

Autonomics of the Head and Neck

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Medicine

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Do.
Make.
Heal.
Innovate.
Reinvent the Future.

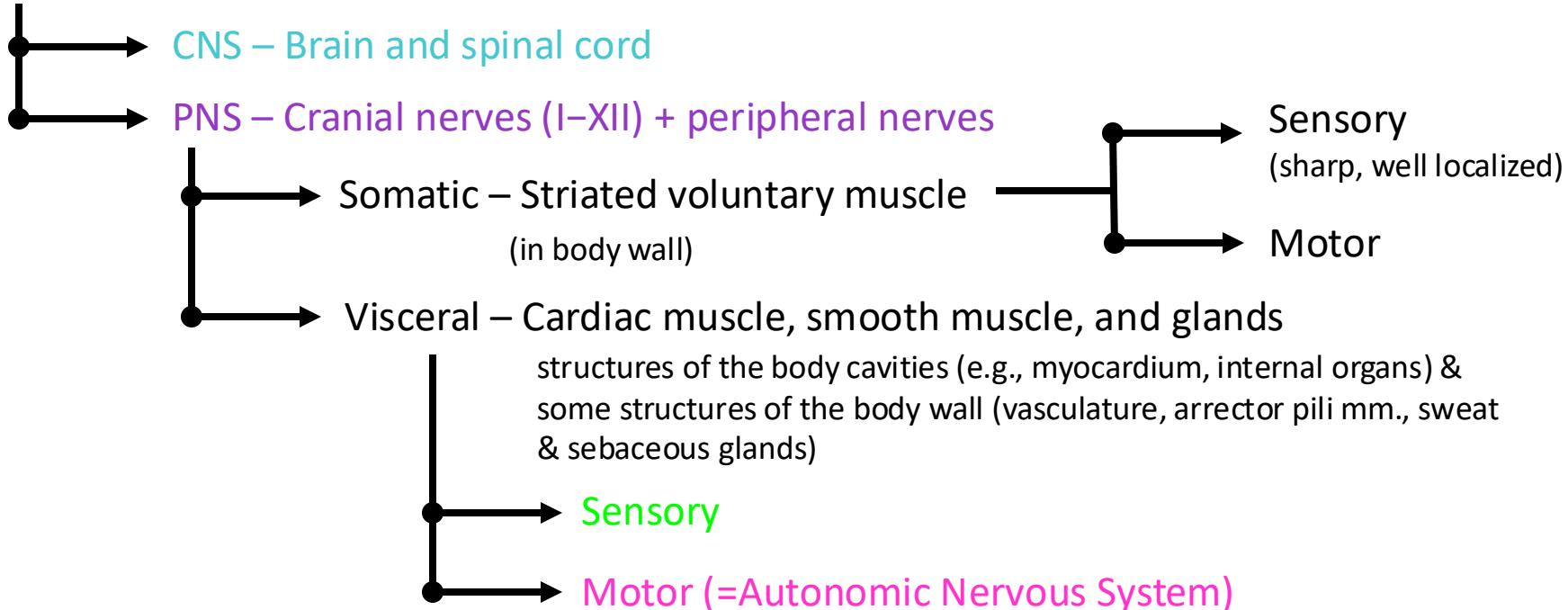
Session Objectives

- Compare and contrast sympathetic and parasympathetic innervation to the head and neck
- List the four parasympathetic ganglia of the head, their preganglionic input and postganglionic output
- Understand the innervation and function of the glands of the head (e.g., lacrimal gland, salivary glands, mucosal glands, sweat glands)
- Explain Horner's syndrome
- Explain Accommodation/Convergence reflex

Division of the Nervous System

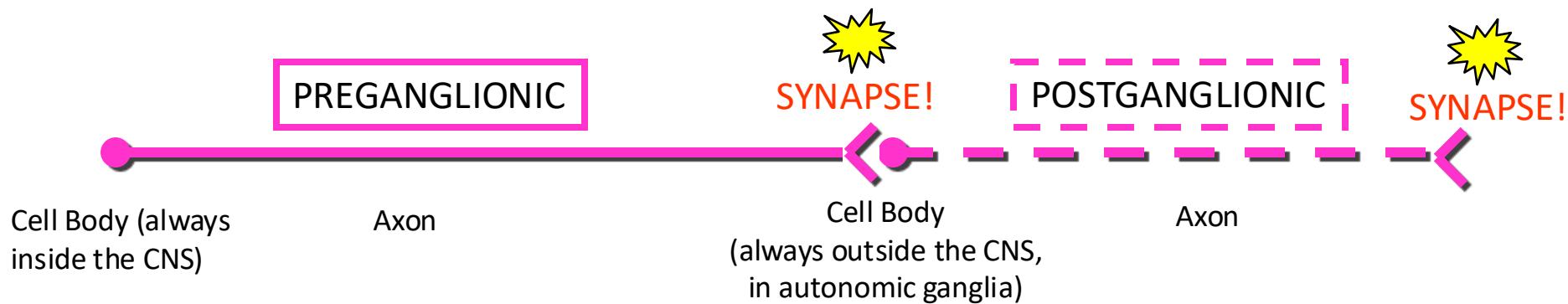
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Nervous System

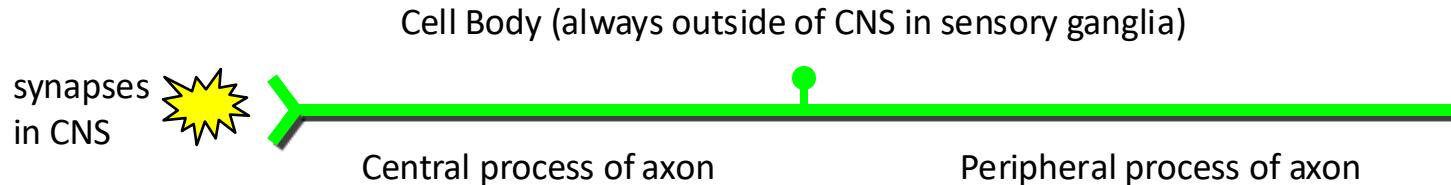


Visceral Neuron Types

Visceral Motor Neuron



Visceral Sensory Neuron



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Visceral Neuron Types

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Sympathetic

- Two neuron system
- Preganglionic cell bodies: T1-L2 spinal cord level
- Postganglionic cell bodies: paravertebral and sub-diaphragmatic ganglia

Parasympathetic

- Two neuron system
- Preganglionic cell bodies: brainstem and S3,S4 (S2)
- Postganglionic cell bodies: walls of organ, minute pelvic ganglia, four ganglia in the head and neck

Visceral structures in the head

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Glands

Lacrimal gland

Mucous glands

Salivary glands (parotid, submandibular, sublingual)

Sweat glands

Sebaceous glands (e.g., tarsal glands/meibomian gland)

Smooth muscle

Blood vessels

Superior tarsal muscle/Müller's muscle

Constrictor pupillae/sphincter pupillae

Dilator pupillae

Ciliary muscle

Selected functions of the ANS

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Organ	Sympathetic Effect	Parasympathetic effect
Lacrimal gland	?	Secretion
Salivary glands	Secretion	Secretion
Sweat glands	Secretion	none
Superior tarsal muscle	Contraction	none
Dilator pupillae	Contraction	none
Constrictor pupillae	none	Contraction
Ciliary muscle	none	Contraction
Blood vessels	Constriction (dilation of facial arteries)	Dilation

Sympathetics

Sympathetic Innervation

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Preganglionic cell bodies

- T1-T2 lateral horn

Preganglionic axons

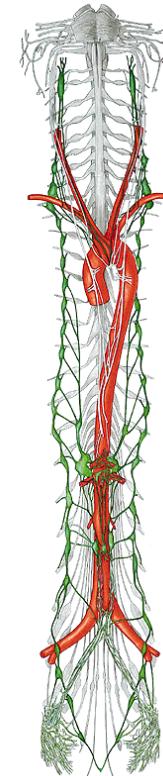
- Ventral roots T1-T2 > spinal nn. T1-T2 > ventral rami T1-T2 > white rami communicantes T1-T2 > paravertebral ganglia T1-T2 > ascend in sympathetic chain

Postganglionic cell bodies

- Superior cervical ganglion

Postganglionic axons

- Internal carotid plexus
- External carotid plexus



Sympathetic Innervation

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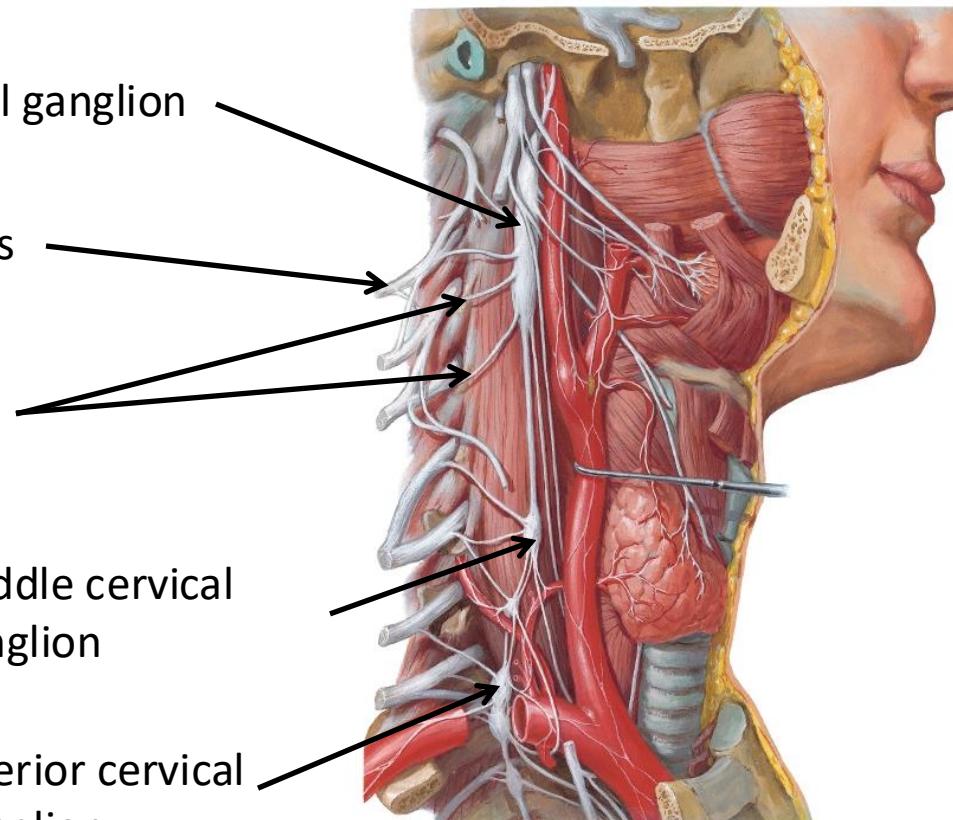
Superior cervical ganglion

C2 ventral ramus

Gray rami
communicantes

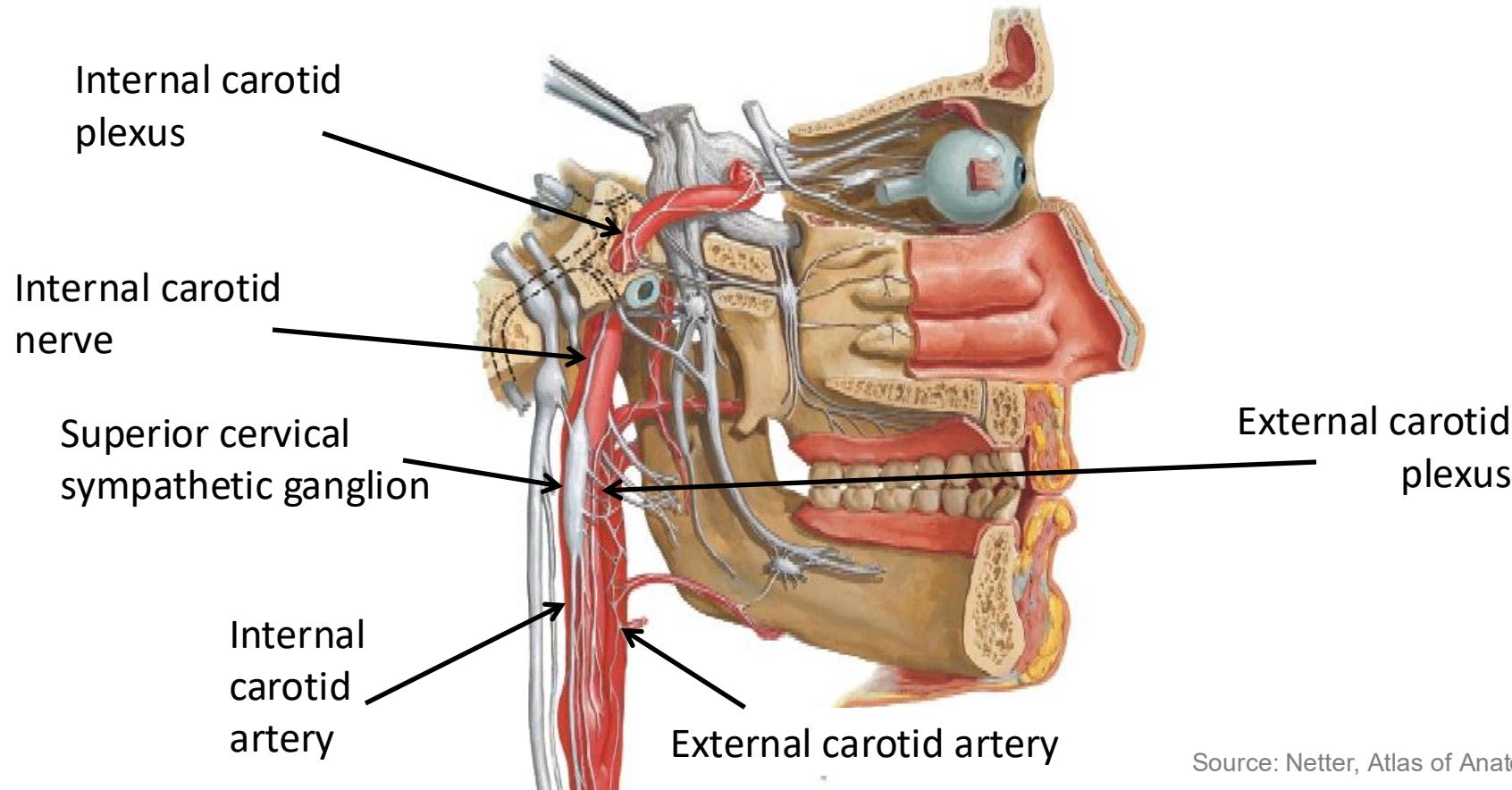
Middle cervical
ganglion

Inferior cervical
ganglion



Sympathetic Innervation

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Internal Carotid Plexus

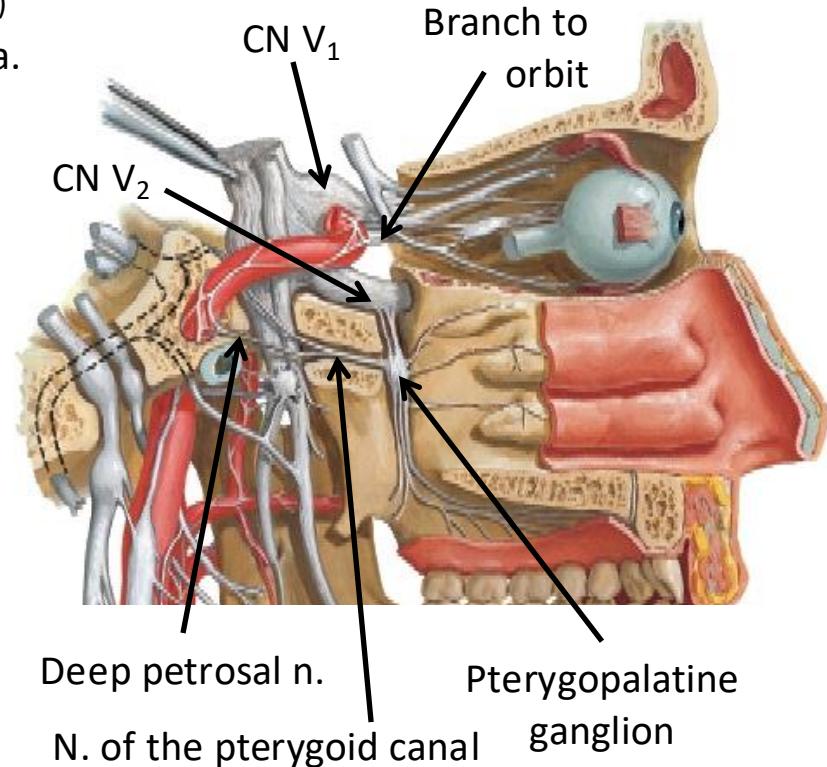
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Orbital branch (through cavernous sinus and superior orbital fissure)

- Vasoconstriction of ocular arterioles via ophthalmic a.
- Contraction of dilator pupillae and superior tarsal muscles via V_1
- Vasodilation of facial arterioles via V_1
- sweat glands of forehead via V_1
- Contraction of arrector pili of forehead via V_1
- Ethmoid air cells via V_1 (effect?)
- (Lacrimal gland)

Deep petrosal (through pterygoid canal)

- Lacrimal gland
- Vasoconstriction of blood vessels in nasal cavity, palate, pharynx via V_2
- No effect on mucous glands



External Carotid Plexus

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Branches with maxillary a.

- Parotid gland

Branches with lingual a.

- Sublingual gland
- Submandibular gland

Branches with facial a.

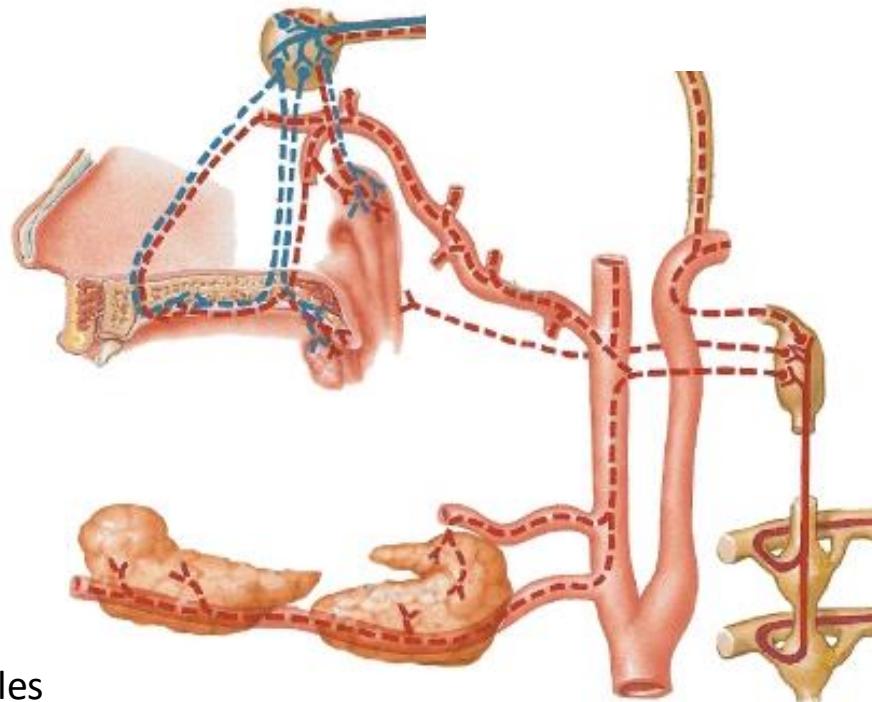
- Submandibular gland

Branches with superior thyroid a.

- Thyroid gland

With all branches

- Vasoconstriction of arterioles
- Facial sweat glands



Sympathetic preganglionic —

Sympathetic postganglionic - - -

Source: Netter, Atlas of Anatomy

Clinical Consideration

Horner's Syndrome



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Cause

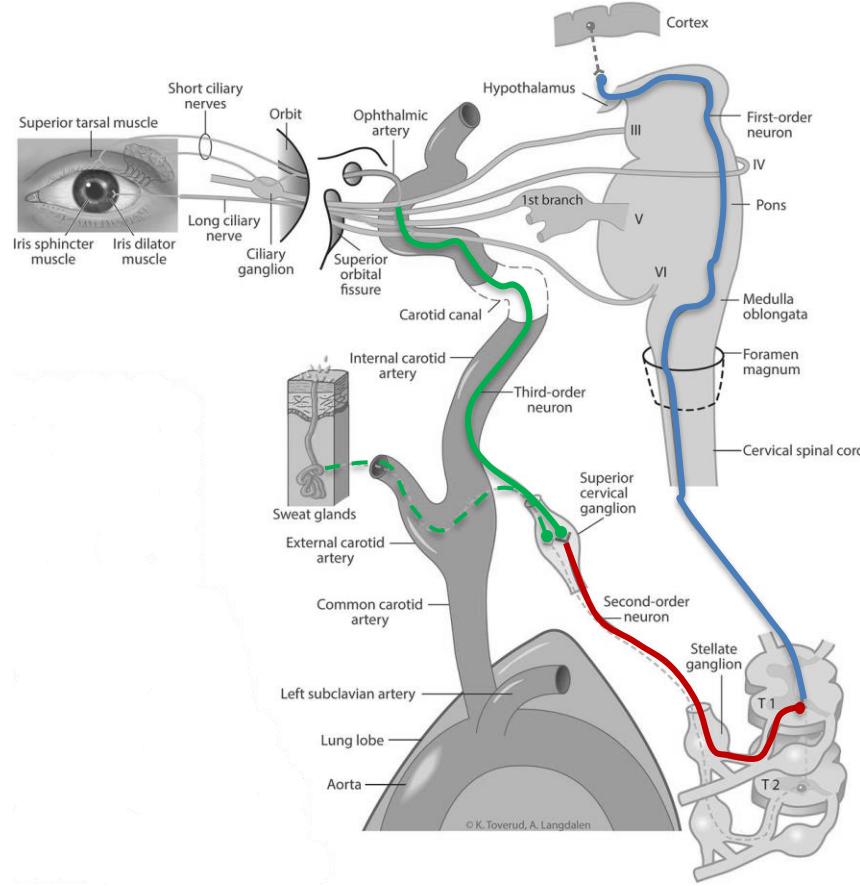
- Damage or blockage of sympathetic pathway to head

Symptoms

- **Constricted pupil (miosis)**
- **Drooping upper eyelid (mild ptosis)**
- **Lack of sweating (anhidrosis)**
- Loss of cutaneous vasodilation in face (cannot blush)
- Loss of ocular vasoconstriction ("bloodshot" eye)

Horner's Syndrome

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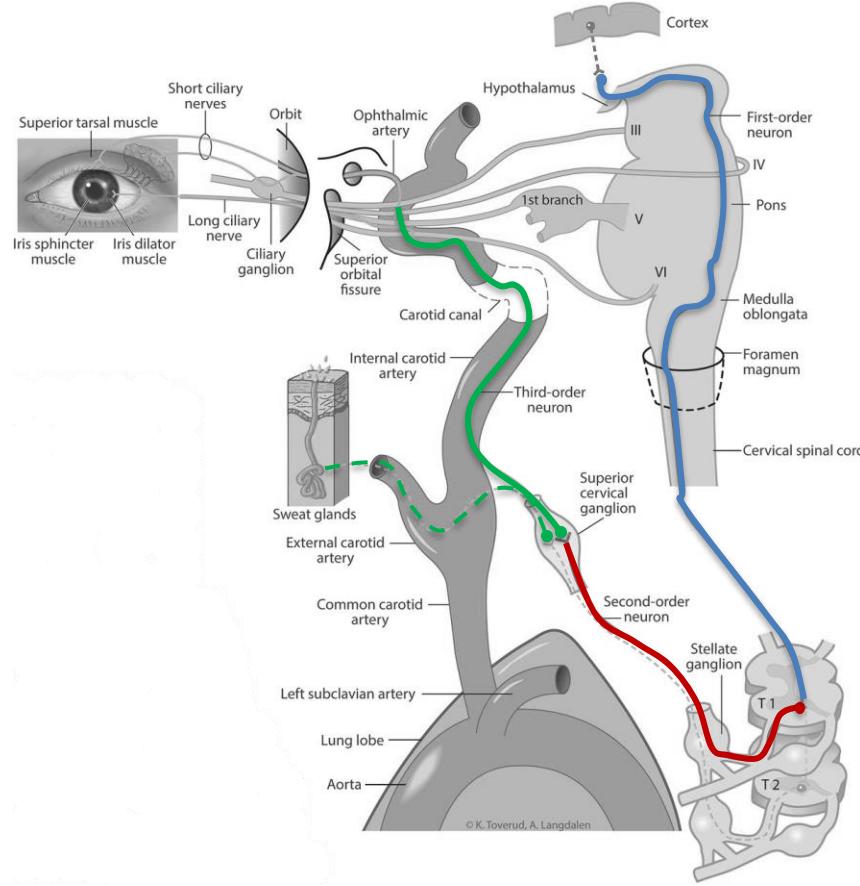
First-order neuron (Central)

Second-order neuron (Preganglionic)

Third-order neuron (Postganglionic)

Horner's Syndrome

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First-order neuron disorder (Central):
stroke, tumor, spinal cord trauma,
cyst or cavity in the spinal cord

Second-order neuron (Preganglionic)
Pancoast tumor, trauma to neck or
chest cavity during surgery or
accident

Third-order neuron (Postganglionic)
Lesion of carotid artery, injury to skull
base

A 25-year-old male presents to your practice with left-sided mild ptosis and constricted pupil. You order a CT scan, which shows a tumor in the superior lobe of the left lung. You suspect the tumor is compressing the sympathetic chain. Which other symptoms would you expect to see?

- A. Lack of sweating on the left
- B. Cannot blush on left side
- C. Bloodshot right eye
- D. Redness of the left face
- E. Dry mouth

Parasympathetics

Parasympathetic Innervation

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Otic ganglion

- connected to V_3

- preganglionics
from CN IX

Submandibular ganglion

- connected to V_3

- preganglionics from
CN VII

Ciliary ganglion

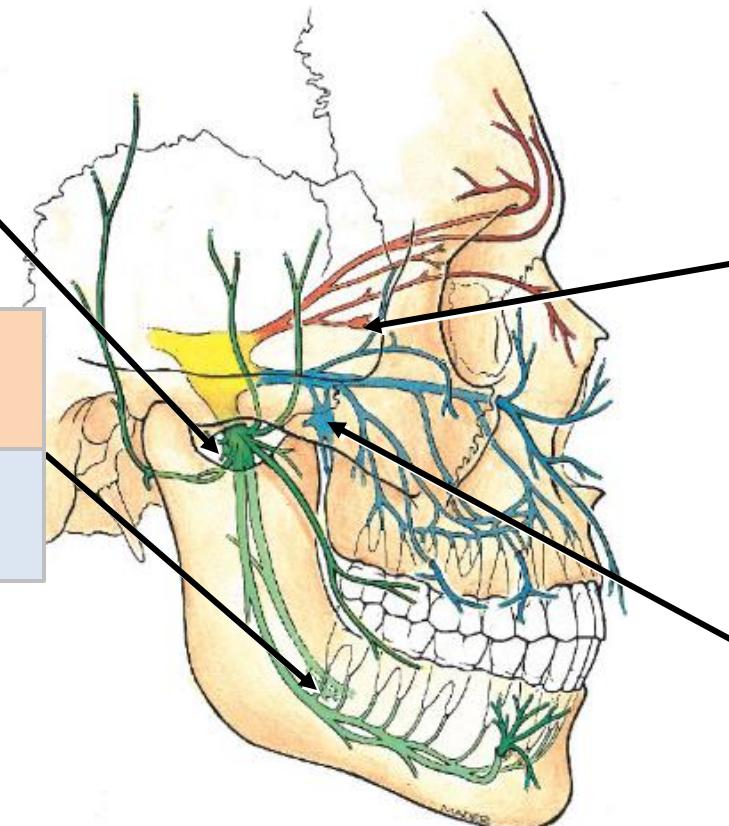
- connected to V_1

- preganglionics
from CN III

Pterygopalatine ganglion

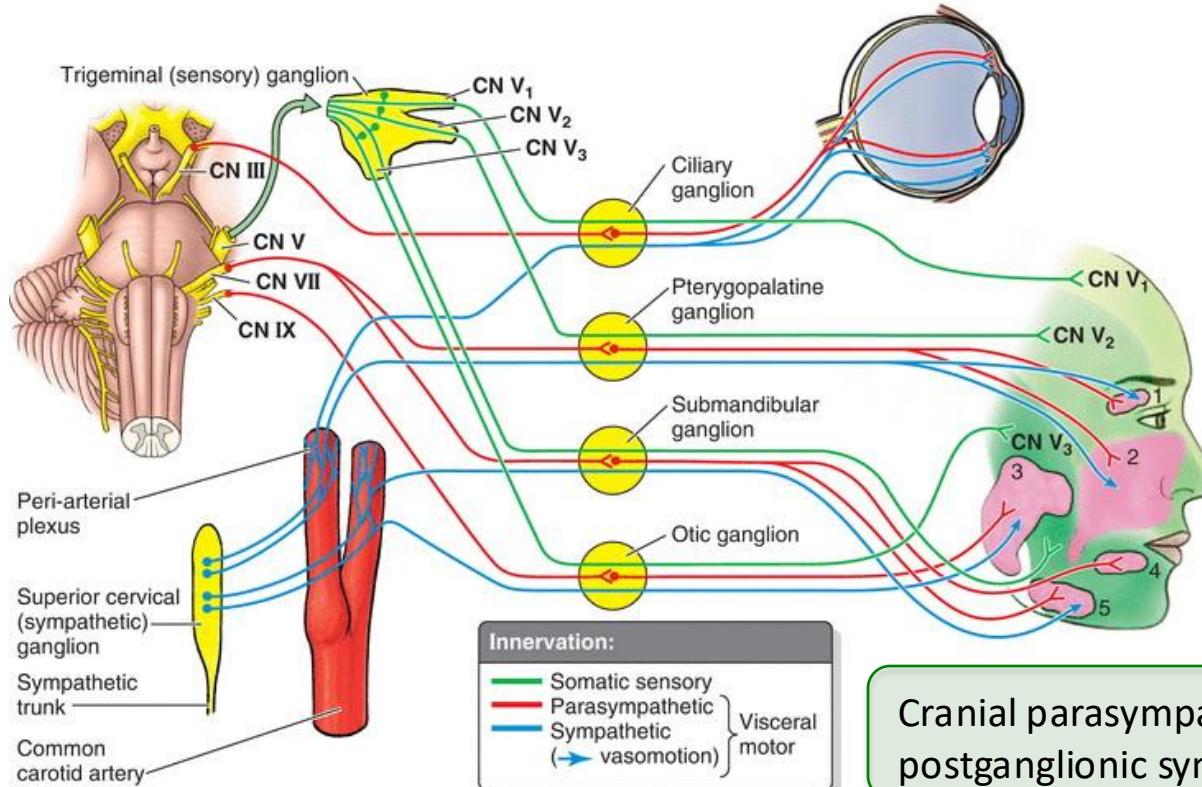
- connected to V_2

- preganglionics from
CN VII



Parasympathetic Innervation

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Innervation:

- Somatic sensory
 - Parasympathetic
 - Sympathetic (→ vasomotion)
- } Visceral motor

Glands:

- 1 Lacrimal
- 2 Nasal, palatine, and pharyngeal
- 3 Parotid
- 4 Sublingual
- 5 Submandibular

Cranial parasympathetic ganglia have sensory and postganglionic sympathetic axons passing through

Ciliary Ganglion

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Preganglionic cell bodies

- Brain (visceral efferent oculomotor nucleus)

Preganglionic axons

- Oculomotor Nerve (CN III)

Postganglionic cell bodies

- Ciliary ganglion

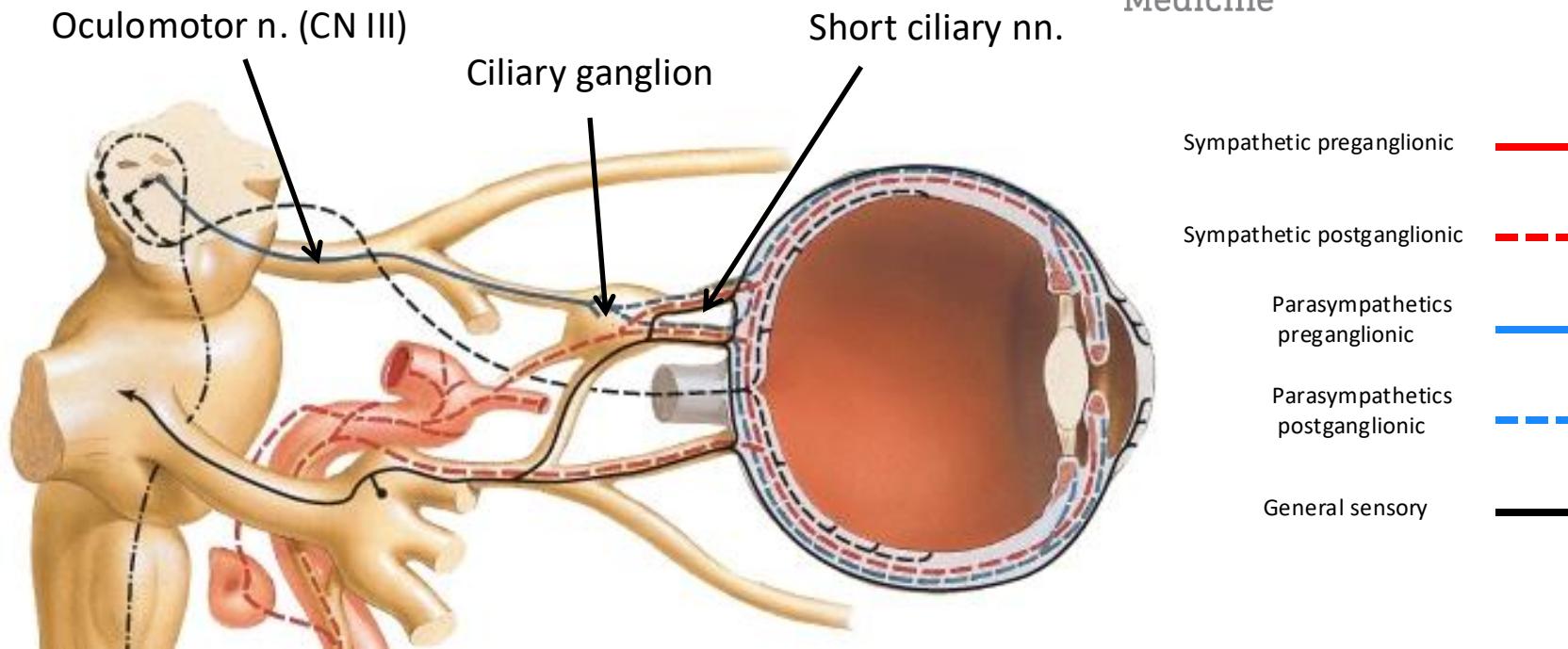
Postganglionic axons

- Short ciliary to: ciliary muscle (muscle of accommodation) and constrictor (= sphincter) pupillae

Ciliary Ganglion

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Constriction and Accommodation

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Pupillary constriction

- when too much light, consensual reflex (both pupils)
- When focusing on nearer objects (prevents diverging light rays from hitting periphery of retina, which results in blurry image)

Accommodation

- Lens of eye assumes rounded shape, light rays are more strongly bent

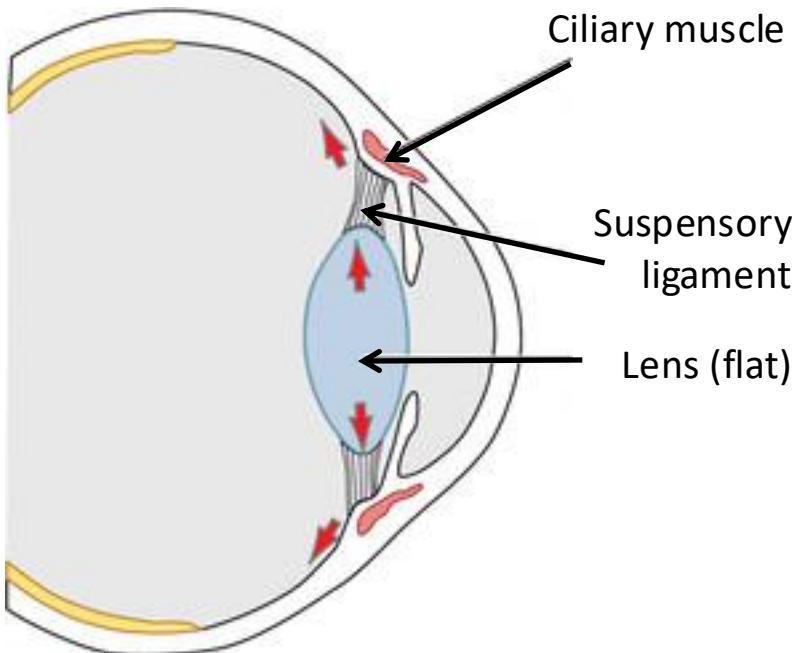
Accommodation/Convergence reflex

- When eyes converge at nearer object
- Lens assumes rounded shape, pupils constrict
- Ciliary muscle and constrictor pupillae

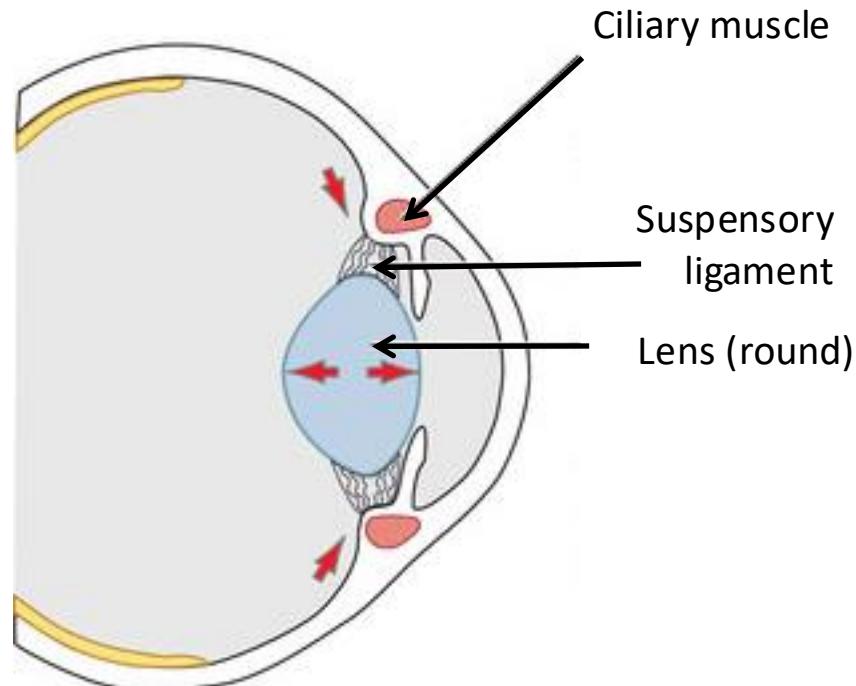
Accommodation

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Relaxed

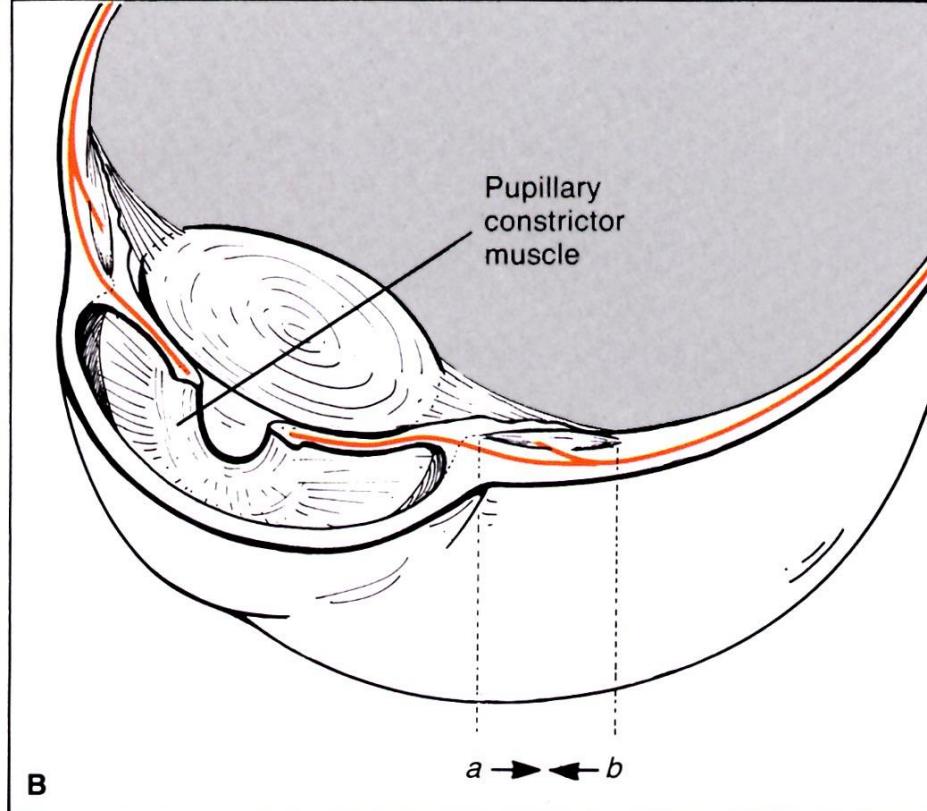
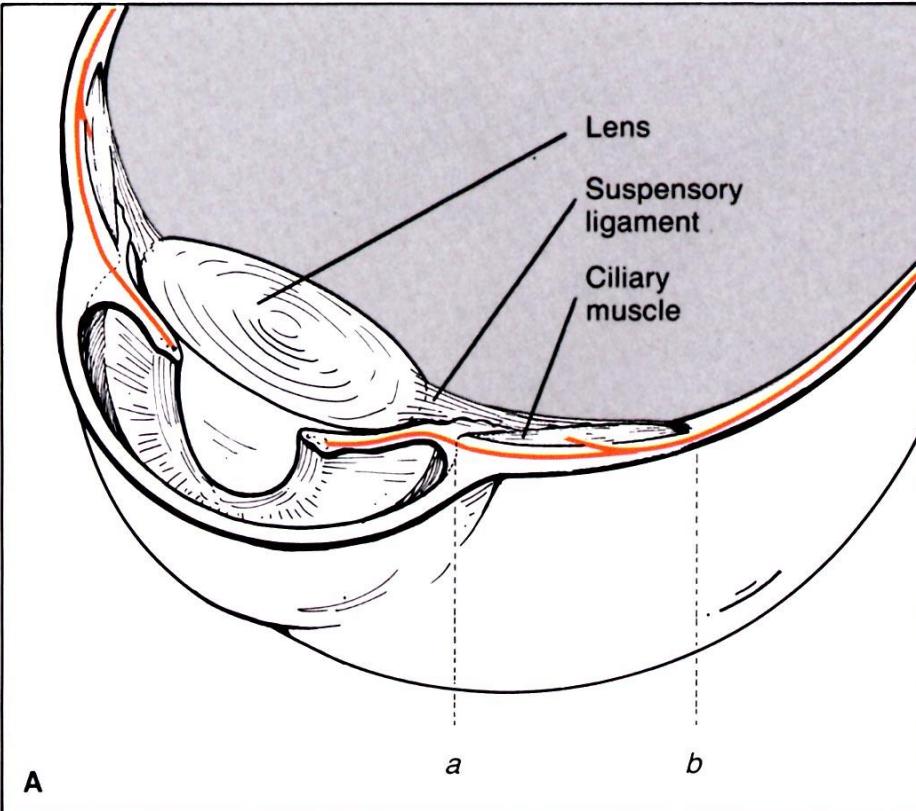


Contracted



Accommodation/Convergence

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A

a

b

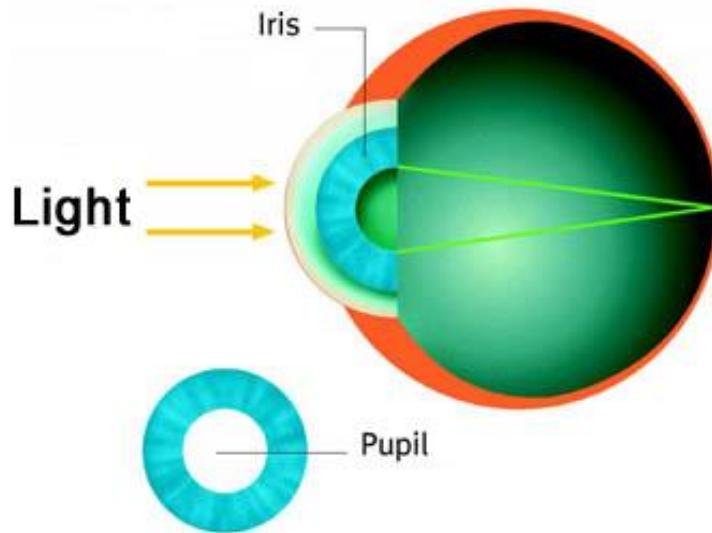
B

a → ← b

Dilation vs. Constriction

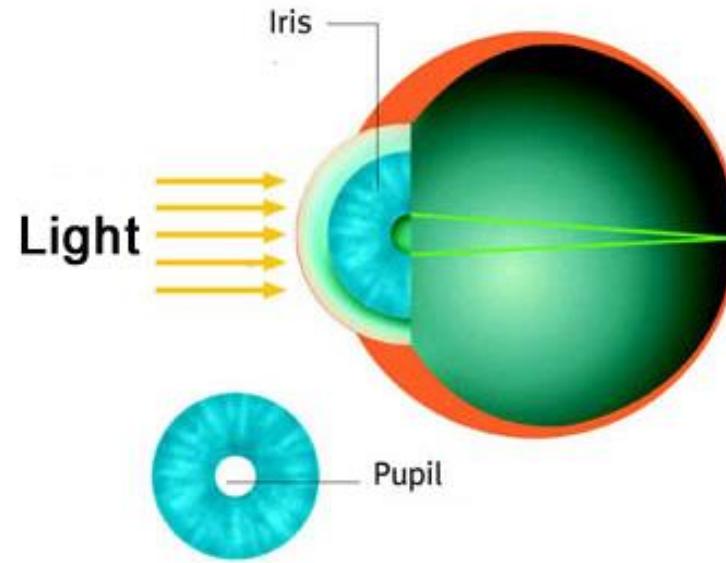
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Dilation



To allow *more* light in
Sympathetic reaction

Constriction



To allow *less* light in
Parasympathetic reaction

Pterygopalatine Ganglion

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Preganglionic cell bodies

- Brain (superior salivary nucleus)

Preganglionic axons

- Facial Nerve (CN VII) > greater petrosal > N. of pterygoid canal

Postganglionic cell bodies

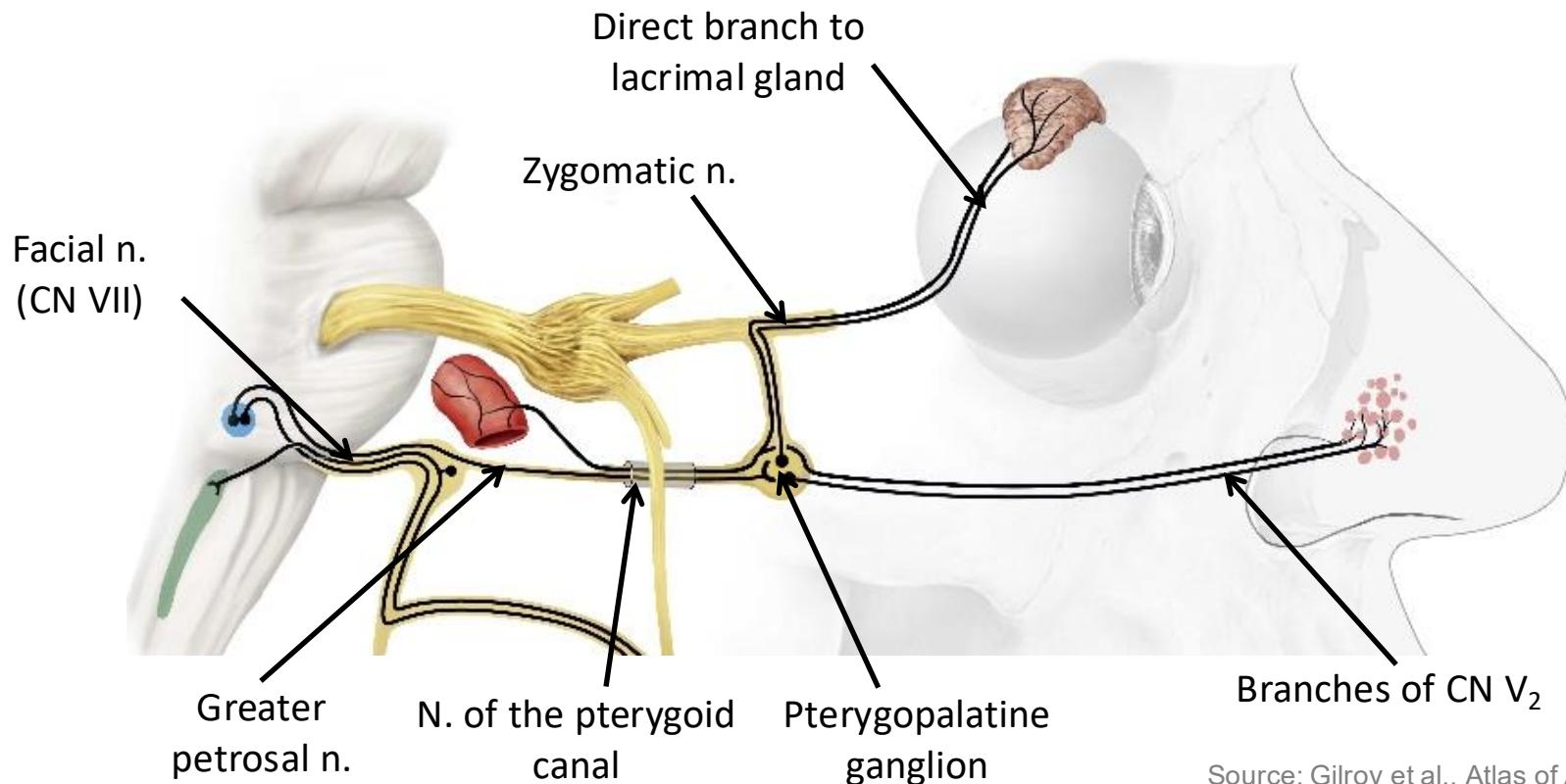
- Pterygopalatine ganglion

Postganglionic axons

- Lacrimal: direct branch to lacrimal gland
- Mucous glands in nasal cavity, palate, sinuses, pharynx: branches of V₂

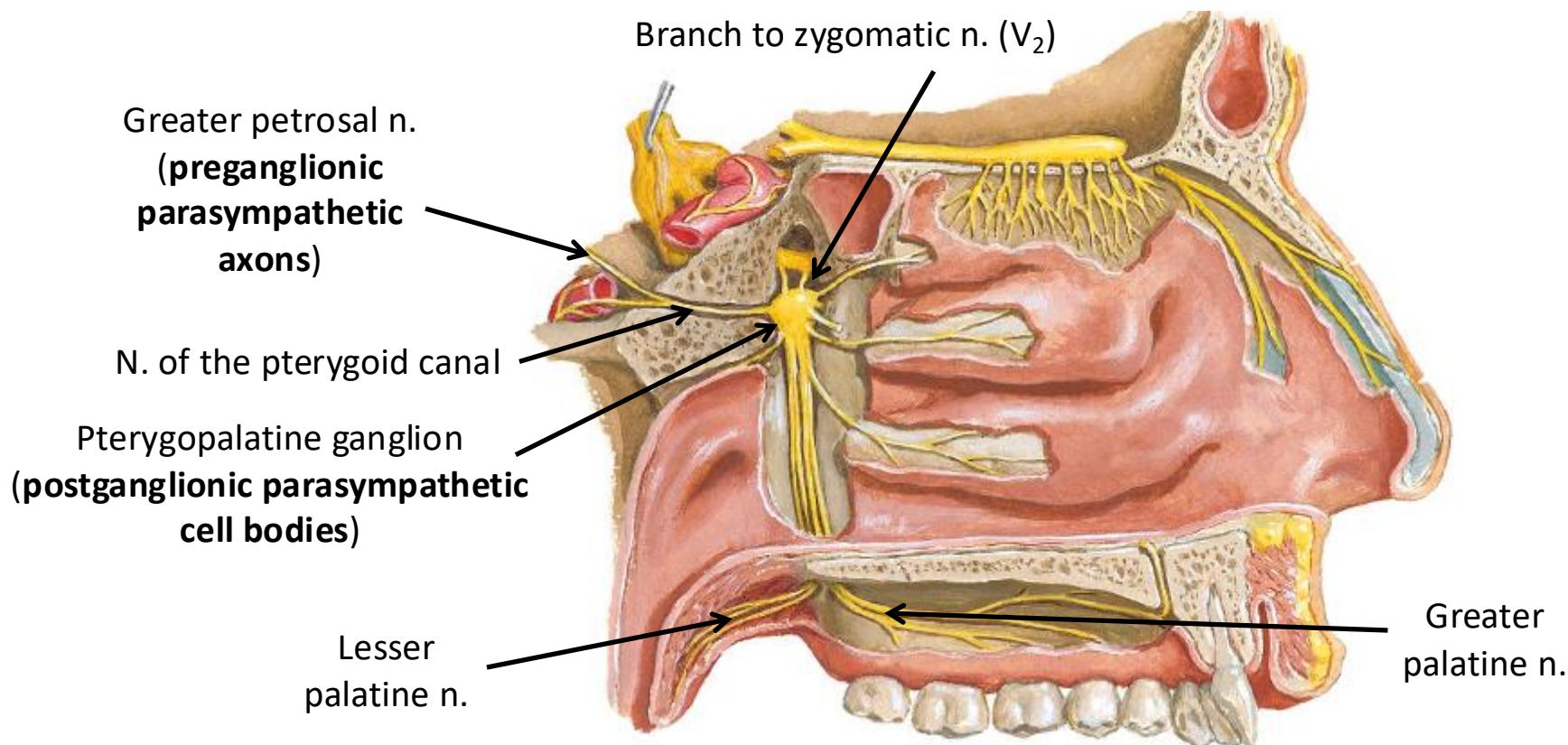
Pterygopalatine Ganglion

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Pterygopalatine Ganglion

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Submandibular Ganglion

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Preganglionic cell bodies

- Brain (superior salivary nucleus)

Preganglionic axons

- Facial Nerve (CN VII) > chorda tympani > lingual n (V_3)

Postganglionic cell bodies

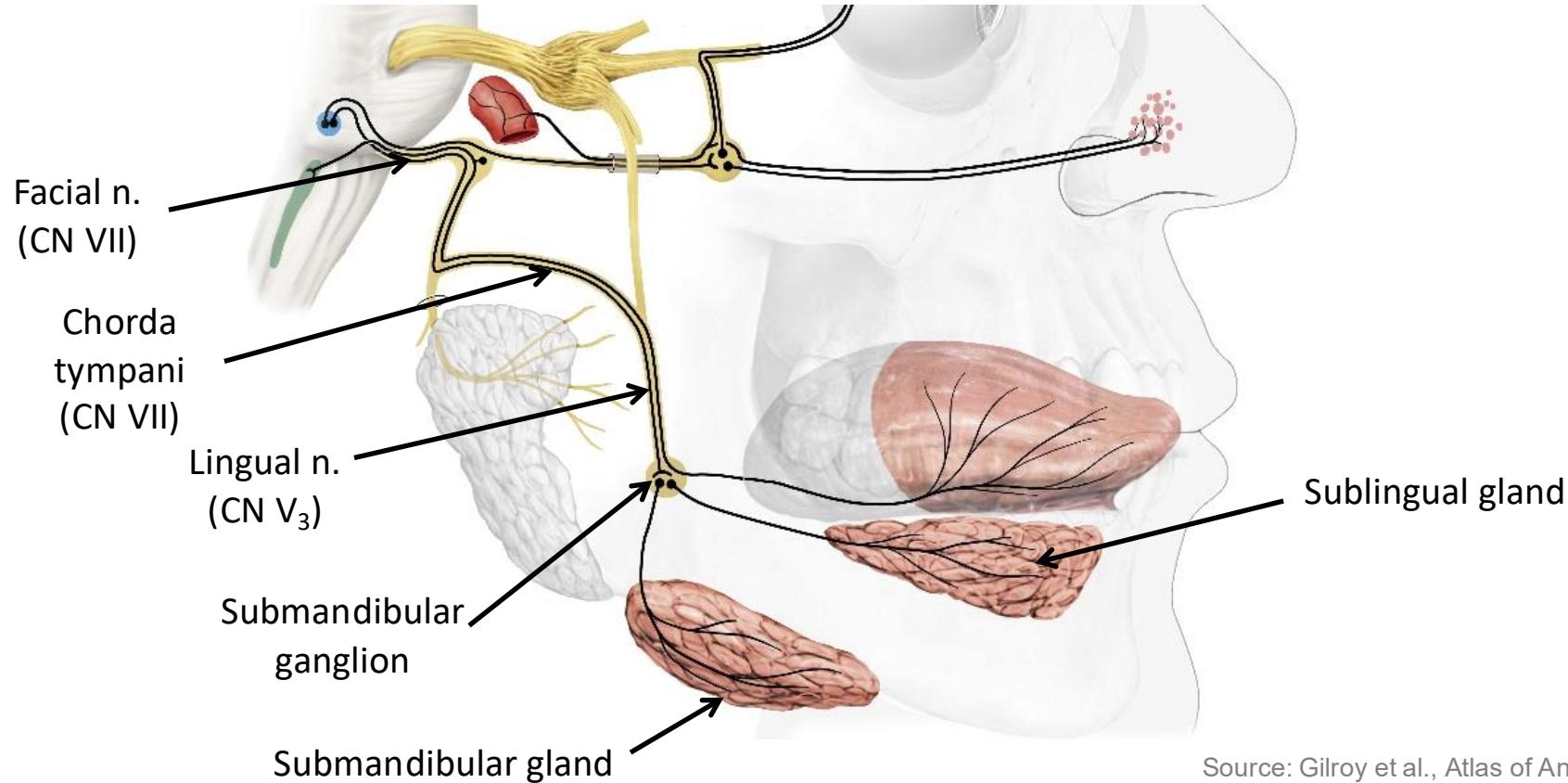
- Submandibular ganglion

Postganglionic axons

- Submandibular gland: direct branches
- Sublingual gland: Lingual n.

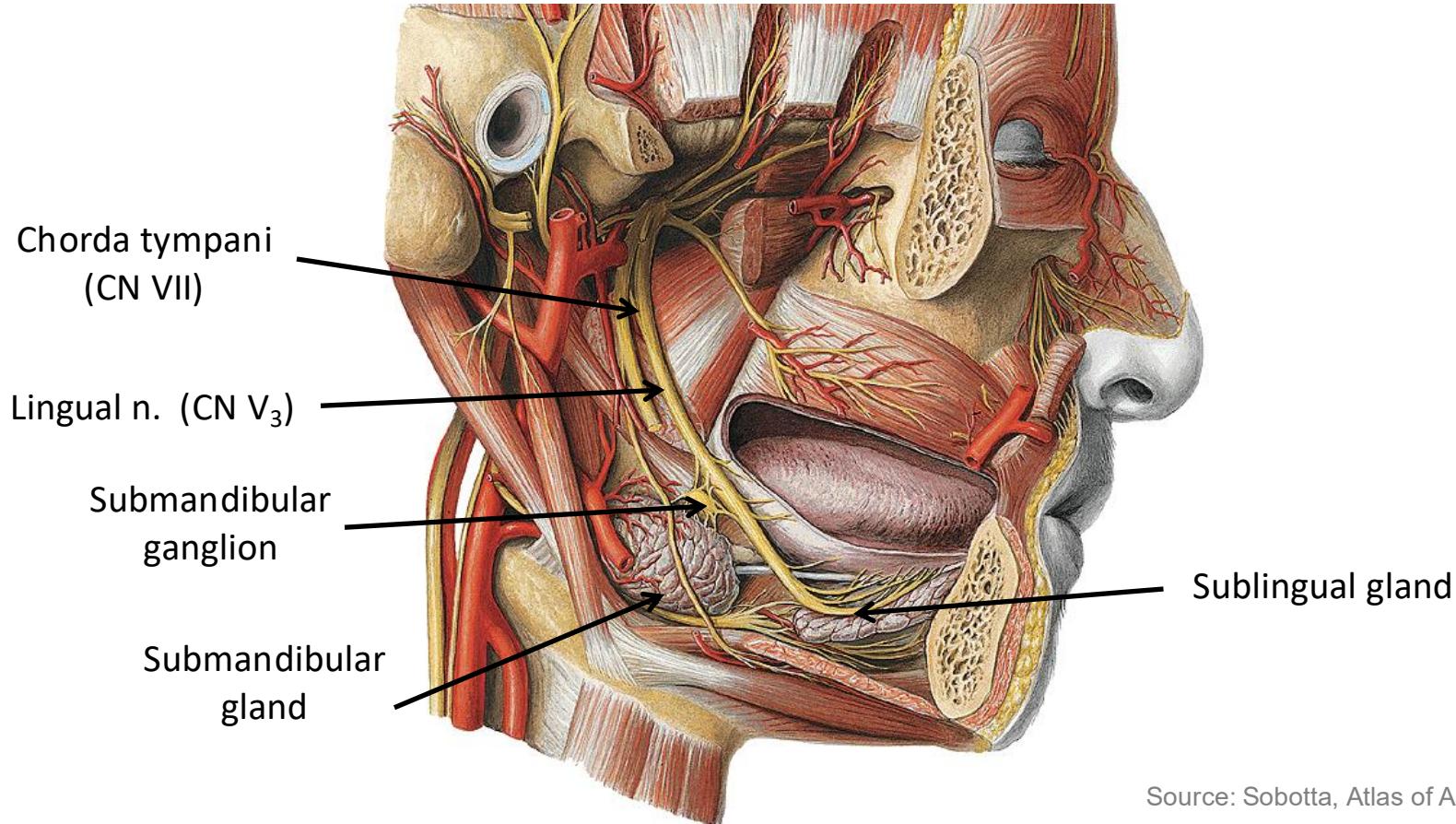
Submandibular Ganglion

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Submandibular Ganglion

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Otic Ganglion

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Preganglionic cell bodies

- Brain (inferior salivary nucleus)

Preganglionic axons

- Glossopharyngeal n (IX) > tympanic nerve > tympanic plexus > lesser petrosal

Postganglionic cell bodies

- Otic ganglion

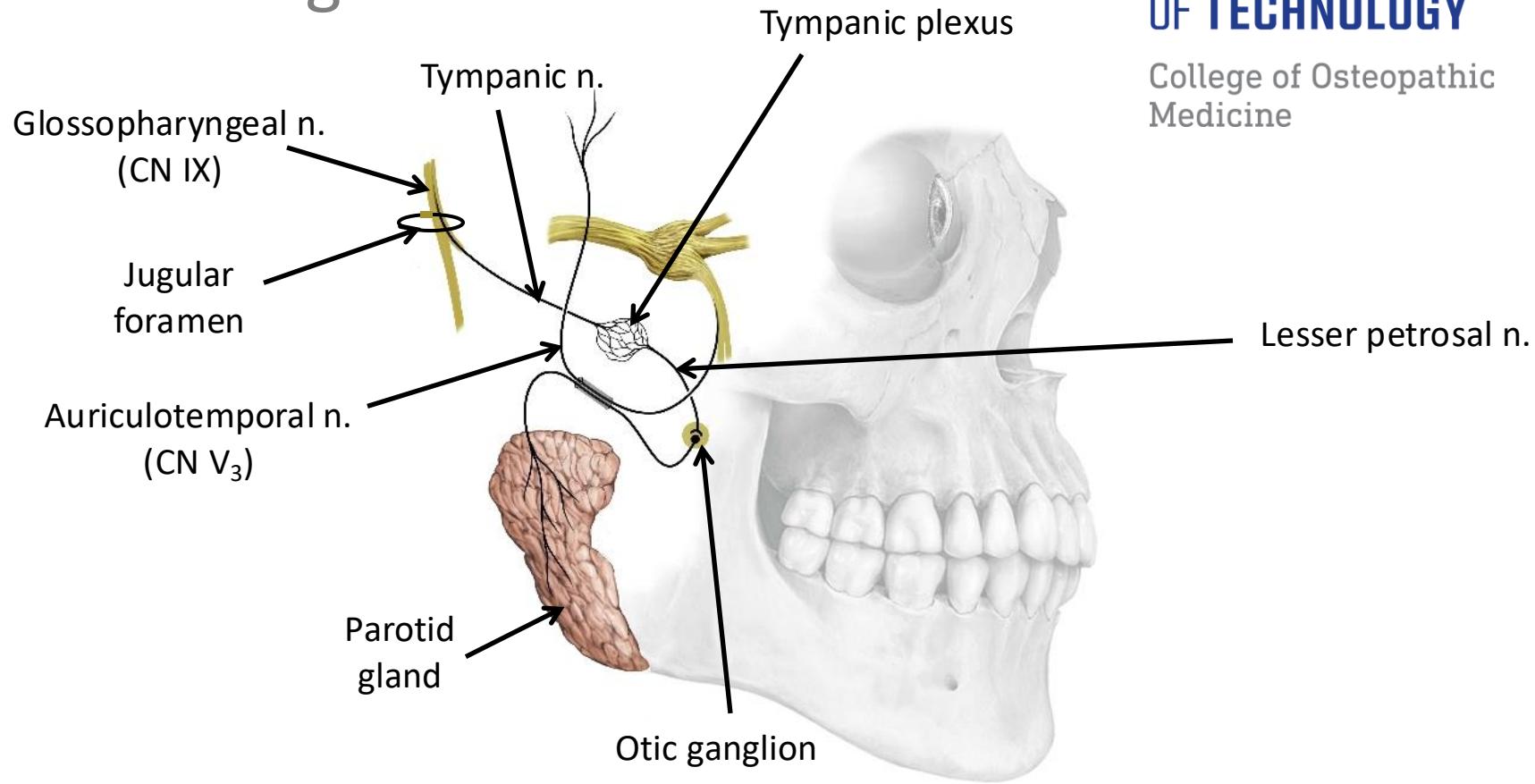
Postganglionic axons

- Parotid gland: Auriculotemporal n. (V_3)

Otic Ganglion

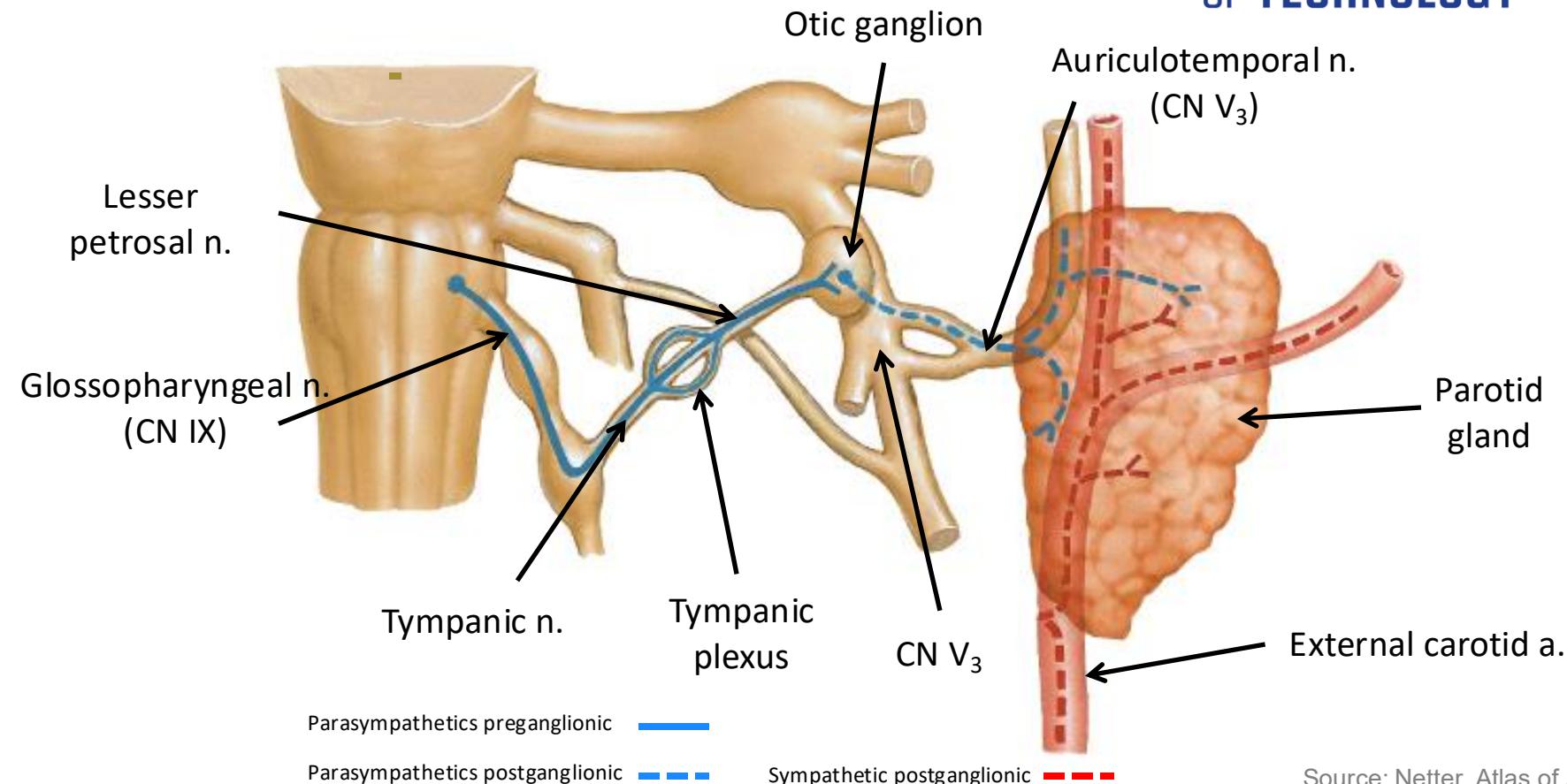
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Otic Ganglion

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Vagus n.

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Preganglionic cell bodies

- Brain (dorsal motor vagus nucleus)

Preganglionic axons

- Vagus n.

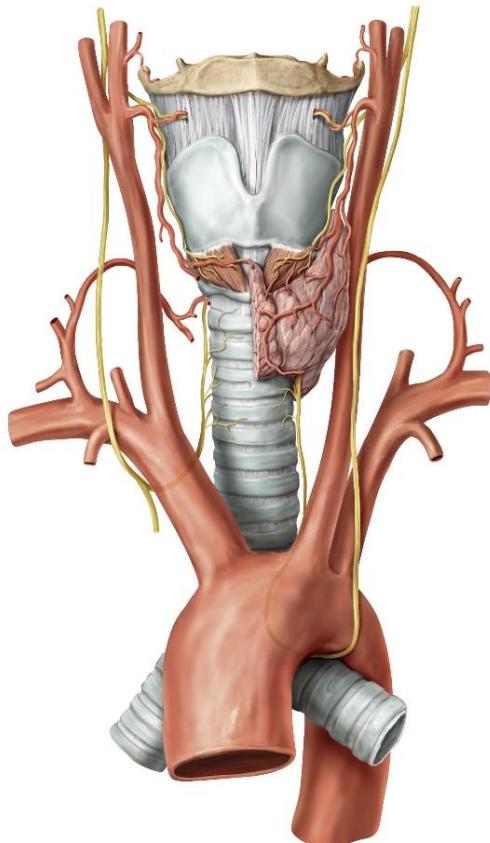
Postganglionic cell bodies

- Close to target organ

Postganglionic axons

- Glands and blood vessels in pharynx
- Mucous glands and blood vessels in larynx

Vagus n.



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Pharyngeal branches

- Pharyngeal glands

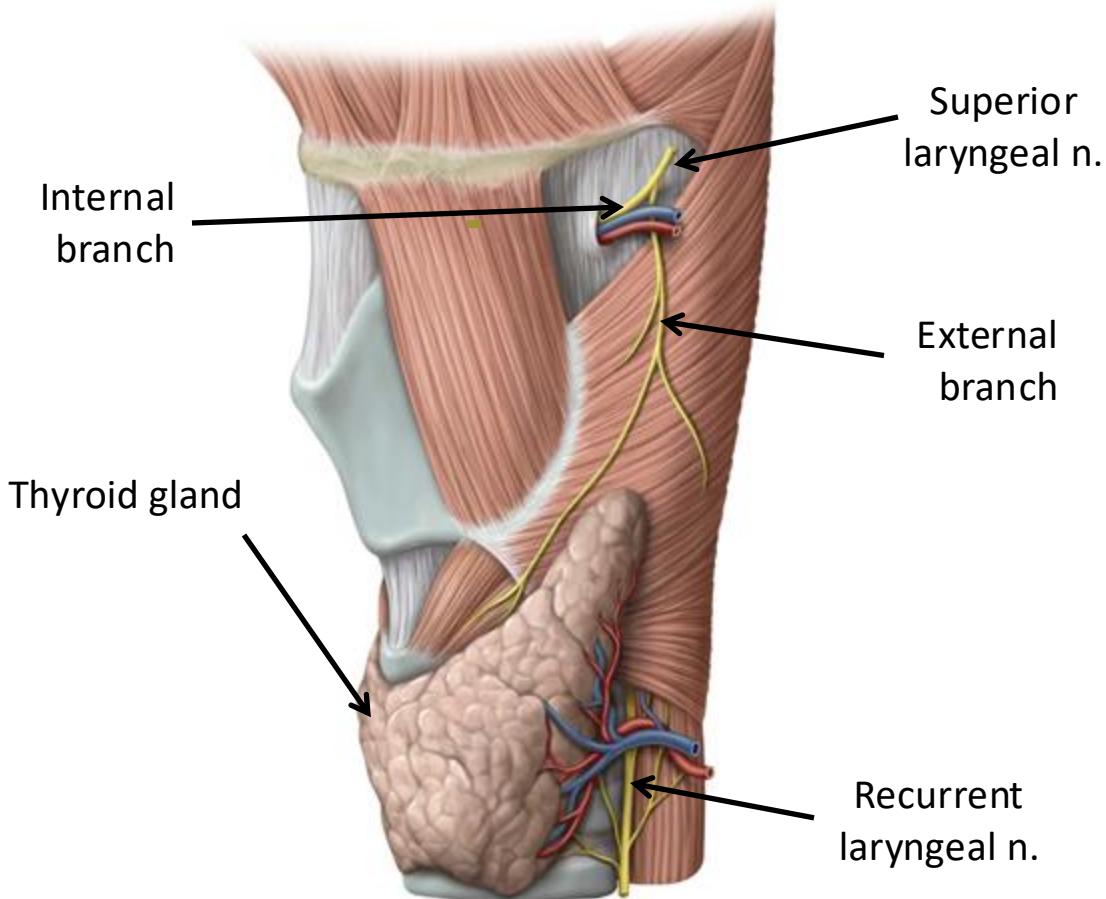
Superior laryngeal n.

- Larynx above vocal fold

Recurrent laryngeal n.

- To thyroid and parathyroid glands
- Larynx below vocal folds

Vagus n.



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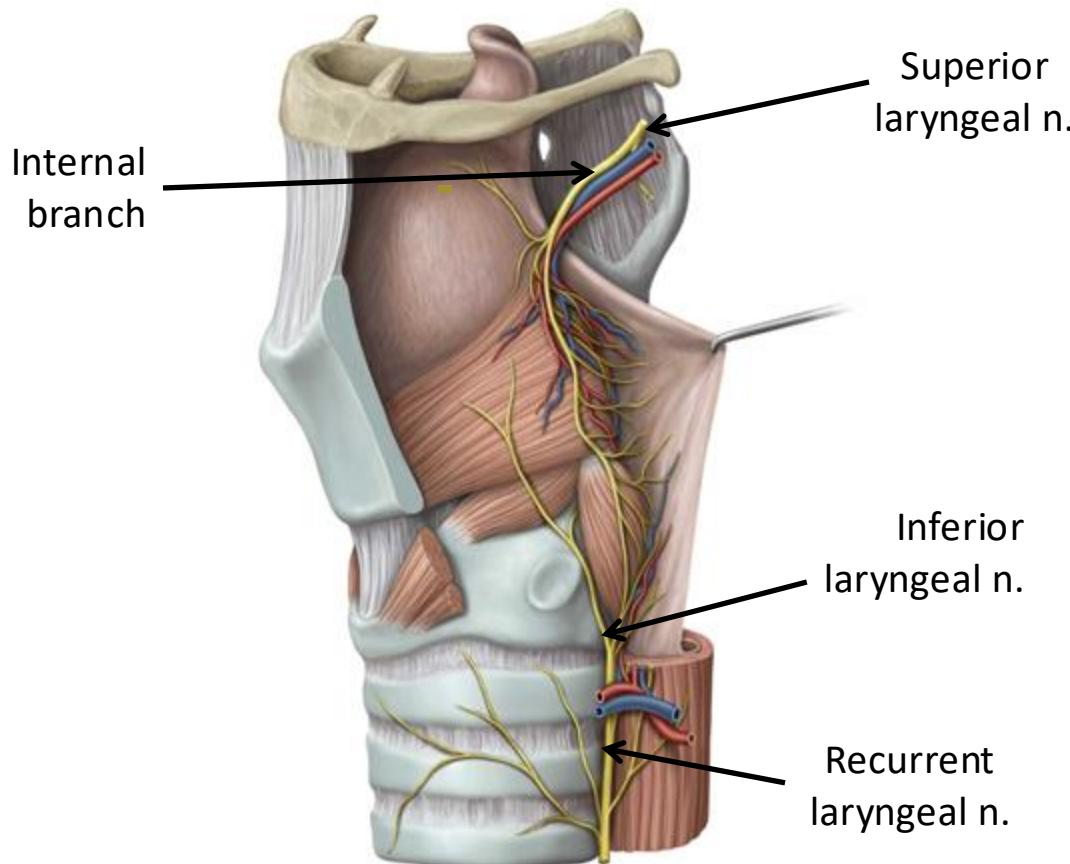
Superior laryngeal n.

- Larynx above vocal fold

Recurrent laryngeal n.

- To thyroid and parathyroid glands
- Larynx below vocal folds

Vagus n.



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Superior laryngeal n.

- Larynx above vocal fold

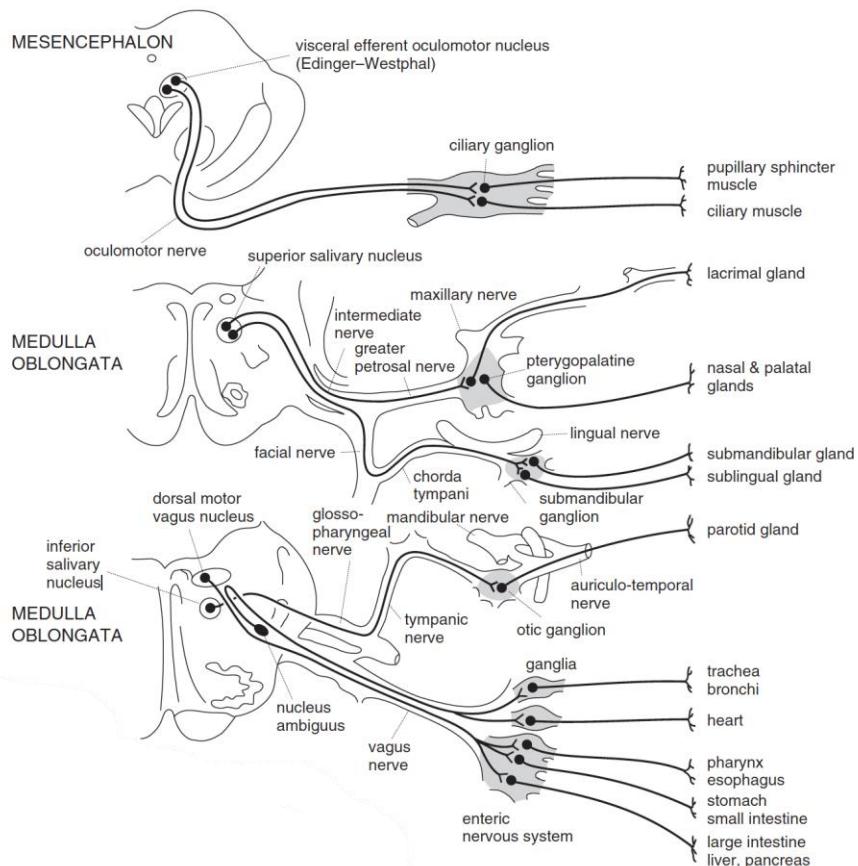
Recurrent laryngeal n.

- To thyroid and parathyroid glands
- Larynx below vocal folds

Summary Parasympathetics

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Source: Jänig, 2006

Clinical Consideration

Damage to Oculomotor n.

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Possible Causes

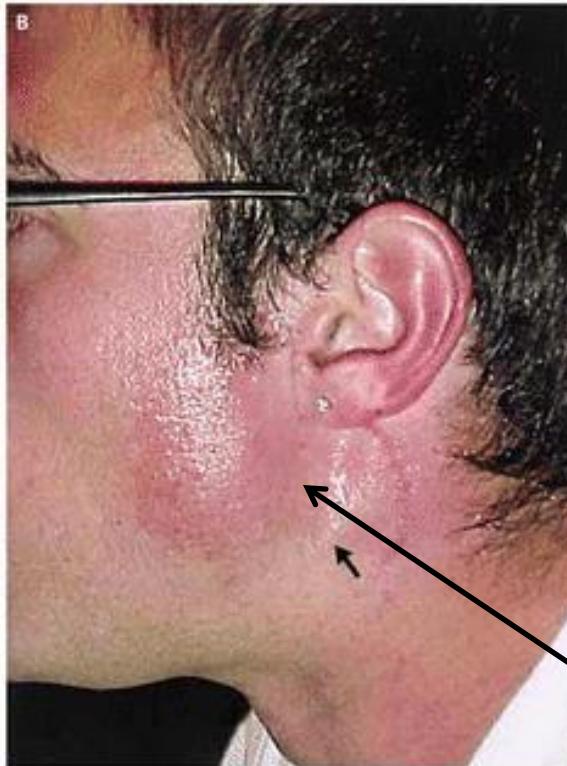
- Oculomotor n. palsy
- Pituitary gland tumor
- Aneurysm of basilar a. or posterior communicating a.

Possible Symptoms

- Parasympathetic: Loss of accommodation/convergence causes double vision, inability to constrict pupil on affected side, the pupil maybe dilated on the affected side.
- Somatic: upper eyelid drops on affected side, impairment of certain eye movements.

Frey's Syndrome

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Lucja Frey

Gustatory sweating

Source: Gray's Anatomy

Clinical Scenario

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A 35-year old female presents to the office with the following symptoms: ptosis and constricted pupil on the right side. Which nerve is most likely damaged?

- A. Optic n.
- B. Trigeminal n.
- C. Facial n.
- D. Oculomotor n.
- E. Internal carotid plexus

Summary

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- **Sympathetics:** preganglionic axons from T1-T2 lateral horn, synapse in superior cervical ganglion, postganglionic axons with internal and external carotid plexus
- **Parasympathetics:** preganglionic axons from CN III, VII, IX, X, synapse in four ganglia, postganglionic axons travel with CN V
- Best References: Jack Stern, ‘Core Concepts’ or ‘Essentials of Gross Anatomy’ (<https://jackstern.org/EGA/EGA2003.html>); Moore et al. Clinically Oriented Anatomy; Jänig. 2006. The Integrative Action of the Autonomic Nervous System

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Synonyms

Sensory = part of afferents

Motor = part of efferents

Visceral Motor = Autonomics (note there are other definitions e.g. Autonomics = Visceral motor and sensory)

Ventral horn/root/ramus = Anterior horn/root/ramus

Dorsal horn/root/ramus = Posterior horn/root/ramus

Dorsal root ganglion = Spinal ganglion

Lateral horn = Intermediolateral column

Preganglionic = Presynaptic

Postganglionic = Postsynaptic

Sympathetic organ nerve = cardiopulmonary splanchnics

Sympathetic chain = sympathetic trunk = paravertebral chain

Paravertebral ganglia = sympathetic chain ganglia = sympathetic trunk ganglia

Prevertebral ganglia = sympathetic ganglia for pelvic and hindgut organs below the aorta

Preaortic ganglia = sympathetic ganglia for abdominal and pelvic organs on the aorta

Subdiaphragmatic ganglia = prevertebral and preaortic ganglia