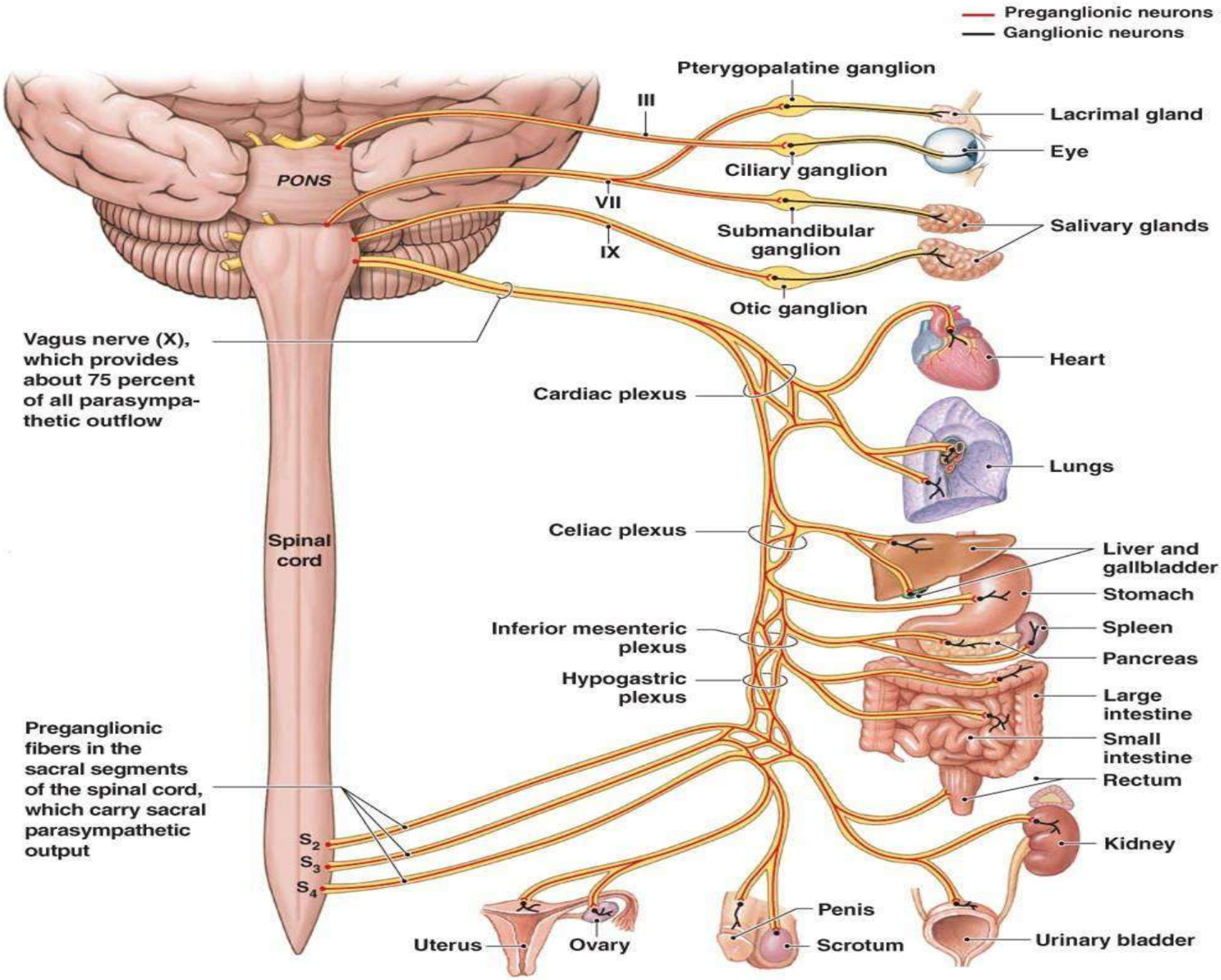
1. The origin of the sympathetic nervous system (Thoraco-lumbar nervous system):

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.**

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

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

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
S2
S3
S4
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).
- **The SNS supplies:**
  1. Skin of the body (its arterioles, sweat glands).
  2. Blood vessels of the limbs (its smooth muscles).
  3. Deep viscera.
- **The PSNS supplies the deep viscera only.**
- Each of the two systems consists of two order neurons.

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 D1-L2 and AHCs of S2-S4 of the spinal cord

- The axons of these cells carry stimuli to the autonomic ganglia **(called preganglionic fibers which are white or myelinated).**

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).**

Types of Autonomic Ganglia

They are present outside the CNS and may be:

1. **Paravertebral ganglia (Sympathetic):** as sympathetic trunk (chain).
2. **Collateral ganglia (Peripheral or Sympathetic):** as celiac, superior mesenteric and inferior mesenteric ganglia.
3. **Terminal ganglia (Parasympathetic):** they are present on the walls of the viscera.

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.**

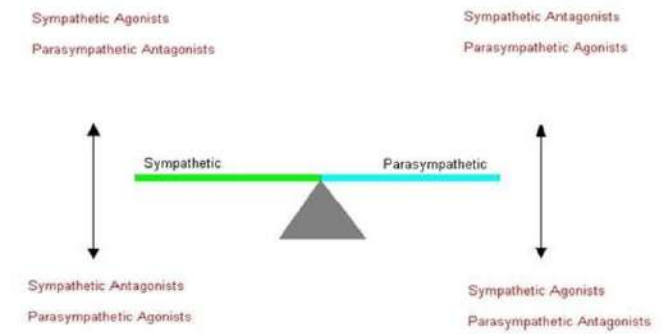
How are the Visceral Structures Supplied by Autonomic (Motor) Fibers?

The autonomic supply to the visceral structures in two points:

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".**

Balance

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.**
   b. body of the second neuron is found in the PNS and its axon is called **a postganglionic fiber.**



in the heart or GIT → PSNS [stimulator], SNS [inhibitor]

Transmitters of the Autonomic Nervous System

1. The preganglionic transmitter:

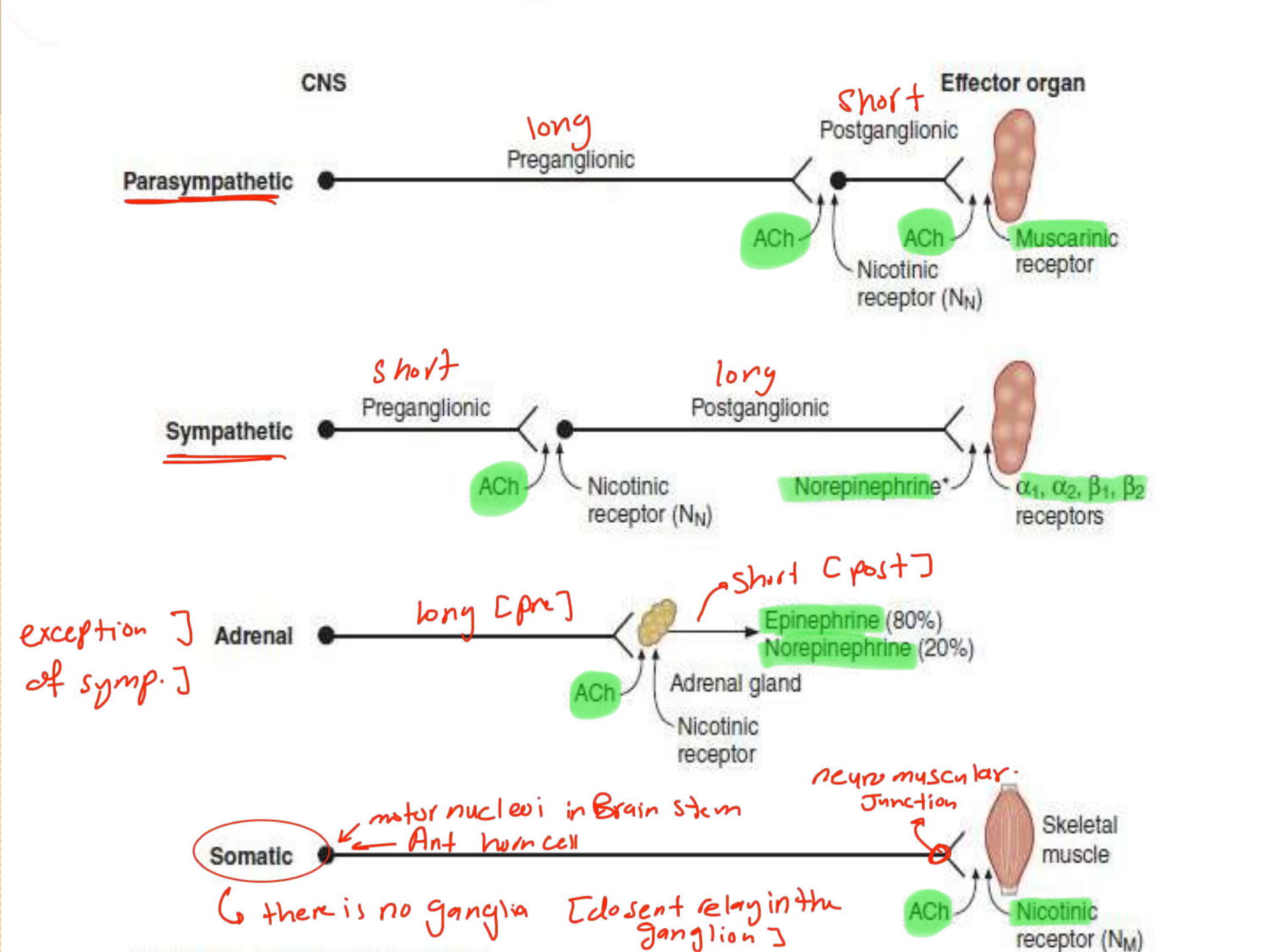
For sympathetic and parasympathetic preganglionic transmitter is **Acetylcholine.**

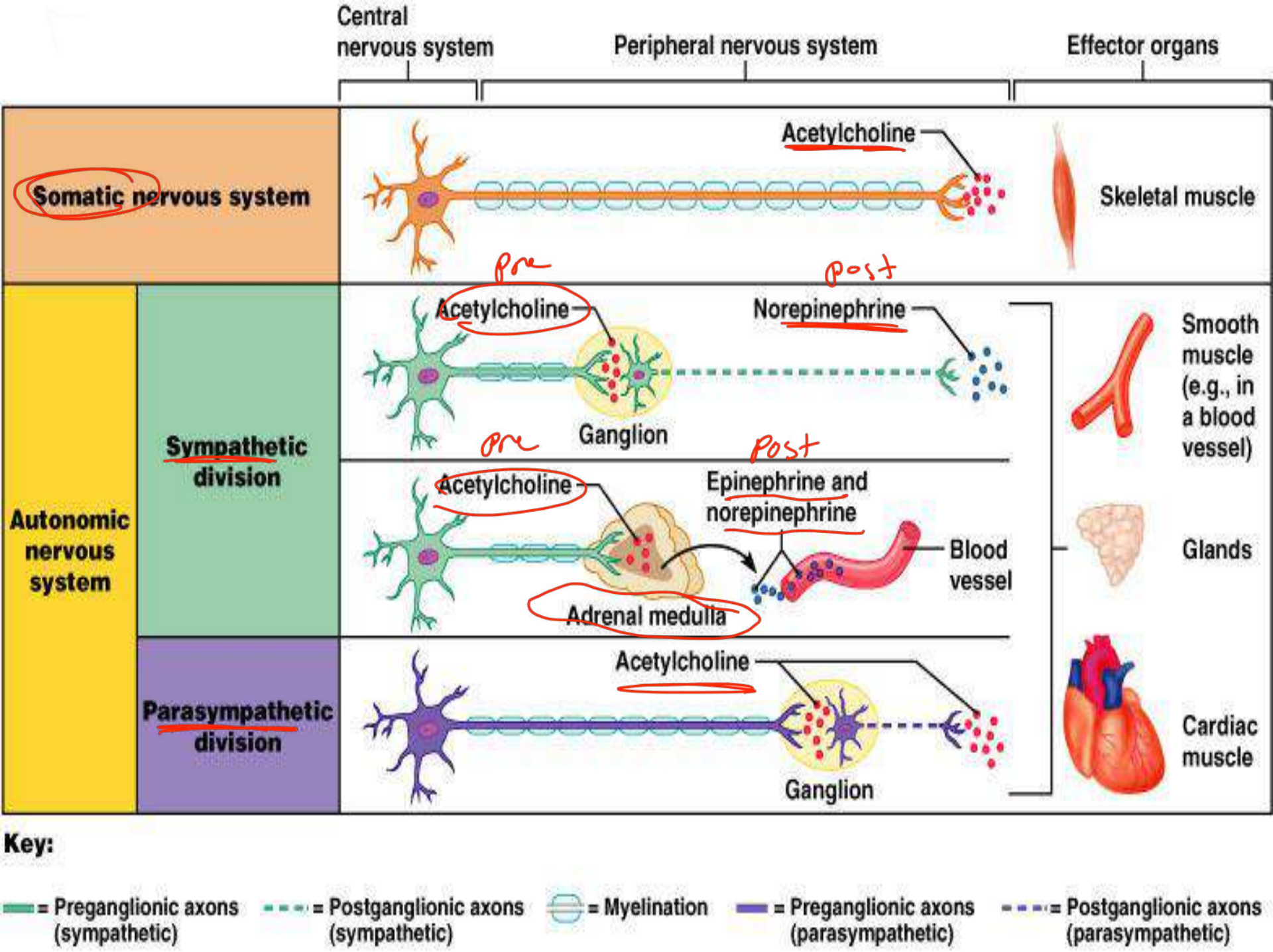
2. The postganglionic transmitter:

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

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

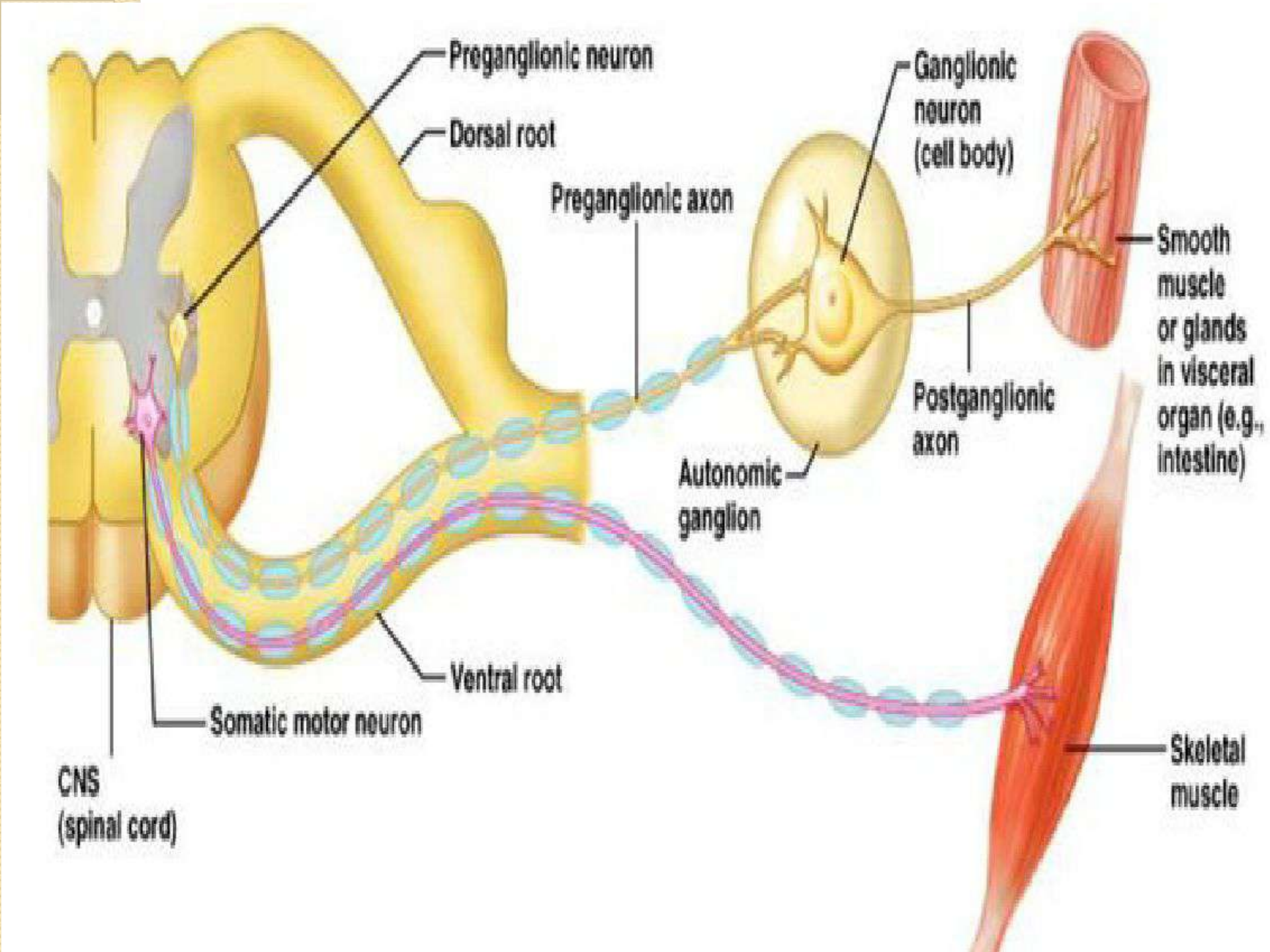
C. The few which are known to be **Acetylcholine** (for the sweat glands).


CNS
Effector organ
long
Preganglionic
Short
Postganglionic
Parasympathetic
ACh
Nicotinic receptor (N_N)
ACh
Muscarinic receptor
Short
Preganglionic
long
Postganglionic
Sympathetic
ACh
Nicotinic receptor (N_N)
Norepinephrine*
α_1, α_2, β_1, β_2 receptors
exception] of symp.]
Adrenal
long [pre]
short [post]
Epinephrine (80%)
Norepinephrine (20%)
ACh
Adrenal gland
Nicotinic receptor
neuromuscular Junction
motor nucleoi in Brain stem
Ant horn cell
Somatic
Skeletal muscle
there is no ganglia [closest relay in the ganglion]
ACh
Nicotinic receptor (N_M)

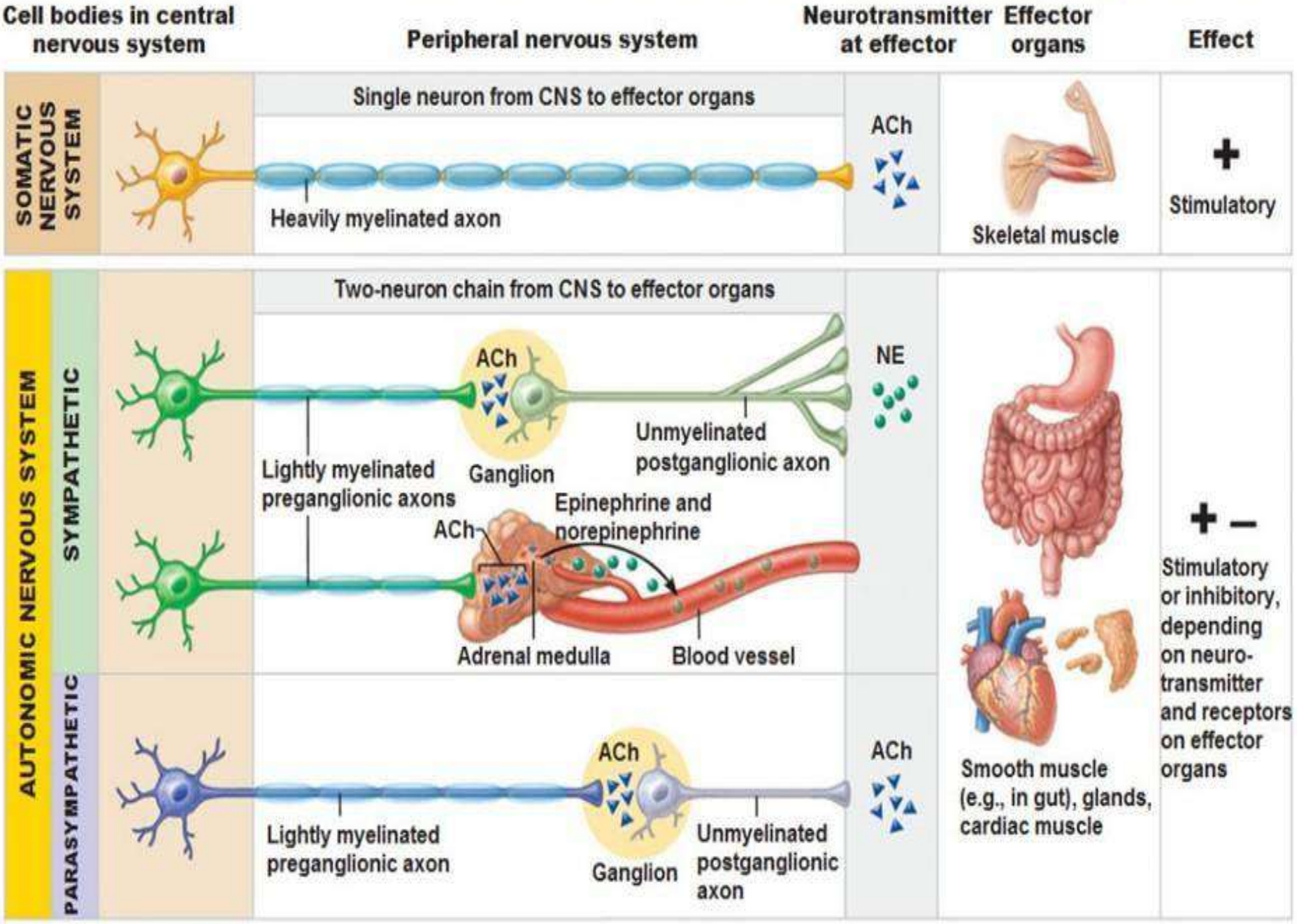

Central nervous system
Peripheral nervous system
Effector organs
Somatic nervous system
Acetylcholine
Skeletal muscle
Autonomic nervous system
Sympathetic division
Pre
Post
Acetylcholine
Norepinephrine
Ganglion
Smooth muscle (e.g., in a blood vessel)
Pre
Post
Acetylcholine
Epinephrine and norepinephrine
Blood vessel
Adrenal medulla
Glands
Parasympathetic division
Acetylcholine
Ganglion
Cardiac muscle
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).	Fibers synapse once at a ganglion after they leave the CNS (two-neuron chain). Motor control.
Innervates skeletal muscle fibers, always stimulatory	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
Autonomic ganglion
Ventral root
Somatic motor neuron
CNS (spinal cord)
Skeletal muscle

Comparison of Autonomic and Somatic Motor Systems



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

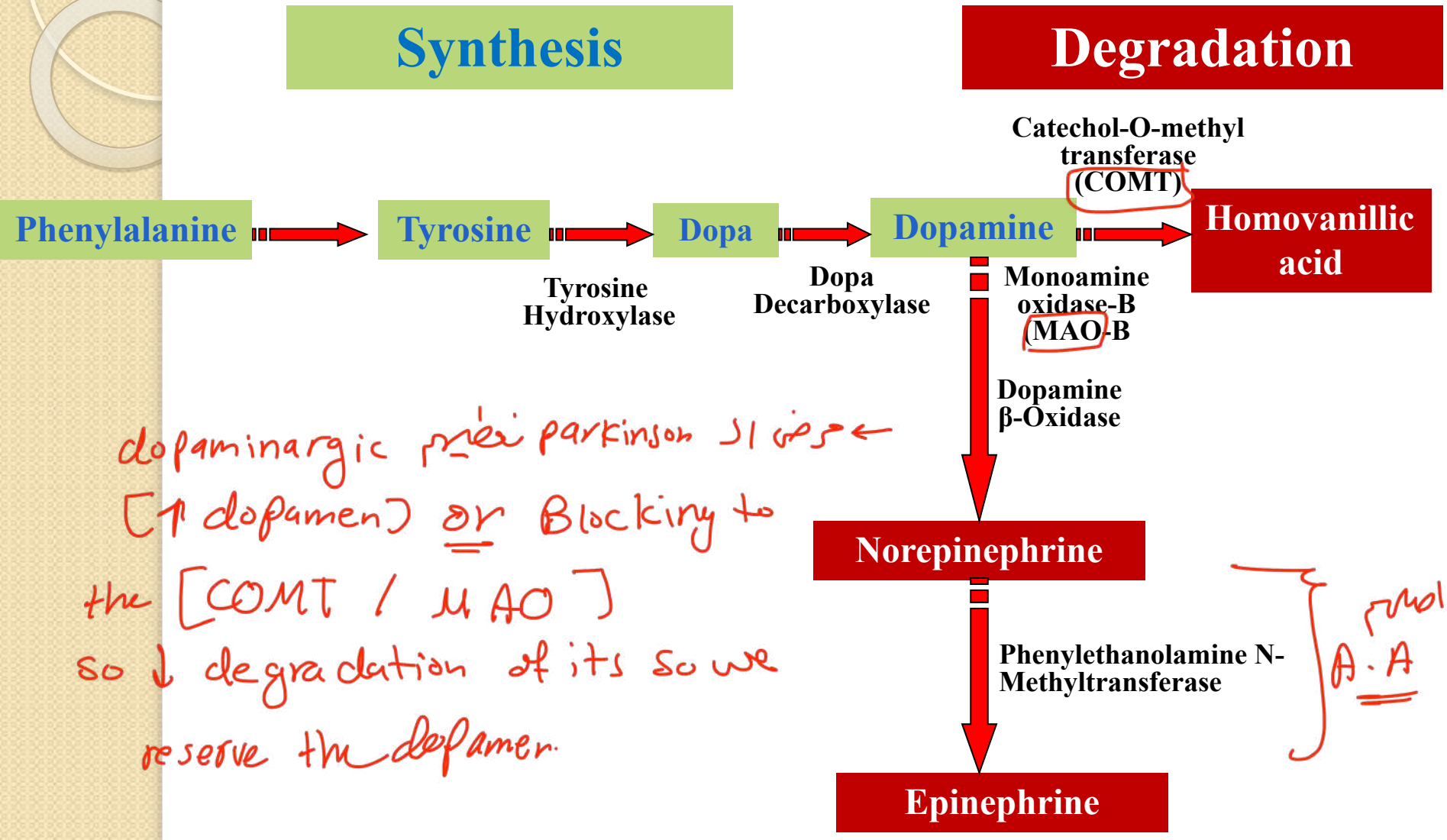
Neurotransmission at adrenergic Neurons

- **The process involves five steps:**

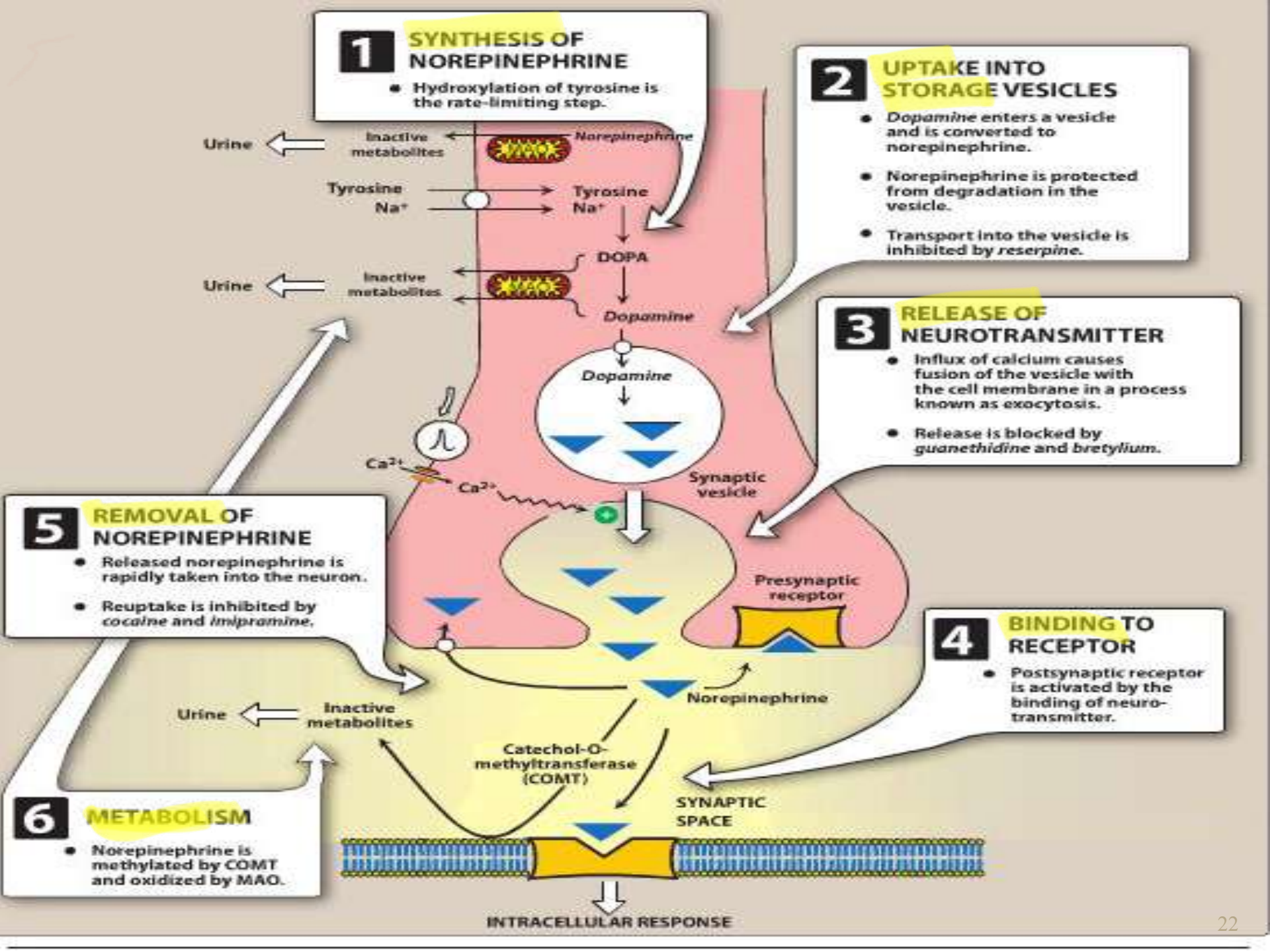
1. Synthesis.
2. Storage. uptake
3. Release.
4. Receptor binding.
5. Removal of the neurotransmitter . and metabolism

بيتم اخر بتركيز neurotransmitter

Pathway of Dopamine Metabolism



dopaminargic مثل parkinson ← [↑ dopamen] or Blocking to the [COMT / MAO] so ↓ degradation of its so we preserve the dopamen.


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 neurotransmitter.
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
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:

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

Receptor Types in the ANS

1. Adrenergic receptors (adrenoreceptors):

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).

mydriasis, contraction of sph. → Bladder, GIT, Rectum; constriction of BV.

- **Alpha "α_2" Receptors:** are located on walls of GIT, and wall of bladder.
  - ✔ **Effect:** often produce inhibition effect or relaxation.

wall of Bladder, rectum [relaxed in the rest].

Alpha 1 receptors

Vasoconstriction

↑BP

Mydriasis

dilatation of iris M.

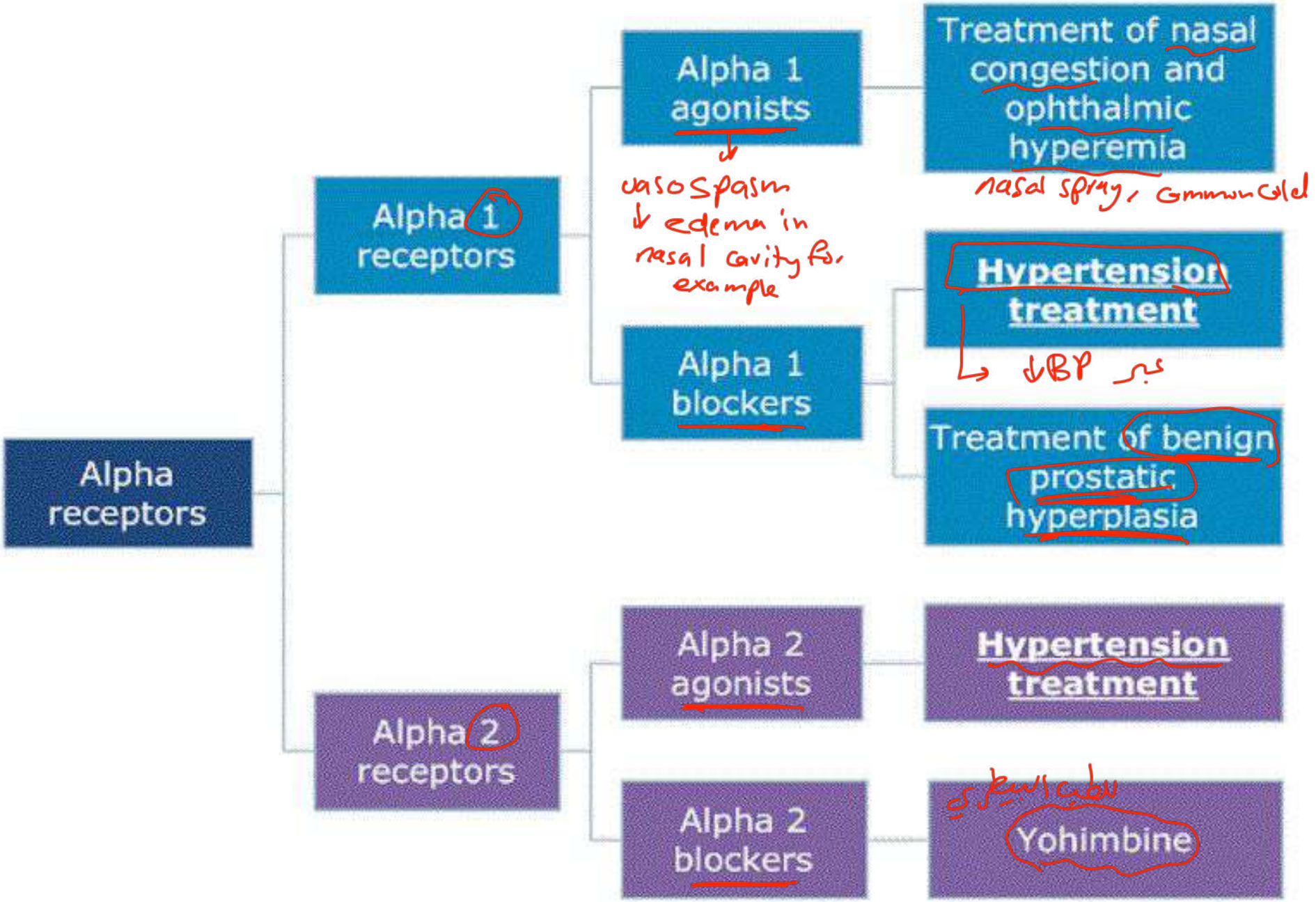
Increased closure of internal sphincter of the bladder

urination ل منع / defecation.

Increased peripheral resistance

Increased blood pressure

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).

- **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.
  - ✔ **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

↑ heart rate

Increased chronotropy and inotropy

Increased AV-node conduction velocity

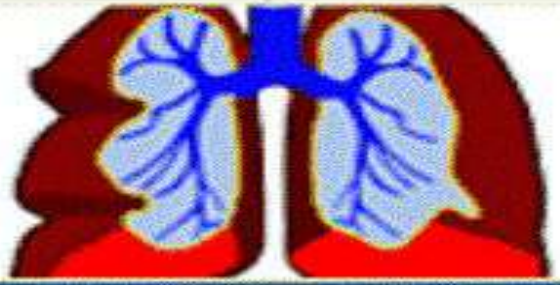
Renal juxtaglomerular cells

↑ renin production

Increased renin release

↑ angiotensin

β-2 receptors



Bronchial smooth muscle

resp.

Bronchodilation

spasm relaxation

we it use in Bronchial asthma

Uterine muscle

Uterine relaxation (tocolysis)

β-2 receptors

Bladder detrusor muscle

Relaxation

Eye ciliar muscle

Relaxation

GI tract

Decreased motility

Liver

Increased glucose metabolism, lipolysis

Smooth muscle

Relaxation

2. Cholinergic Receptors (cholinoreceptors)

Laparasympathatic.

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.

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

a. Are **inhibitory in the heart** (e.g., decreased heart rate, decreased conduction velocity in AV node).

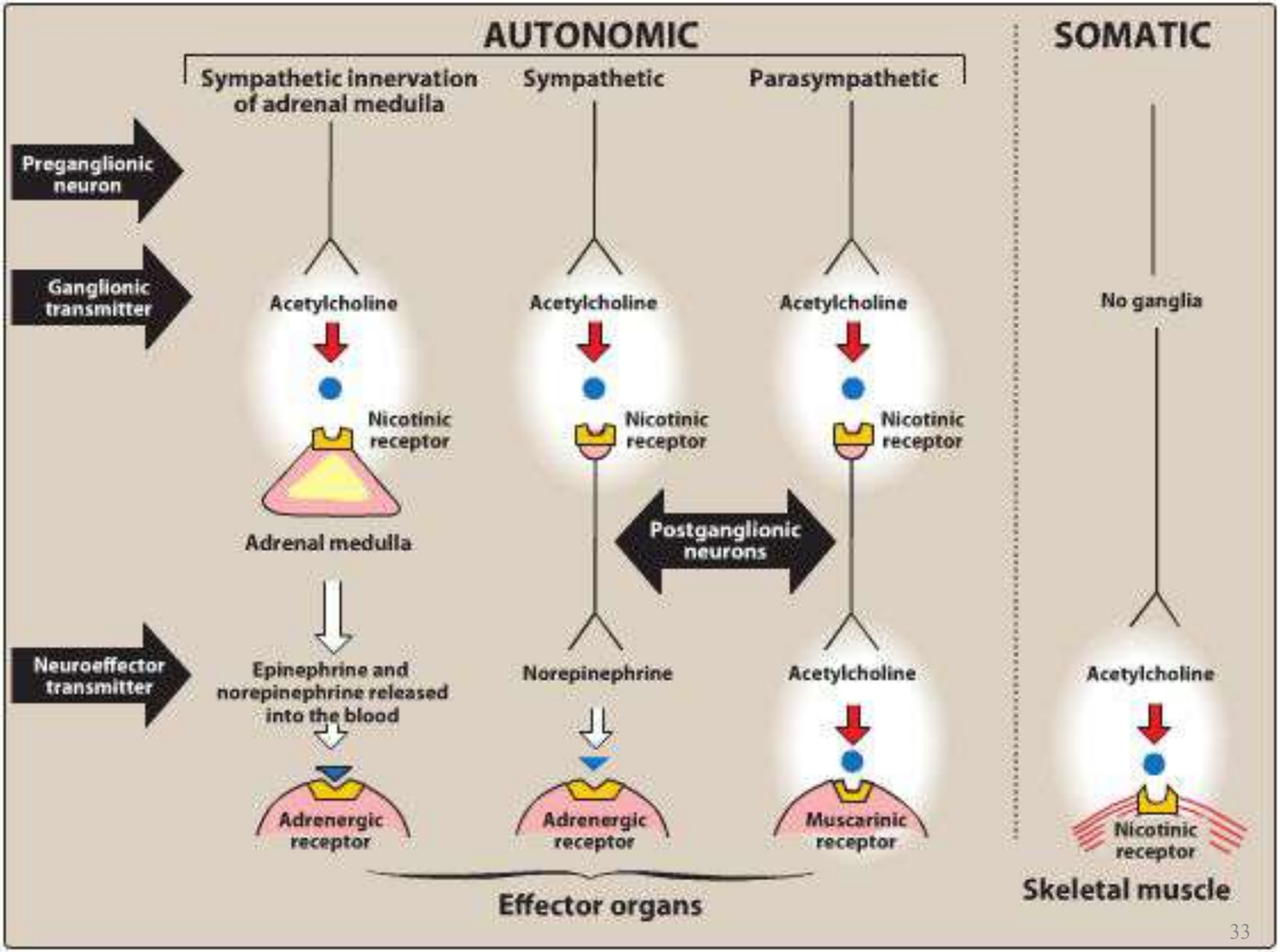
b. Are **excitatory in smooth muscle** and **glands** (e.g., increased GI motility, increased secretion).

c. Are activated by **ACh and muscarine.**

d. Are blocked by **atropine.**

Adrenal Medulla

- 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.
- **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
Ganglionic transmitter
Neuroeffector transmitter
Acetylcholine
Acetylcholine
Acetylcholine
No ganglia
Nicotinic receptor
Nicotinic receptor
Nicotinic receptor
Adrenal medulla
Postganglionic neurons
Epinephrine and norepinephrine released into the blood
Norepinephrine
Acetylcholine
Acetylcholine
Adrenergic receptor
Adrenergic receptor
Muscarinic receptor
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.

↳ anti-emetic act in the vomiting centres in the medulla oblongata.

3. Midbrain:

- Micturition center.

4. Hypothalamus:

irritation to hypothalmus ← ventricular system داخل ← ضغط داخلي ← تزيف

- Temperature regulation center. + ↑ temp when we give him anti biotic [عند يعطى] due to central fever.
- Thirst and hunger regulatory centers.

Effect of the Autonomic Nervous System on Organ Systems

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

1. **Sympathomimetics Drugs:** stimulation of adrenergic receptor.
2. **Sympatholytic Drugs:** block the action of the neurotransmitters at the adrenergic receptors.
3. **Cholinergic "Anticholinesterase" Drugs:** stimulation the cholinergic receptors.
4. **Anticholinergic Drugs:** block cholinergic receptors.

The Parasympathetic Ganglia in the Head and Neck

There are four parasympathetic ganglia in the head and neck:

1. Ciliary ganglion.
2. Submandibular ganglion.
3. Sphenopalatine (pterygopalatine) ganglion.
4. Otic ganglion.

ocular motor nerve

facial nerve via chorda tympani N.

glossopharyngeal nerve.

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:**

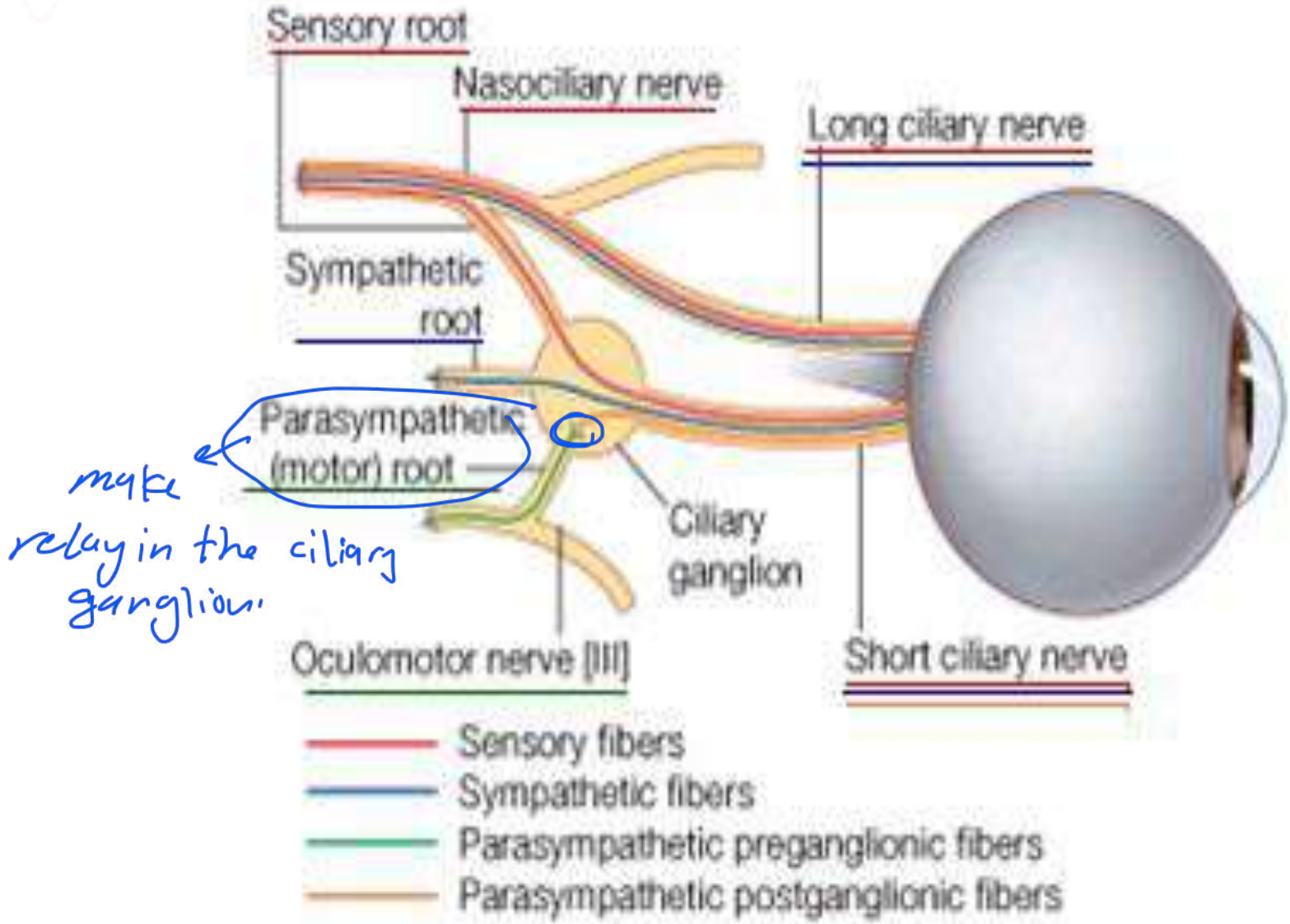
1. **Sensory root:** branch from nasociliary nerve (branch of ophthalmic nerve).
2. **Sympathetic root:** from the sympathetic plexus around the ICA.
3. **Parasympathetic root:** from nerve to inferior oblique muscle (branch of oculomotor nerve).

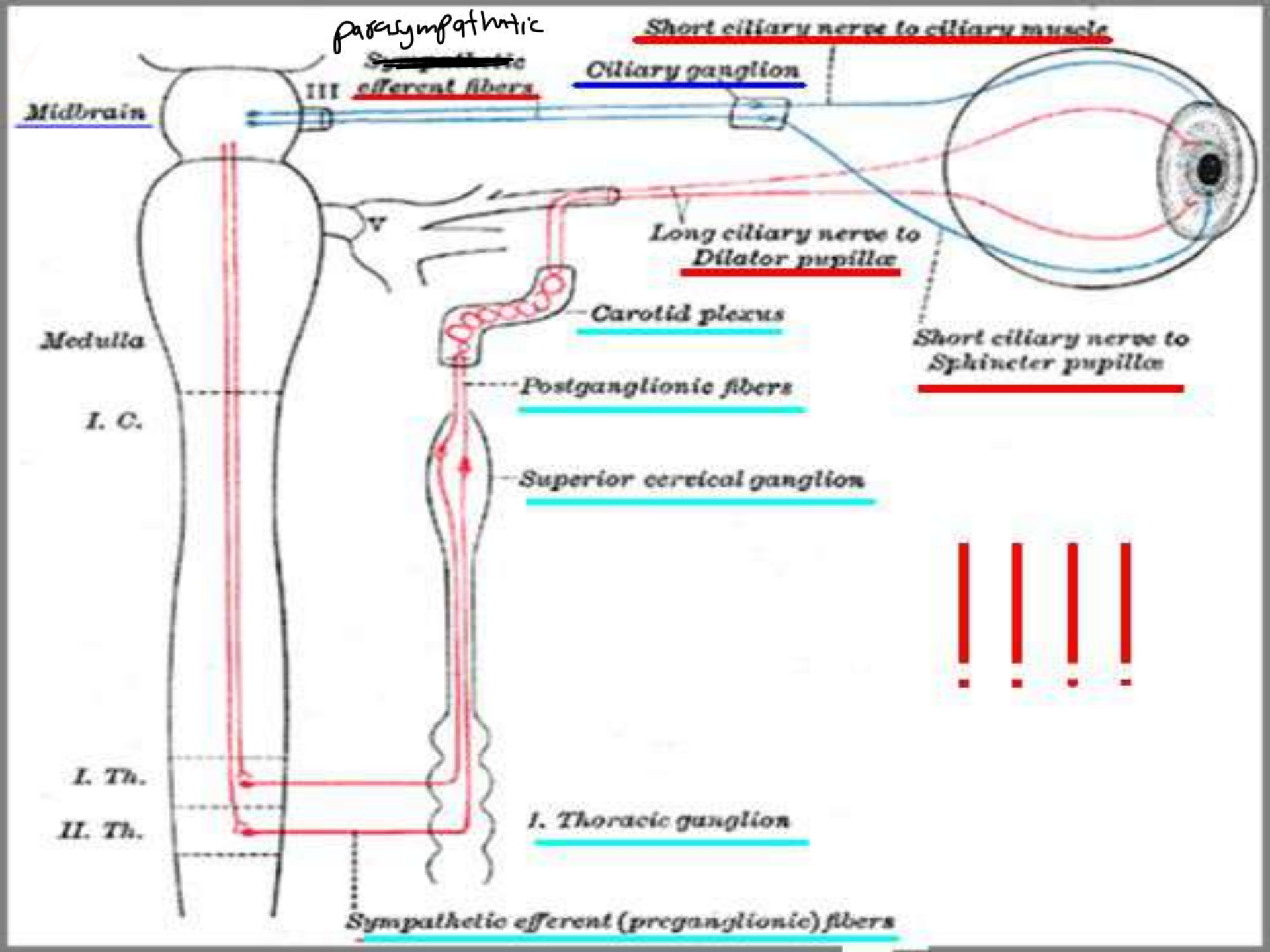
Branches of the Ciliary Ganglion

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

They contain:

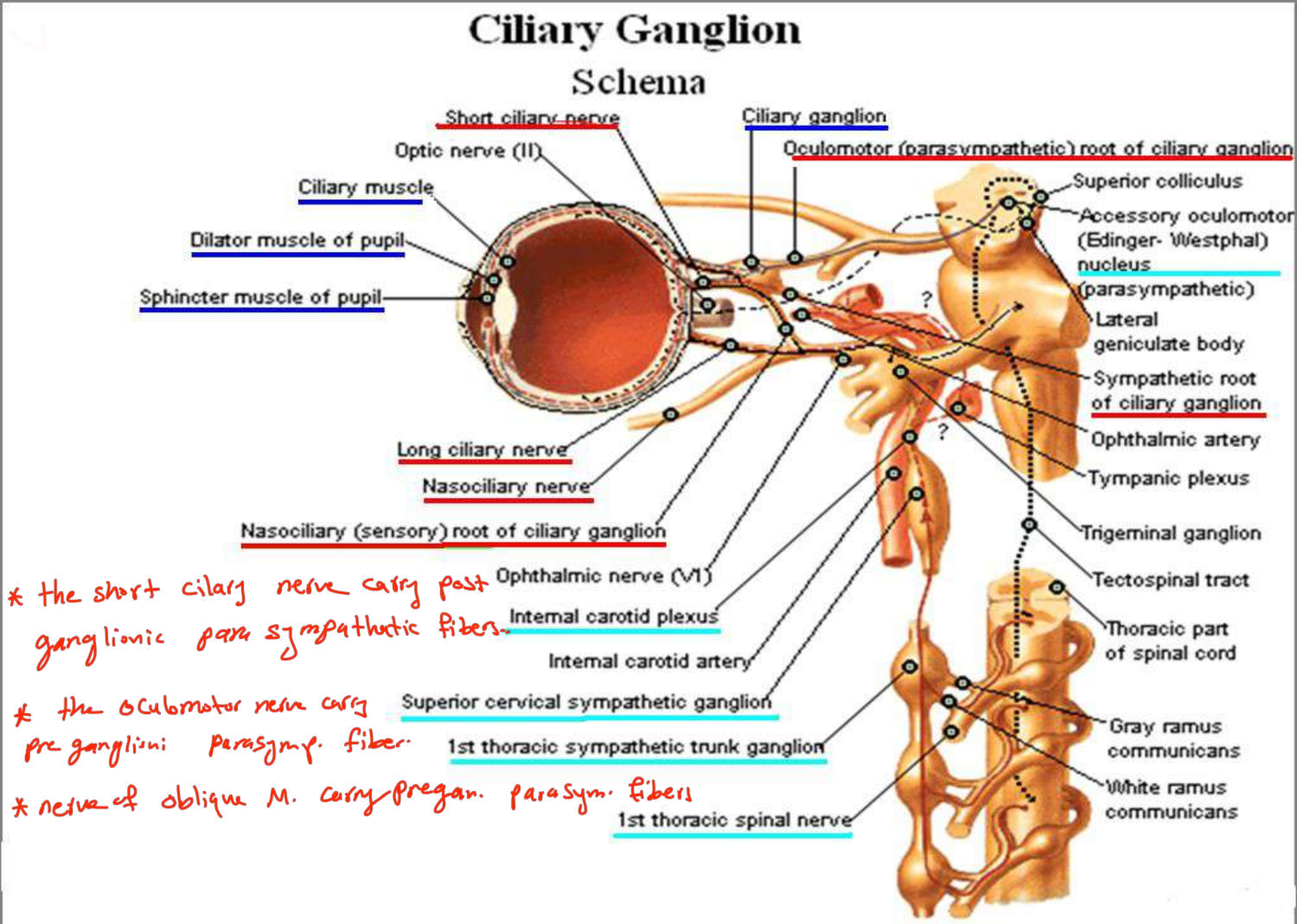
1. **Sympathetic fibers:** to the blood vessels of the eye.
2. **Sensory fibers:** to the cornea and iris.
3. **Parasympathetic fibers:** to the supply the sphincter pupillae (for light reflex) and ciliary muscle (for accommodation).


Sensory root
Nasociliary nerve
Long ciliary nerve
Sympathetic root
Parasympathetic (motor) root
make relay in the ciliary ganglion
Ciliary ganglion
Oculomotor nerve [III]
Short ciliary nerve
Sensory fibers
Sympathetic fibers
Parasympathetic preganglionic fibers
Parasympathetic postganglionic fibers


parasympathetic
Short ciliary nerve to ciliary muscle
Ciliary ganglion
III efferent fibers
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



* the short cilary nerve cary post ganglionic para sympathetic fibers.

* the oculomotor nerve cary pre ganglionic parasymp. fiber.

* nerve of oblique M. cary pregan. parasym. fibers

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:**

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

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.**

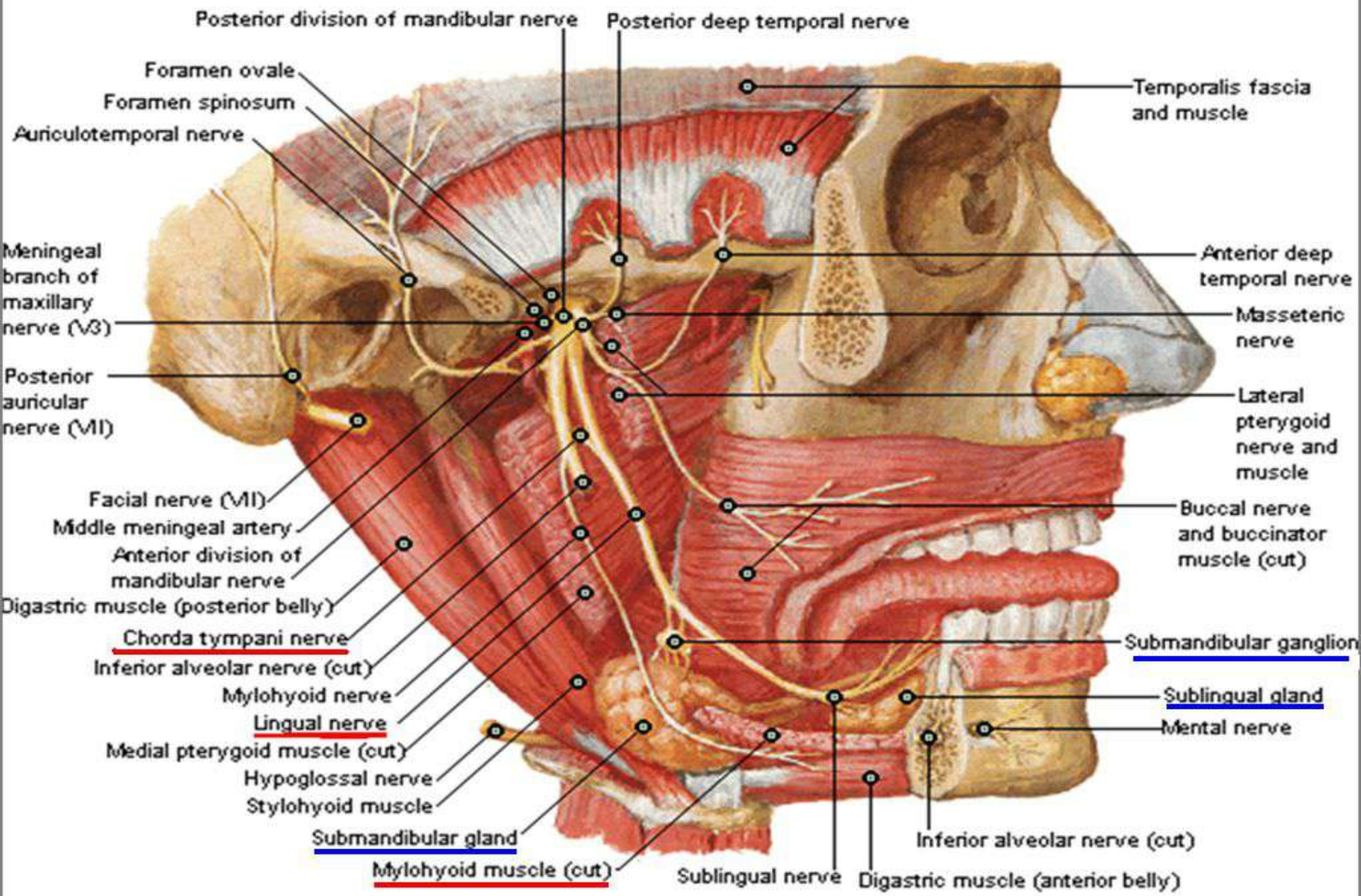
target organ

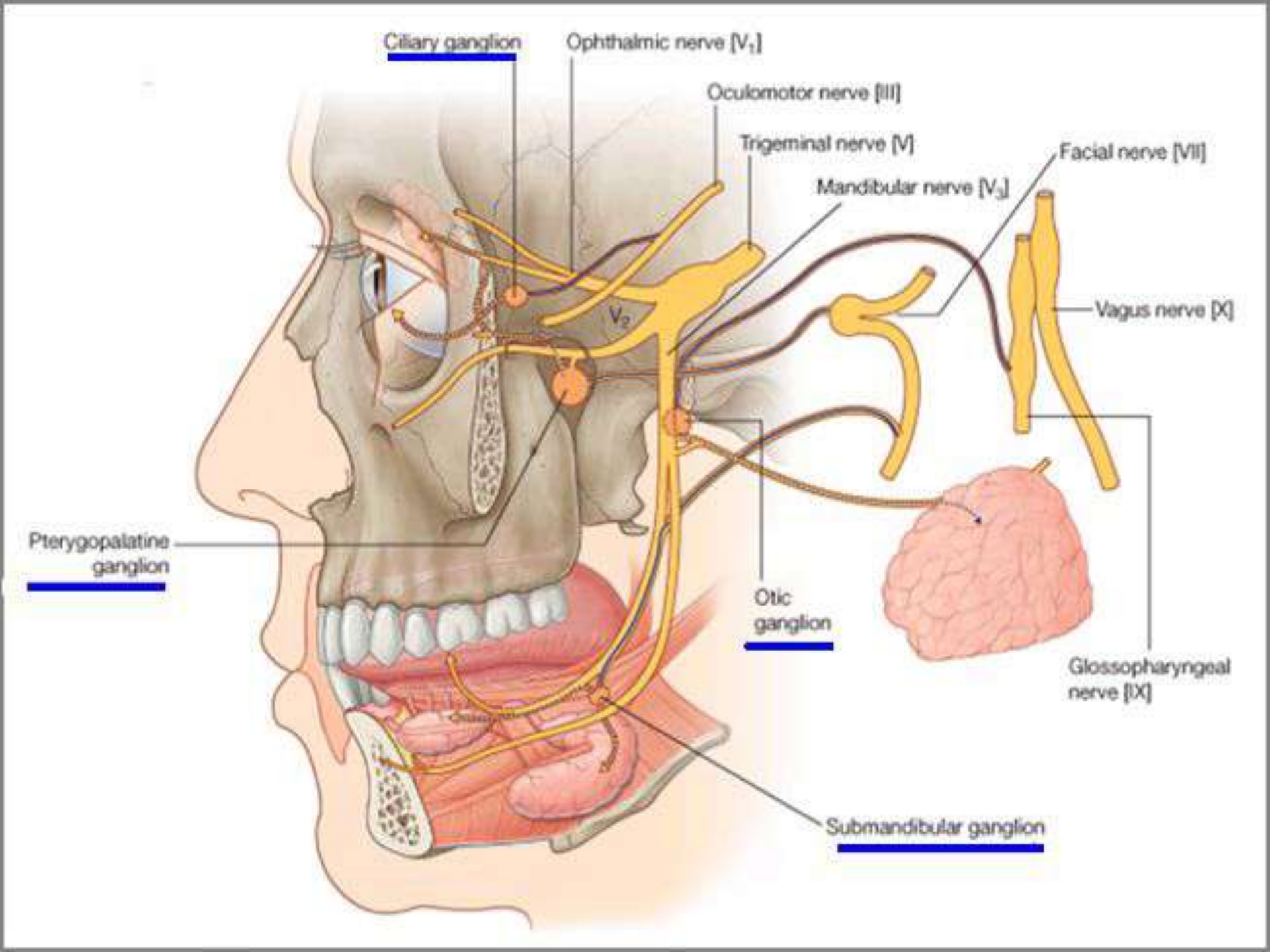
target organ.

of parasymp.

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

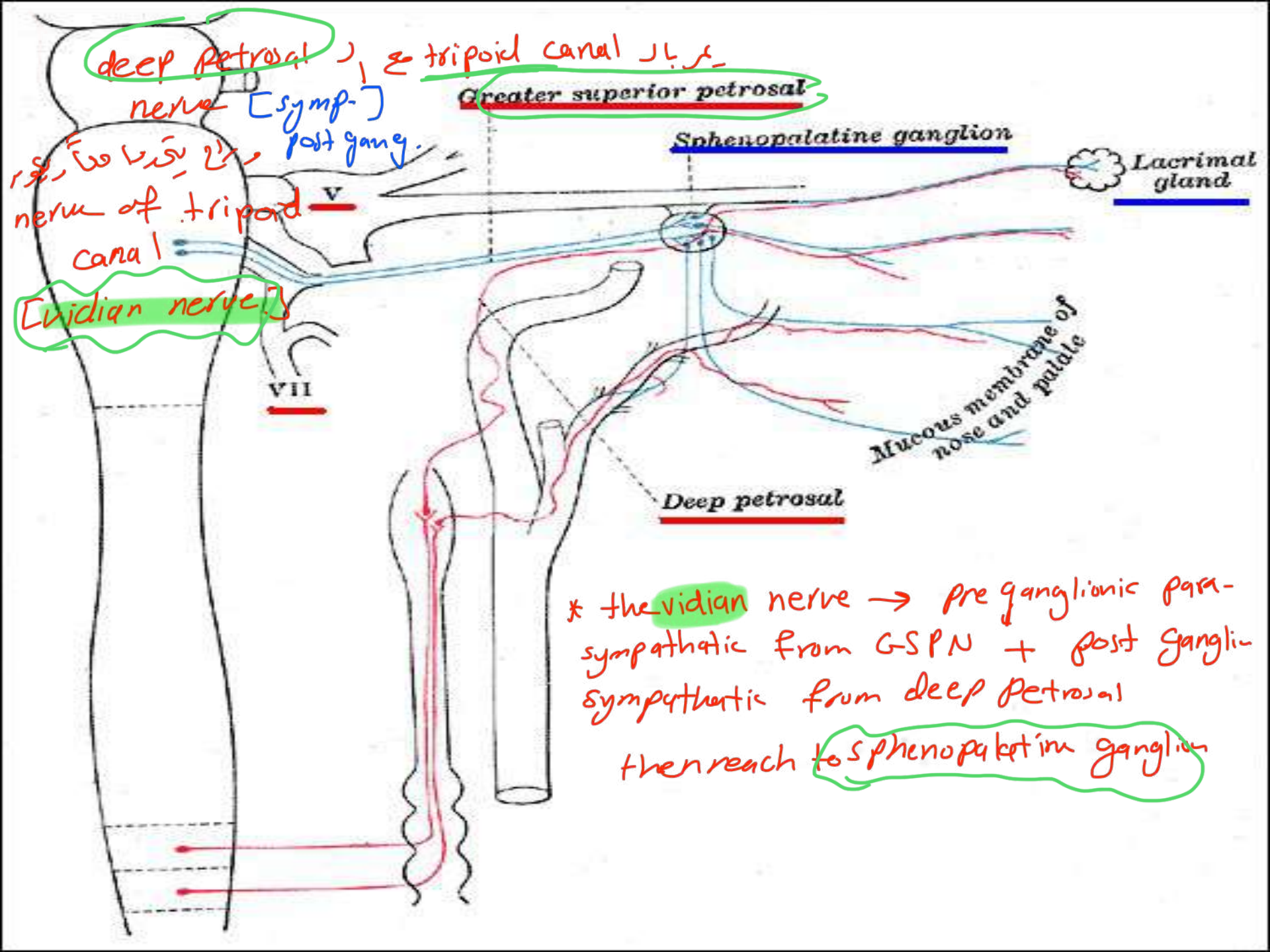
Sphenopalatine (Pterygopalatine) Ganglion

- **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.
  2. **Sympathetic root:** the deep petrosal nerve from sympathetic plexus around the ICA.
  3. **Parasympathetic root:** the greater petrosal nerve (branch of facial nerve).

superior

GSPN

make relay.

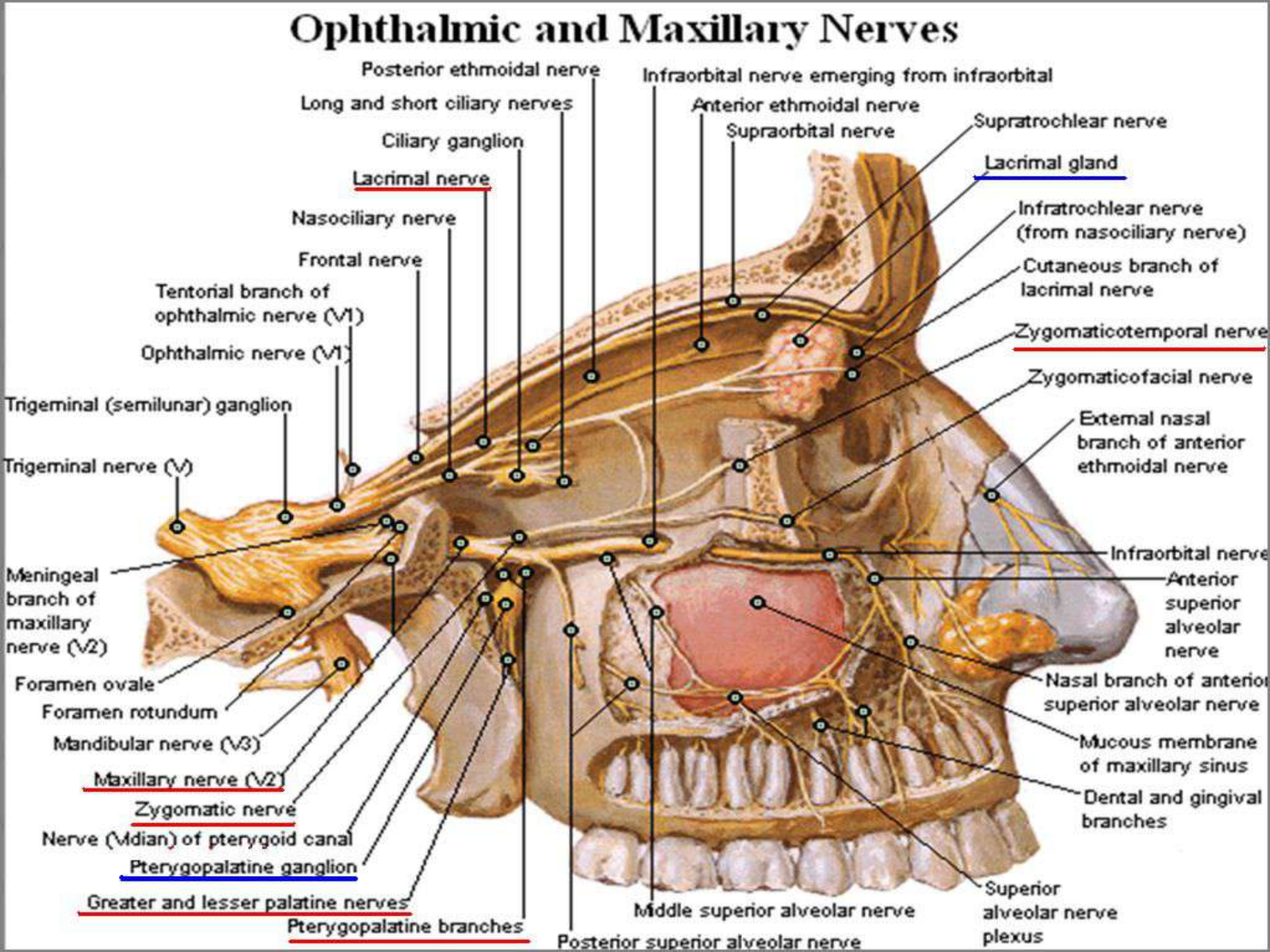


* the vidian nerve → preganglionic parasympathetic from GSPN + post ganglionic sympathetic from deep petrosal then reach to sphenopalatine ganglion

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



Otic Ganglion

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

1. **Motor root:** arising from nerve to medial pterygoid muscle (branch of the main trunk of mandibular nerve).
2. **Parasympathetic root:** formed by lesser superficial petrosal nerve (branch of glossopharyngeal nerve).
3. **Sympathetic root:** from the plexus around middle meningeal artery (from the plexus around ECA).

* first order neuron → inferior salivary nucleous.

Branches of the Otic Ganglion

* the tympanic N or glosso pharanger, or lesser superficial petrosal N is :- pre ganglionic fiber.

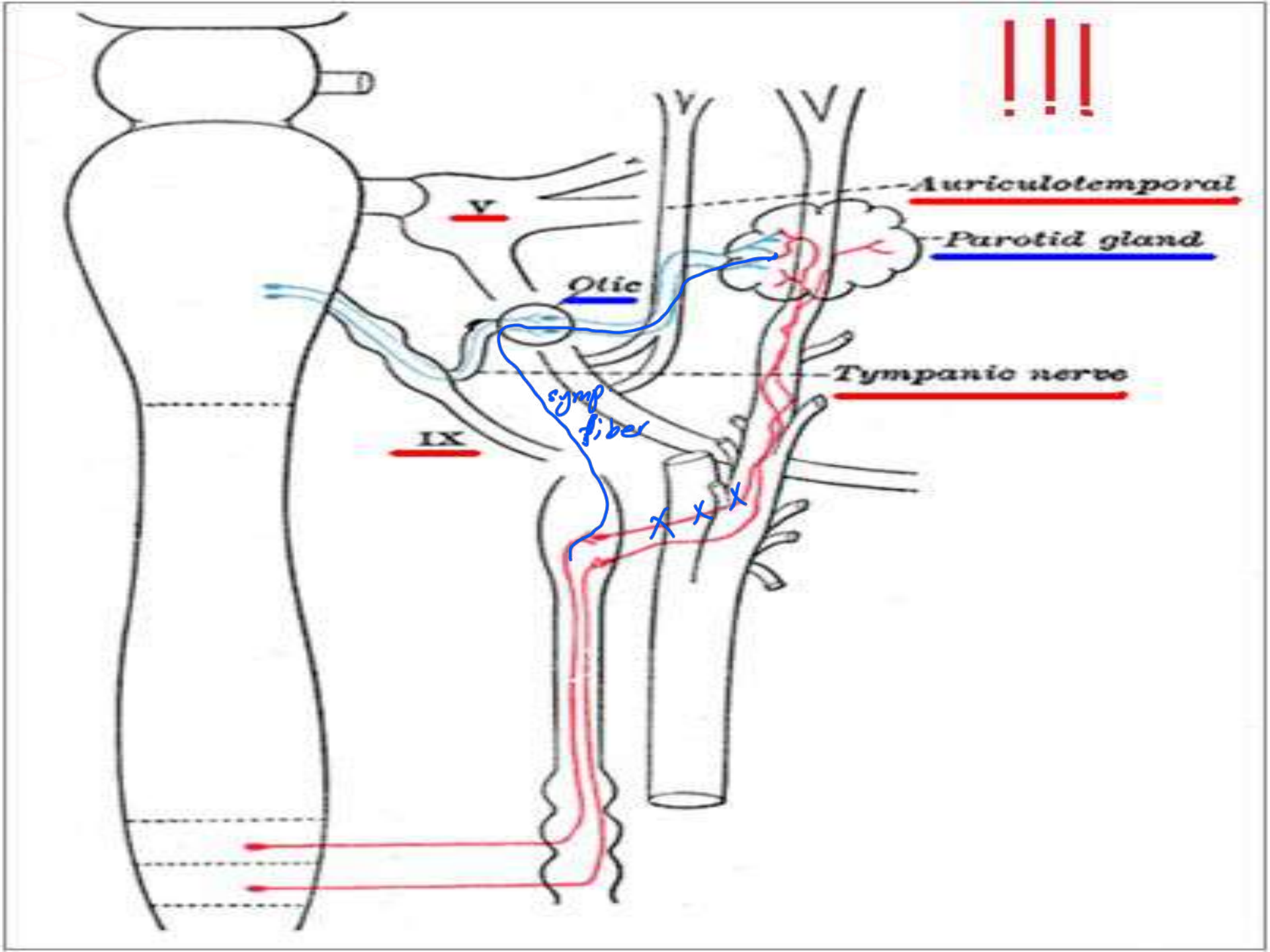
1. **Motor branch:** to tensor palati muscle and another branch to tensor tympani muscle.

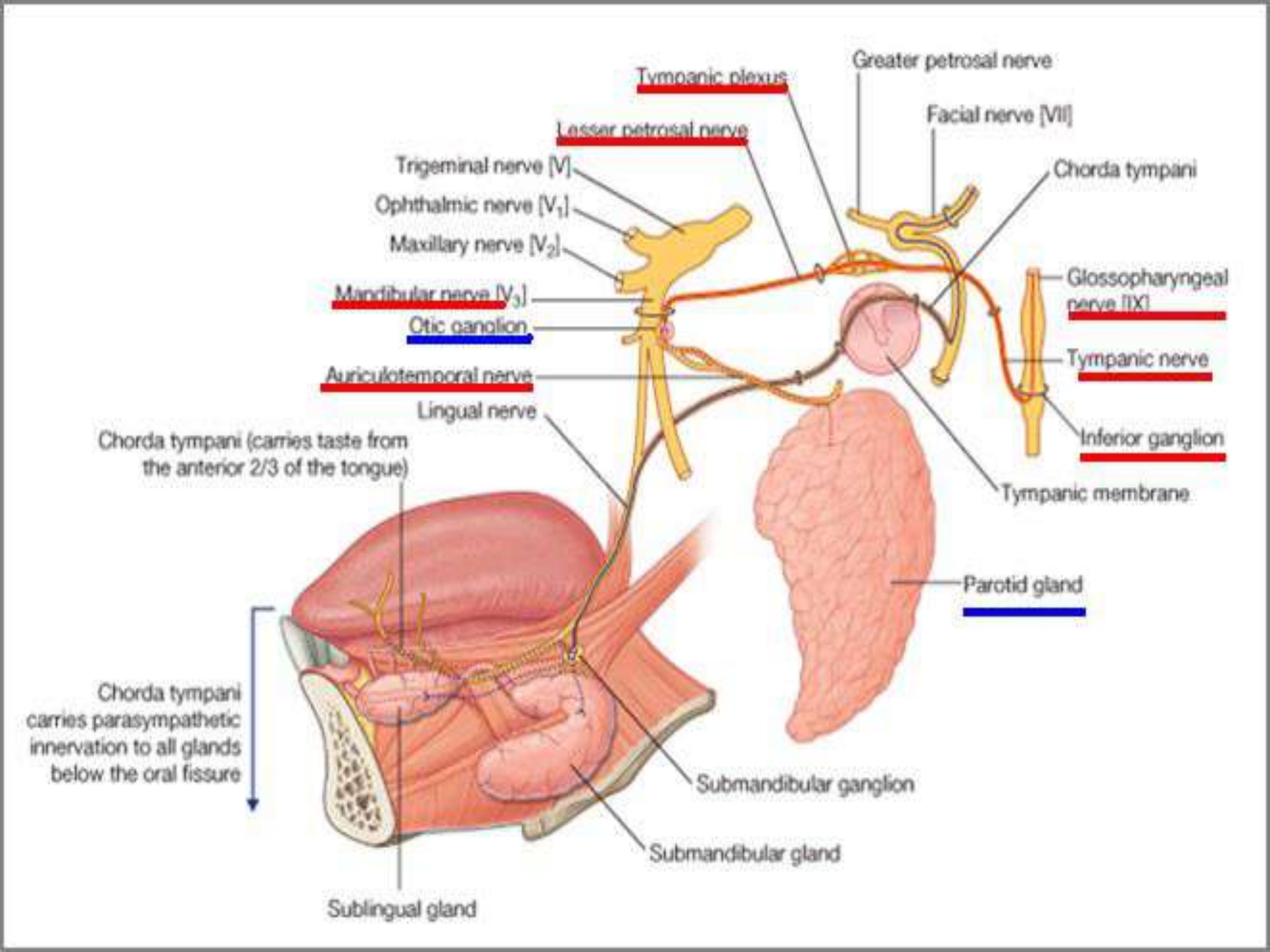
2. **A communicating branch:** to auriculotemporal nerve, this branch is formed of:

   a. **Sympathetic fibers:** to supply the blood vessels of parotid gland.

   b. **Parasympathetic fibers:** secretomotor to parotid gland.

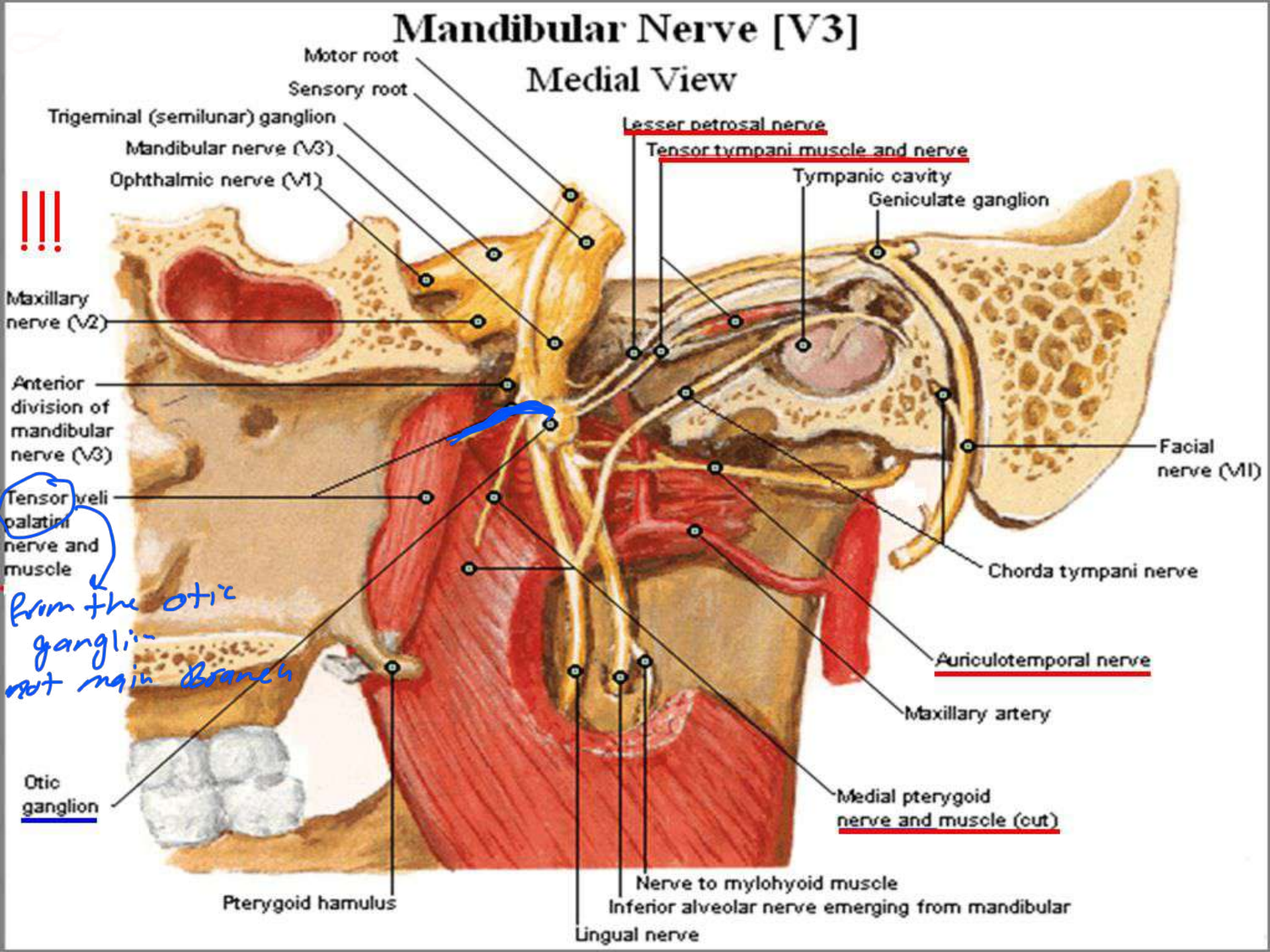
* the 2nd order neuron :→ otic ganglion
* the target organ :- parotid gland.


!!!
V
V
V
Auriculotemporal
Parotid gland
Otic
Tympanic nerve
symp fiber
IX
X X X


Tympanic plexus
Greater petrosal nerve
Facial nerve [VII]
Lesser petrosal nerve
Trigeminal nerve [V]
Ophthalmic nerve [V1]
Maxillary nerve [V2]
Chorda tympani
Mandibular nerve [V3]
Glossopharyngeal nerve [IX]
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

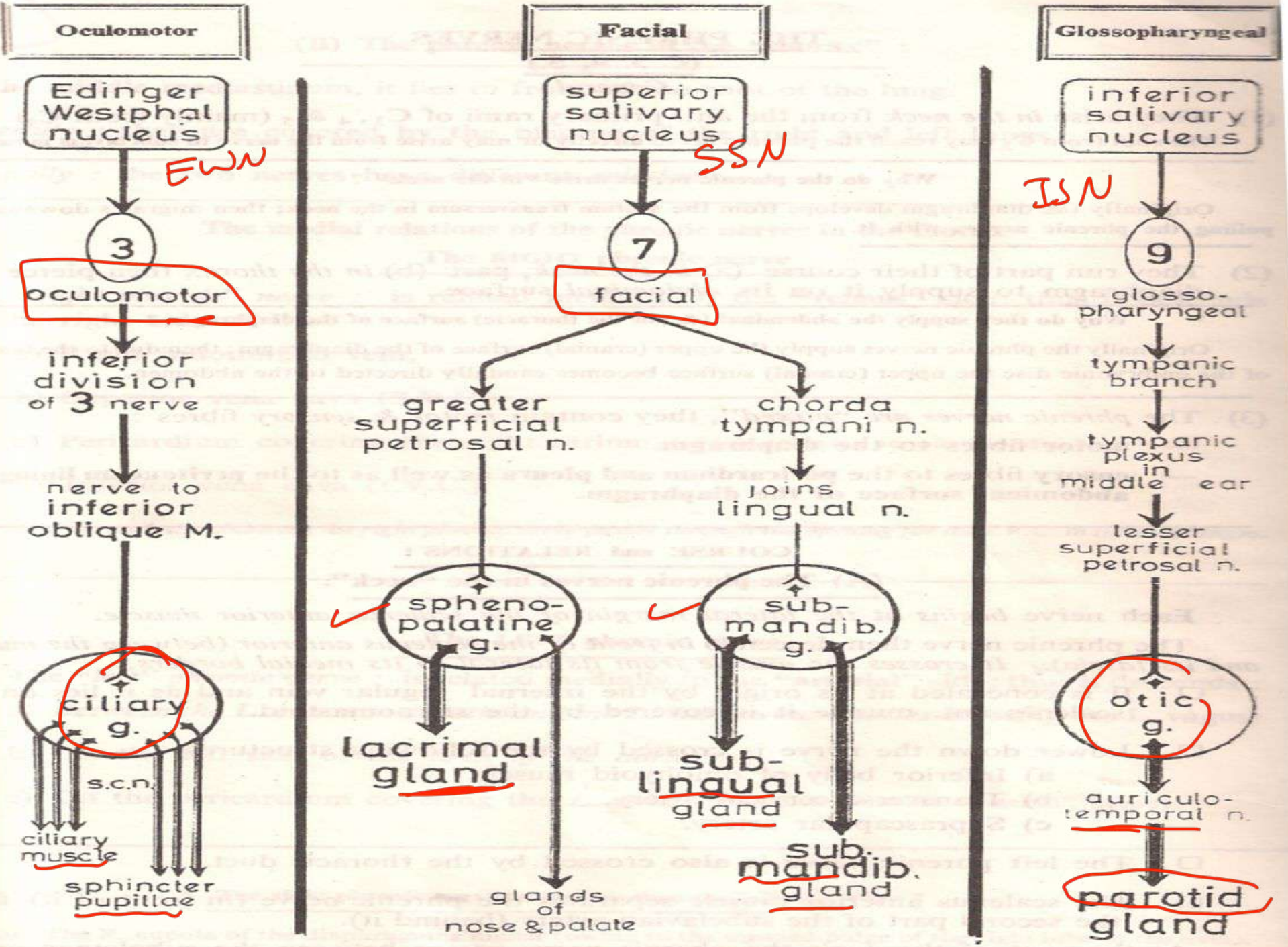
Mandibular Nerve [V3]

Medial View



The Parasympathetic Ganglia in the Head and Neck

Ganglion	Nucleus	Parasympathetic root	Sensory or motor root	Sympathetic root	Organs supplied
Ciliary	Edinger-Westphal	Oculomotor nerve	Nasociliary	Nasociliary nerve from internal carotid plexus	Sphincter pupillae and ciliary muscles
Sphenopalatine	Superior salivary	Greater superficial petrosal nerve from VII nerve	Maxillary	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	Mandibular "Motor"	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


Oculomotor
Edinger Westphal nucleus
EWN
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
SSN
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
ISN
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

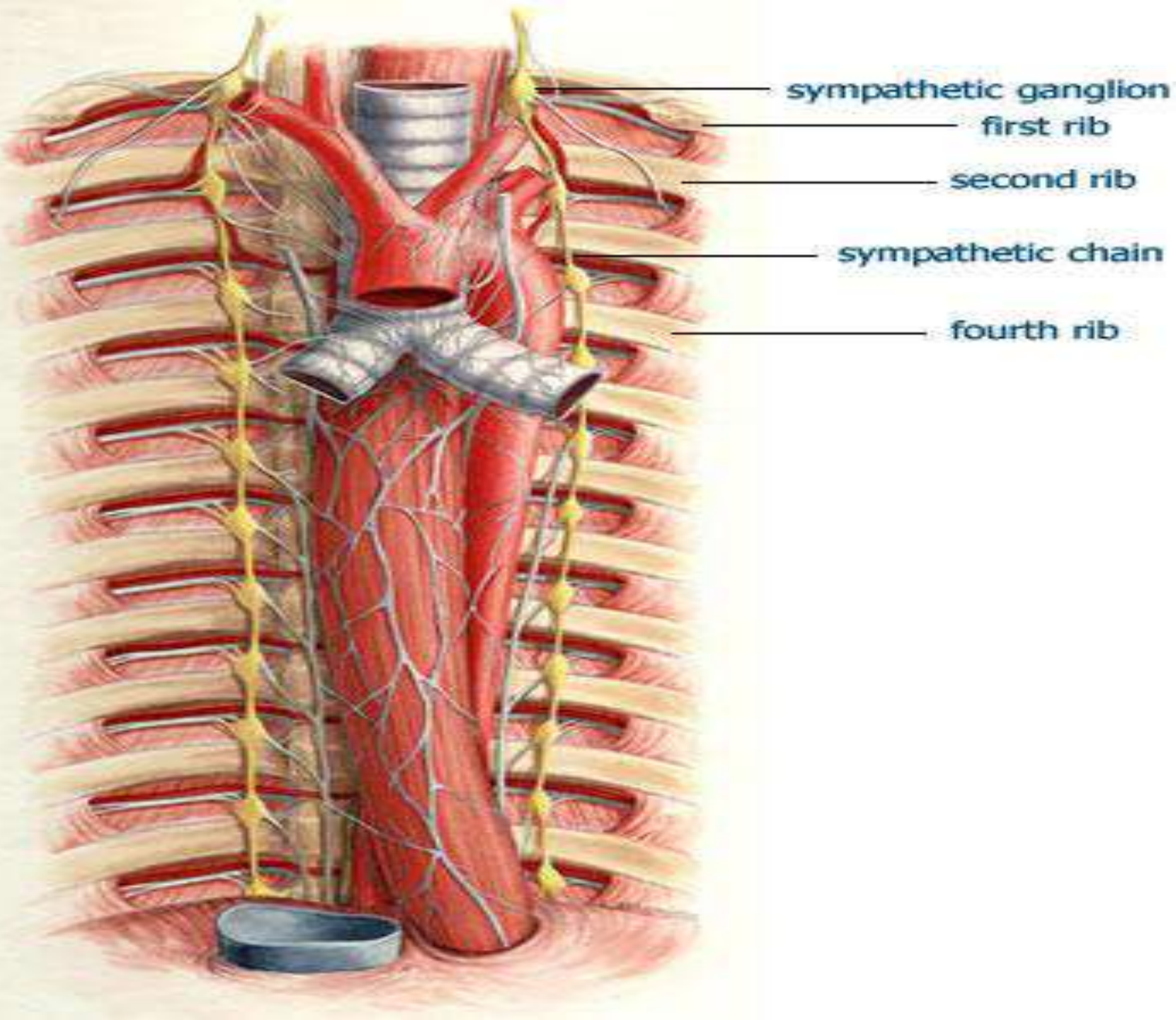
1. **Paravertebral Ganglia:** which formed the sympathetic chain or trunk.
   - ❖ There are two sympathetic chains (right and left) on each side of the vertebral column.
   - ❖ Each chain extends from the level of the **first cervical vertebra** (above) to front of **the coccyx** (below) where two chains 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.**

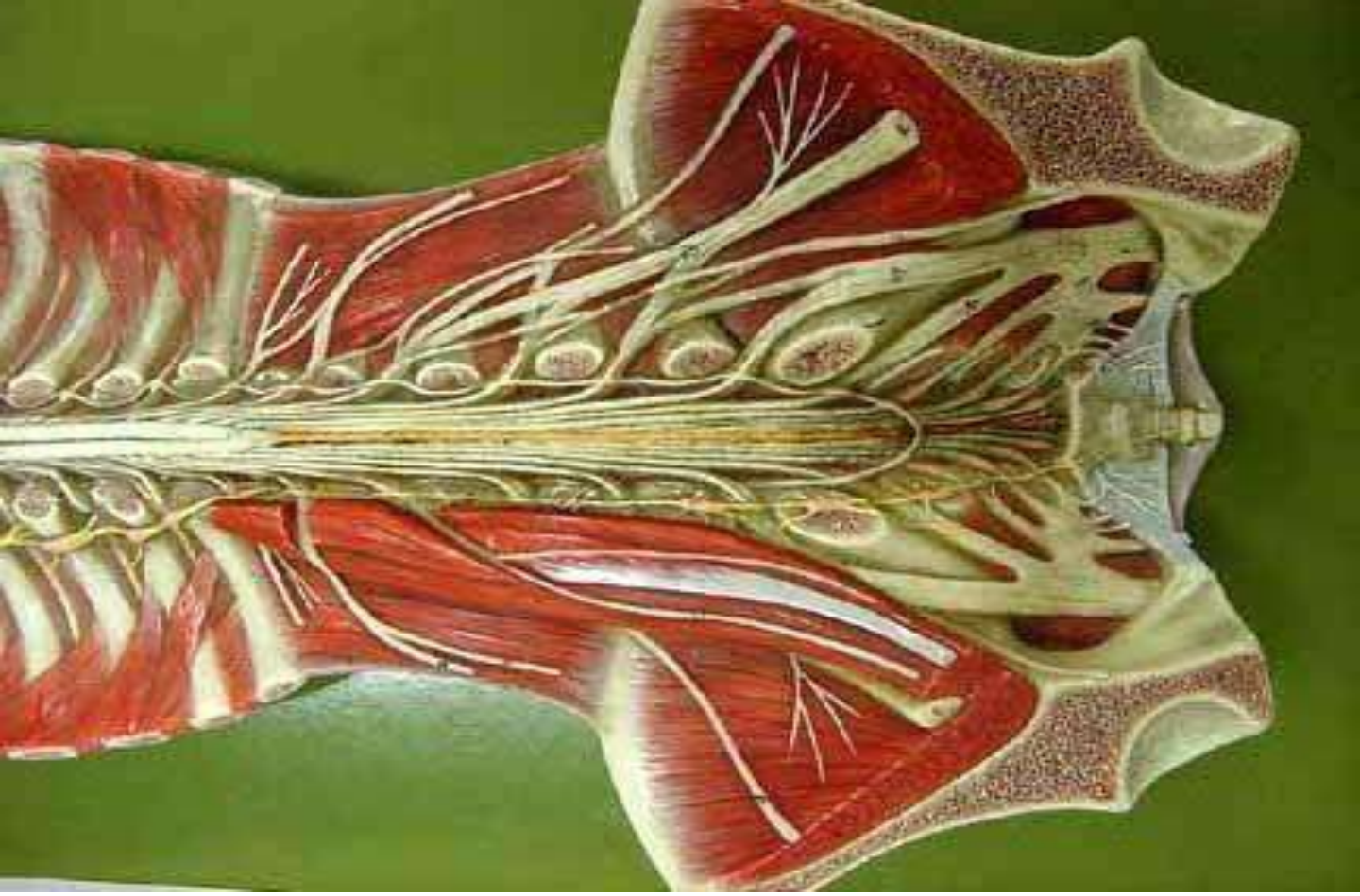
How Many Sympathetic Ganglia are Found in the Sympathetic Chains?

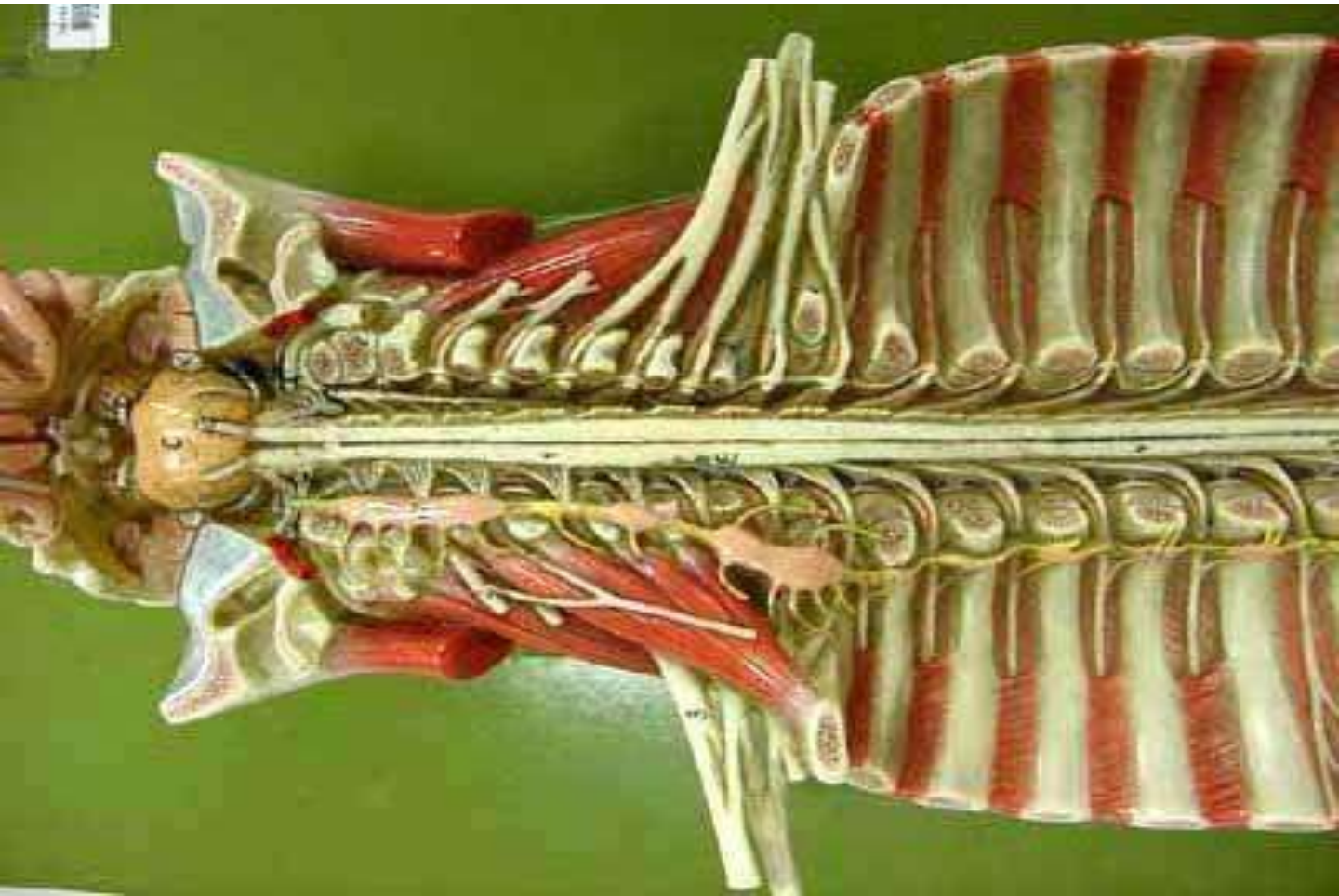
* there is 14 symp. segment but 22 paravertebral ganglion [two] :-

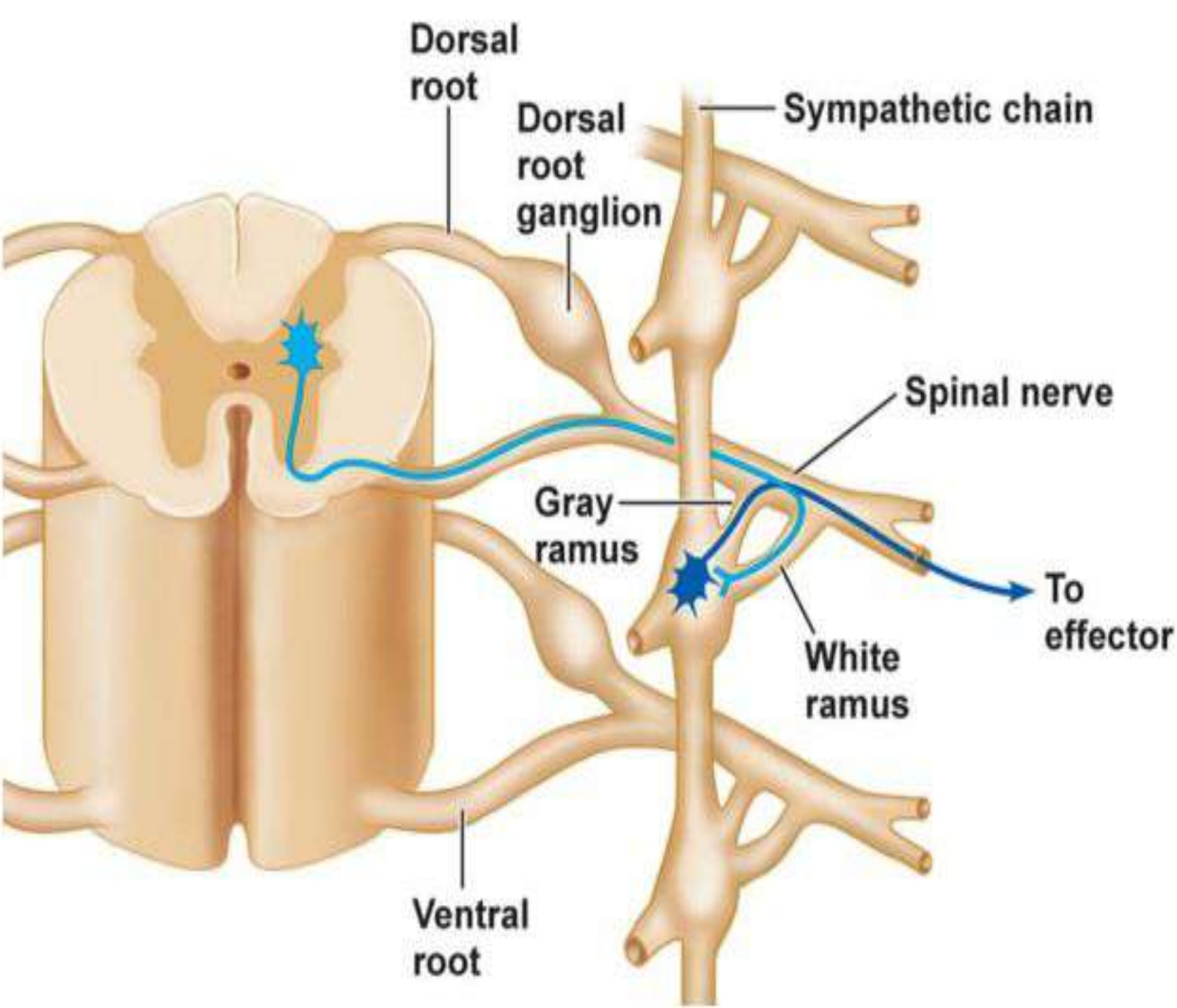
1. **Cervical ganglia:** 3 pairs.
2. **Thoracic ganglia:** 10-12 pairs.
3. **Lumbar ganglia:** 4-5 pairs.
4. **Sacral ganglia:** 4-5 pairs.
1. **Coccygeal ganglion:** one fused together (impar ganglion).

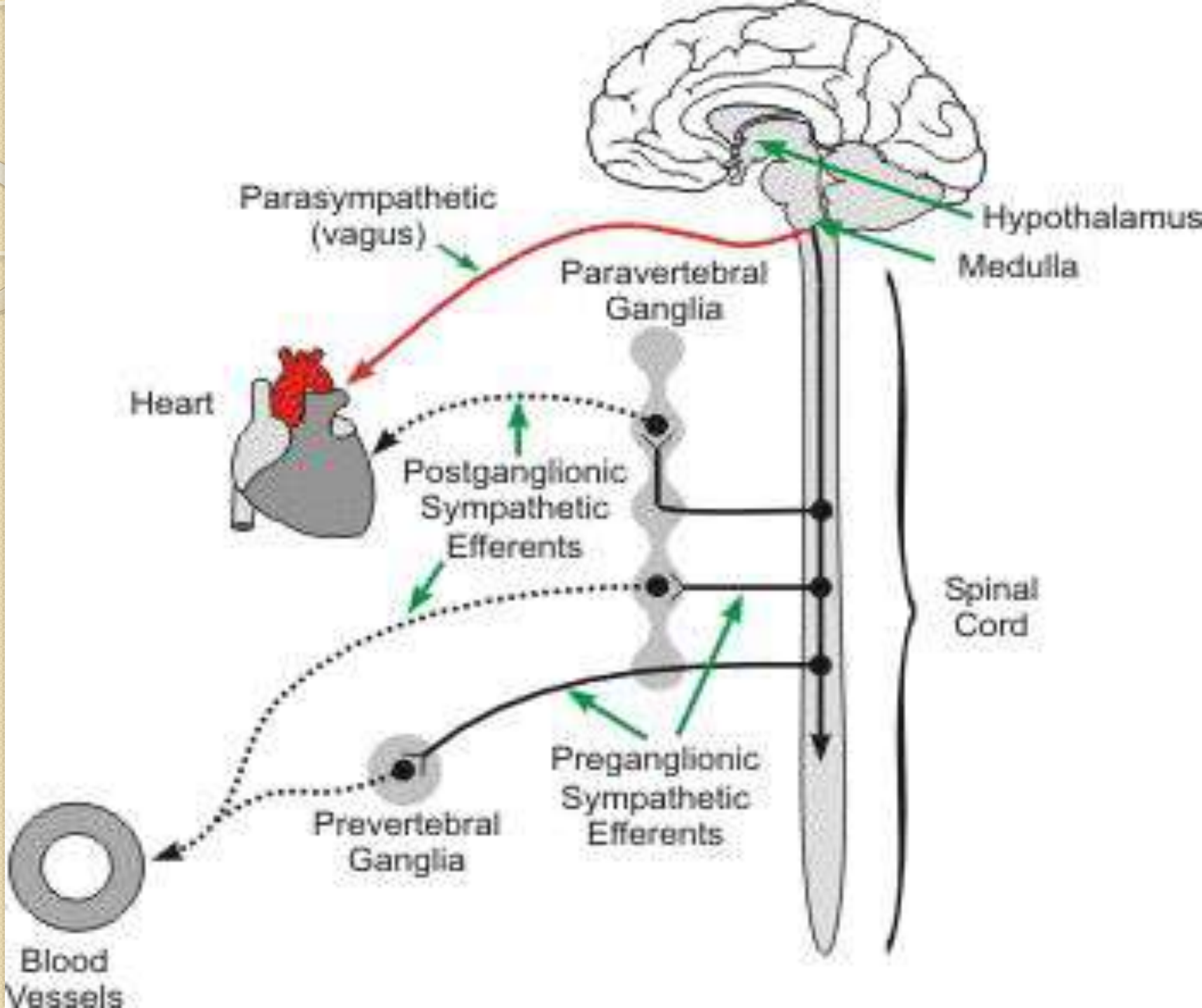
* the inf. cervical sympath. ganglion fuse with the first thoracic and called stellate ganglion...

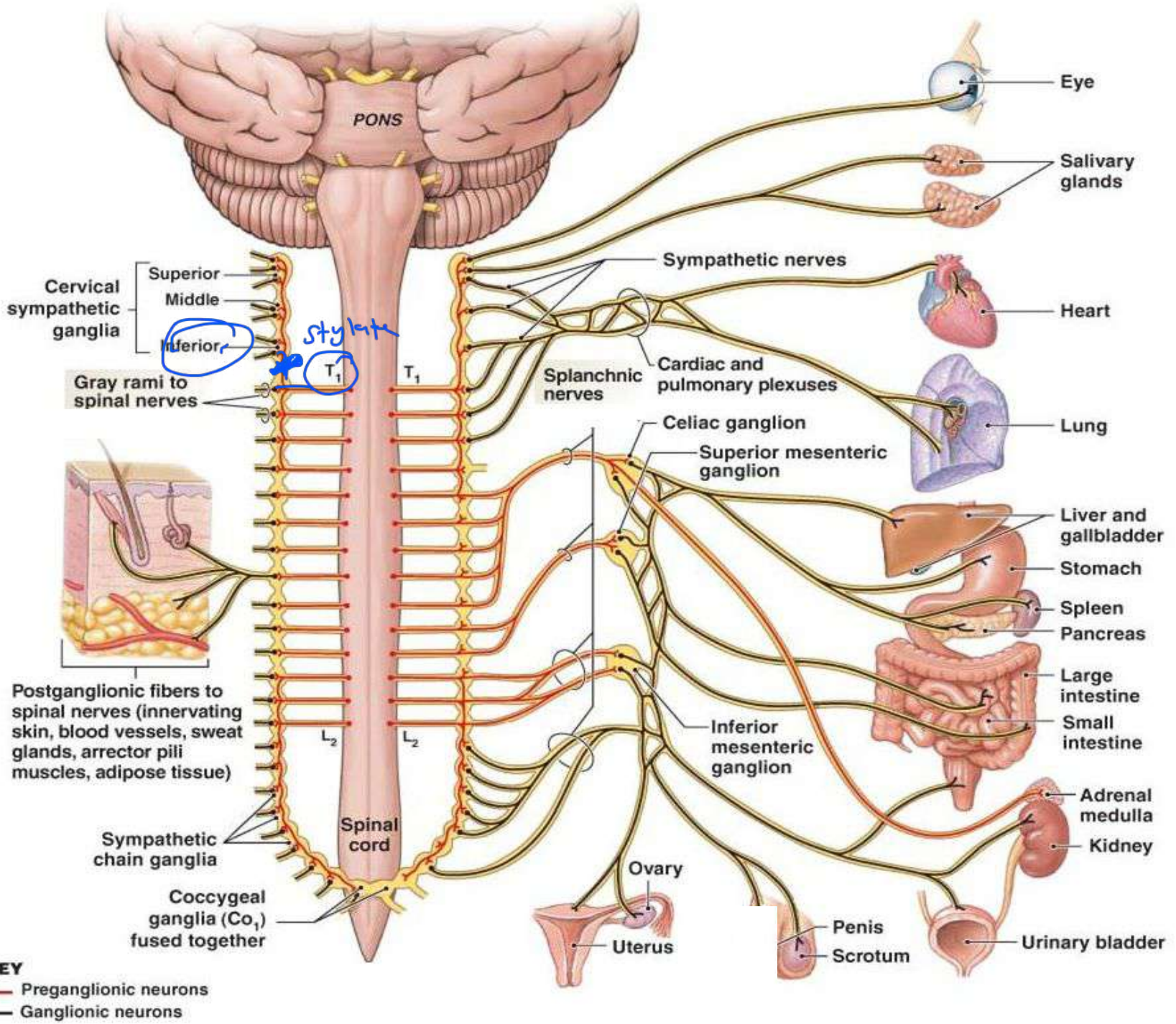

sympathetic ganglion
first rib
second rib
sympathetic chain
fourth rib






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
Stylate
T_1
T_1
Gray rami to spinal nerves
Splanchnic nerves
Cardiac and pulmonary plexuses
Lung
Celiac ganglion
Superior mesenteric ganglion
Liver and gallbladder
Stomach
Spleen
Pancreas
Large intestine
Small intestine
Postganglionic fibers to spinal nerves (innervating skin, blood vessels, sweat glands, arrector pili muscles, adipose tissue)
L_2
L_2
Inferior mesenteric ganglion
Adrenal medulla
Kidney
Sympathetic chain ganglia
Spinal cord
Ovary
Coccygeal ganglia (Co_1) fused together
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.

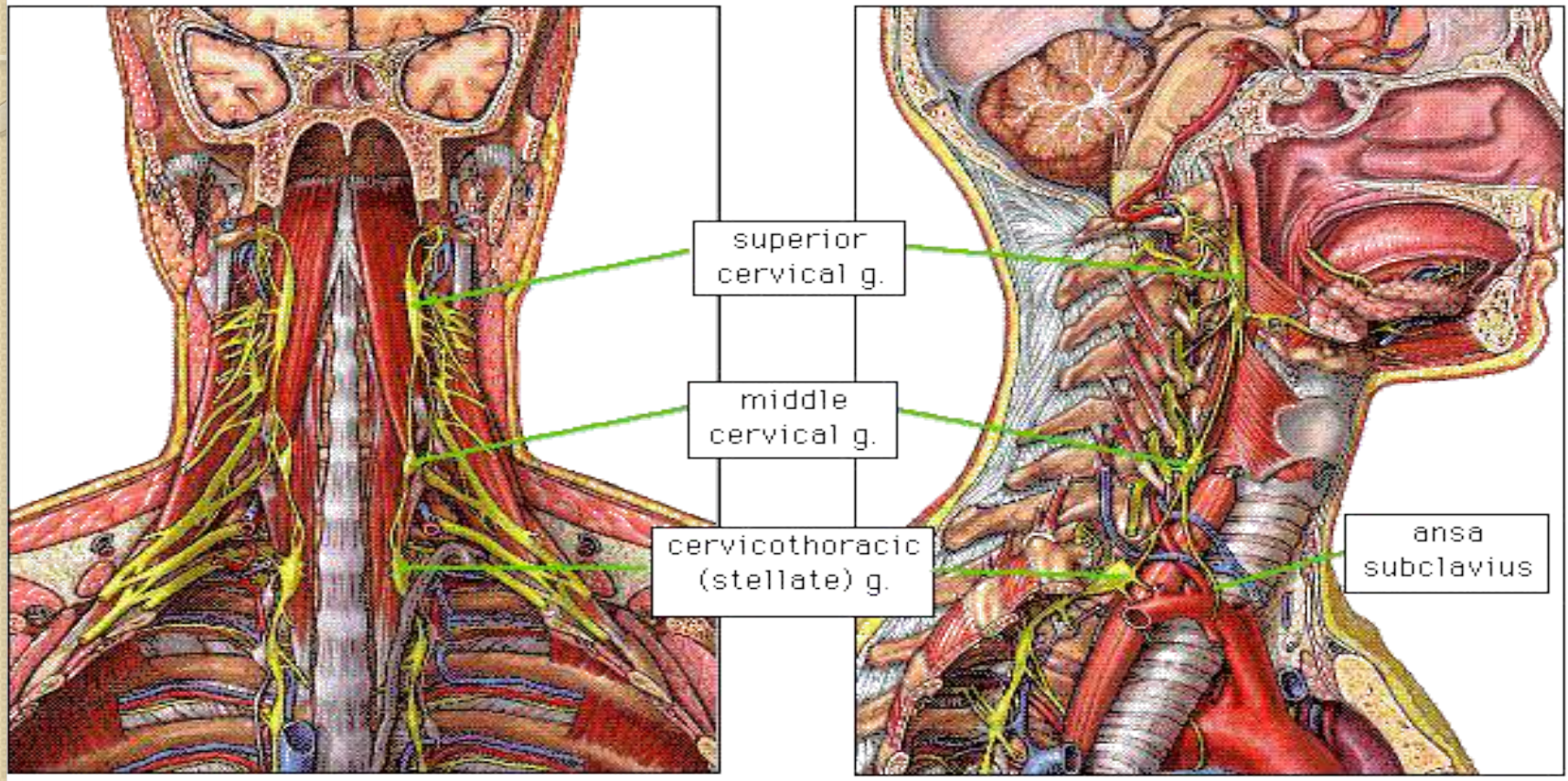
It has:

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. (largest)
2. Middle cervical sympathetic ganglion.
3. Inferior cervical sympathetic ganglion.
   ↳ fuse with first thoracic forming stellate 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:**

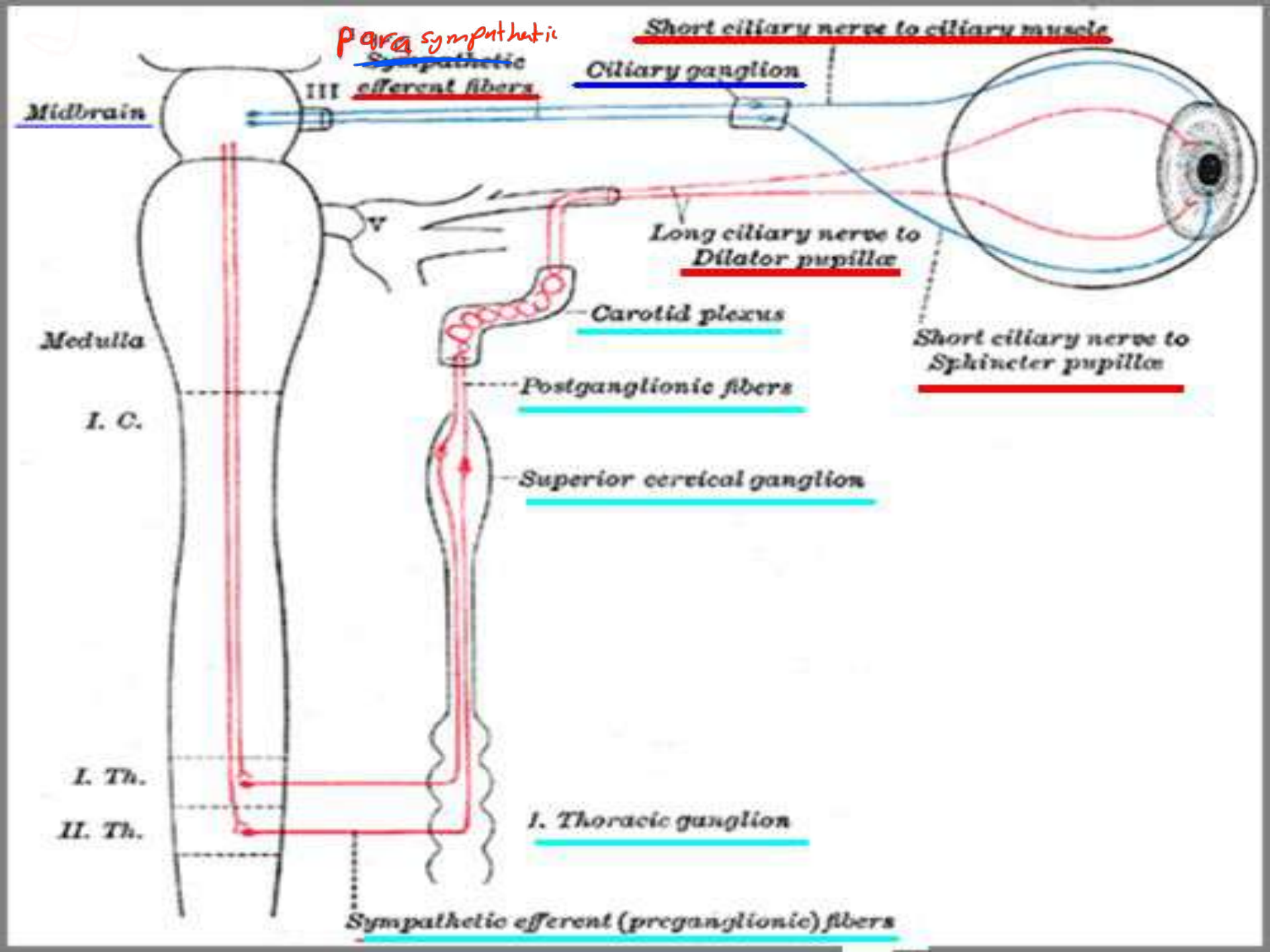
1. Myosis.
2. Partial ptosis.
3. Anhydrosis.
4. Enophthalamus.

miosis
partial ptosis

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.

lead to mydriasis


Parasympathetic
Short ciliary nerve to ciliary muscle
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

Innervation of the Urinary Bladder and Rectum

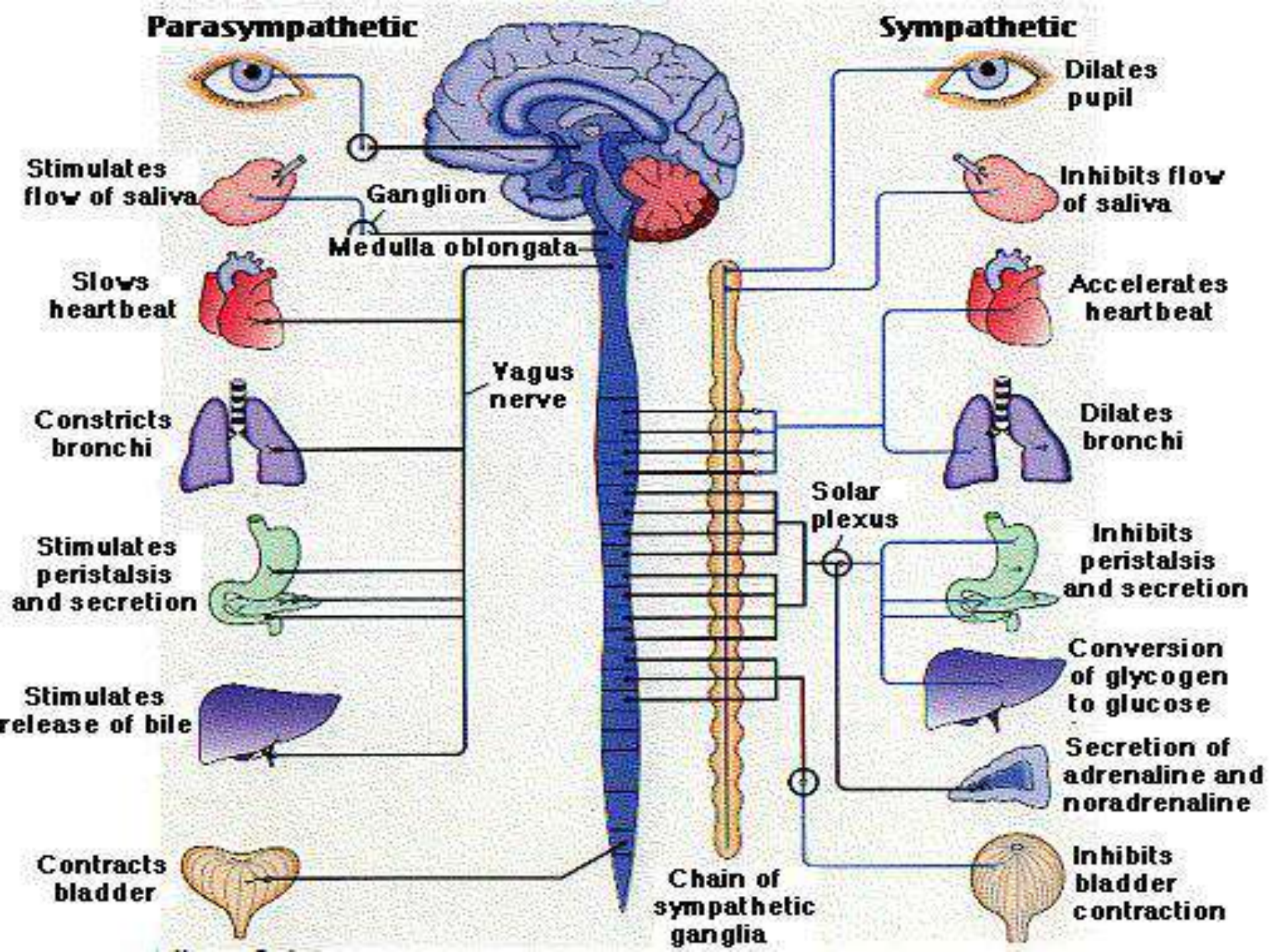
They receive 3 types of nerves:

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

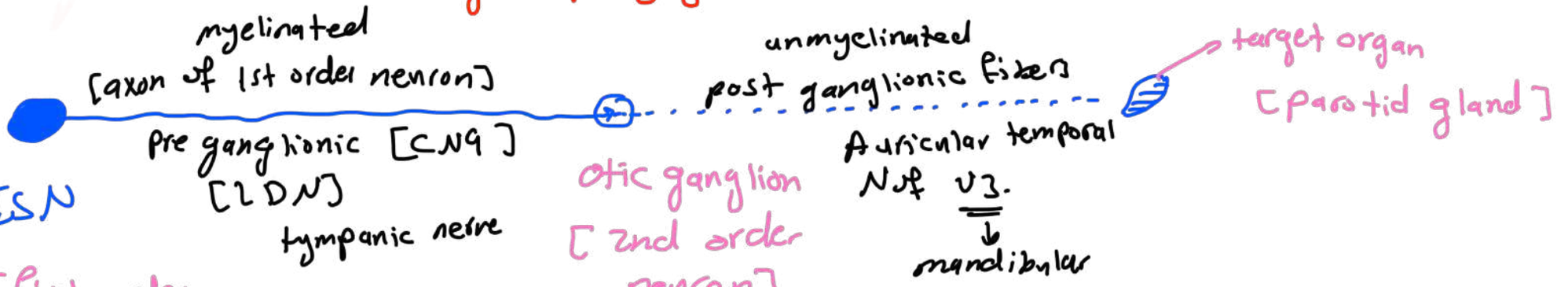
Organ	Sympathetic action	Parasympathetic action
Eye:		
•Pupil	- Dilates	- Constricts
•Ciliary muscle	- Relaxes	- Contracts
Glands:		
•Lacrimal & nasopharyngeal glands	- Reduces secretion	- Increase secretion
•Salivary glands	- Vasoconstriction	- Increase secretion
Heart	- Heart rate & muscle contraction 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	- Increases secretion	-
• Pilomotor muscle	- 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

glossopharyngeal nerve:-



* in the PSNS → the preganglionic:- long..
→ the post ganglionic:- short..

[sympathetic في حكس ال في]
في شي بتختلف

in sympathetic chain close to the spinal cord ال [pre gan:- short / post gan:- long]

[sympathetic] adrenal gland and the colateral ganglia
..para sympathetic ال في تفرعات

celiac or inf + Superior mesentiric ganglion

Sympathetic innervation of pupil -: Slide 72 في

→ the symp. give the signal from $C_8 - T_1$ spinal cord → pre ganglionic more lay at the same side → ascend to sup. cervic symp. ganglion → post ganglionic fiber accompanied the ICA → give long ciliary nerve supply the dilato ocular muscle lead to mydriasis..