

# Autonomics of the Head and Neck

**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine

**Simone Hoffmann**  
**Anatomy**  
**[simone.hoffmann@nyit.edu](mailto:simone.hoffmann@nyit.edu)**

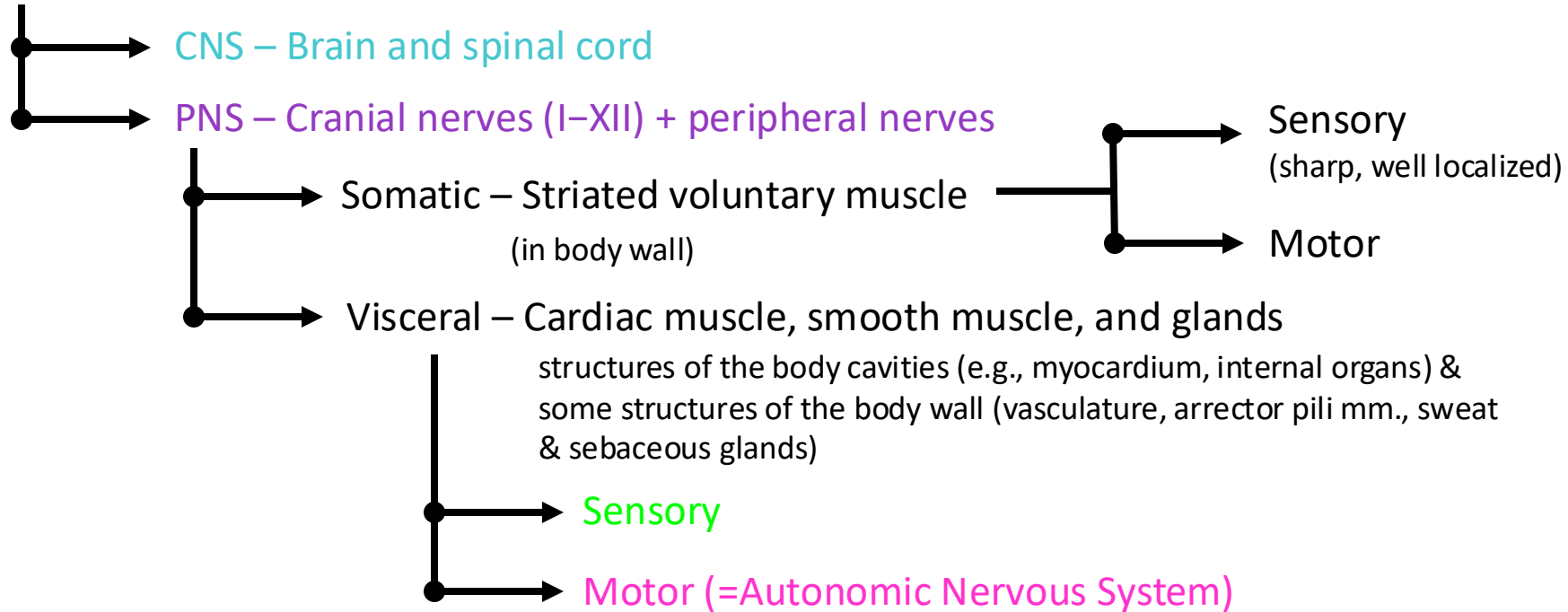
Do.  
Make.  
Heal.  
Innovate.  
Reinvent the Future.

# 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

## Nervous System

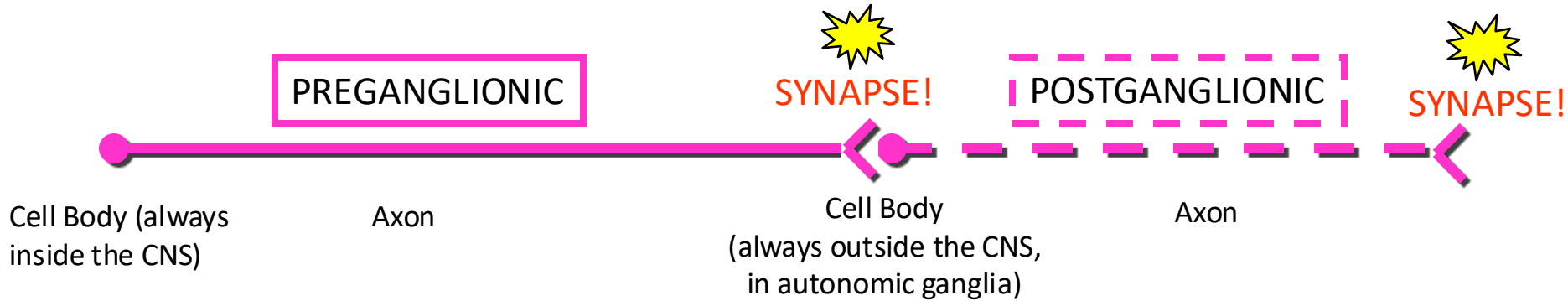


# Visceral Neuron Types

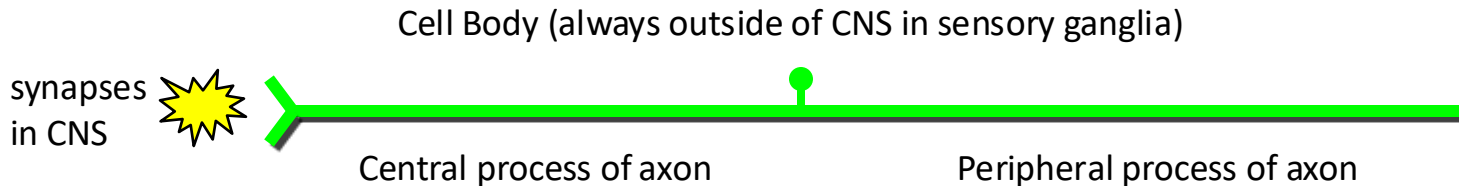
NEW YORK INSTITUTE  
OF TECHNOLOGY

College of Osteopathic  
Medicine

## Visceral Motor Neuron



## Visceral Sensory Neuron



# Visceral Neuron Types

## 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

## **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

<b>Organ</b>	<b>Sympathetic Effect</b>	<b>Parasympathetic effect</b>
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

## Preganglionic cell bodies

- T1-T2 lateral horn

## Preganglionic axons

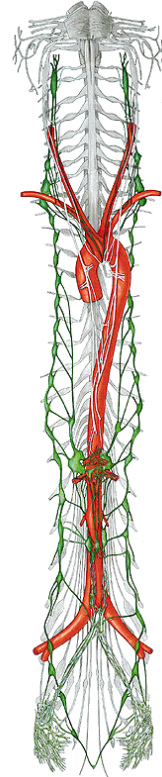
- Ventral roots T1-T2 > spinal nn. T1-T2 > ventral rami T1-T2 > white rami communicantes T1-T2 > paravertebral ganglia T1-T2 > ascend in sympathetic chain

## Postganglionic cell bodies

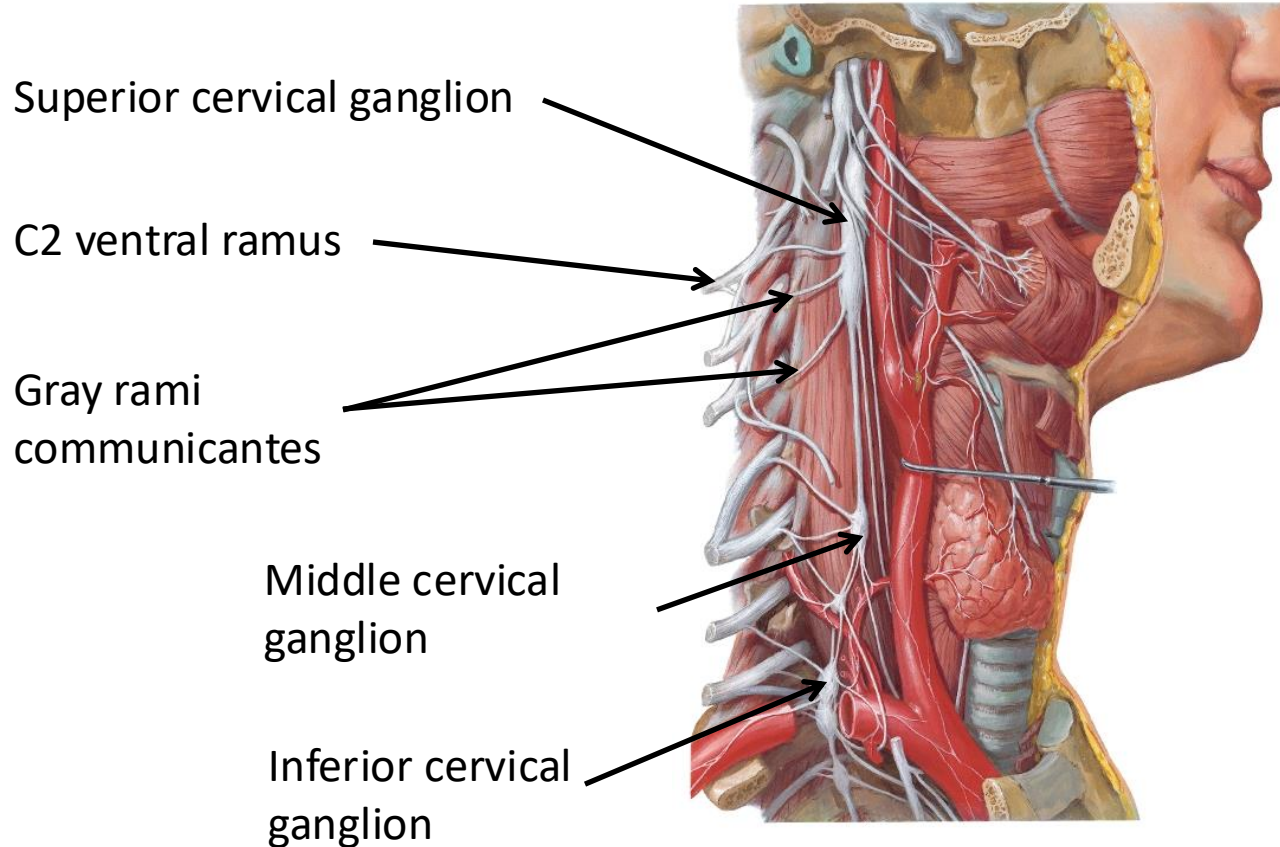
- Superior cervical ganglion

## Postganglionic axons

- Internal carotid plexus
- External carotid plexus

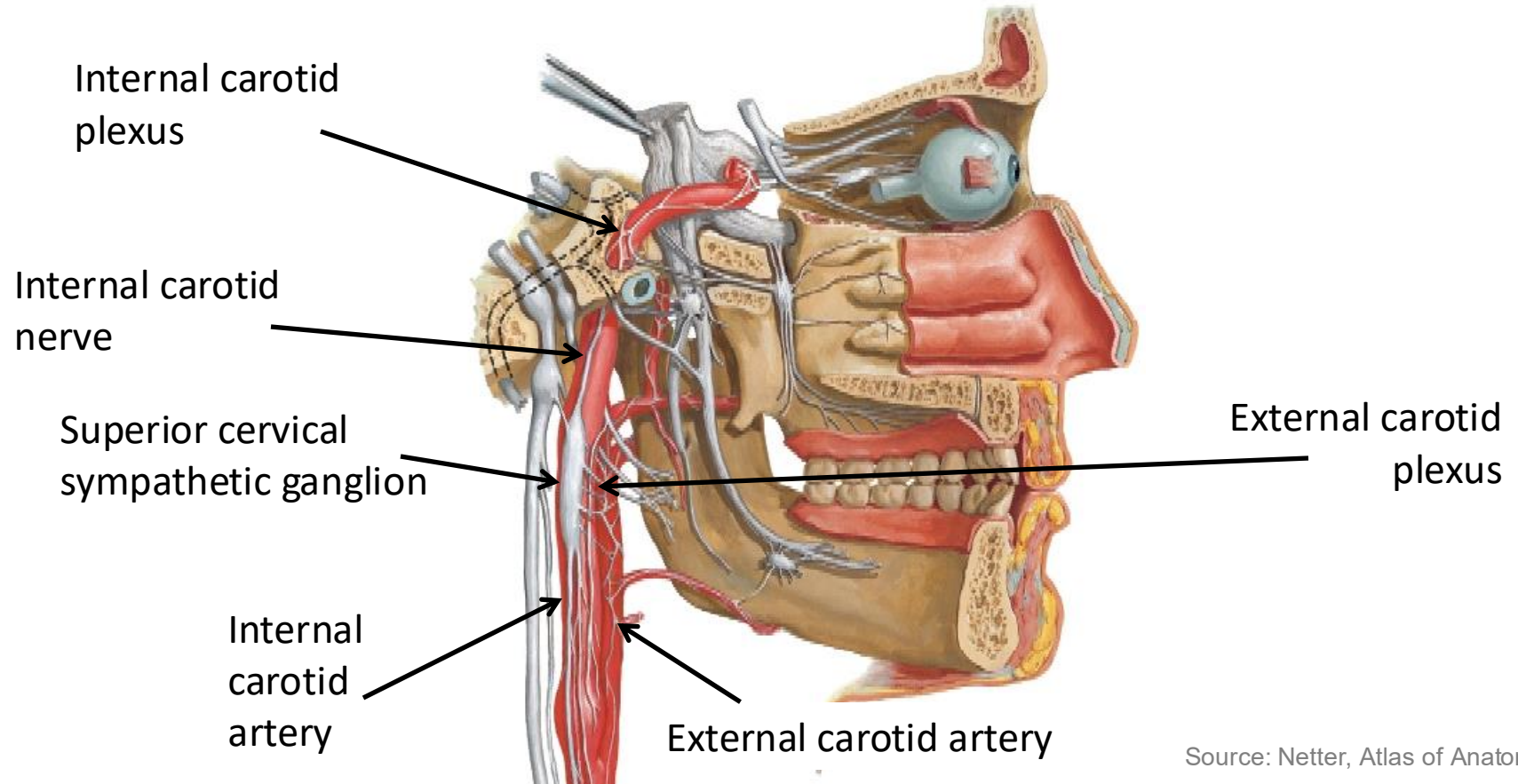


# Sympathetic Innervation



# Sympathetic Innervation

**NEW YORK INSTITUTE  
OF TECHNOLOGY**



Source: Netter, Atlas of Anatomy

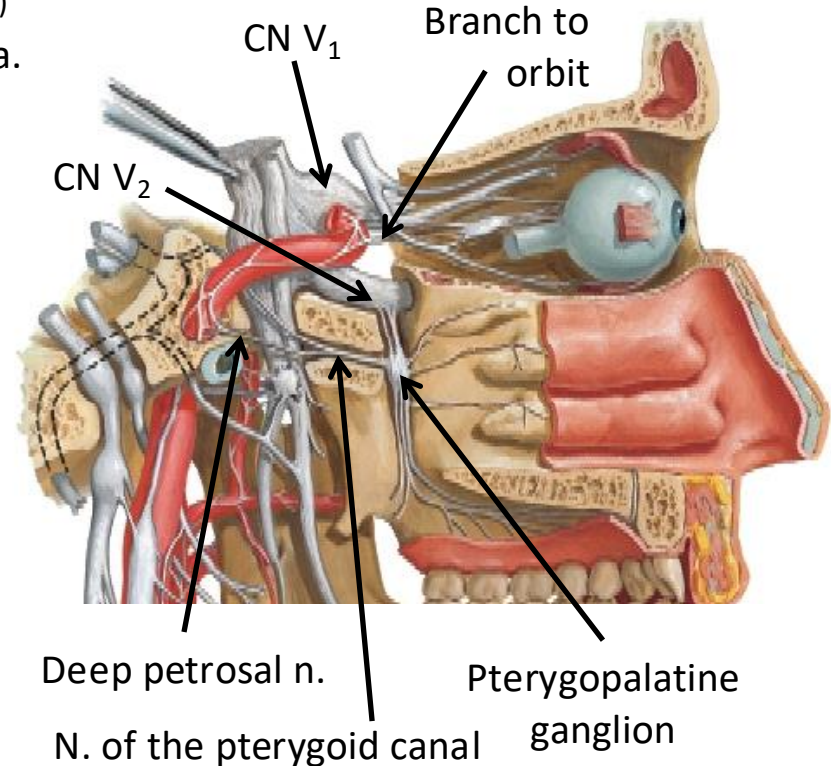
# Internal Carotid Plexus

## **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

## Branches with maxillary a.

- Parotid gland

## Branches with lingual a.

- Sublingual gland
- Submandibular gland

## Branches with facial a.

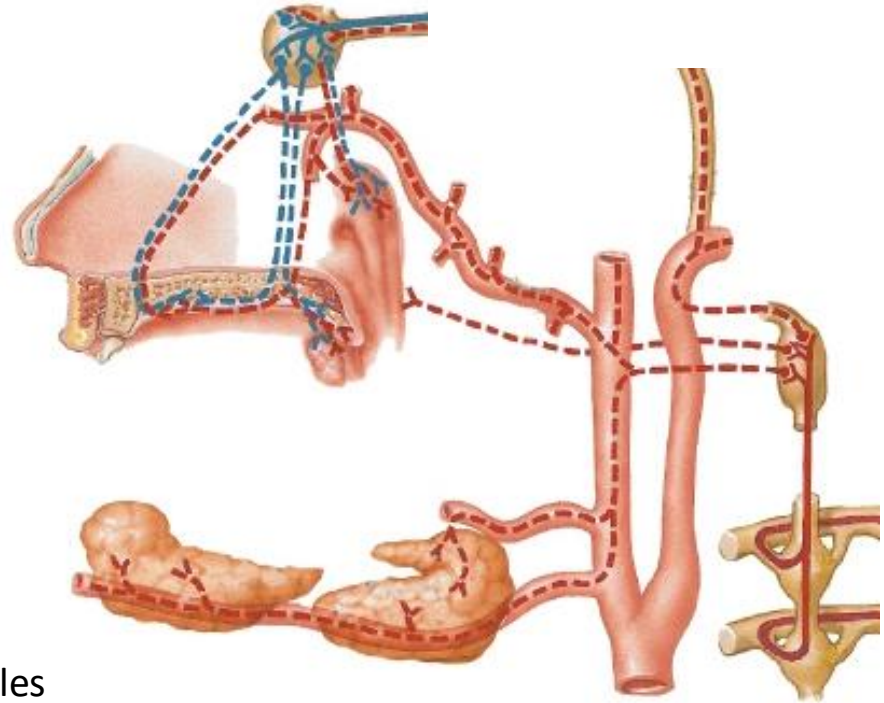
- Submandibular gland

## Branches with superior thyroid a.

- Thyroid gland

## With all branches

- Vasoconstriction of arterioles
- Facial sweat glands



Sympathetic preganglionic ———

Sympathetic postganglionic - - -

# Clinical Consideration



# Horner's Syndrome



## Cause

- Damage or blockage of sympathetic pathway to head

## Symptoms

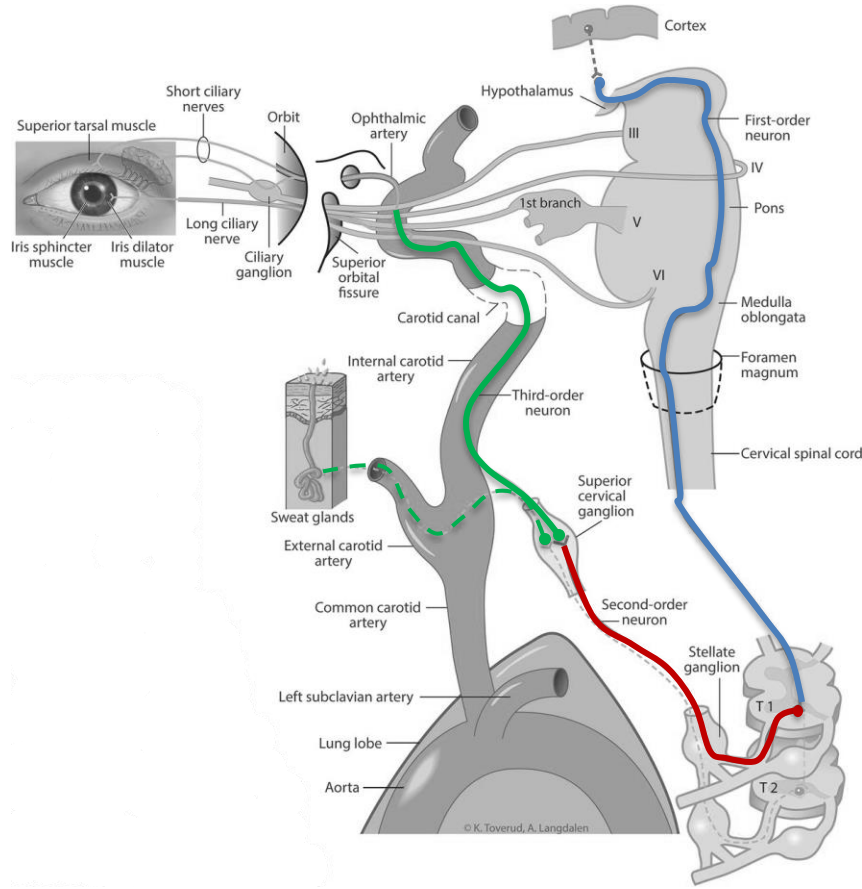
- **Constricted pupil (miosis)**
- **Drooping upper eyelid (mild ptosis)**
- **Lack of sweating (anhidrosis)**
- Loss of cutaneous vasodilation in face (cannot blush)
- Loss of ocular vasoconstriction ("bloodshot" eye)

# Horner's Syndrome

First-order neuron (Central)

Second-order neuron (Preganglionic)

Third-order neuron (Postganglionic)



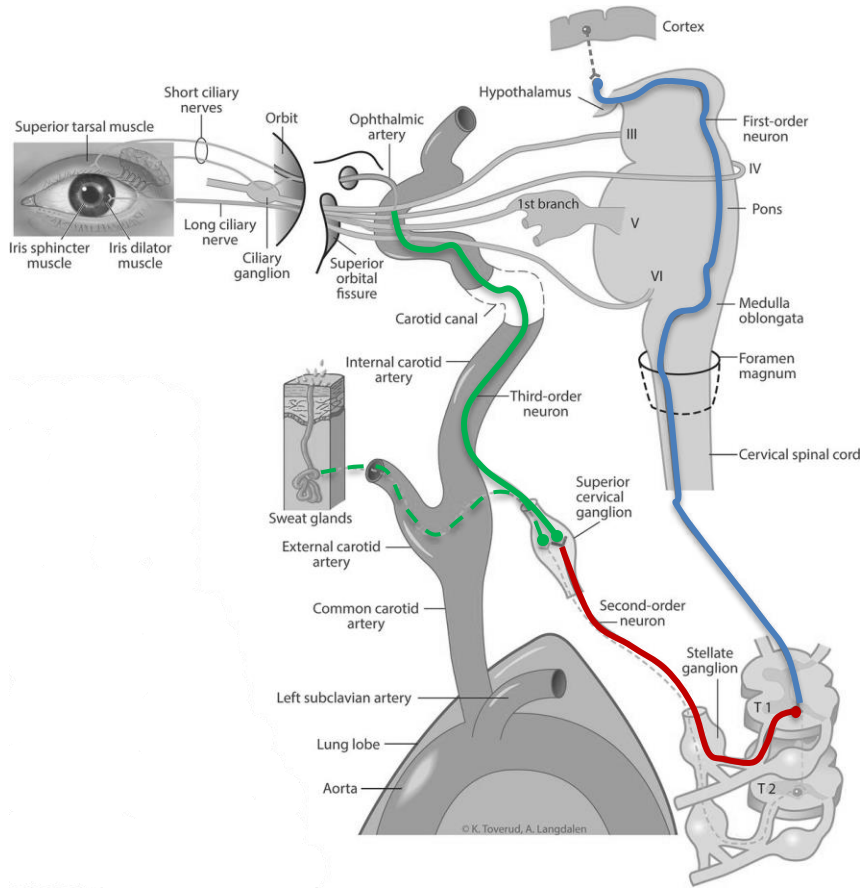


# Horner's Syndrome

**First-order neuron (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



# Clinical Scenario

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

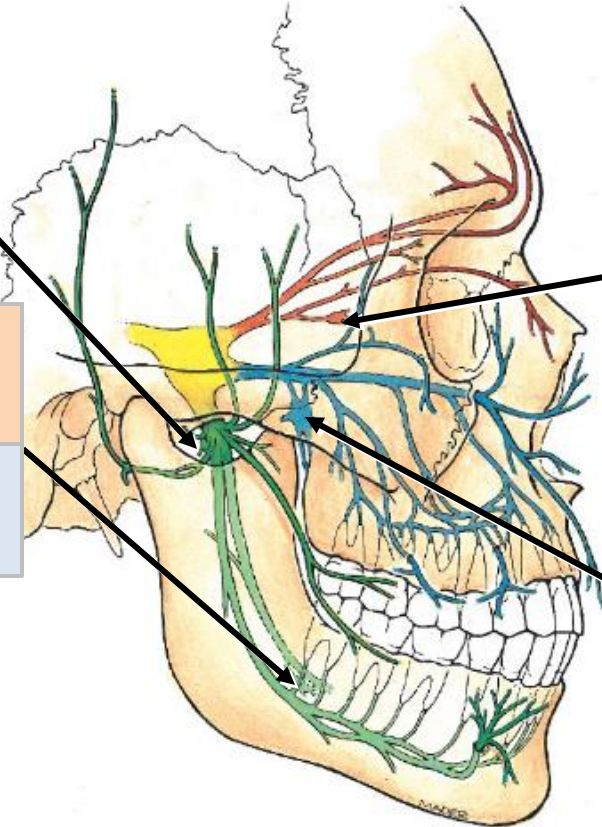
# Parasympathetic Innervation

**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine

Otic ganglion  
- connected to  $V_3$   
- preganglionics  
from CN IX

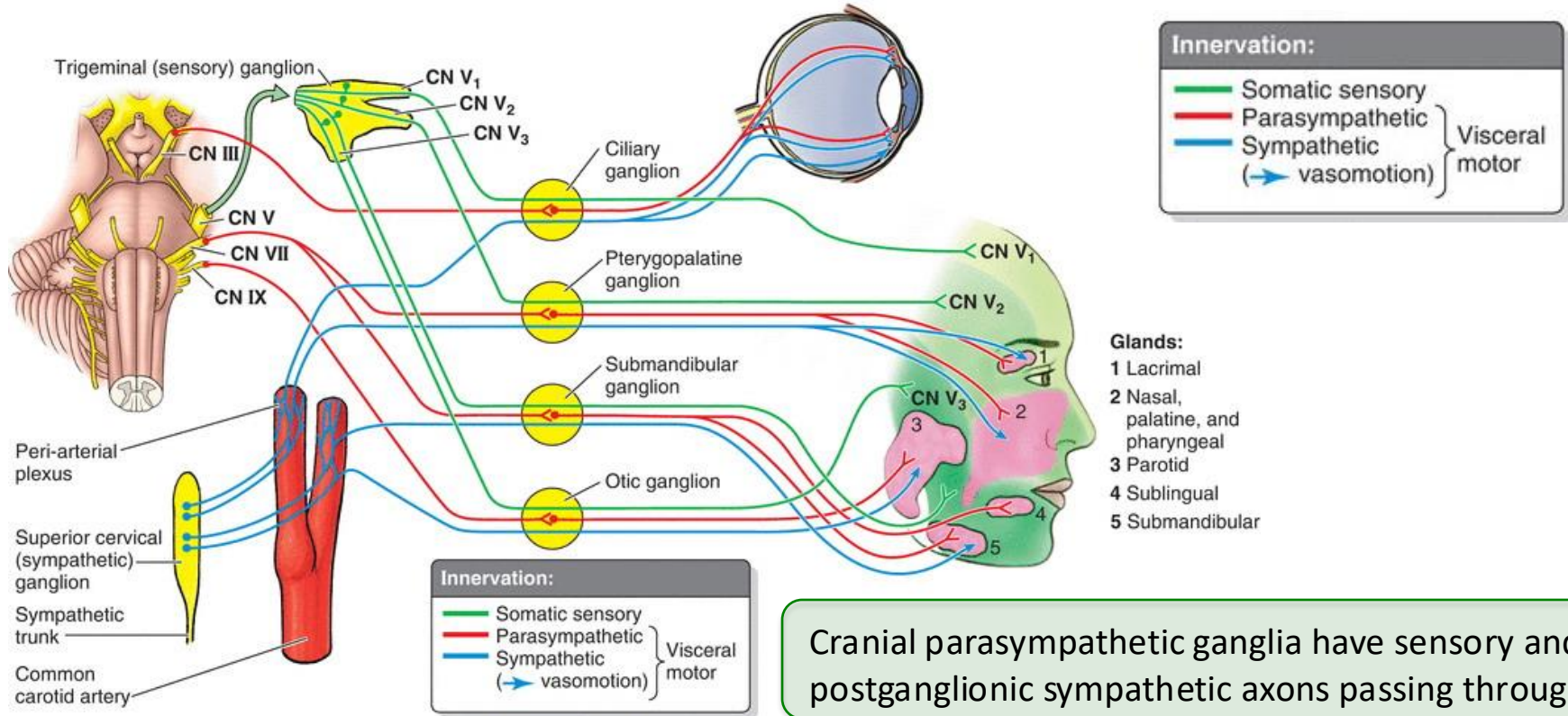
Submandibular ganglion  
- connected to  $V_3$   
- preganglionics from  
CN VII



Ciliary ganglion  
- connected to  $V_1$   
- preganglionics  
from CN III

Pterygopalatine ganglion  
- connected to  $V_2$   
- preganglionics from  
CN VII

# Parasympathetic Innervation



# Ciliary Ganglion

## **Preganglionic cell bodies**

- Brain (visceral efferent oculomotor nucleus)

## **Preganglionic axons**

- Oculomotor Nerve (CN III)

## **Postganglionic cell bodies**

- Ciliary ganglion

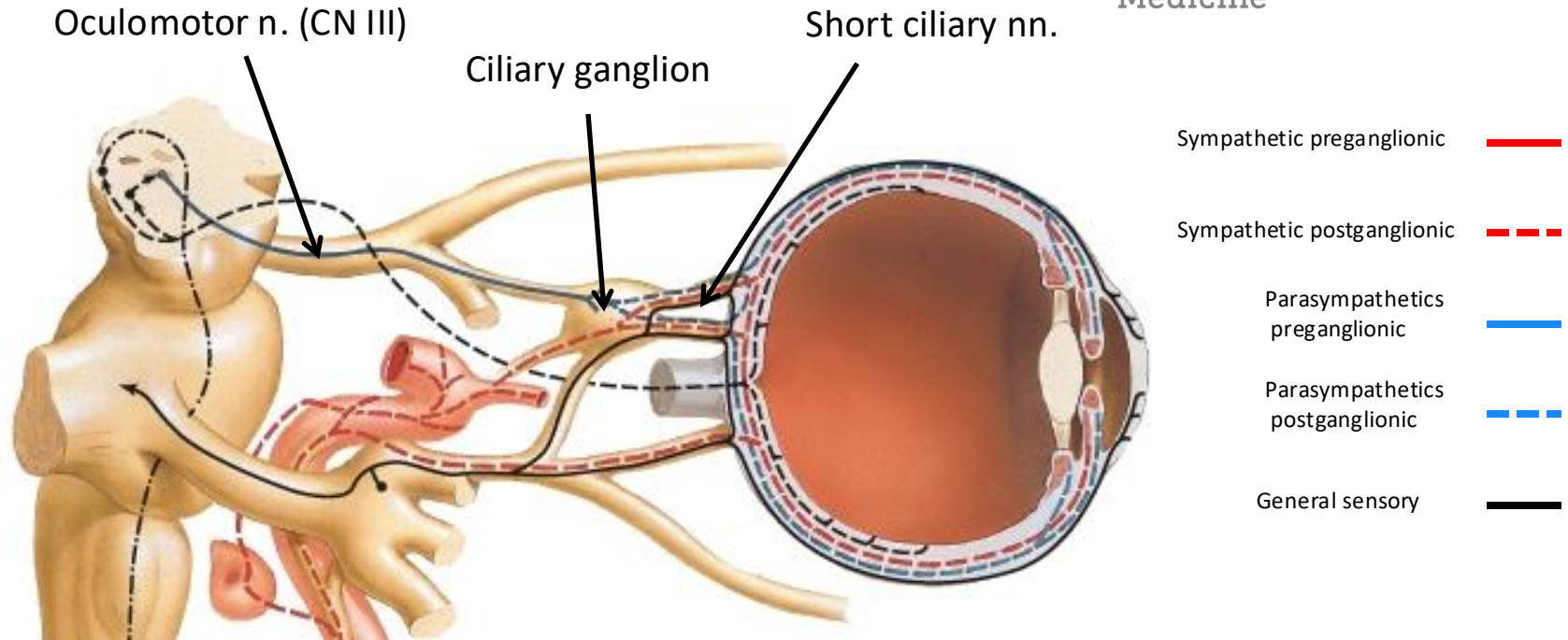
## **Postganglionic axons**

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

# Ciliary Ganglion

**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine



## **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

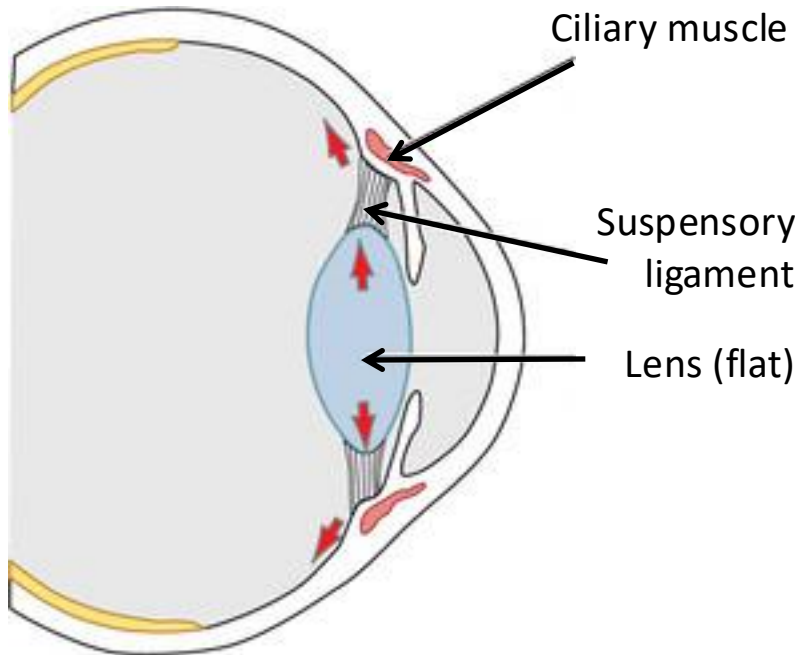
## **Accommodation/Convergence reflex**

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

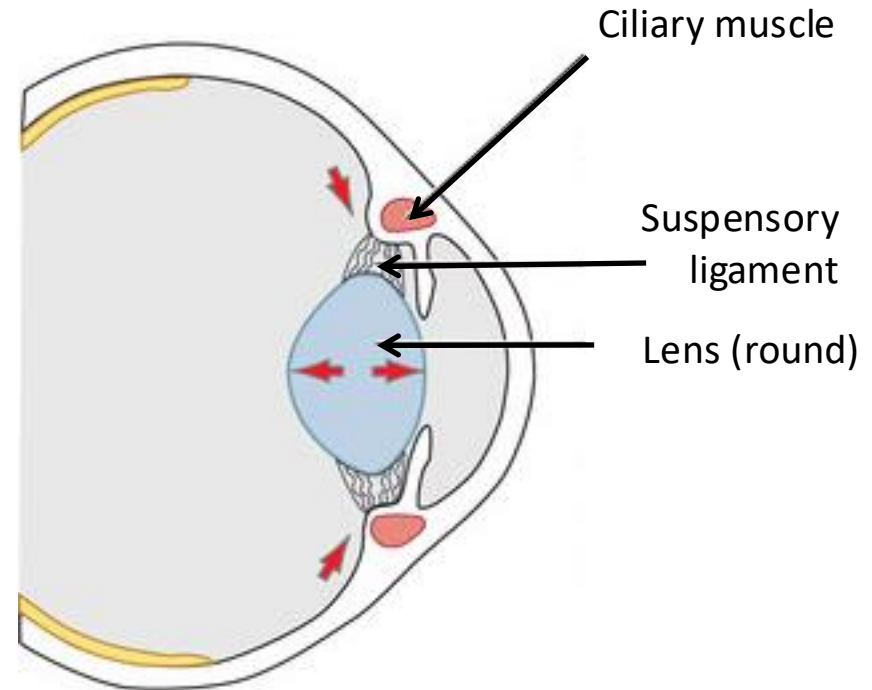


# Accommodation

## Relaxed

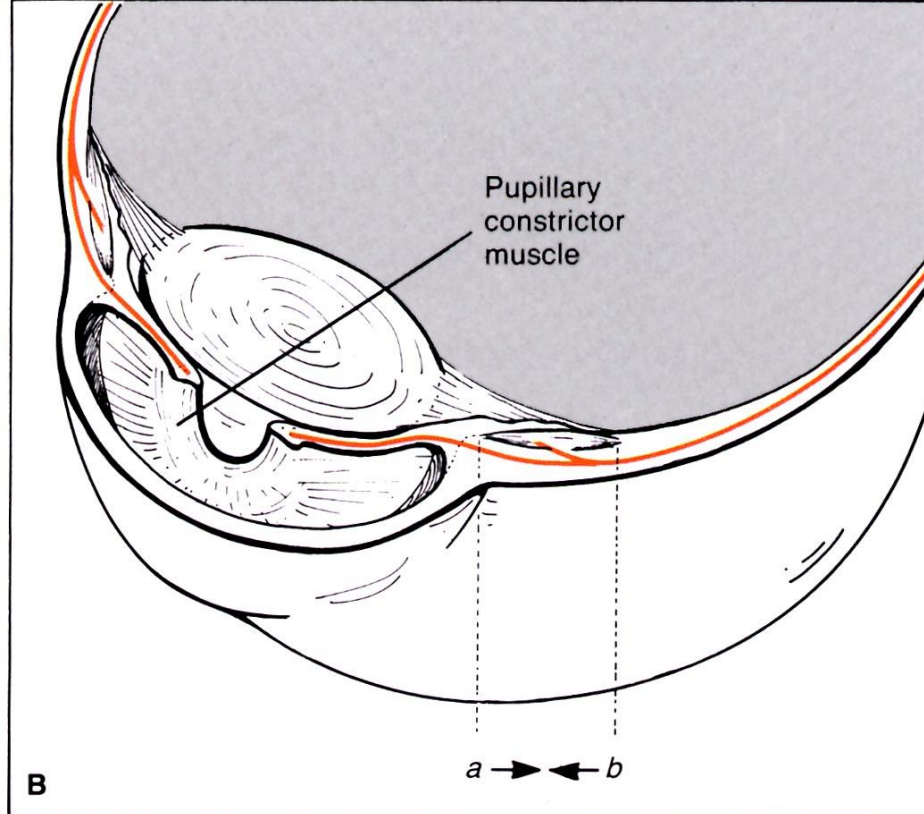
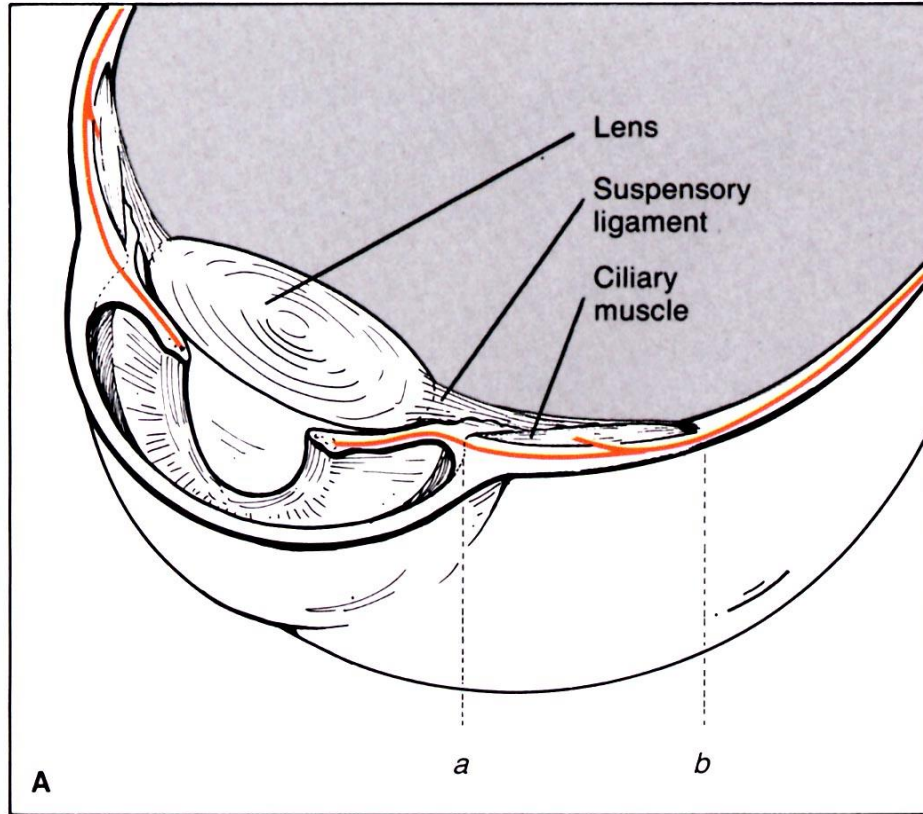


## Contracted



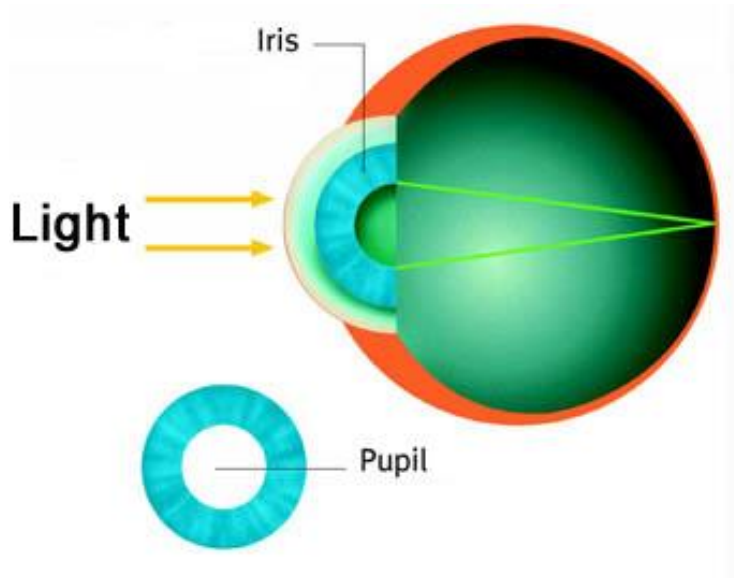
# Accommodation/Convergence

NEW YORK INSTITUTE  
OF TECHNOLOGY



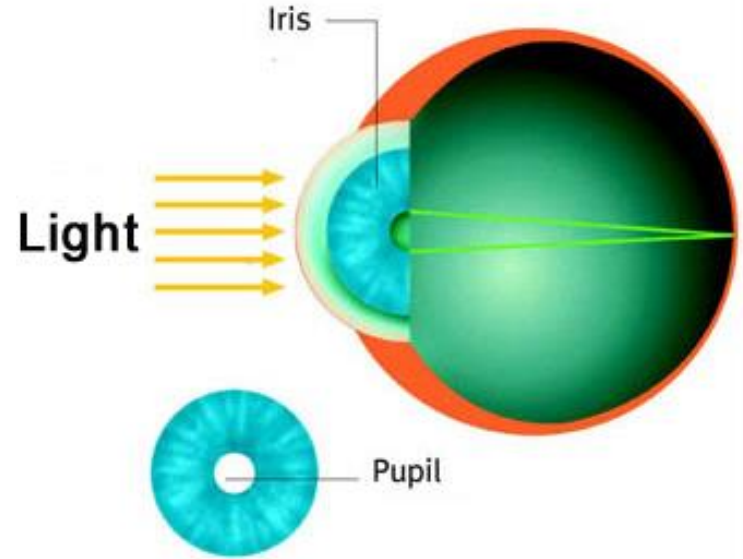
# Dilation vs. Constriction

## Dilation



To allow *more* light in  
*Sympathetic* reaction

## Constriction



To allow *less* light in  
*Parasympathetic* reaction

# Pterygopalatine Ganglion

## **Preganglionic cell bodies**

- Brain (superior salivary nucleus)

## **Preganglionic axons**

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

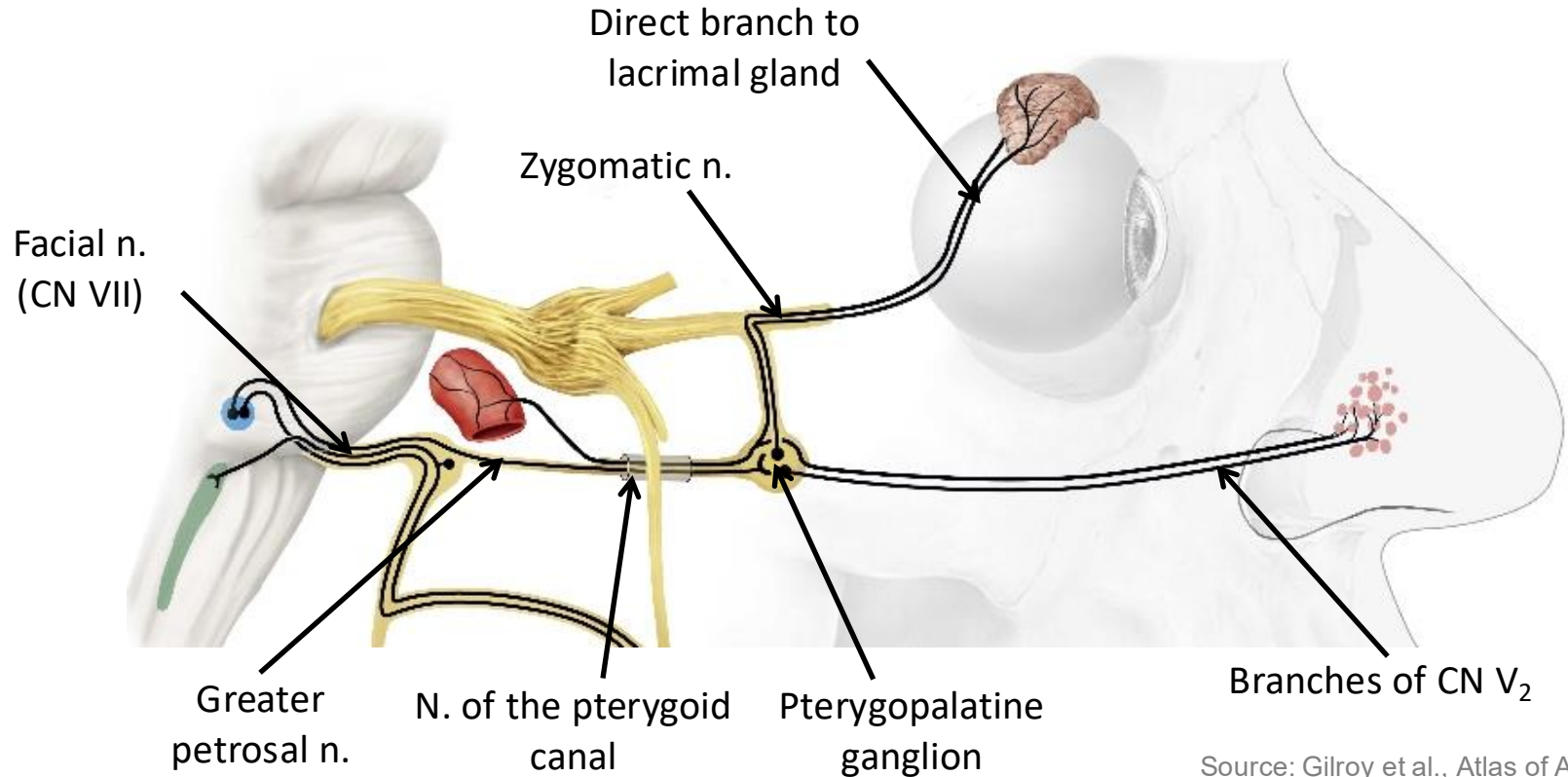
## **Postganglionic cell bodies**

- Pterygopalatine ganglion

## **Postganglionic axons**

- Lacrimal: direct branch to lacrimal gland
- Mucous glands in nasal cavity, palate, sinuses, pharynx: branches of V<sub>2</sub>

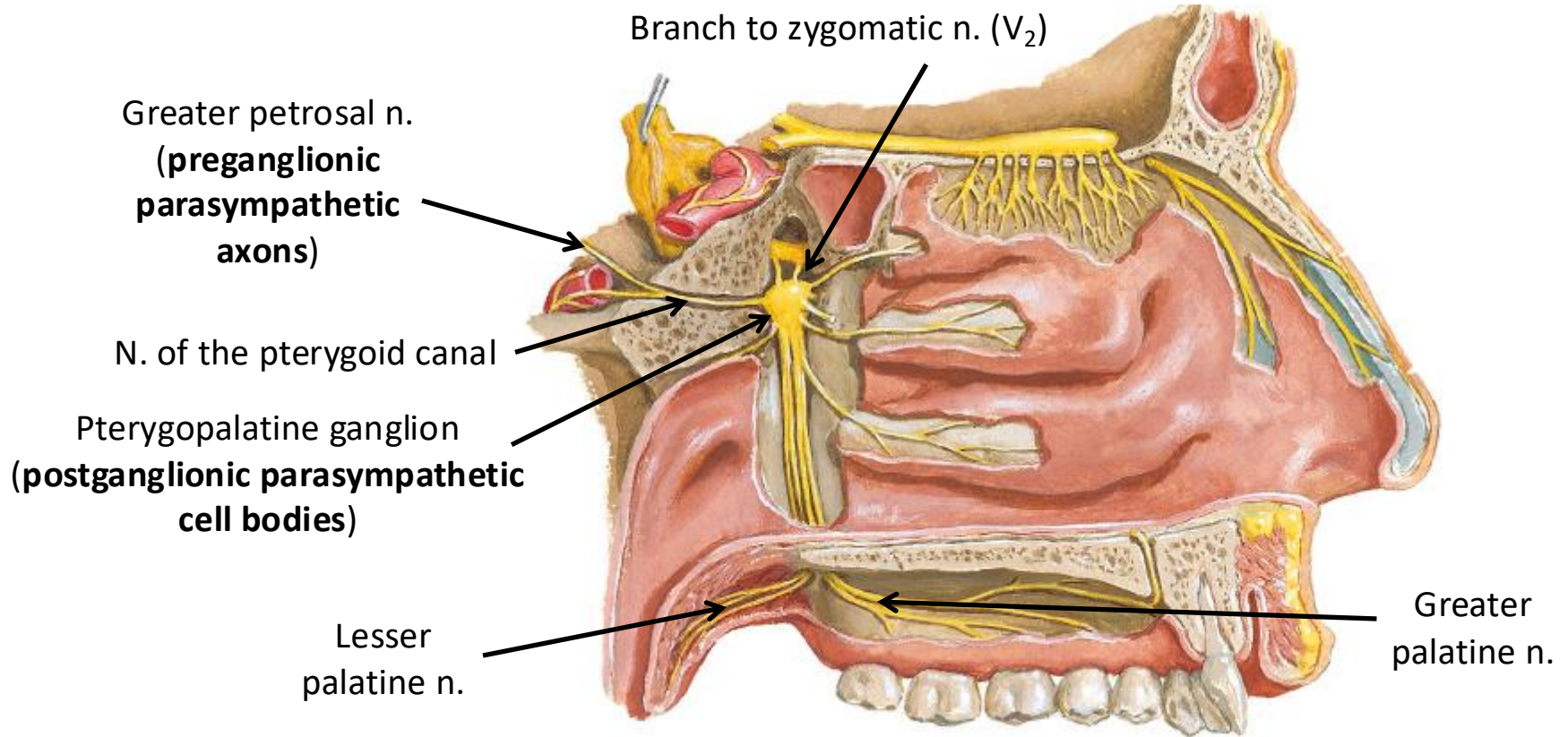
# Pterygopalatine Ganglion





# Pterygopalatine Ganglion

NEW YORK INSTITUTE  
OF TECHNOLOGY



# Submandibular Ganglion

## **Preganglionic cell bodies**

- Brain (superior salivary nucleus)

## **Preganglionic axons**

- Facial Nerve (CN VII) > chorda tympani > lingual n (V<sub>3</sub>)

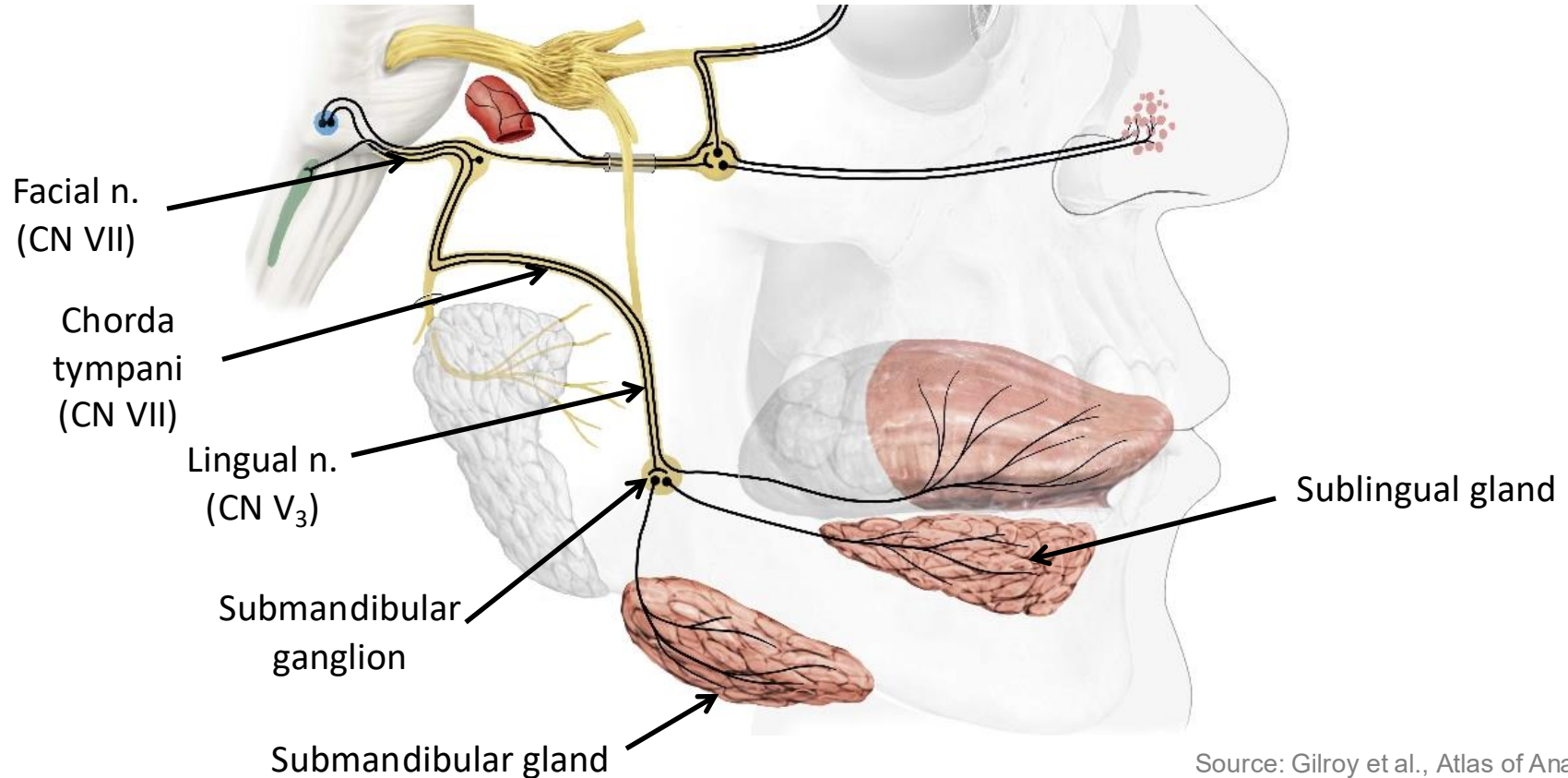
## **Postganglionic cell bodies**

- Submandibular ganglion

## **Postganglionic axons**

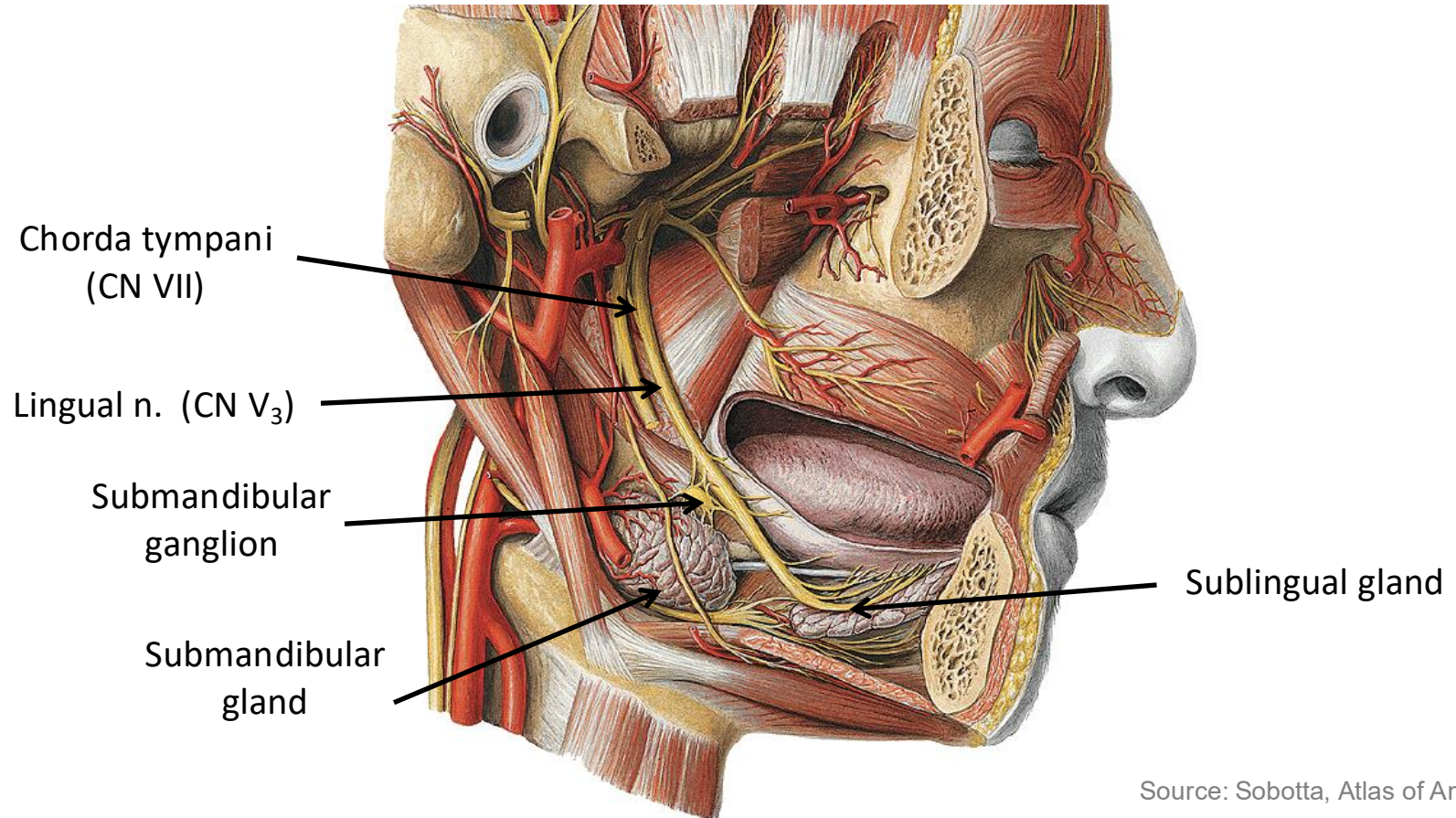
- Submandibular gland: direct branches
- Sublingual gland: Lingual n.

# Submandibular Ganglion





# Submandibular Ganglion



# Otic Ganglion

## **Preganglionic cell bodies**

- Brain (inferior salivary nucleus)

## **Preganglionic axons**

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

## **Postganglionic cell bodies**

- Otic ganglion

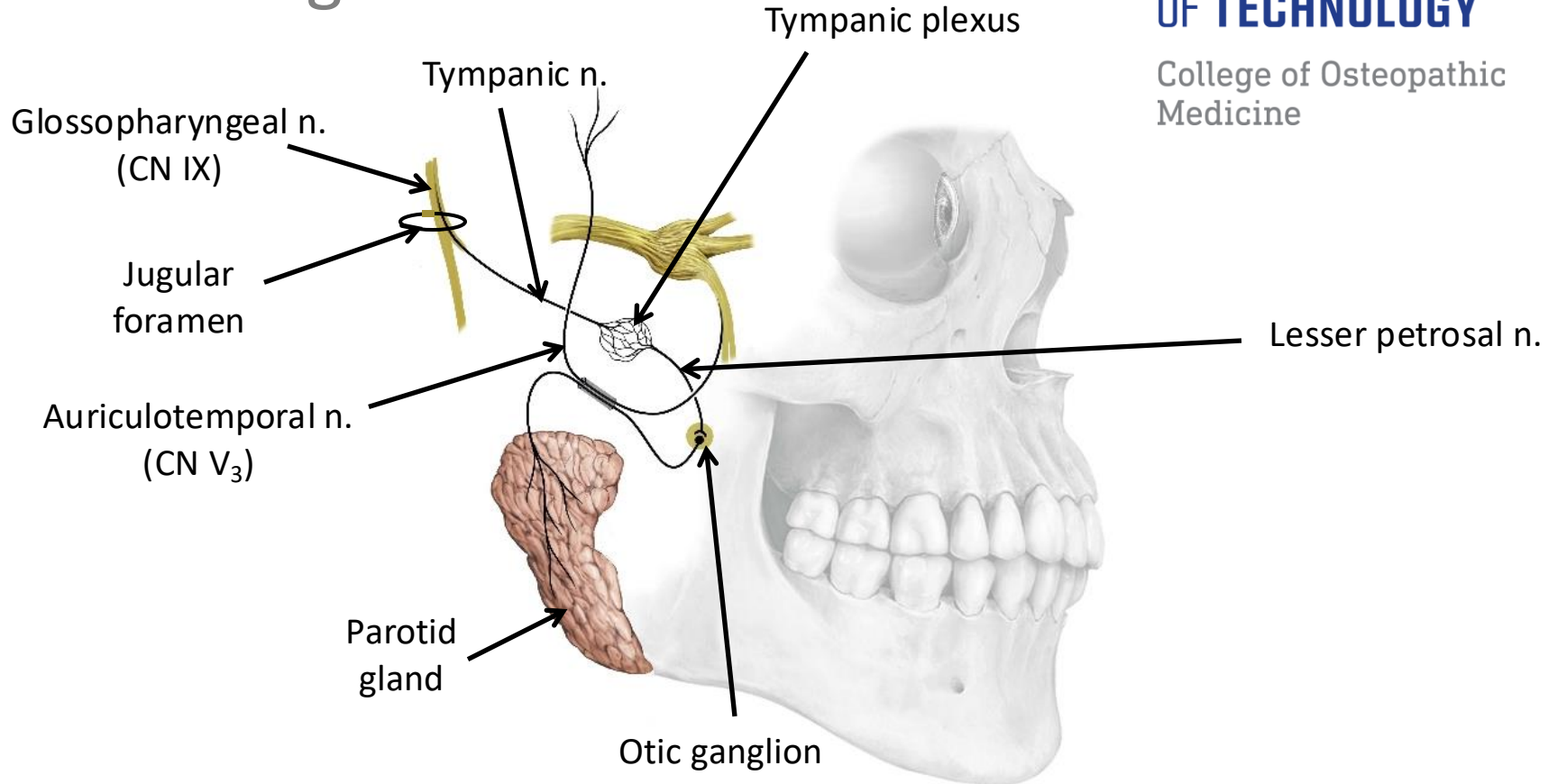
## **Postganglionic axons**

- Parotid gland: Auriculotemporal n. (V<sub>3</sub>)

# Otic Ganglion

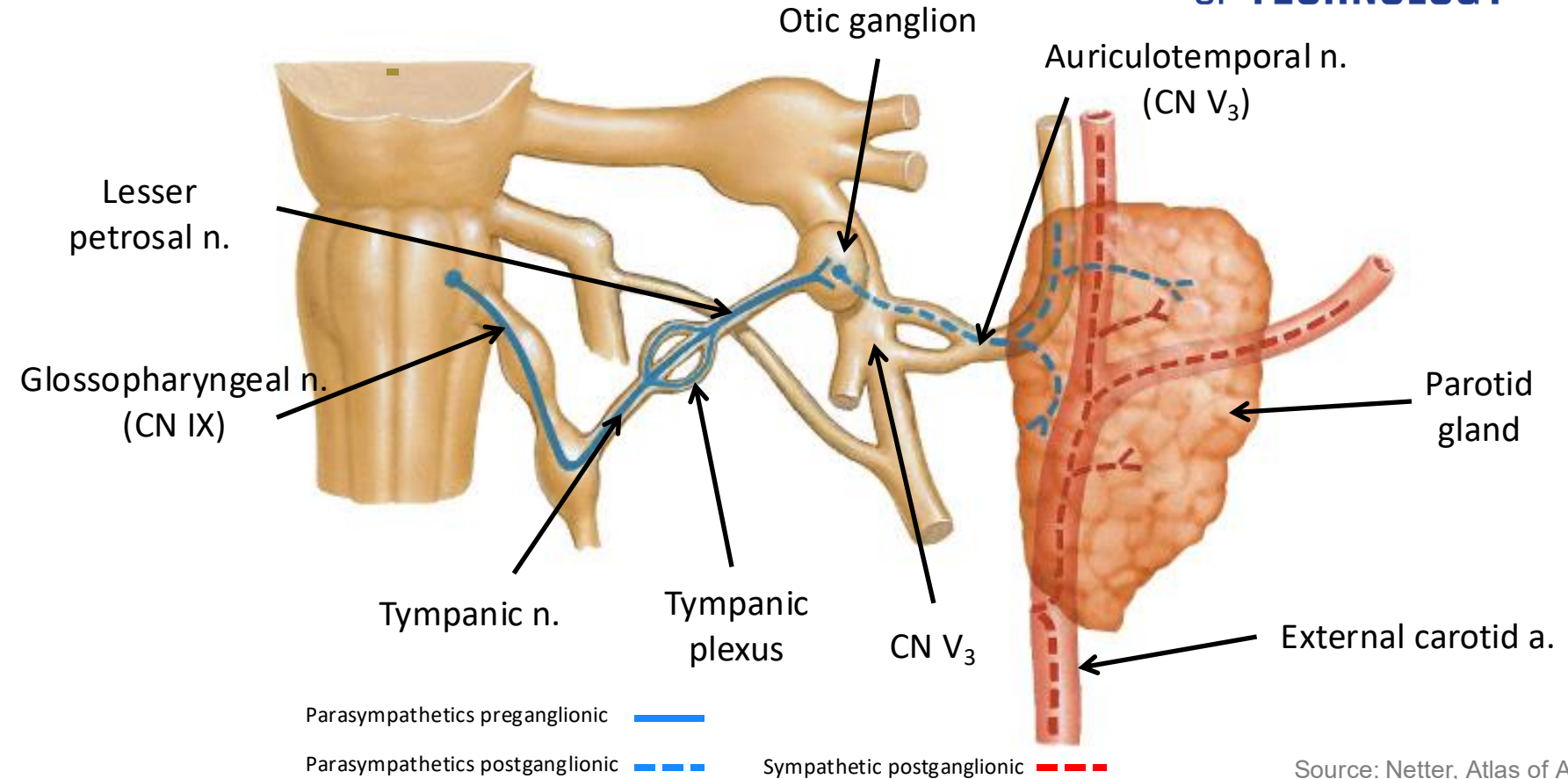
**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine



# Otic Ganglion

NEW YORK INSTITUTE  
OF TECHNOLOGY



# Vagus n.

## **Preganglionic cell bodies**

- Brain (dorsal motor vagus nucleus)

## **Preganglionic axons**

- Vagus n.

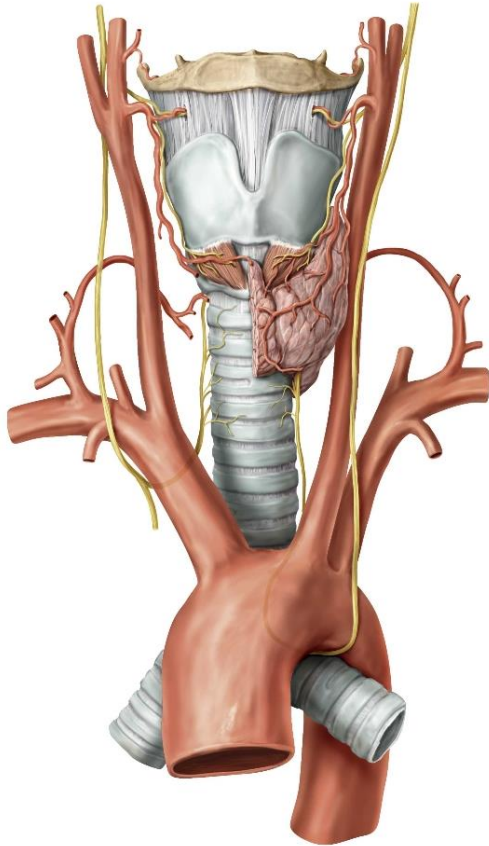
## **Postganglionic cell bodies**

- Close to target organ

## **Postganglionic axons**

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

# Vagus n.



## **Pharyngeal branches**

- Pharyngeal glands

## **Superior laryngeal n.**

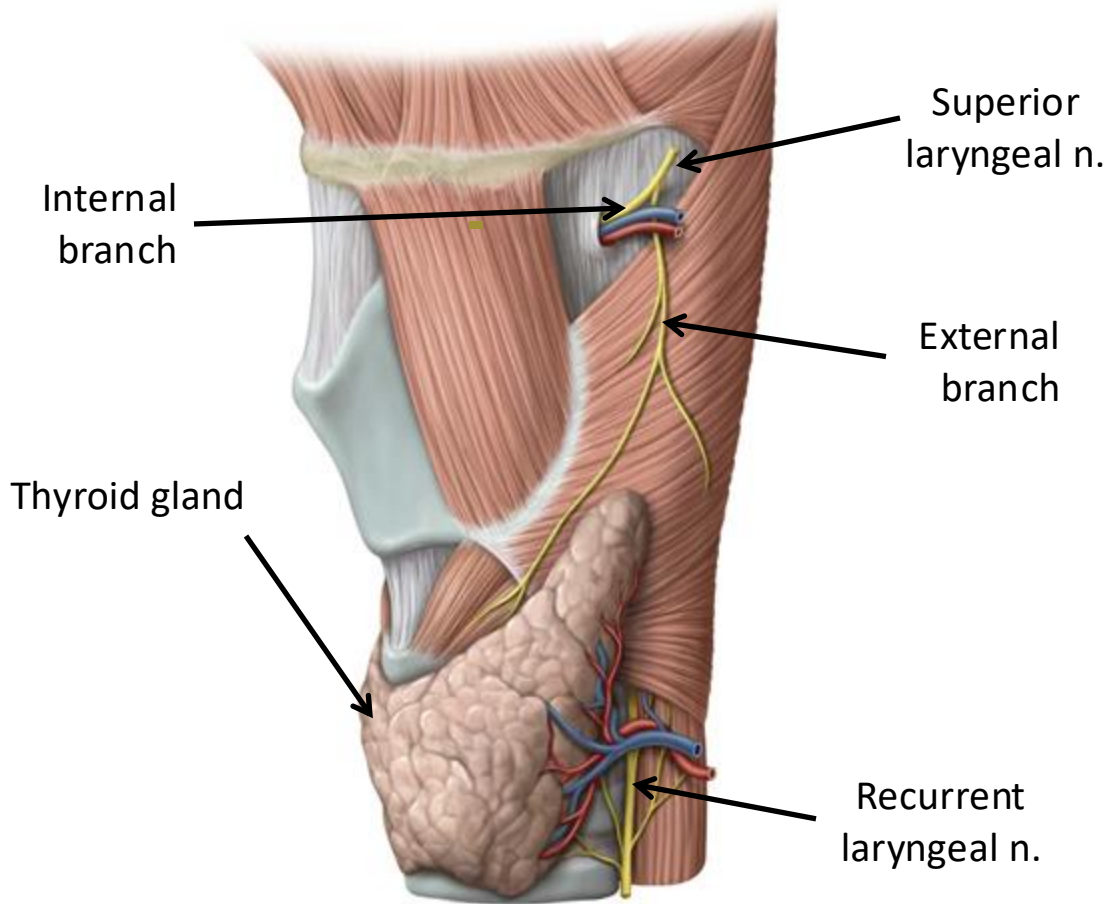
- Larynx above vocal fold

## **Recurrent laryngeal n.**

- To thyroid and parathyroid glands
- Larynx below vocal folds



# Vagus n.



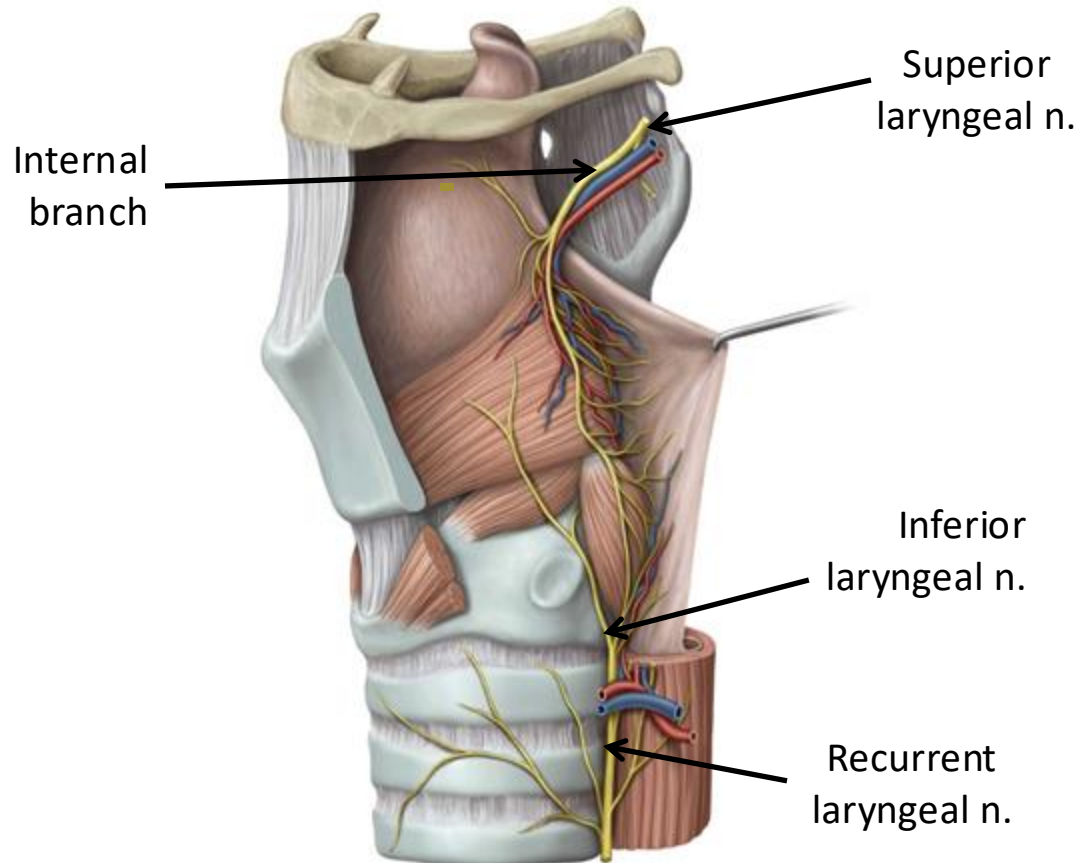
## **Superior laryngeal n.**

- Larynx above vocal fold

## **Recurrent laryngeal n.**

- To thyroid and parathyroid glands
- Larynx below vocal folds

# Vagus n.



## NEW YORK INSTITUTE OF TECHNOLOGY

College of Osteopathic  
Medicine

### **Superior laryngeal n.**

- Larynx above vocal fold

### **Recurrent laryngeal n.**

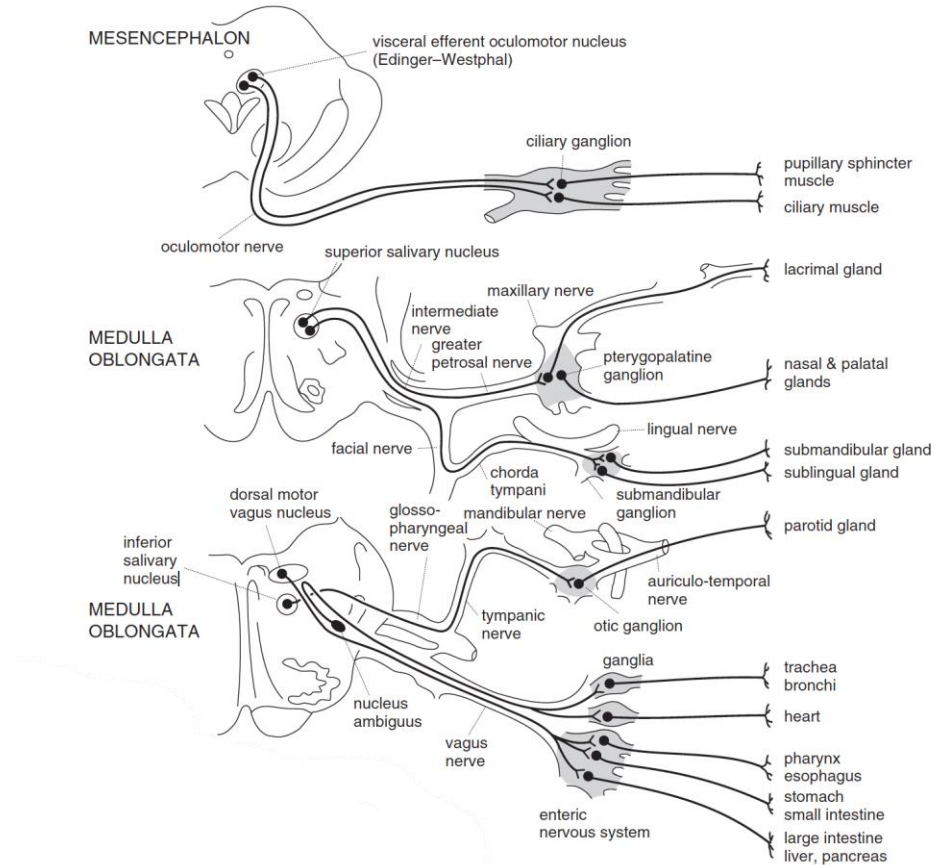
- To thyroid and parathyroid glands
- Larynx below vocal folds



# Summary Parasympathetics

**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine



Source: Jänig, 2006

# Clinical Consideration

# Damage to Oculomotor n.

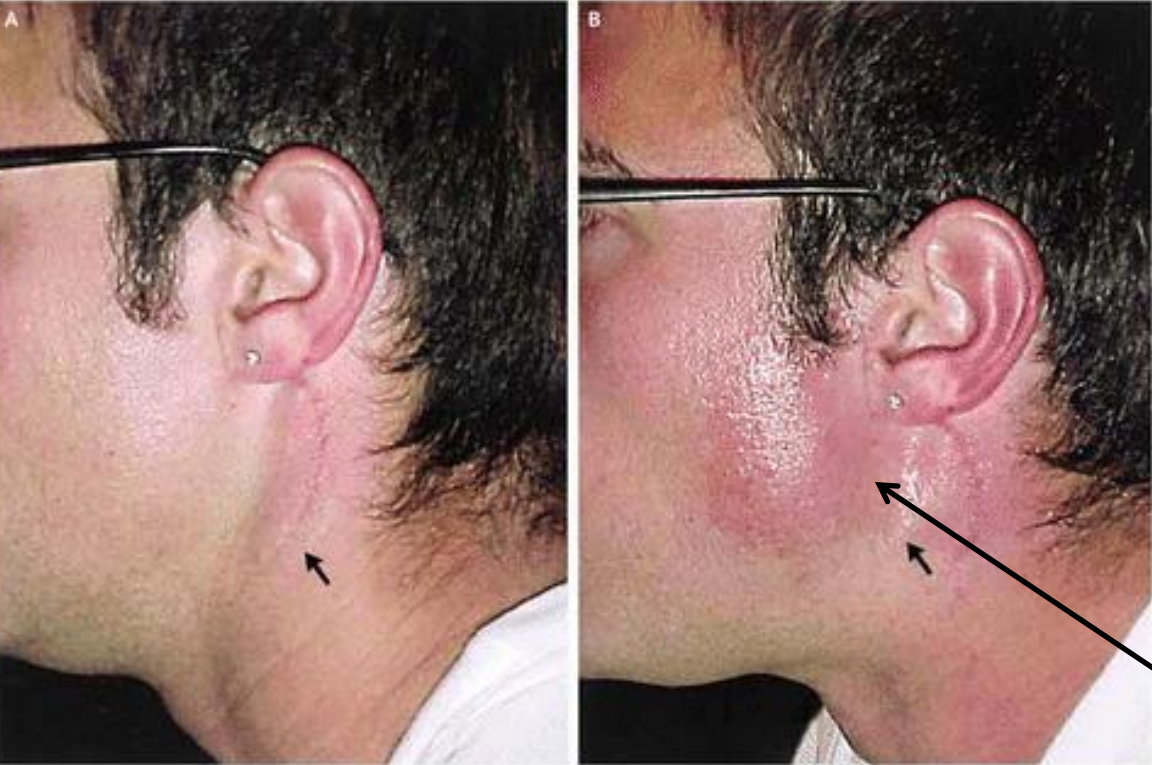
## **Possible Causes**

- 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



**NEW YORK INSTITUTE  
OF TECHNOLOGY**



Lucja Frey

Gustatory sweating

# Clinical Scenario

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

- **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

# Lecture Feedback Form

**NEW YORK INSTITUTE  
OF TECHNOLOGY**

College of Osteopathic  
Medicine

<https://comresearchdata.nyit.edu/redcap/surveys/?s=HRCY448FWYXREL4R>



# 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