

Cranial nerves: II, IV & VI

NEW YORK INSTITUTE
OF TECHNOLOGY

College of Osteopathic
Medicine

Paths and Functions of Somatic Afferents and Efferents of the Head and Neck

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

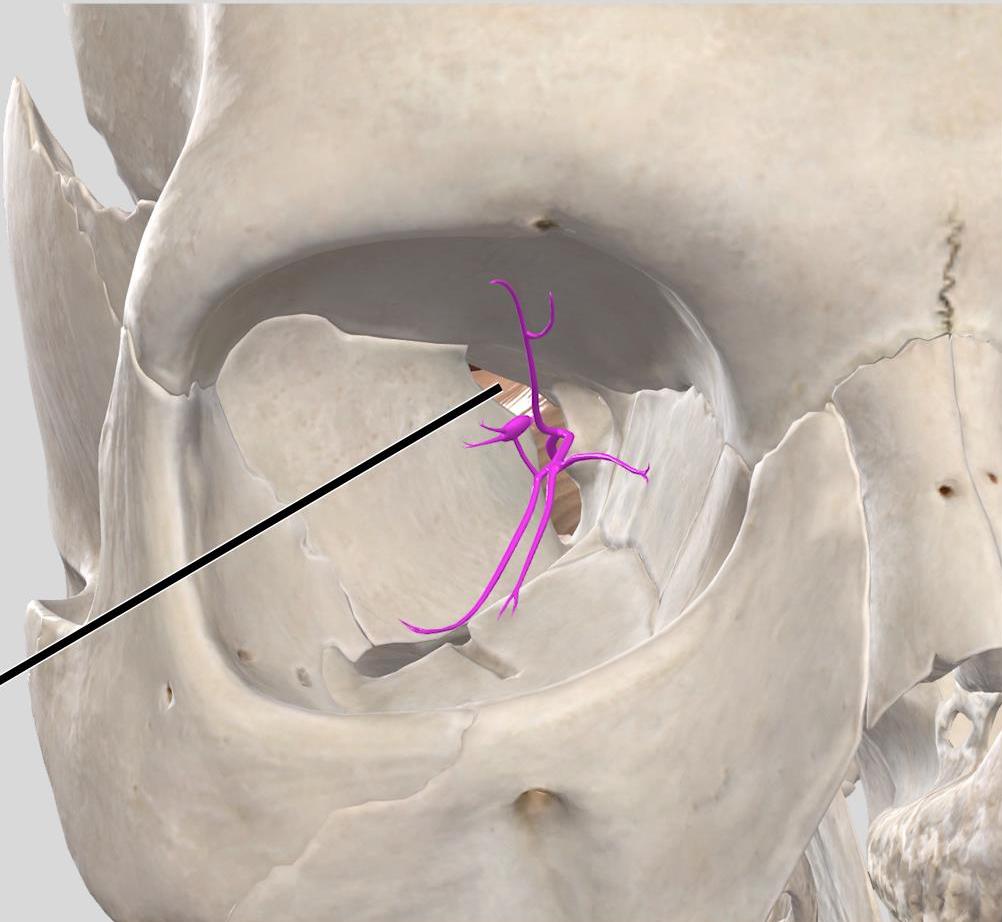
Oculomotor

Main motor nerve for eye

Travels in the lateral wall of
the cavernous sinus

*Exits endocranum through
superior orbital fissure*

superior orbital fissure



Oculomotor

Nerve splits into 2 divisions

Superior division

Innervates:

- superior rectus
- levator palpebrae superioris

Inferior division

Innervates:

- medial rectus
- inferior rectus
- inferior oblique

- ciliary body
- sphincter pupillae

via ciliary ganglion → short ciliary nerves



Oculomotor

Oculomotor palsy examples

Ptosis



weak or paralyzed levator palpebrae superioris

lesion located in the superior division



medial rectus palsy

lesion located in inferior division

Complete lesion



weakness or paralysis of 4 of the 6 extraocular muscles.
Unopposed muscles pull eye down and out

Anisocoria



Weakness or paralysis of ^{David Bowie} sphincter pupillae.
Affected eye remains more dilated than contralateral eye.

Trochlear

right lateral view

Smallest of the cranial nerves

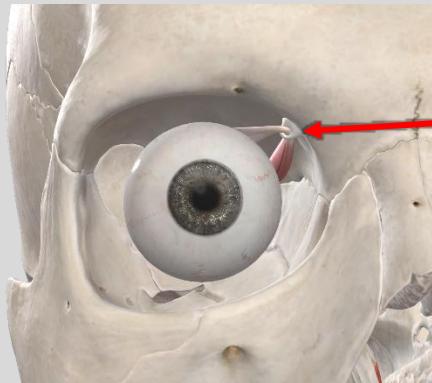
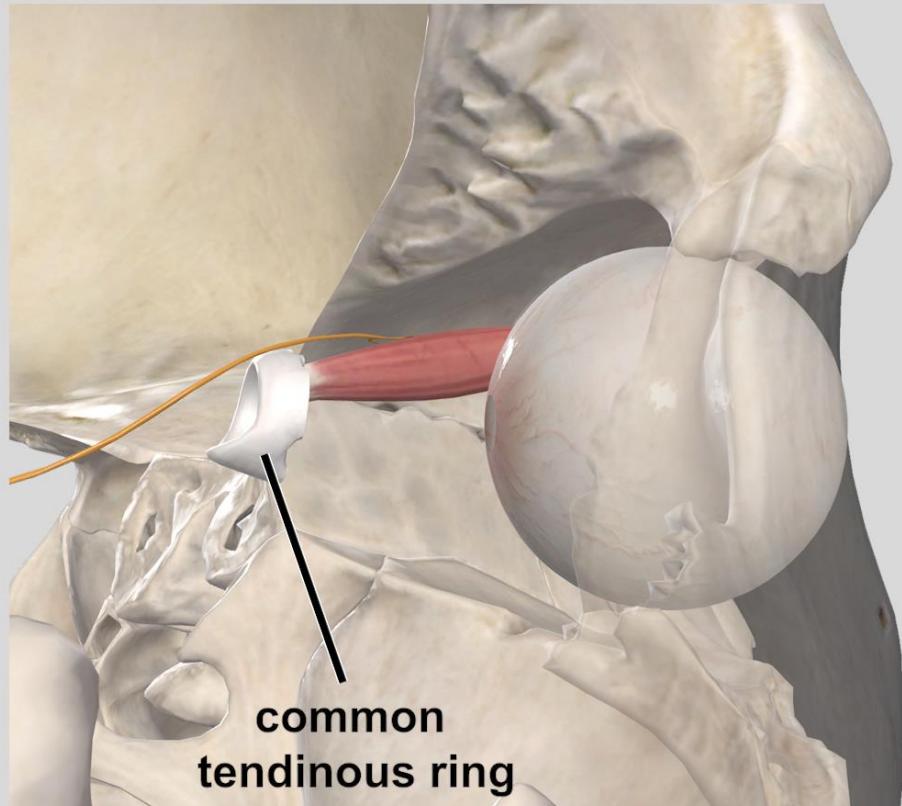
Exits dorsally off the midbrain

Travels in the lateral wall of the cavernous sinus

Exits endocranum through superior orbital fissure

Innervates only the superior oblique muscle

Trochlear nerves pulls on the only eye muscle to use a trochlea (pulley)



Trochlear

Trochlear nerve (Fourth Nerve) Palsy

Small size of trochlear makes it susceptible to damage

Lesion produces weakness / paralysis of superior oblique

Unopposed muscles draw the affected eye up and in



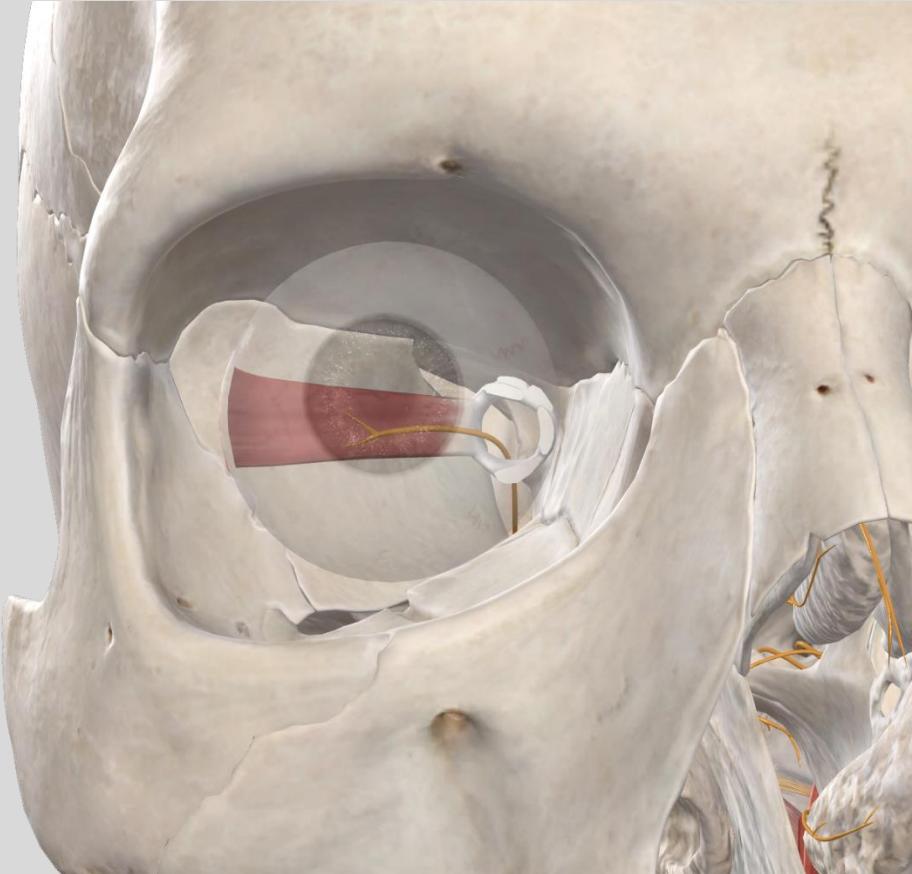
This is an extreme example of trochlear nerve palsy. The effect is often more subtle than this.

Abducens / Abducent

Travels in lateral wall of cavernous sinus

Exits endocranum at superior orbital fissure

Only innervates lateral rectus



A-B-ducens innervates the muscle that A-B-ducts the eye

Clinical Correlate

Abducens Palsy

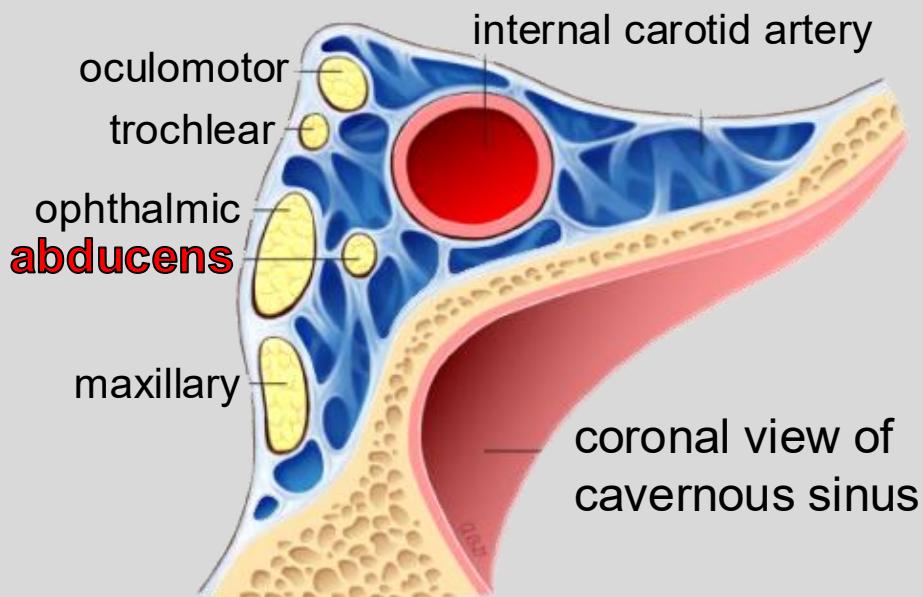
Lesion produces weakness / paralysis of the lateral rectus muscle

Unopposed medial rectus pulls eye towards nose



Abducens lies most medial in the cavernous sinus

This placement puts the nerve ***the most at risk*** for compression related to aneurysms and blood clots



Lecture Feedback Survey

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

Cranial Nerves V (V_1 , V_2 , V_3) and VII

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Don't get hung up on the branching patterns!

For each nerve, answer these 3 questions

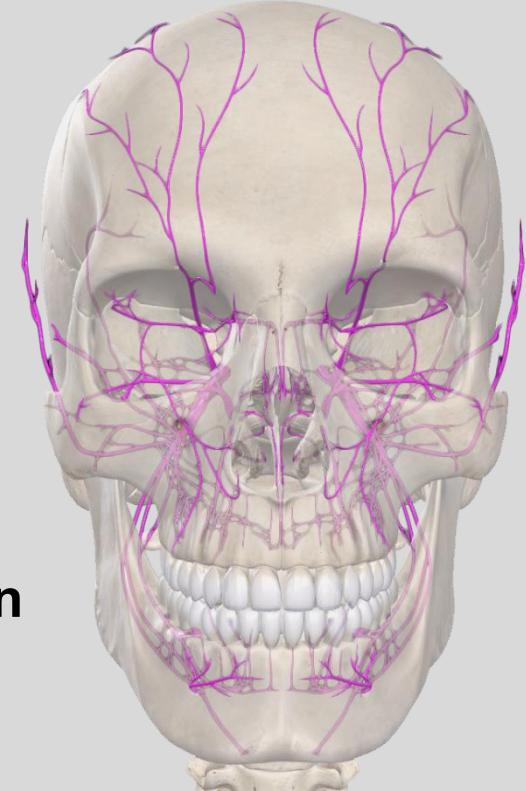
- 1. What root / division is the nerve from?**
- 2. Where does it exit the endocranum and skull?**
- 3. What does the nerve innervate?**

Trigeminal

Trigeminal is the largest cranial nerve

It provides sensation to most of the head and neck

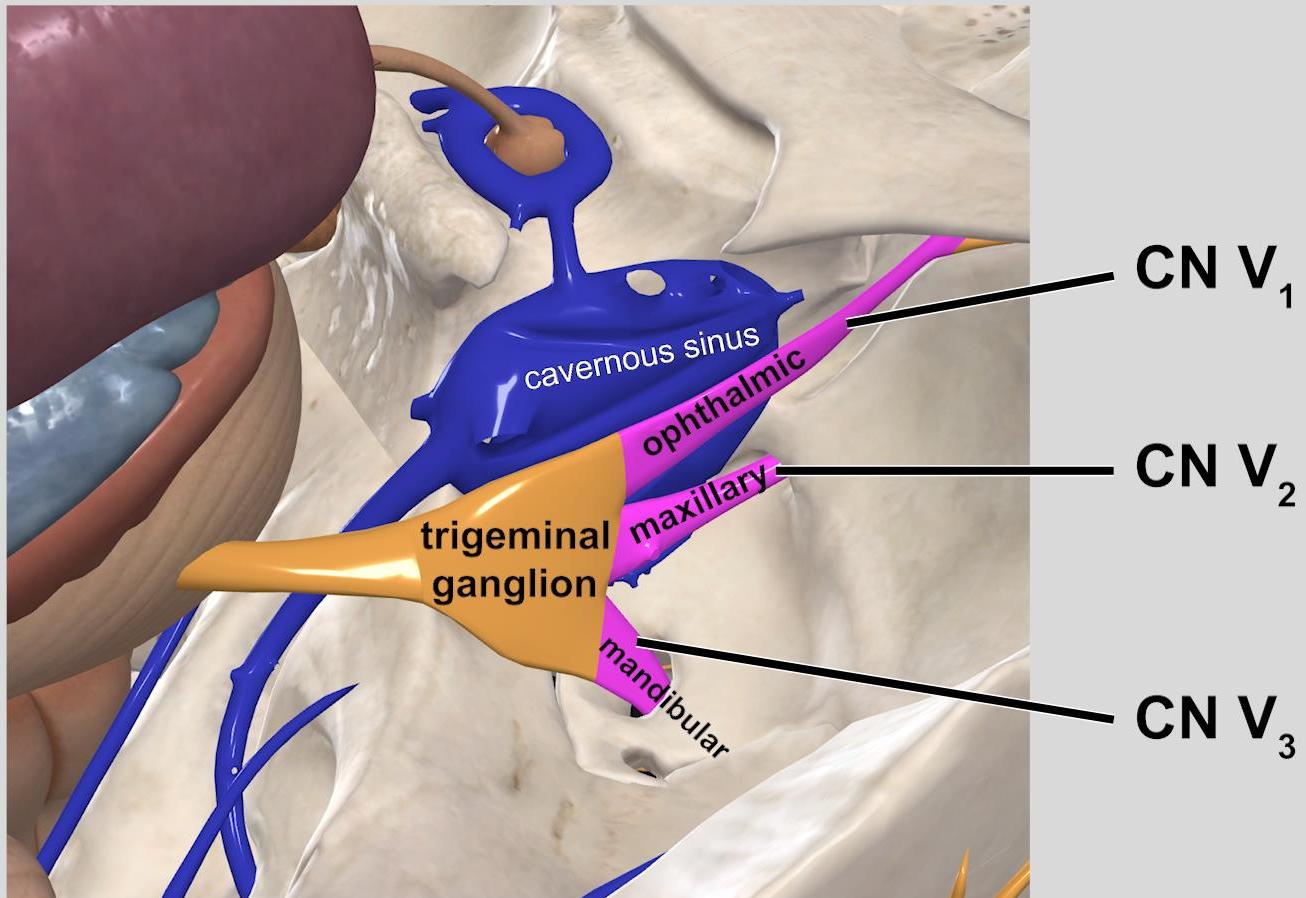
The name trigeminal, refers to the unique trifurcation taken off the brain



Trigeminal

Trigeminal starts as roots leaving the brain and entering the trigeminal ganglion

From the ganglion, trigeminal splits into its 3 major divisions



right superolateral view

CN V₁ – Ophthalmic

Smallest division of trigeminal

Travels in lateral wall of cavernous sinus

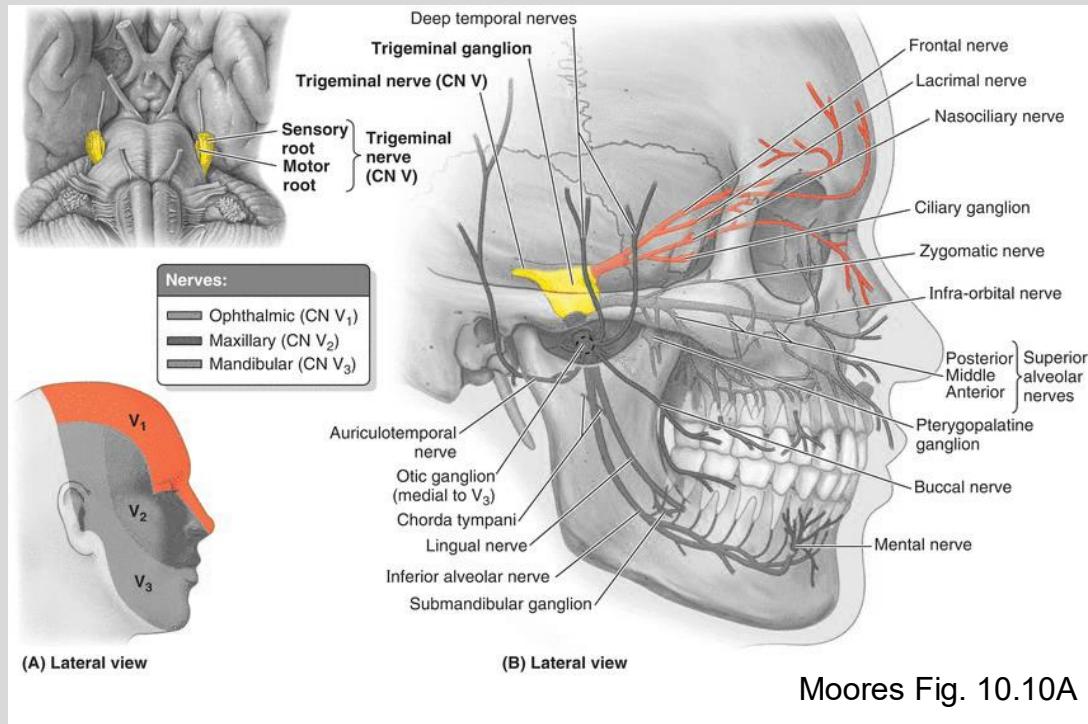
Exits endocranum through superior orbital fissure

100% sensory

Provides sensation from upper eyelid through the scalp, cornea and most of external nose

Has three main branches

- Frontal nerve
- Nasociliary nerve
- Lacrimal nerve



Moores Fig. 10.10A

CN V₁ — Ophthalmic

Frontal Nerve

Runs along roof of orbit

Has 2 terminal branches

Supraorbital nerve

Exits skull via supraorbital foramen / notch

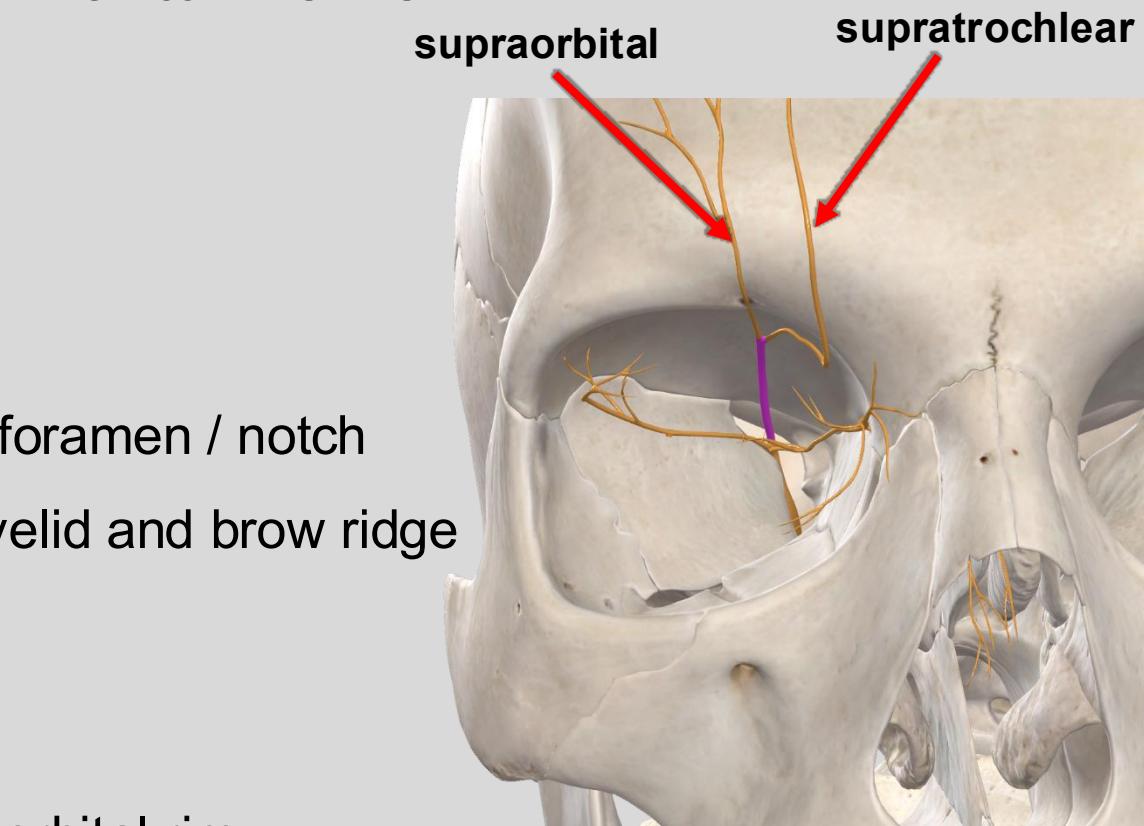
Innervates skin of upper eyelid and brow ridge

Supratrochlear nerve

Lies on medial wall of orbit

Exits skull from the medial orbital rim

Innervates the midline of brow ridge and nose



CN V₁ — Ophthalmic

Nasociliary Nerve

Runs anteromedially through the orbit

Several branches of nasociliary

Anterior and Posterior ethmoidal nerves

Pierce ethmoid to innervate paranasal sinuses and part of nasal septum

Long Ciliary nerves

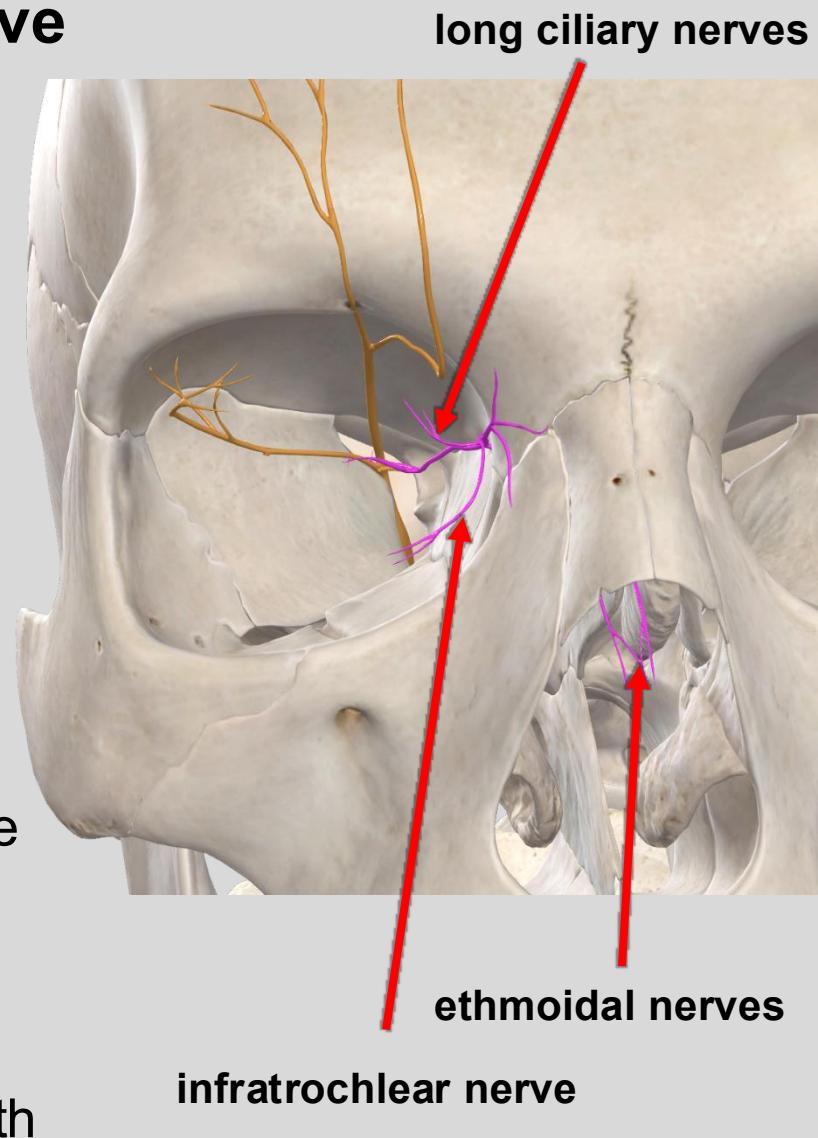
Provides sensation to rest of eyeball

Routes postganglionic sympathetics to eye

Infratrochlear nerve

Exits skull from medial orbital rim

Cutaneous sensation to most of nose, both eyelids and conjunctiva

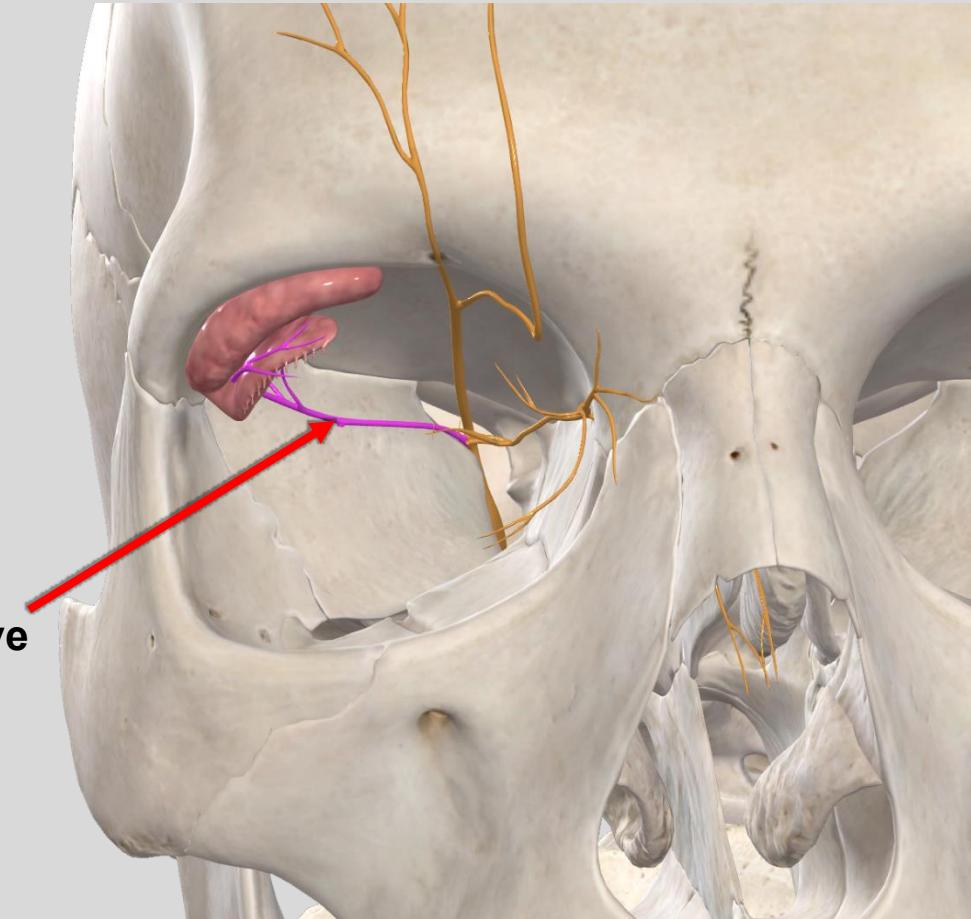


CN V₁ – Ophthalmic

Lacrimal Nerve

Smallest branch of ophthalmic

Moves along posterolateral wall to lacrimal gland



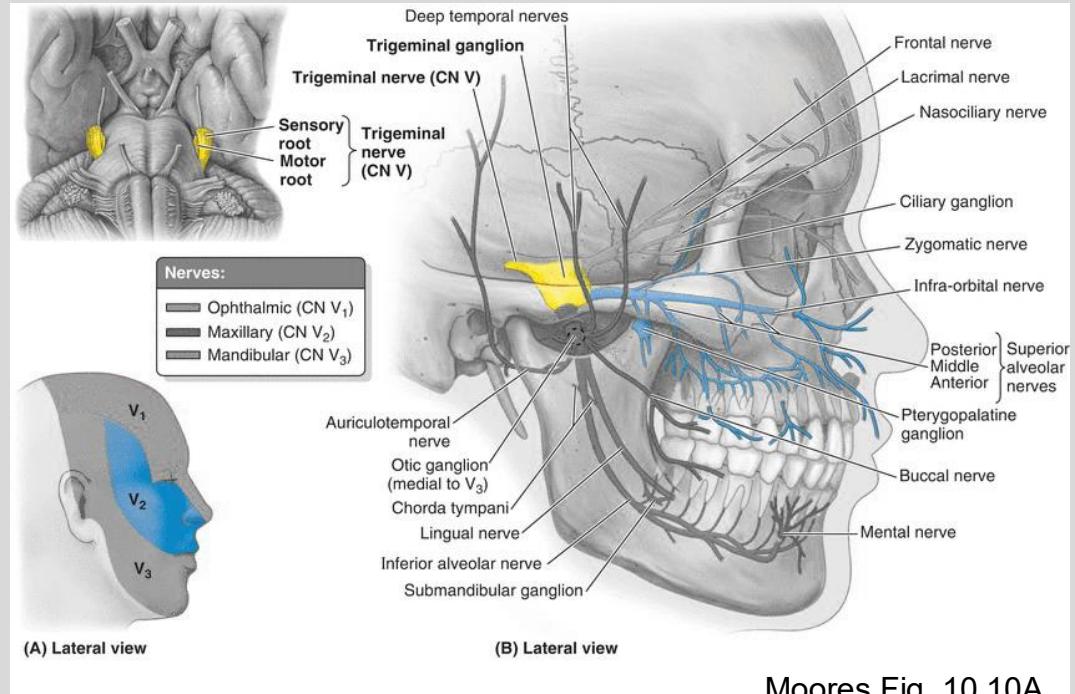
Provides ***sensory innervation*** to lacrimal gland

CN V₂ — Maxillary

100% sensory nerve

Has the most difficult branching pattern to see in a dissection

Exits the endocranum at the foramen rotundum



Moores Fig. 10.10A

You are responsible for only 5 of the multiple branches

1. Greater palatine nerve
2. Lesser palatine nerve
3. Nasopalatine nerve
4. Zygomatic nerve
5. Infraorbital nerve

CN V₂ — Maxillary

One branch of V₂ heads inferiorly into the pterygopalatine ganglion

Trigeminal *does not synapse* in the ganglion

3 nerves descend from the ganglion

1. Greater palatine nerve

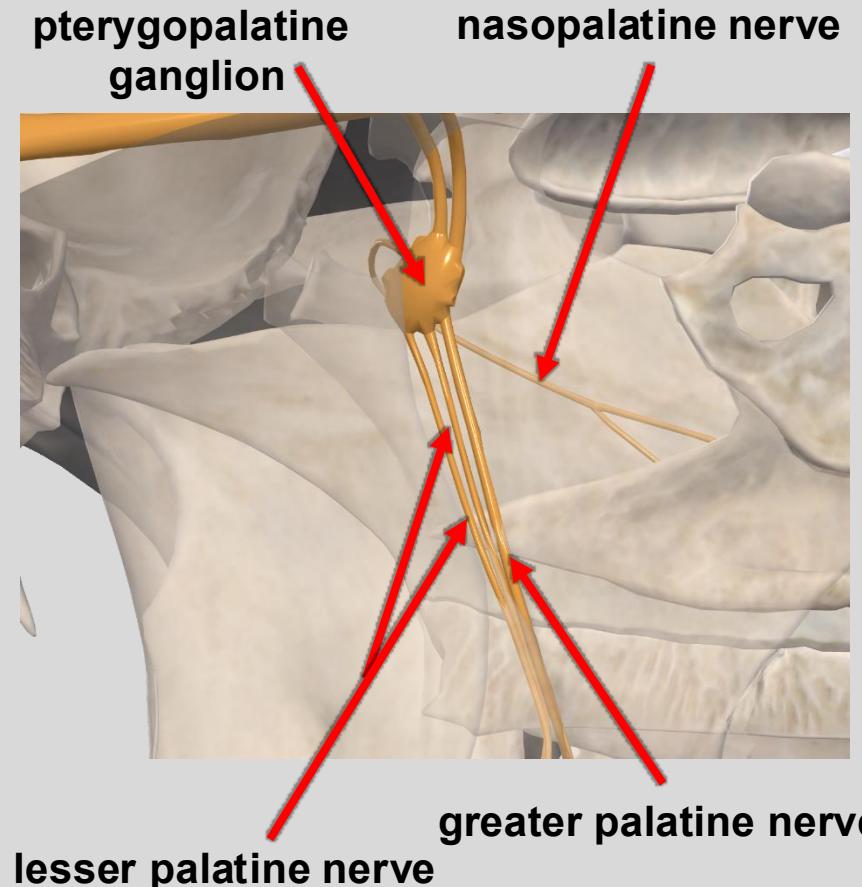
exits skull from greater palatine foramen
innervates hard palate

2. Lesser palatine nerve

exits skull from lesser palatine foramina
innervates soft palate

3. Nasopalatine nerve

enters nasal passage
innervates lateral wall and lower half of nasal septum
exits skull from incisive canal and innervates anterior-most hard palate



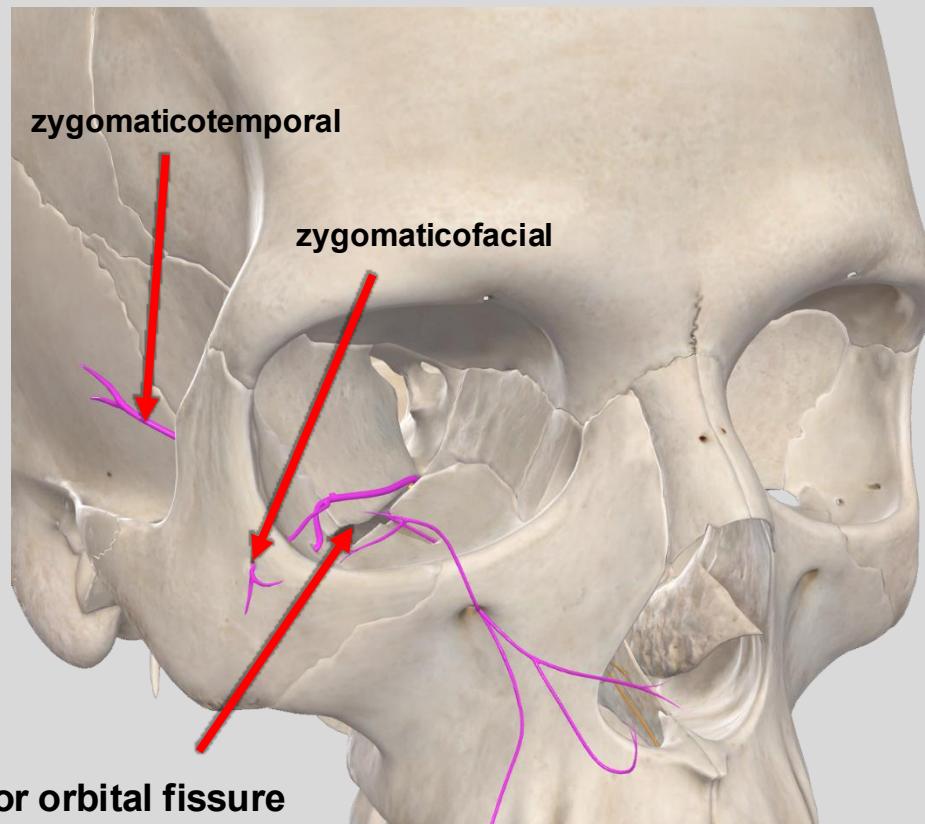
CN V₂ — Maxillary

The second branch of V₂ travels anteriorly into the inferior orbital fissure

Gives off the zygomatic nerve

Zygomatic has 2 terminal branches

1. zygomaticofacial nerve
2. zygomaticotemporal nerve



Nerves exit skull through foramina of same name

Both provide cutaneous innervation to their respective regions of the face

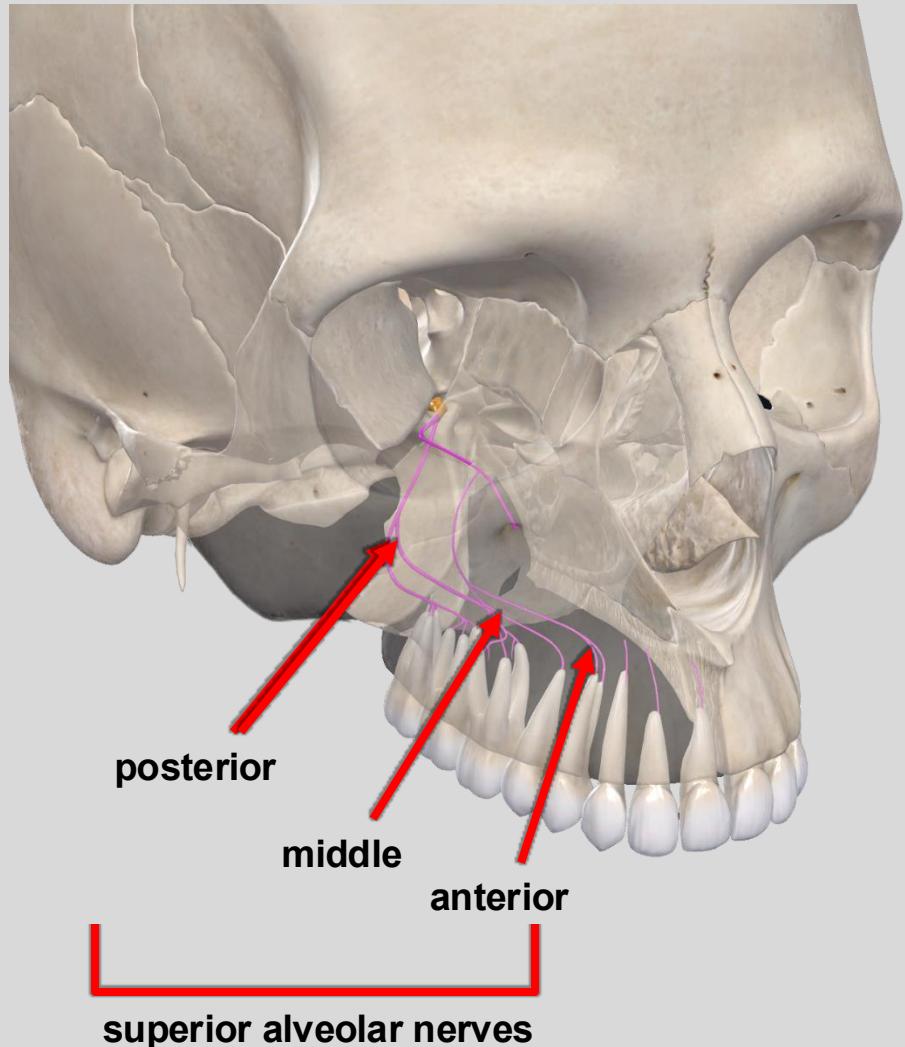
CN V₂ — Maxillary

Infraorbital nerve

Courses in infraorbital groove

Sends out 3 branches to the upper teeth and gums

- Anterior superior alveolar nerve
- Middle superior alveolar nerve
- Posterior superior alveolar nerve



Note: You *do not* need to know which specific tooth is innervated by a specific superior alveolar nerve

CN V₂ — Maxillary

Infraorbital nerve

Courses in infraorbital groove

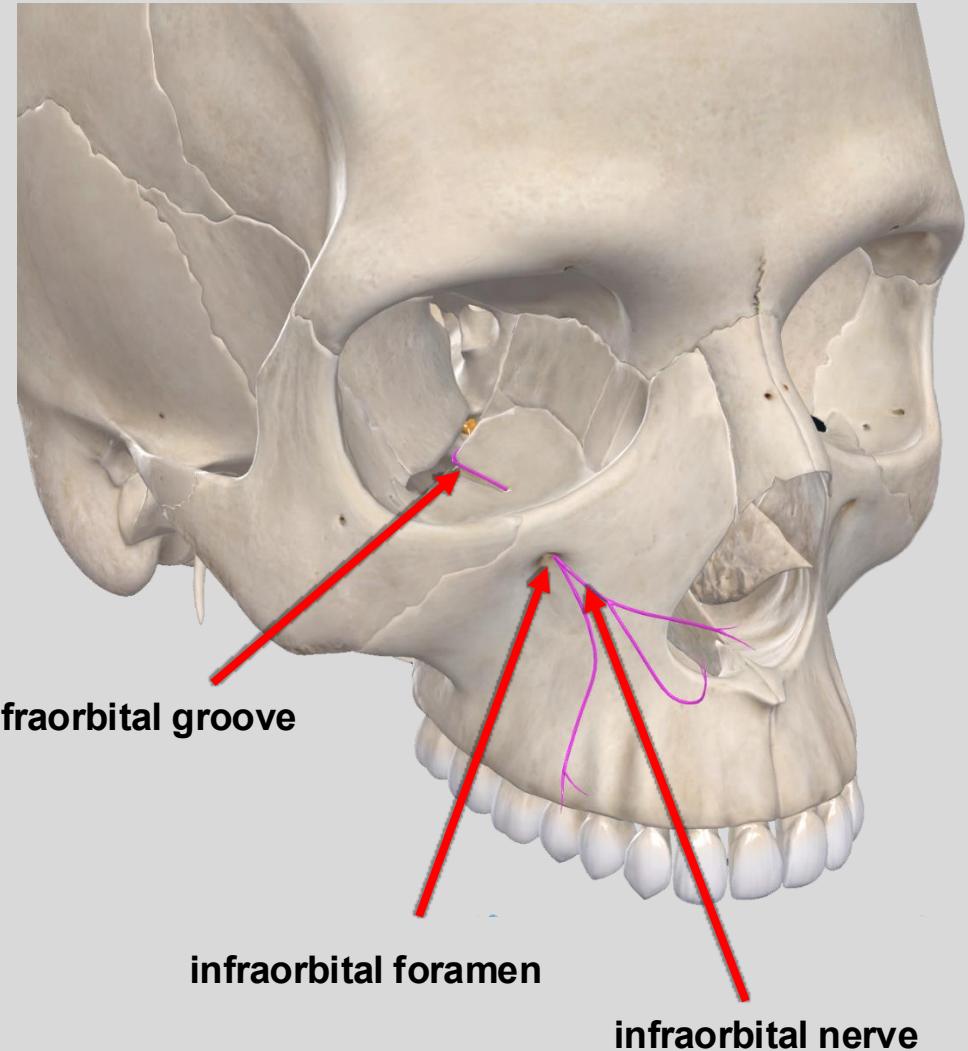
Exits skull from infraorbital foramen

Provides cutaneous innervation to

Lower eyelid

Lateral nose

Upper lip



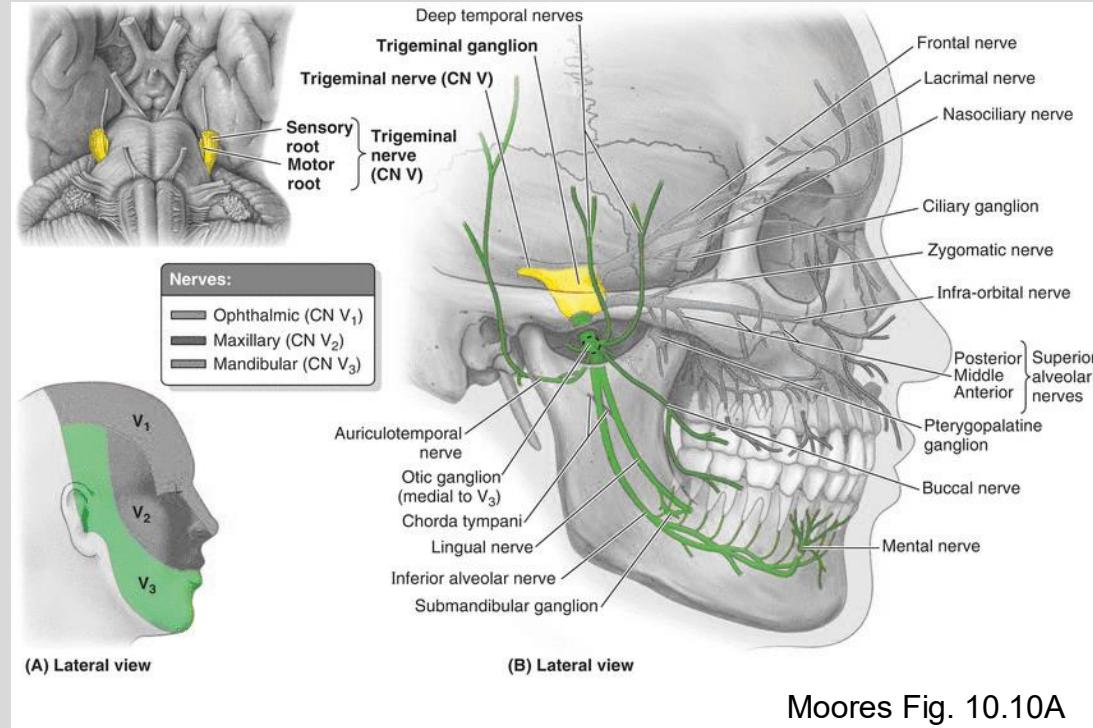
CN V₃ — Mandibular

Sensory nerve of the mandible

The *only part of trigeminal* that has a motor component

Motor roots *do not pass* through the trigeminal ganglion

Trigeminal ganglion is solely a *sensory ganglion*.



Moores Fig. 10.10A

Motor and sensory components join up to form CN V₃

CN V₃ exits endocranum through foramen ovale

CN V₃ — Mandibular

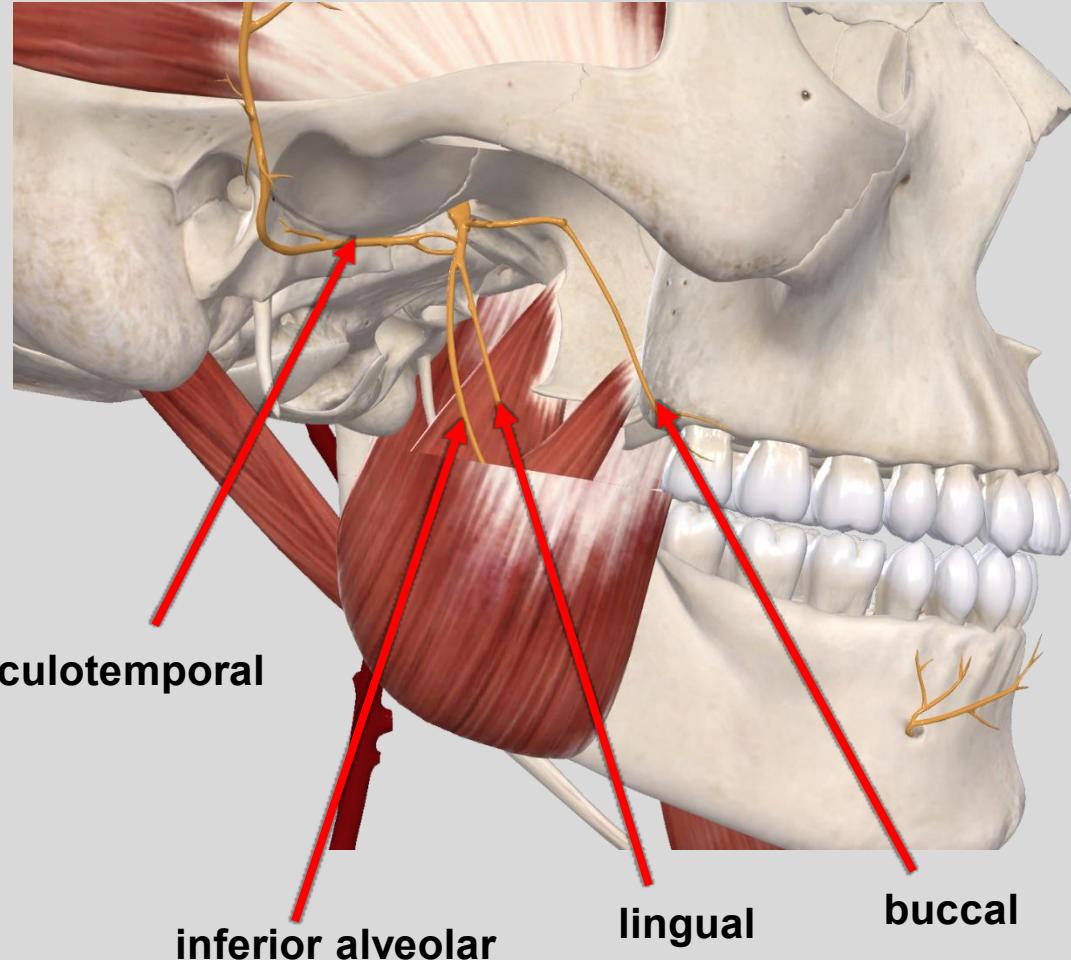
15

infratemporal fossa

Mandibular nerve enters the infratemporal fossa

There are 4 major sensory nerves

1. auriculotemporal nerve
2. buccal / long buccal nerve
3. lingual nerve
4. inferior alveolar nerve



CN V₃ — Mandibular

Auriculotemporal Nerve

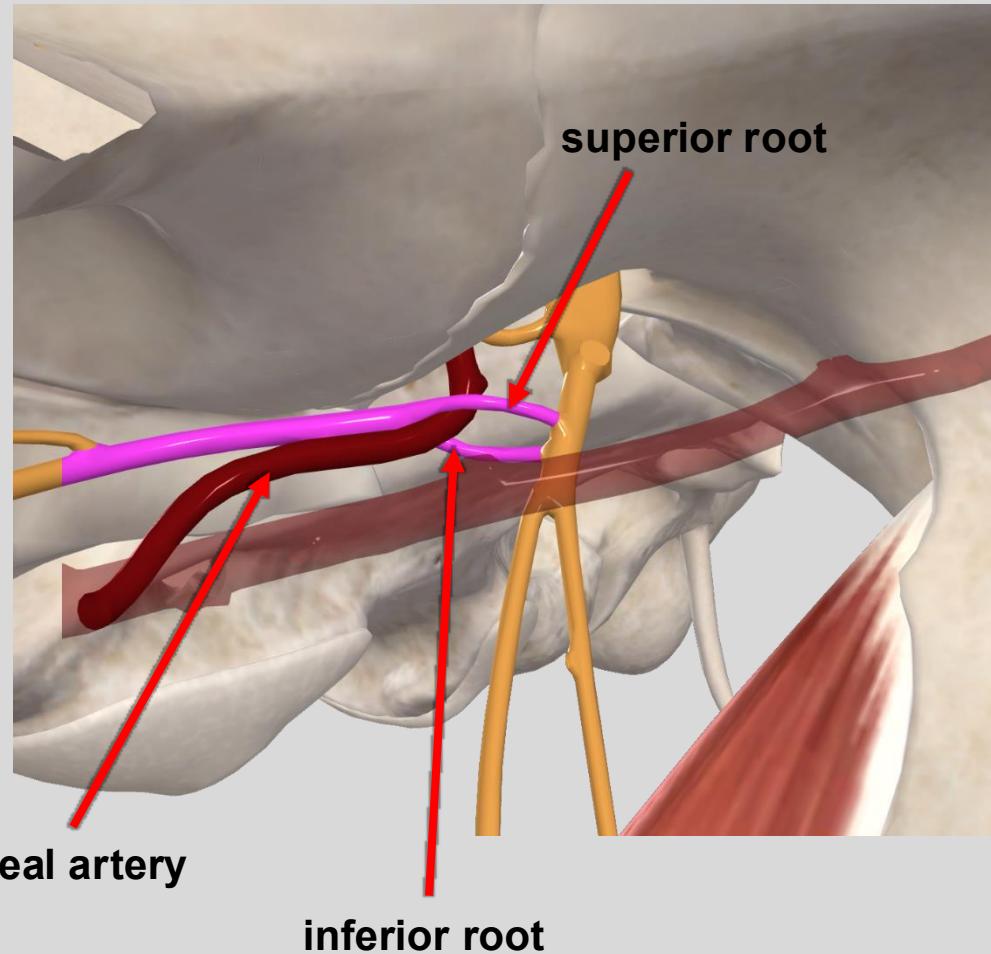
Sensory innervation for temples and ear

Starts as two separate roots

Superior root

Inferior root

Splits around the middle meningeal artery



CN V₃ — Mandibular

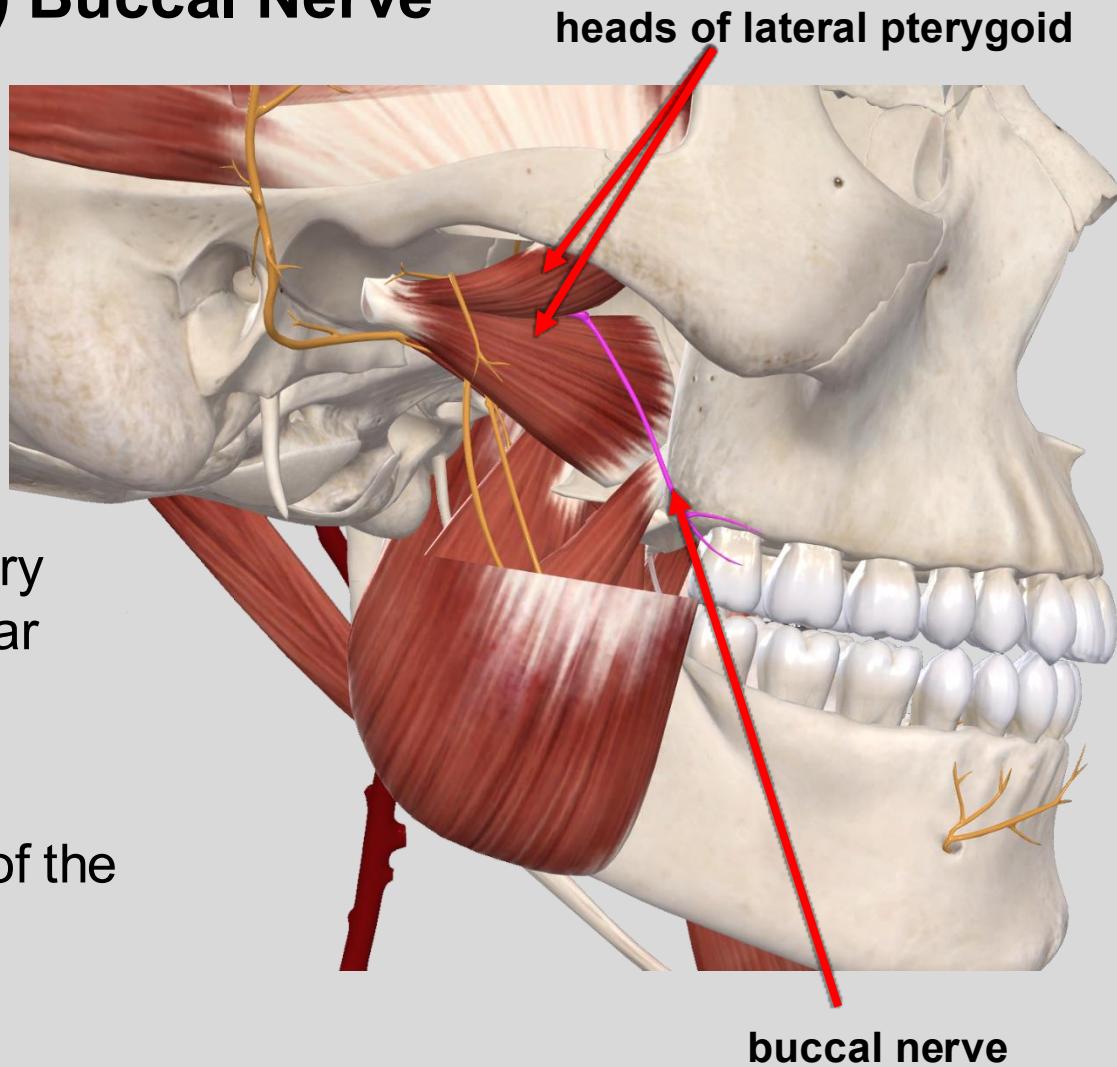
(Long) Buccal Nerve

Passes between both heads of lateral pterygoid muscle

Provides sensory information for the cheek mucosa

Variably known to provide sensory innervation to 2nd & 3rd mandibular molars

Can be confused with a branch of the facial nerve (buccal branch)



Buccal nerve is *strictly sensory*

CN V₃ — Mandibular

Inferior Alveolar Nerve

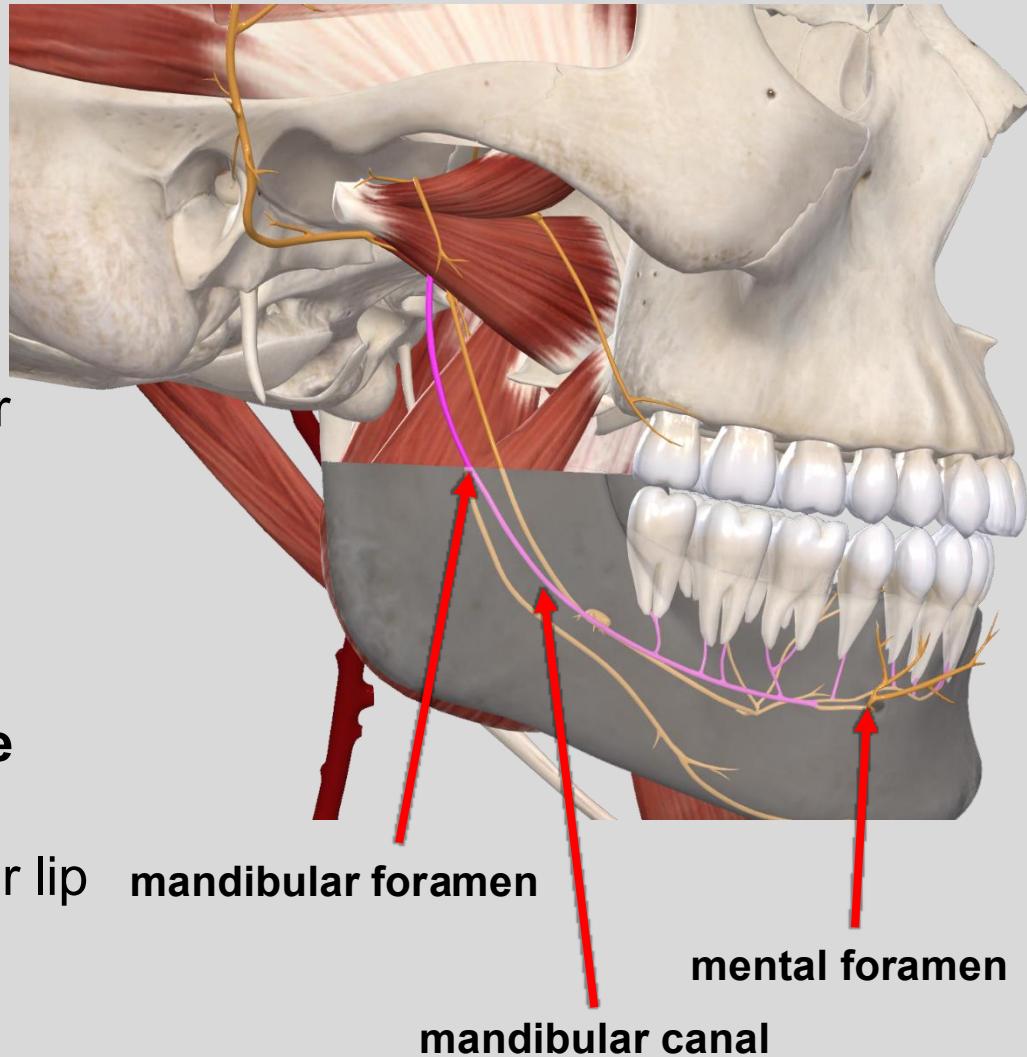
The only nerve to *enter* the mandible
enters at mandibular foramen
travels in the mandibular canal

Innervates most or all the mandibular teeth

Exits skull at mental foramen

Changes names to the **mental nerve**

Provides sensory innervation to lower lip and chin



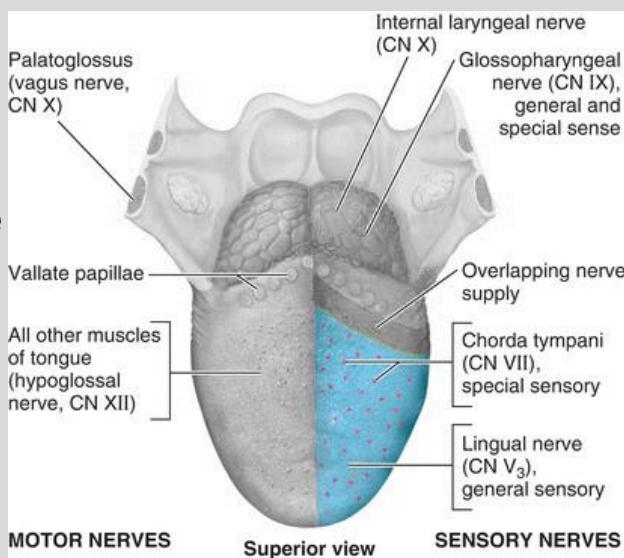
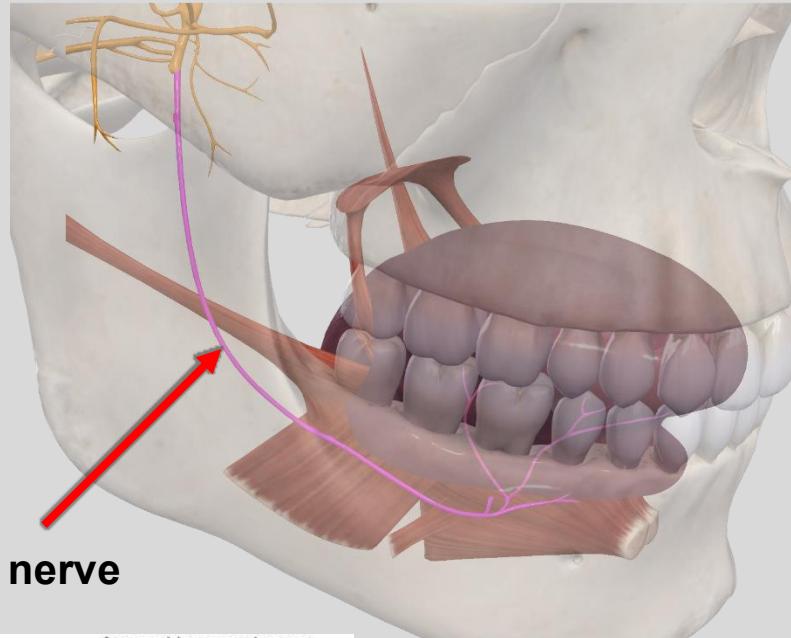
CN V₃ — Mandibular

Lingual Nerve

Lingual nerve runs parallel to inferior alveolar nerve

Turns anteromedially near mandibular foramen

Provides somatic sensation to the anterior 2/3^{rds} of the tongue



Moores Fig. 8.91

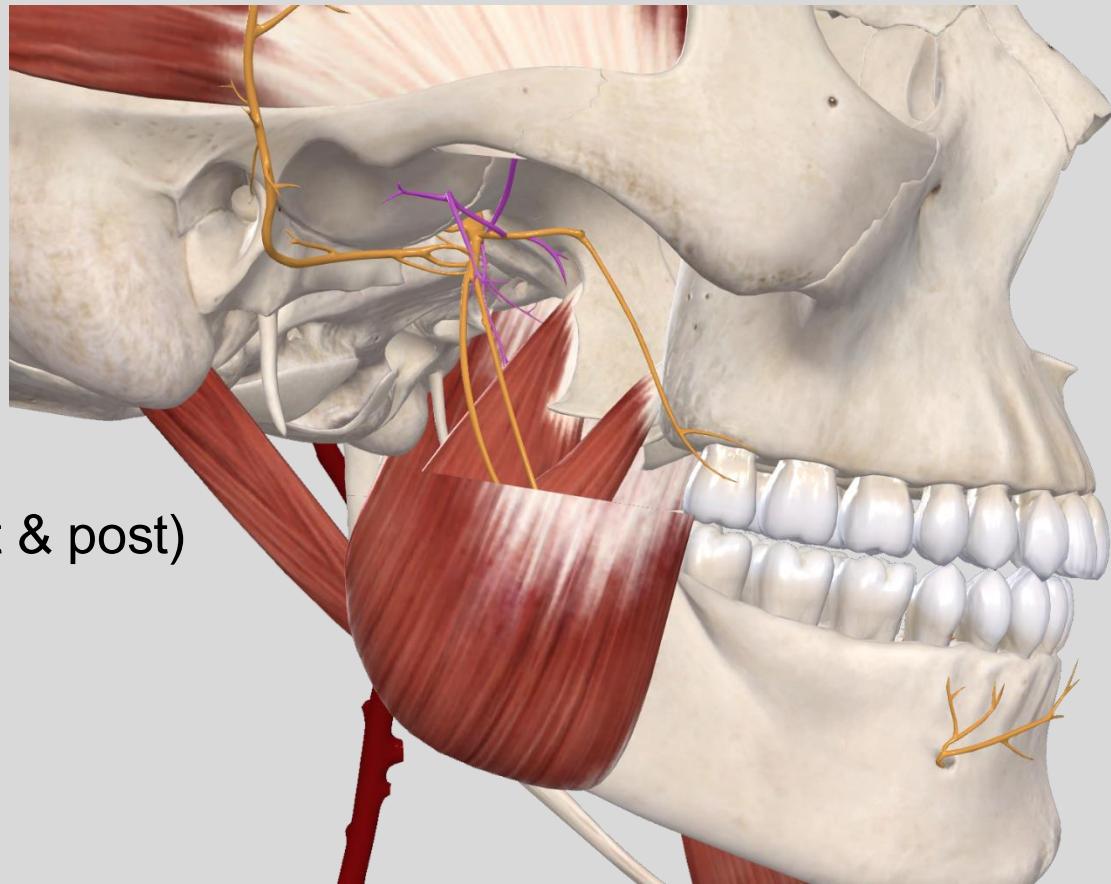
CN V₃ — Mandibular Motor Component

Smallest portion of V₃

**Innervates all the muscles
of mastication**

5 branches that go to their
respective masticatory muscles

1. Deep temporal nerves (ant & post)
2. Lateral pterygoid nerve
3. Medial pterygoid nerve
4. Masseteric nerve
5. Nerve to mylohyoid



This nerve innervates two different muscles

CN V₃ — Mandibular

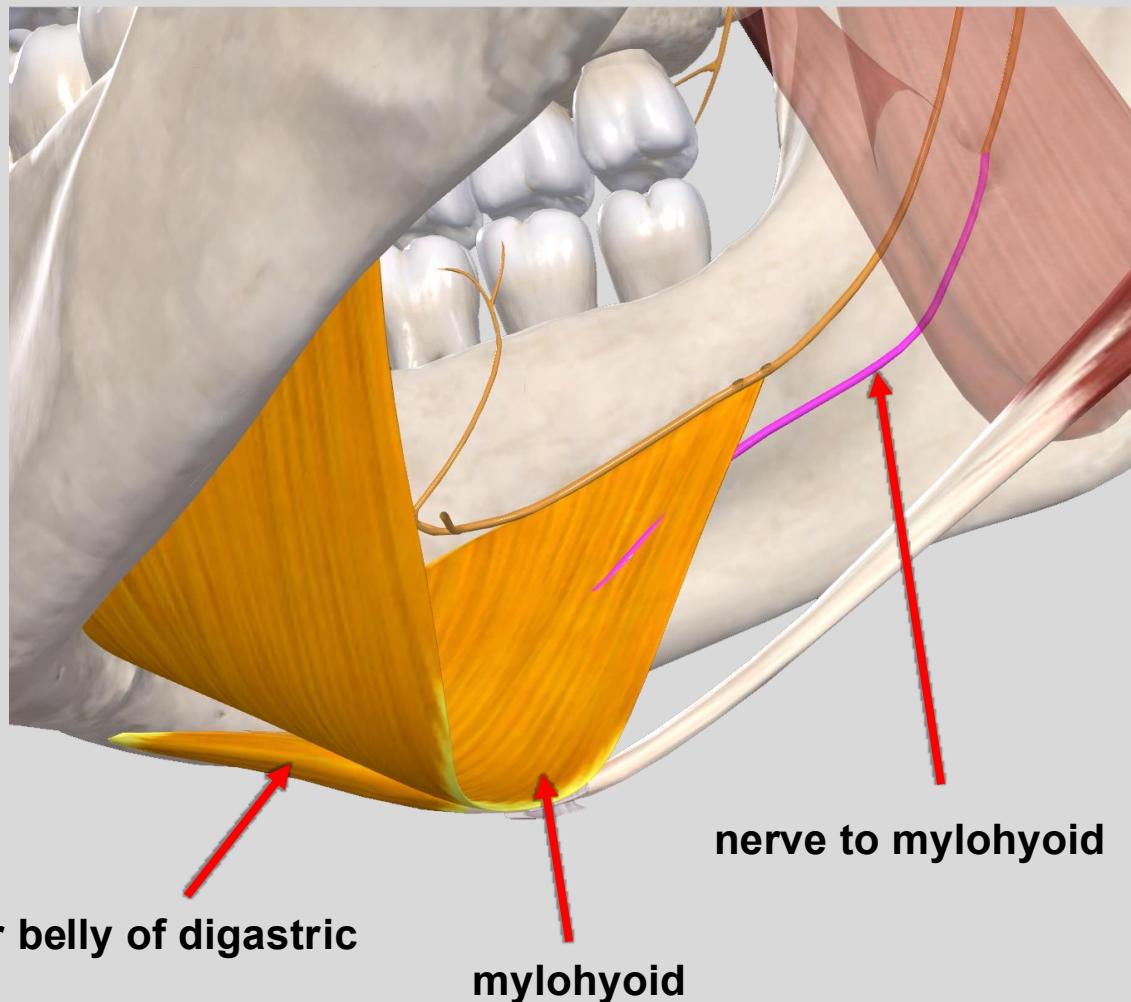
Motor Component

Nerve to mylohyoid runs with
and branches off the inferior
alveolar nerve

Rides along medial side of
mandible to reach its destination

Innervates 2 muscles

1. Mylohyoid
2. Anterior belly of digastric

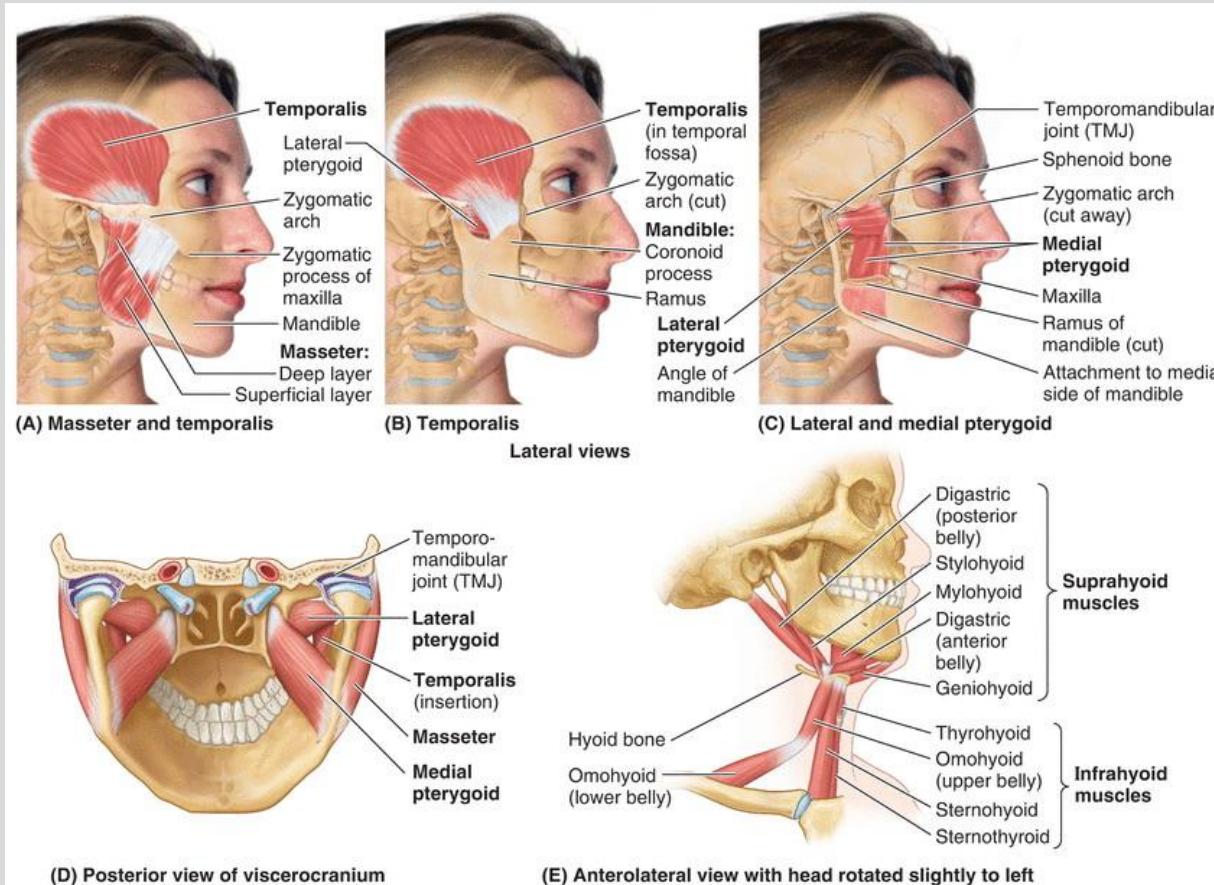


CN V₃ — Mandibular

Muscles of Mastication

Mastication = chewing

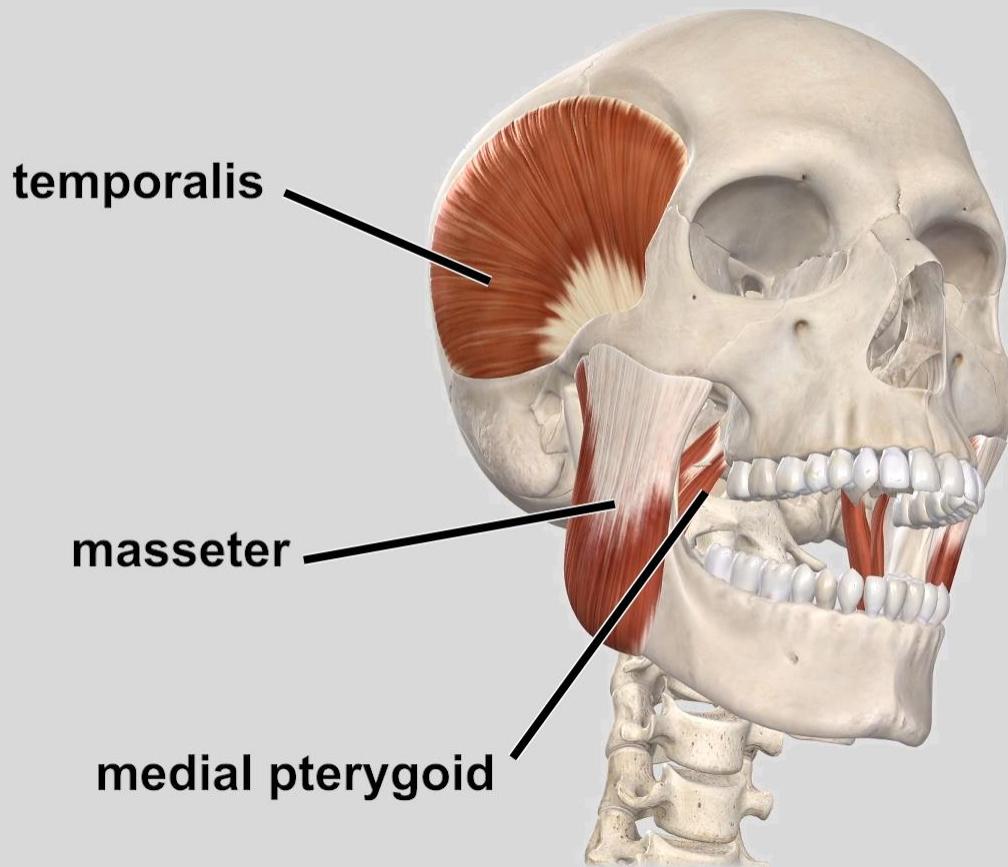
This is a complicated process involving multiple muscles acting together



CN V₃ — Mandibular

Muscles of Mastication

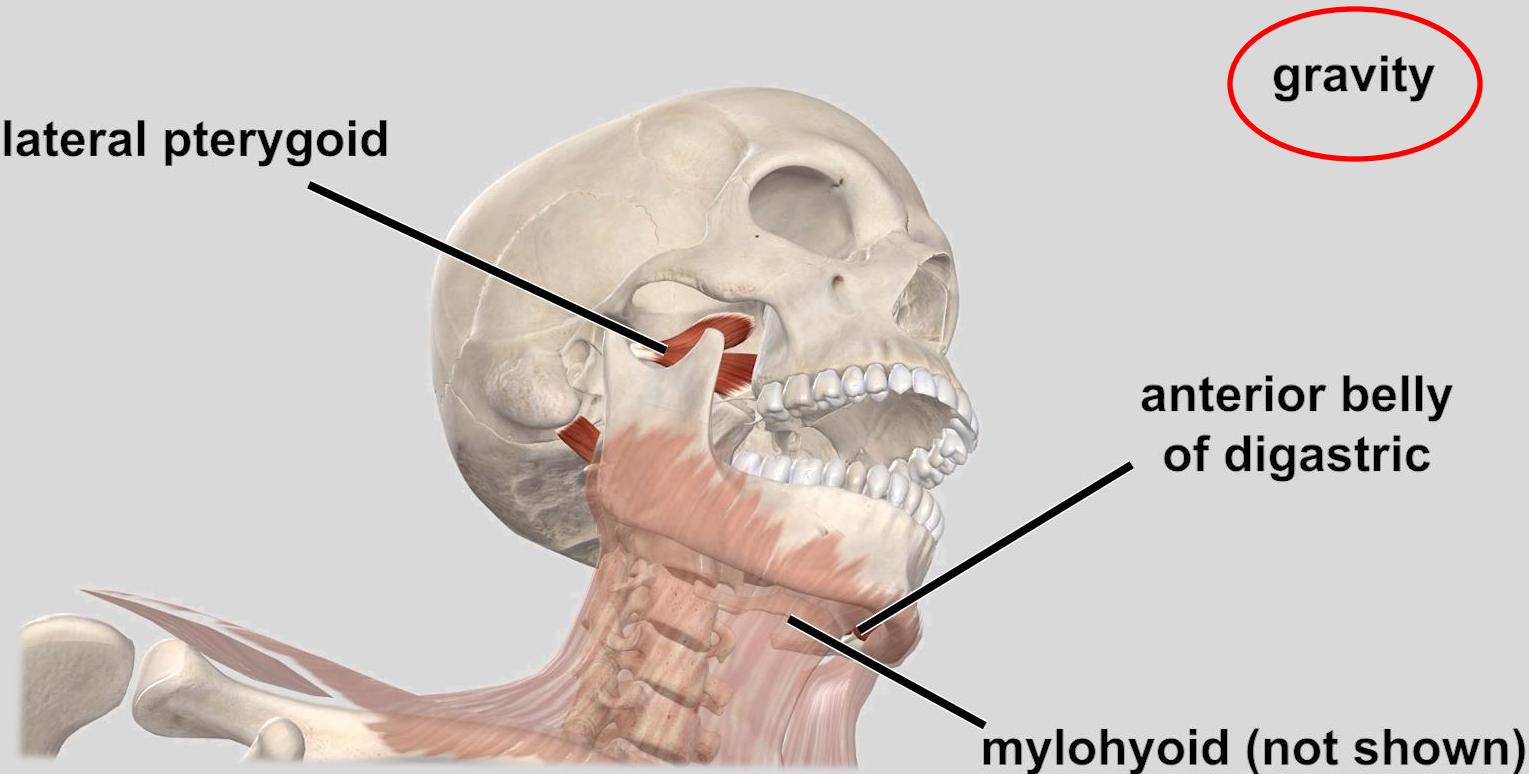
In general, these muscles close the jaw



CN V₃ — Mandibular

Muscles of Mastication

In general, these muscles open the jaw



CN V₃ — Mandibular

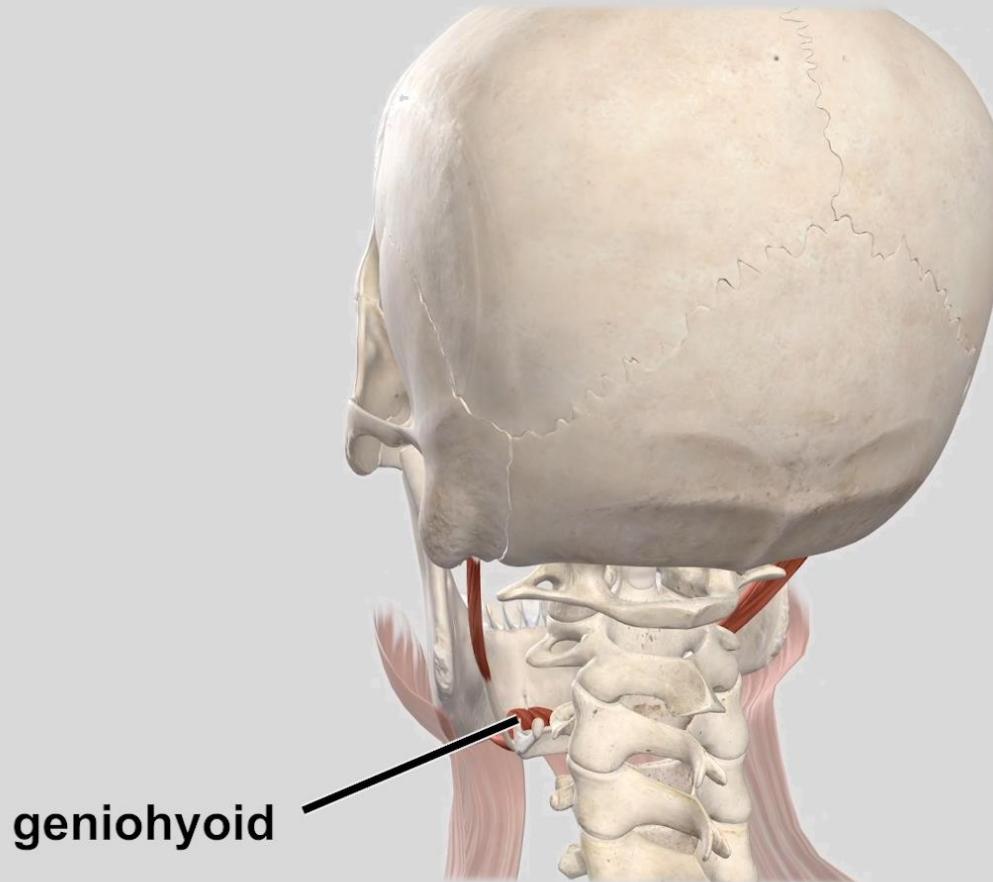
Muscles of Mastication

“Accessory muscles”
of mastication

digastric (post belly)

geniohyoid

infrahyoid muscles



CN V₃ — Mandibular

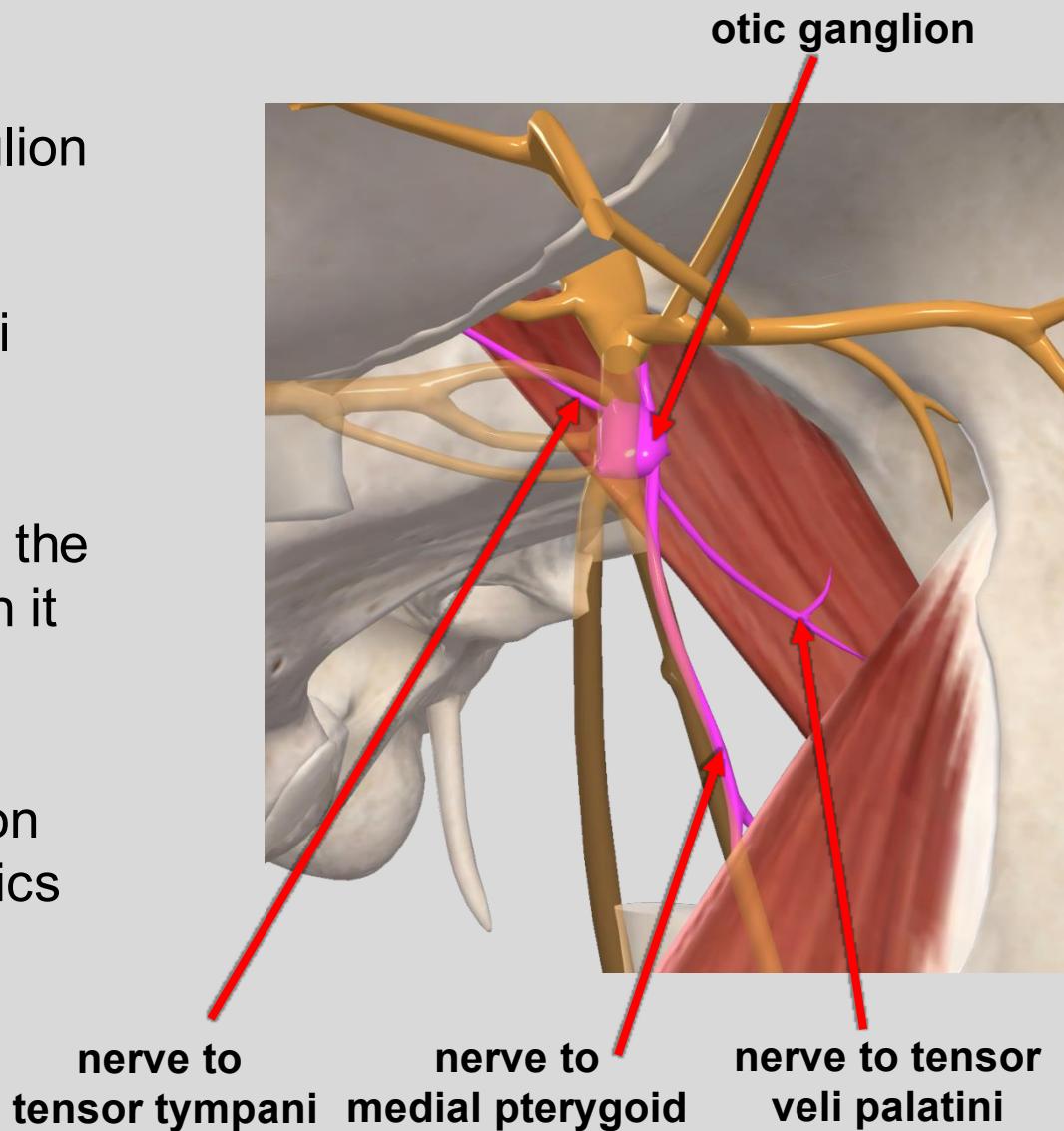
26

3 nerves pass through otic ganglion

1. Nerve to medial pterygoid
2. Nerve to tensor veli palatini
3. Nerve to tensor tympani

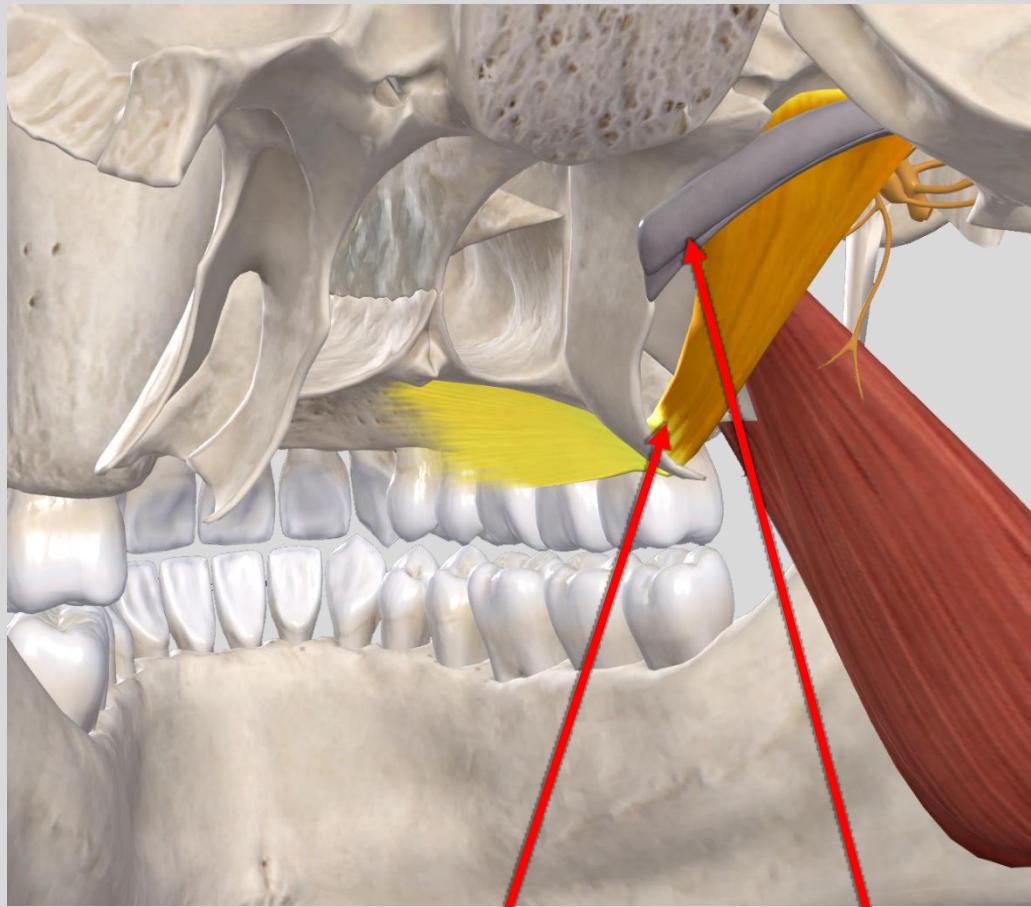
These nerves *do not synapse* in the ganglion. They just pass through it

Otic and pterygopalatine ganglion
are more important for autonomics
(CN VII, CN IX)



CN V₃ — Mandibular

Nerve to Tensor veli palatini



tensor veli palatini

eustachian tube

Innervates the tensor veli palatini

Stiffens soft palate in prep for swallowing

Attaches to floor of eustachian tube
Opens tube during swallowing,
equalizing pressure in ears
("popping" them)

CN V₃ — Mandibular

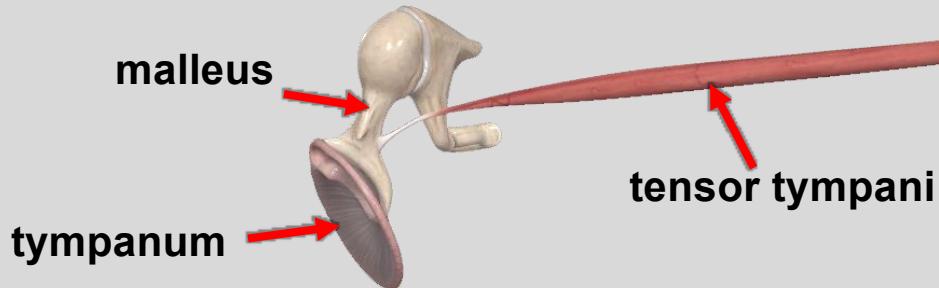
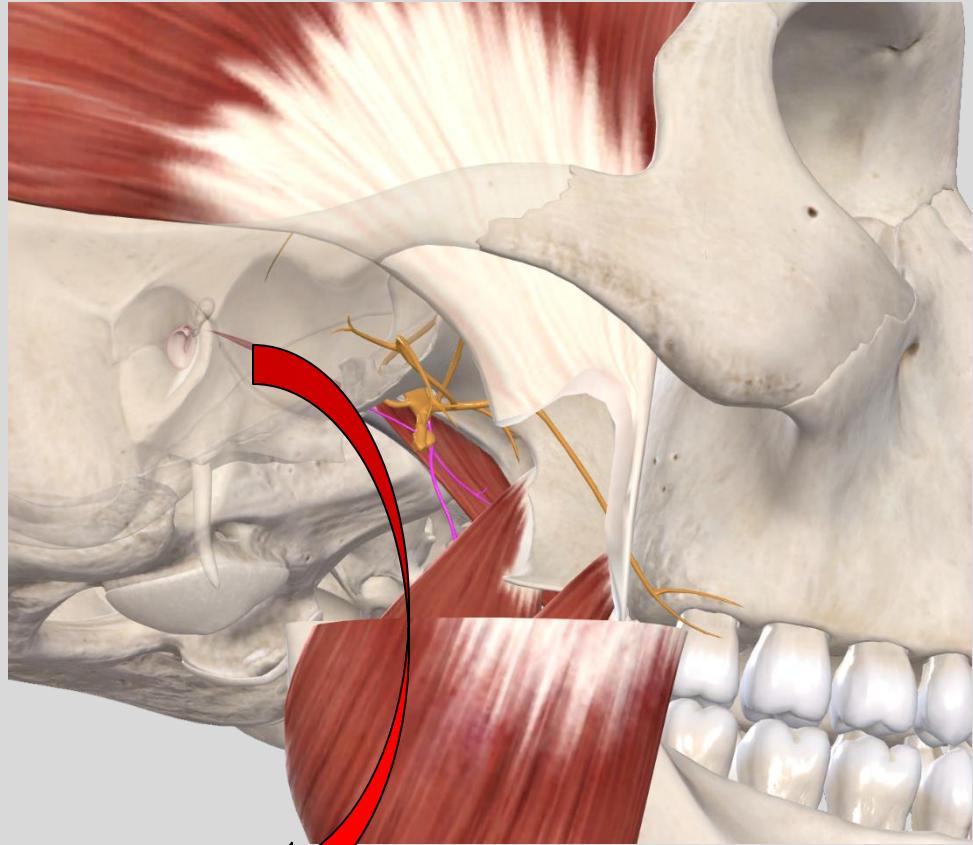
Nerve to Tensor tympani

Innervates the tensor tympani

Attaches to the malleus, stiffening the tympanic membrane

Reduces vibrations from tympanic membrane to ear ossicles, dulling sound

Activates in response to loud sounds



CN V — Trigeminal

Clinical Correlates

Trigeminal neuralgia (tic douloureux)

Misfiring of one or more branches of trigeminal

Patients complain of acute, intense pain on face

Can be stimulated by a slight breeze

Most cases are idiopathic

Treatment varies from local anesthesia to nerve resection



CN V — Trigeminal

Clinical Correlates

TMJ disorders

Problem related to the temporomandibular jaw joint

Unbalanced muscle firing produces

Misaligned teeth

Can lead to tooth grinding (bruxism)

Jaw tenderness

Headaches

Lock jaw

Ear pain (e.g., through auriculotemporal nerve aggravation)



CN VII — Facial

Main motor nerve for the face

Innervates all the muscles of facial expression (20+ muscles)

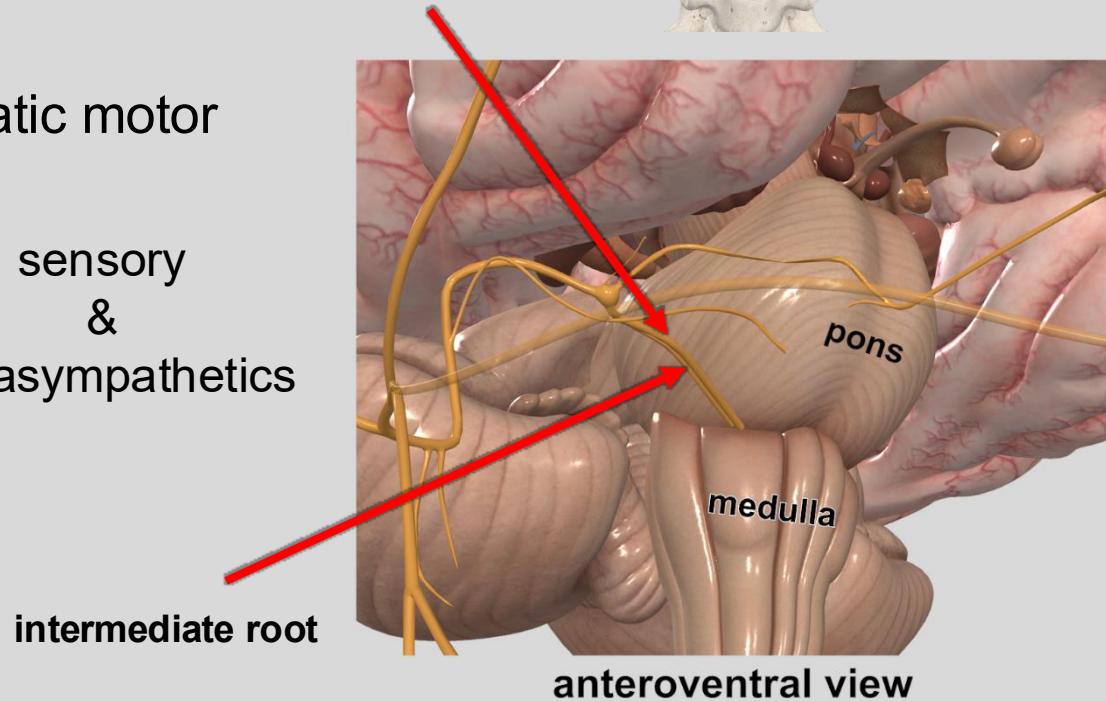
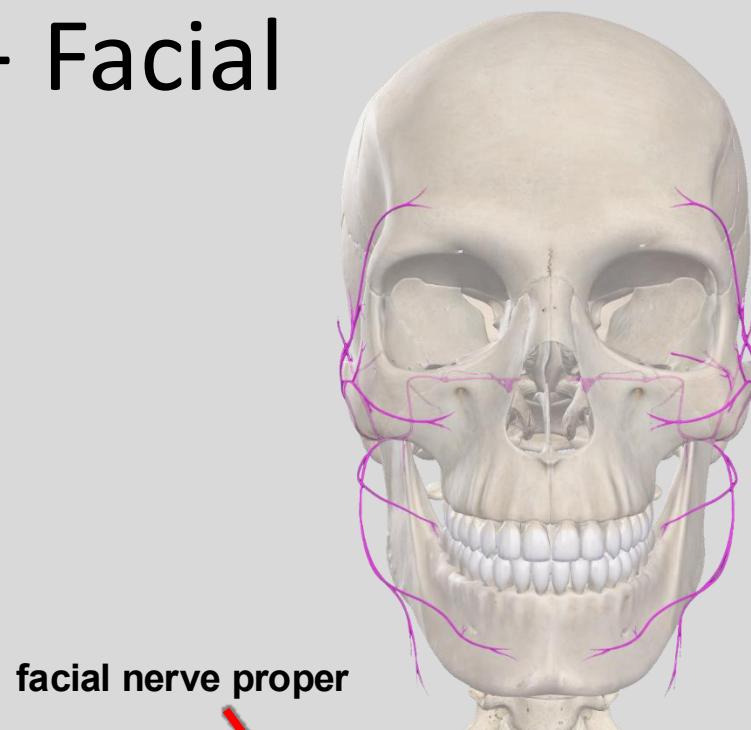
Major autonomic nerve for the face

Facial consists of 2 roots

1. Primary motor root
(facial nerve proper) = somatic motor

2. Intermediate root / nerve = sensory & parasympathetics

Exits endocranum through internal acoustic meatus



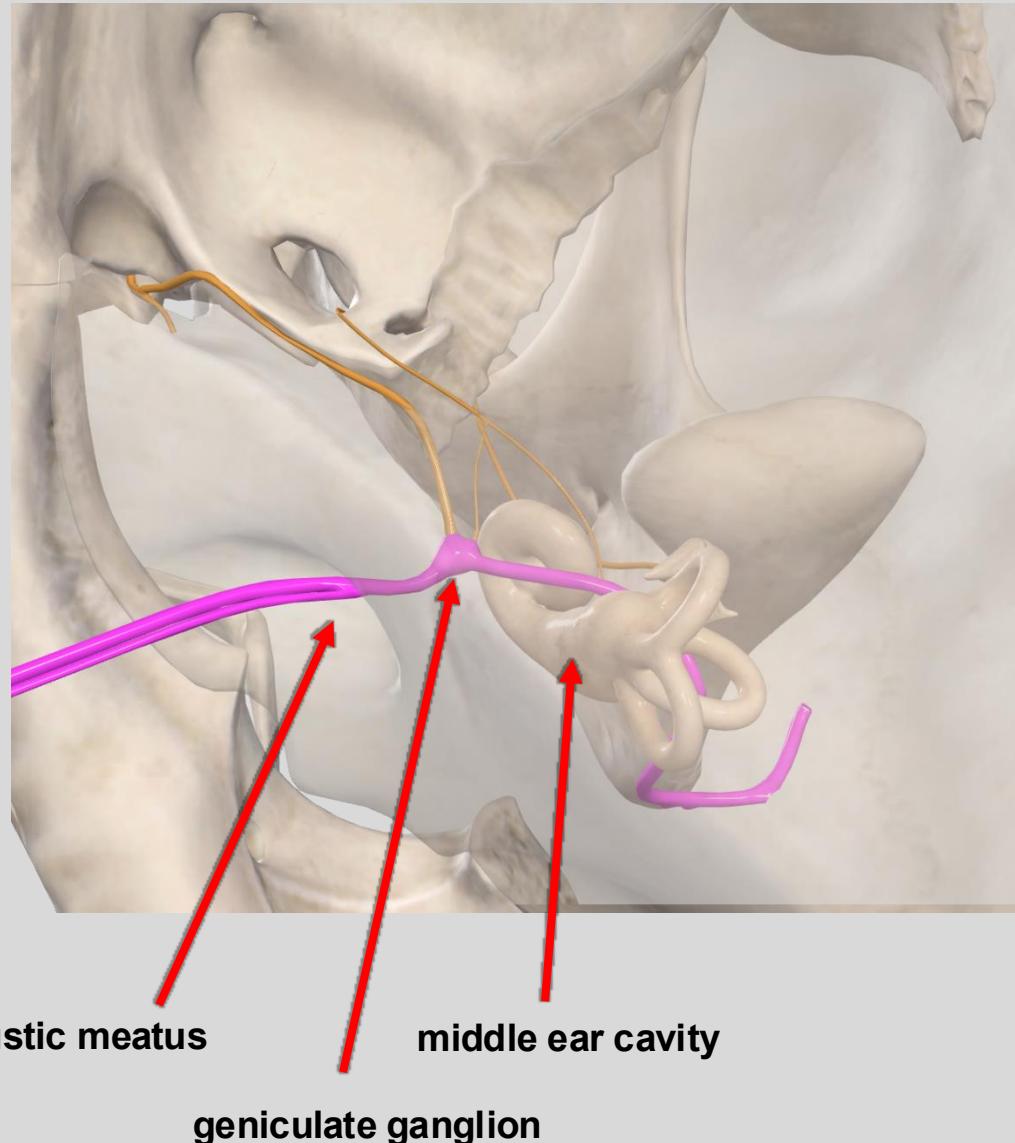
CN VII — Facial

Facial nerve takes the *longest intraosseous course* of any cranial nerve

Facial nerve travels through the facial canal

At geniculum, facial nerve expands into geniculate ganglion

Geniculate ganglion is important for the autonomic component of facial



Latin: genu = knee

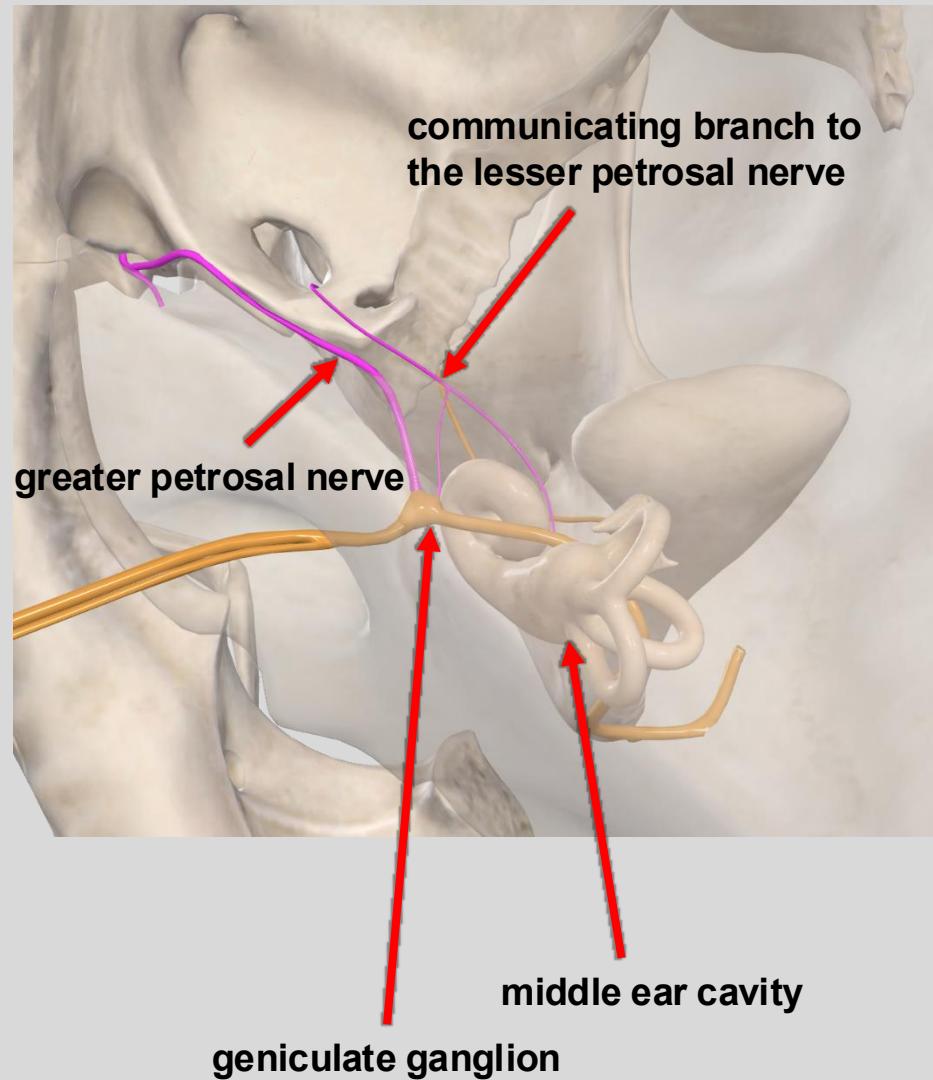
CN VII — Facial

33

3 branches exit the geniculate ganglion

- 1) Greater (superficial) petrosal nerve
- 2) Communicating branch to the lesser petrosal nerve
- 3) External petrosal nerve
(not shown in Complete Anatomy)

These branches send autonomic innervation around the head



CN VII — Facial

34

Nerve to Stapedius

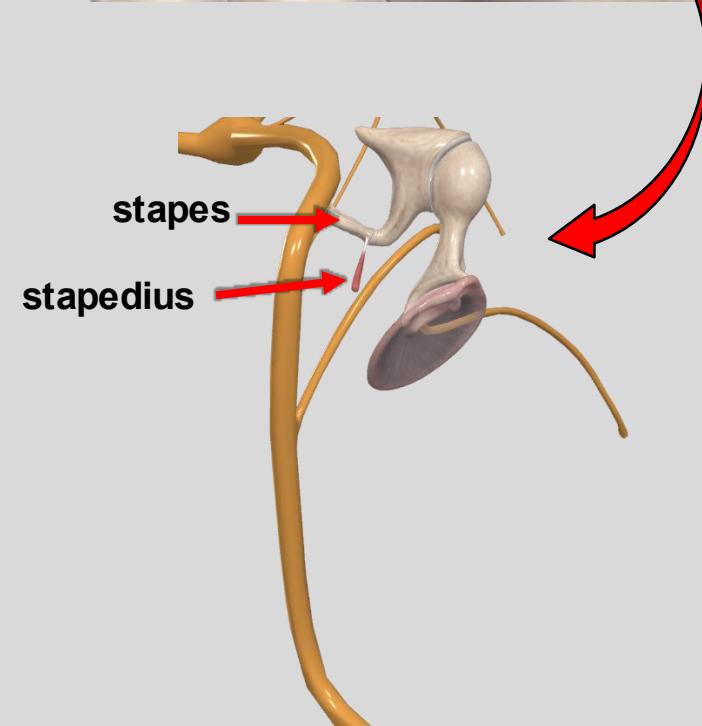
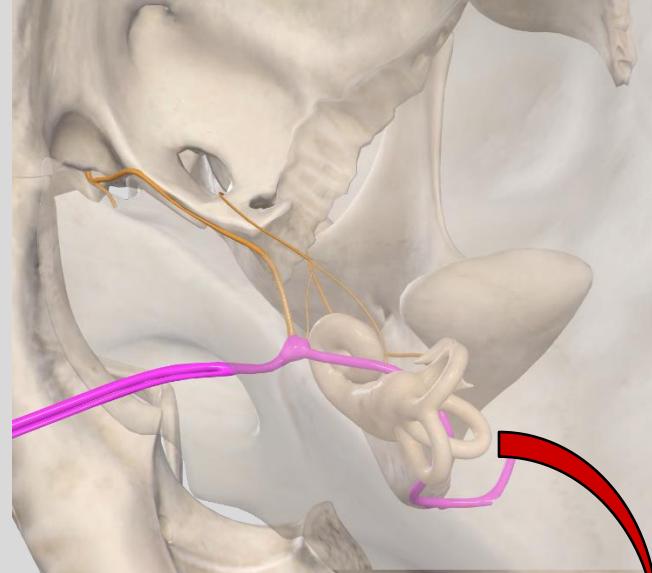
Facial nerve continues around the tympanum

Sends out the nerve to stapedius

Innervates the stapedius muscle

Muscle locks down the stapes
around loud noises

Dulls sound, protecting the ear



CN VII — Facial

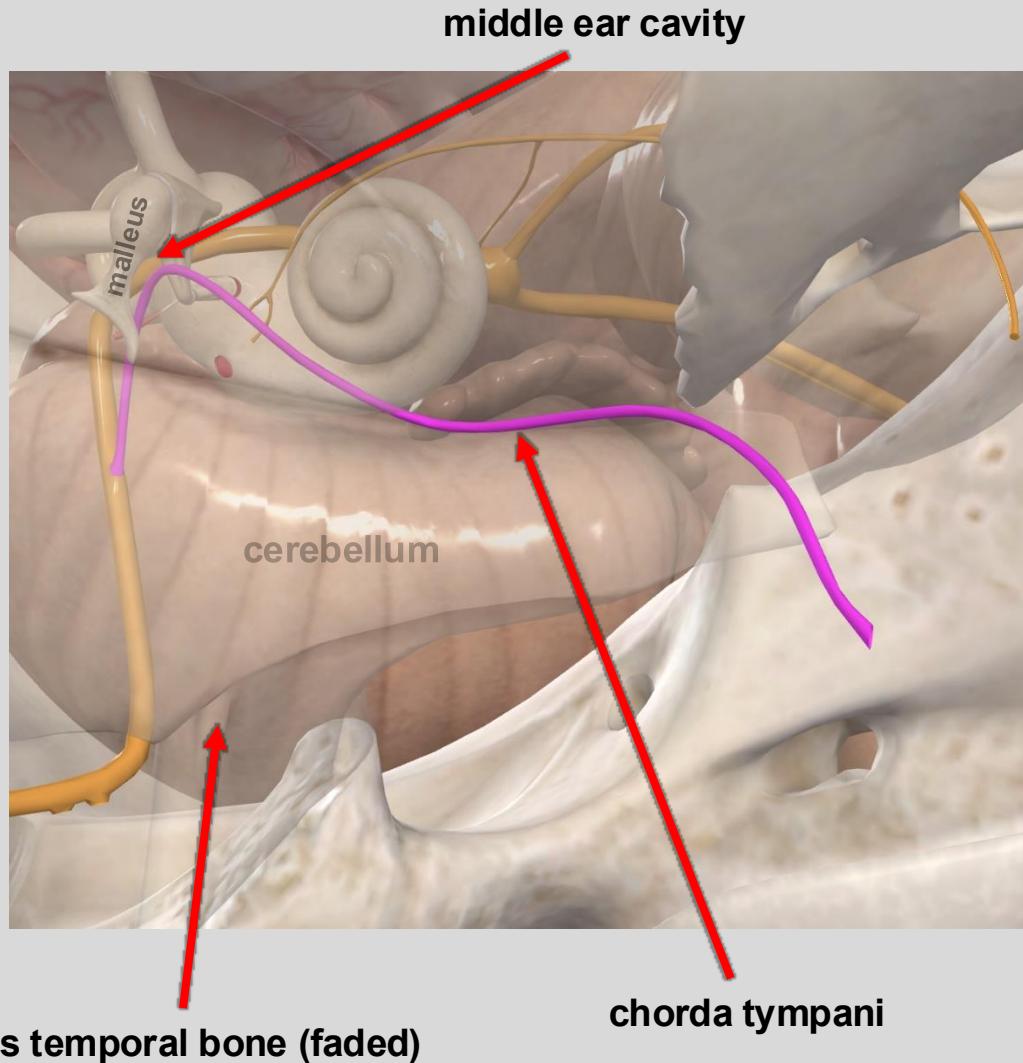
35

Chorda tympani

Facial sends a branch into the middle ear: chorda tympani

Chorda tympani passes through middle ear and *exits skull* through the petrotympanic fissure

Joins with lingual nerve to provide taste to anterior 2/3^{rds} of tongue



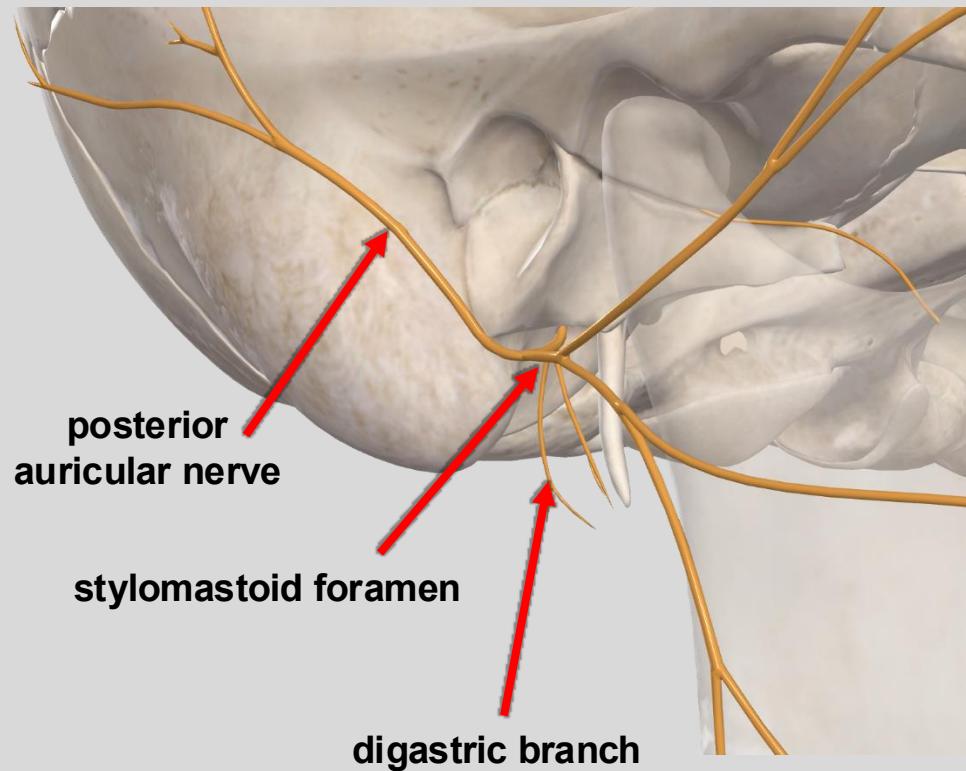
CN VII — Facial

The rest of facial *exits the skull* through the stylomastoid foramen

After exiting, facial sends out the posterior auricular nerve
innervates vestigial ear muscles

The digastric branch innervates the posterior belly of digastric

Digastric muscle has dual innervation
Anterior belly = CN V₃
Posterior belly = CN VII



The rest of facial continues on to form the **parotid plexus**

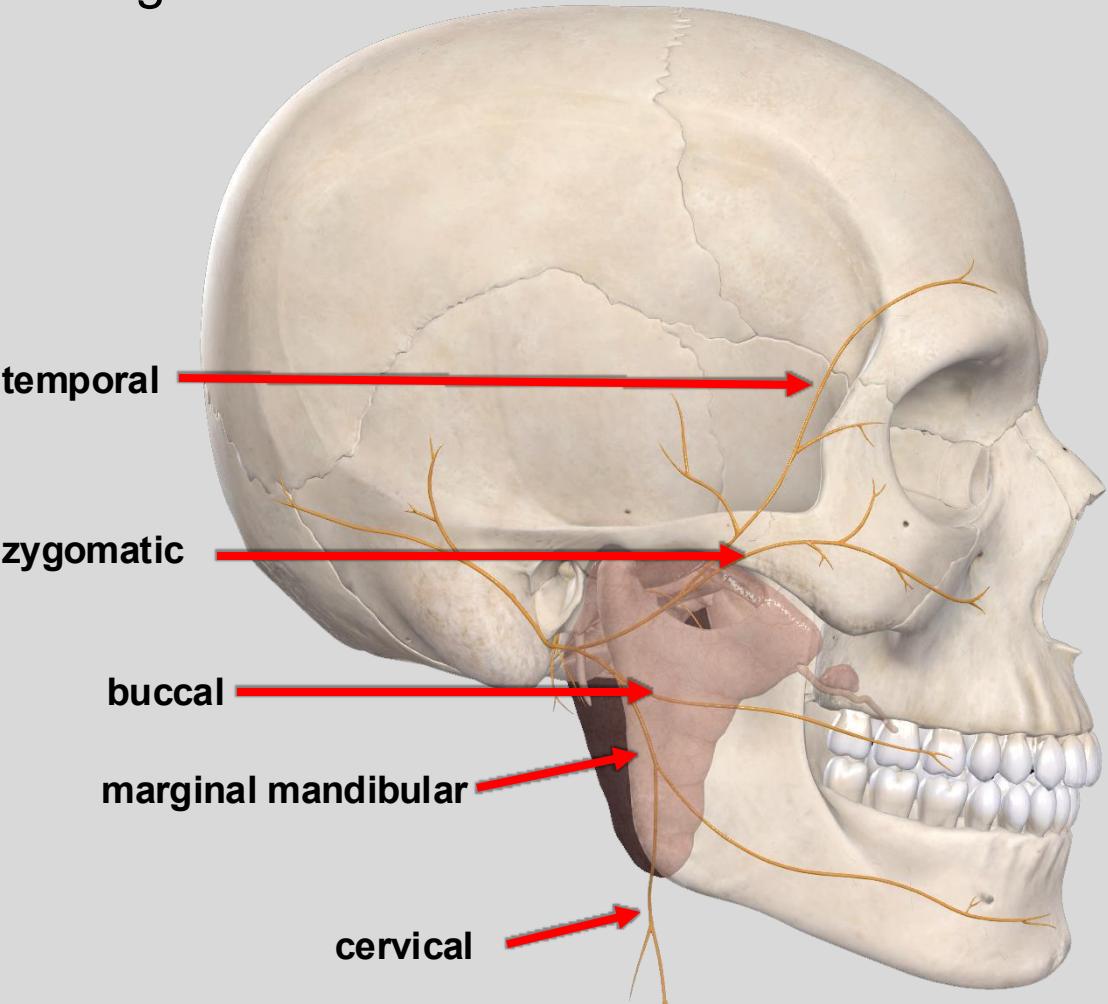
CN VII — Facial

Parotid Plexus

This happens deep within the parotid gland

5 branches of parotid plexus

- 1) Temporal
- 2) Zygomatic
- 3) Buccal
- 4) Marginal Mandibular
- 5) Cervical



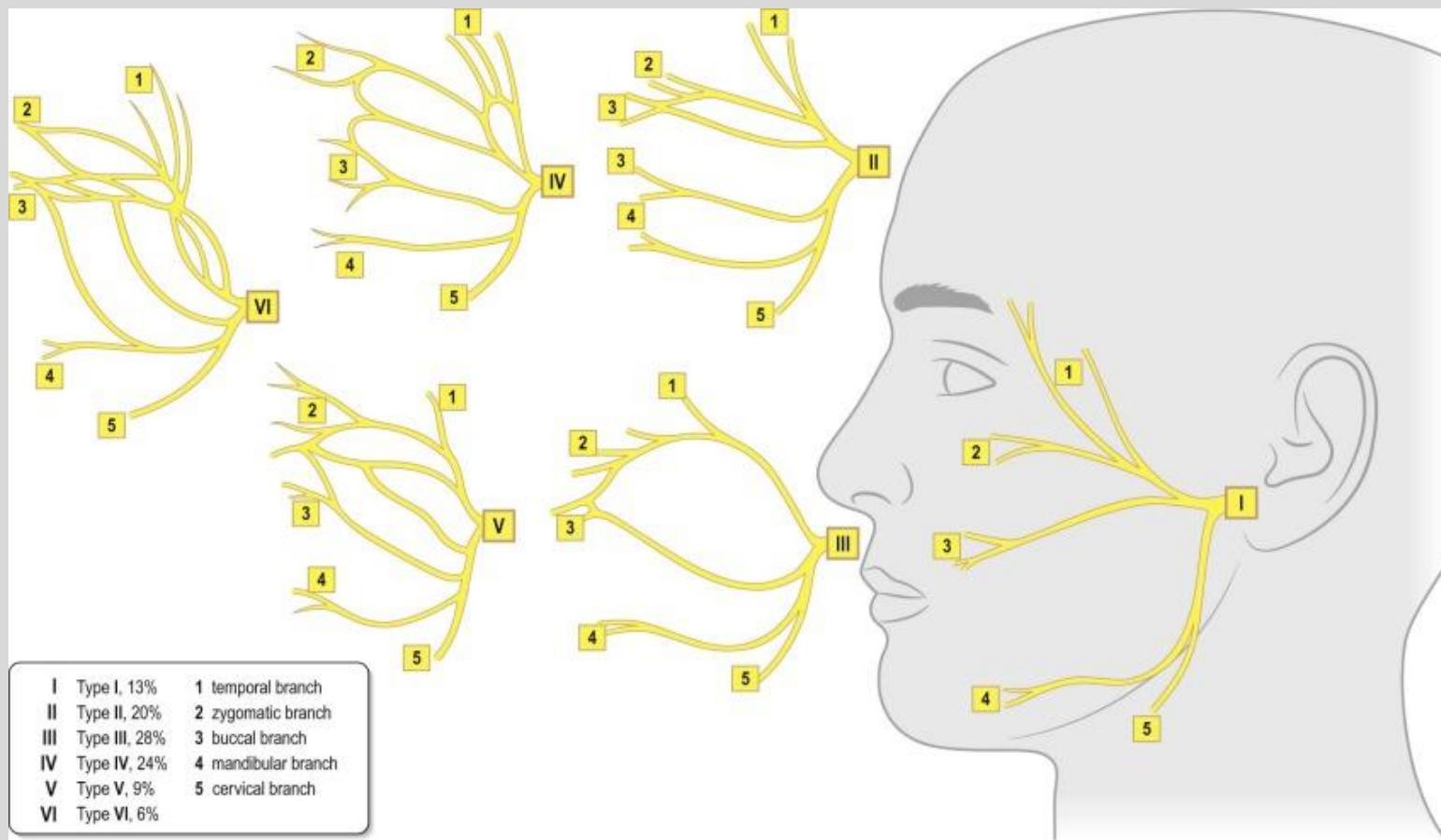
All branches innervate nearby muscles of facial expression

CN VII — Facial

Parotid Plexus

Arbourization pattern of the parotid plexus is highly variable

You will only be tested on the “textbook” version



CN VII — Facial

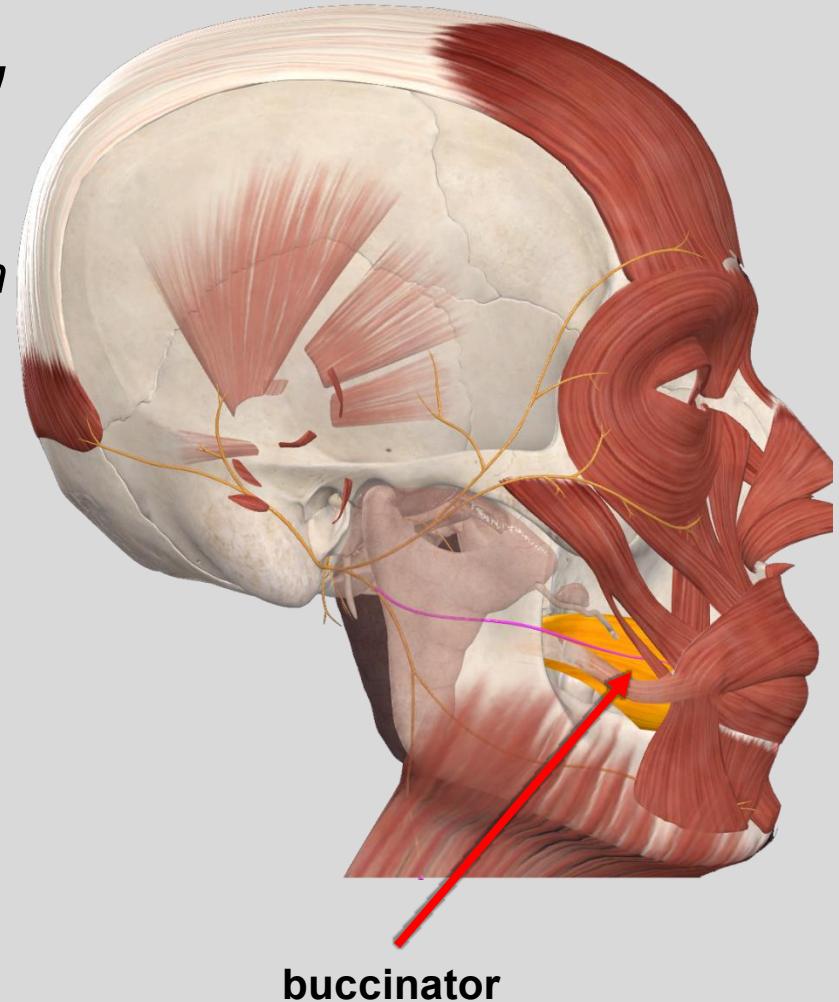
Parotid Plexus

Don't confuse your innervations!

Buccinator is a *muscle of facial expression* that tenses the cheeks

Buccal nerve (V_3) = *sensory innervation to cheek mucosa*

Buccal branch of Facial (VII) = *motor innervation to buccinator*



CN VII — Facial

Clinical Correlate

Bell's Palsy

Lesion to one or more branches of parotid plexus

Causes partial / total paralysis of ipsilateral facial muscles

Most cases are idiopathic

Symptoms usually resolve over weeks / months

Occasionally Bell's Palsy is permanent



Sylvester Stallone
(permanent partial Bell's Palsy)

Lecture Feedback Survey

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

Cranial nerves: IX, X, XI & XII

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Do.
Make.
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Reinvent the Future.

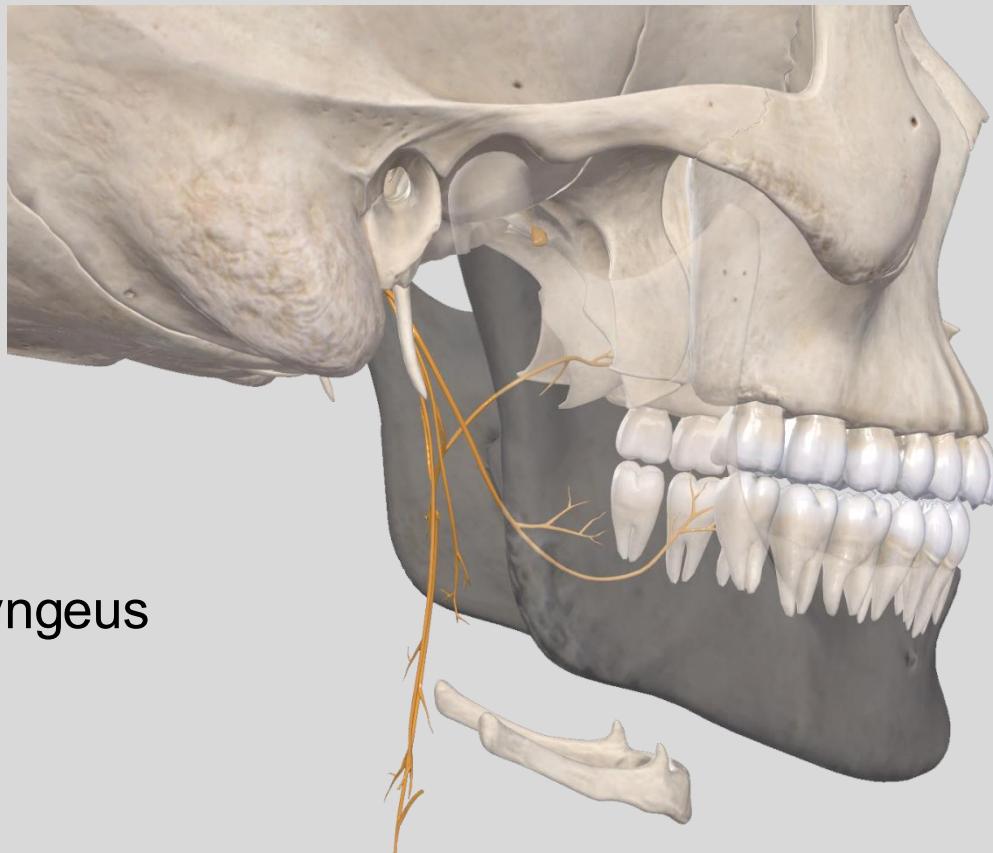
CN IX — Glossopharyngeal

The primary sensory nerve of the pharynx

Transmits somatic sensory and taste innervation for the proximal 1/3rd of the tongue

Innervates a single muscle: stylopharyngeus

Exits endocranum and skull through the jugular foramen

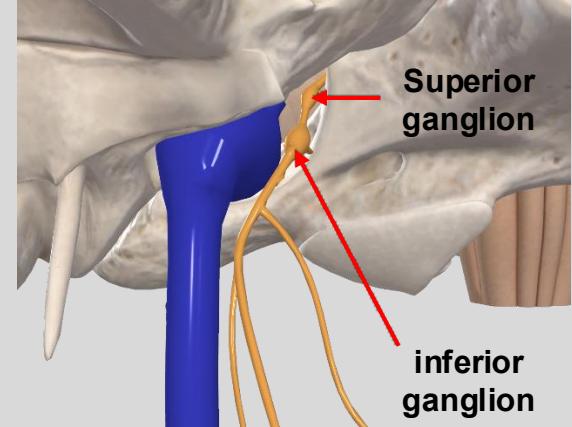


CN IX — Glossopharyngeal

Forms two successive ganglia

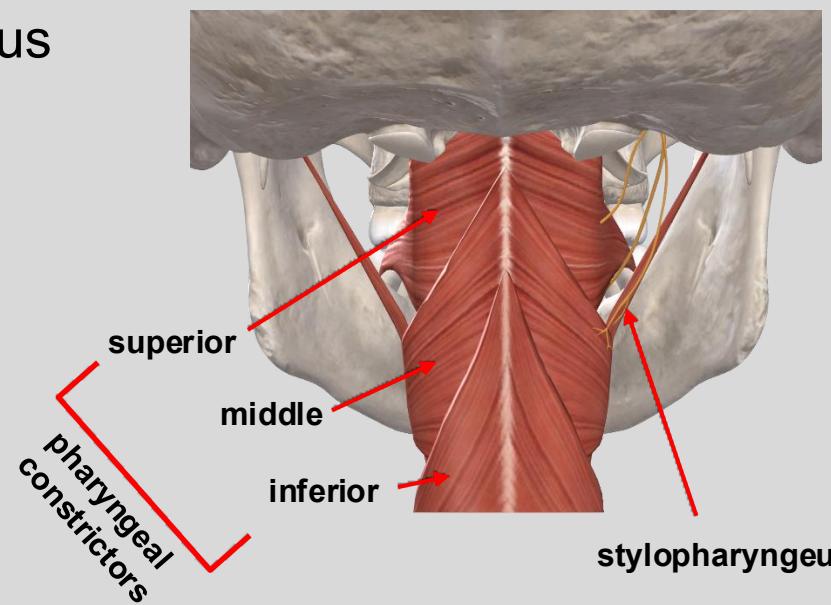
Superior ganglion

Inferior / Petrous ganglion

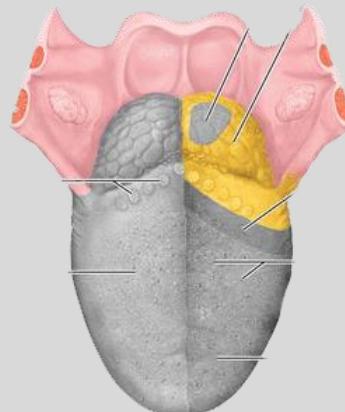


Sends single motor branch to stylopharyngeus

Nerve dives between superior and middle pharyngeal constrictors where it forms the afferent limb of the pharyngeal plexus



Exits constrictors and goes to the posterior tongue

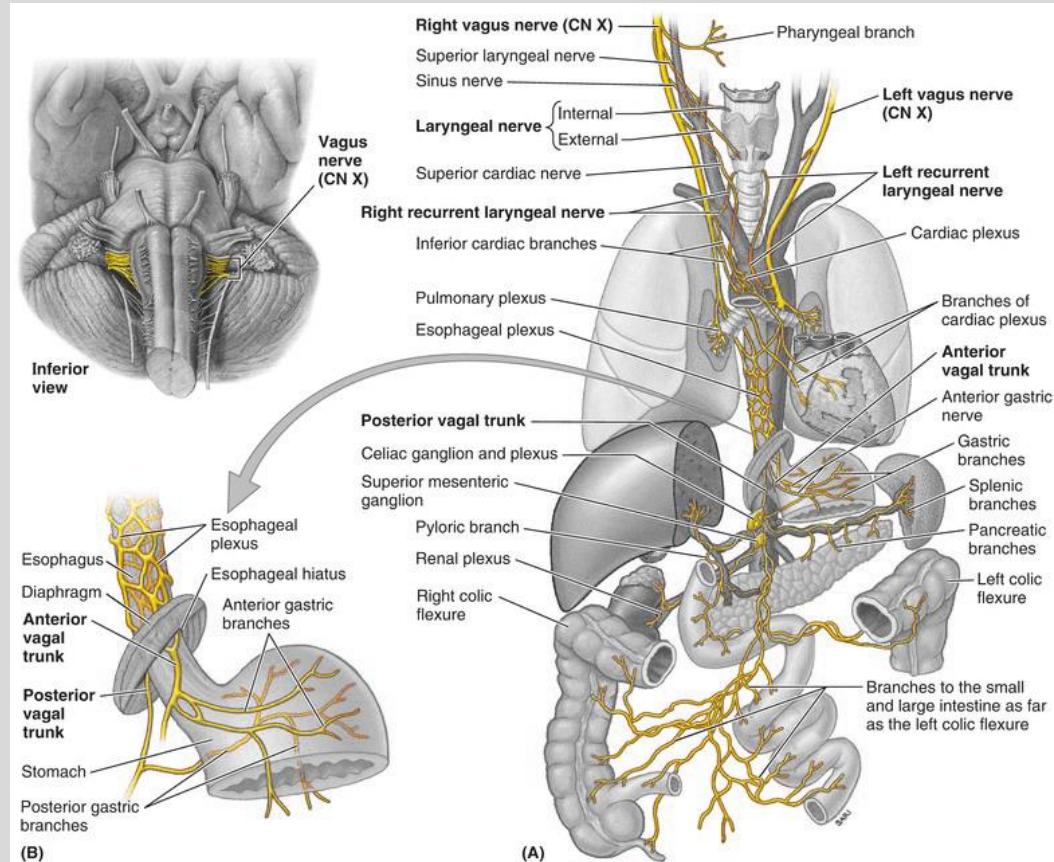


CN X — Vagus

CN X has the most complicated distribution of all the cranial nerves

Main conduit of parasympathetic innervation below the neck

This lecture will only focus on the branches active in the head and neck



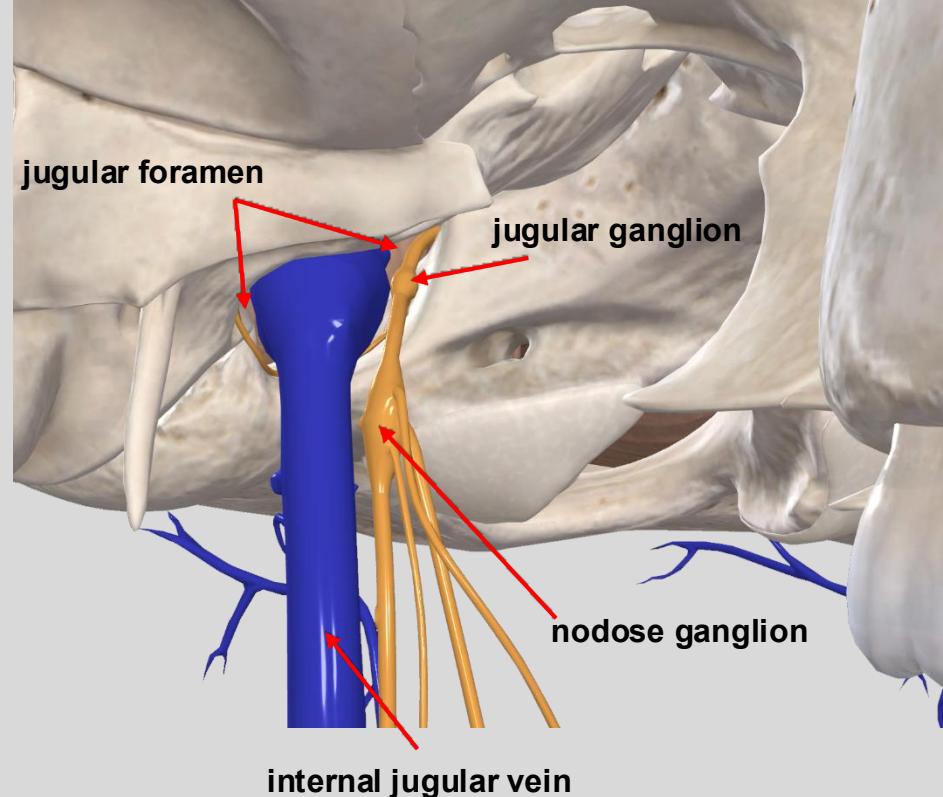
Moores Fig. 10.16

CN X — Vagus

Exits endocranum and skull from jugular foramen

Forms 2 ganglia outside the jugular foramen

1. Superior / Jugular ganglion (sensory)
2. Inferior / Nodose ganglion (parasympathetics)



You are responsible for just 3 branches of vagus

1. Pharyngeal
2. Superior Laryngeal
3. Recurrent Laryngeal / Inferior Laryngeal

CN X — Vagus

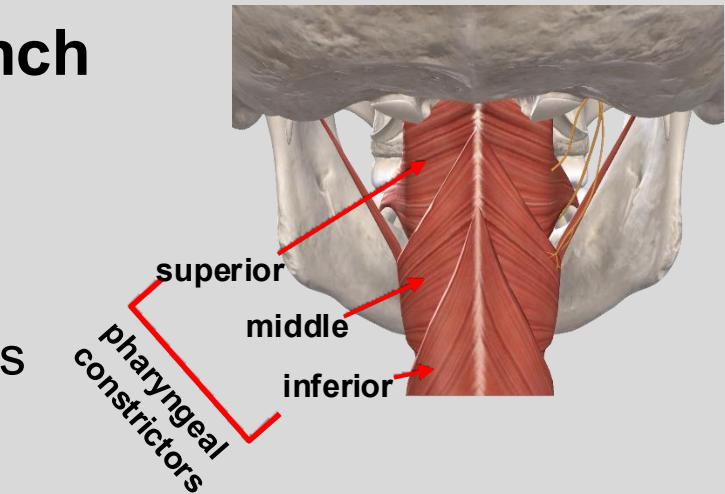
Pharyngeal Branch

The first branch off vagus as it descends

Provides the motor limb to the pharyngeal plexus

Motor innervation for most of the soft palate

Will innervate the palatoglossus muscle of the tongue



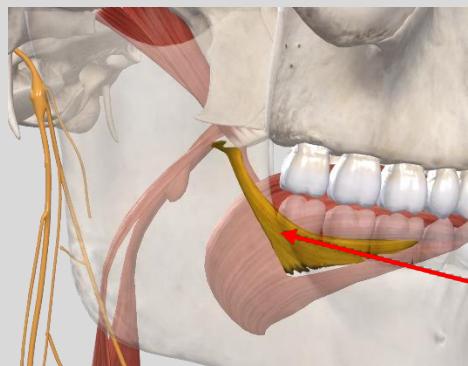
levator veli palatini

salpingopharyngeus

musculus uvulae

palatopharyngeus

tensor veli palatini (CN V₃)



CN X — Vagus

Superior Laryngeal Nerve

Descends neck to innervate larynx

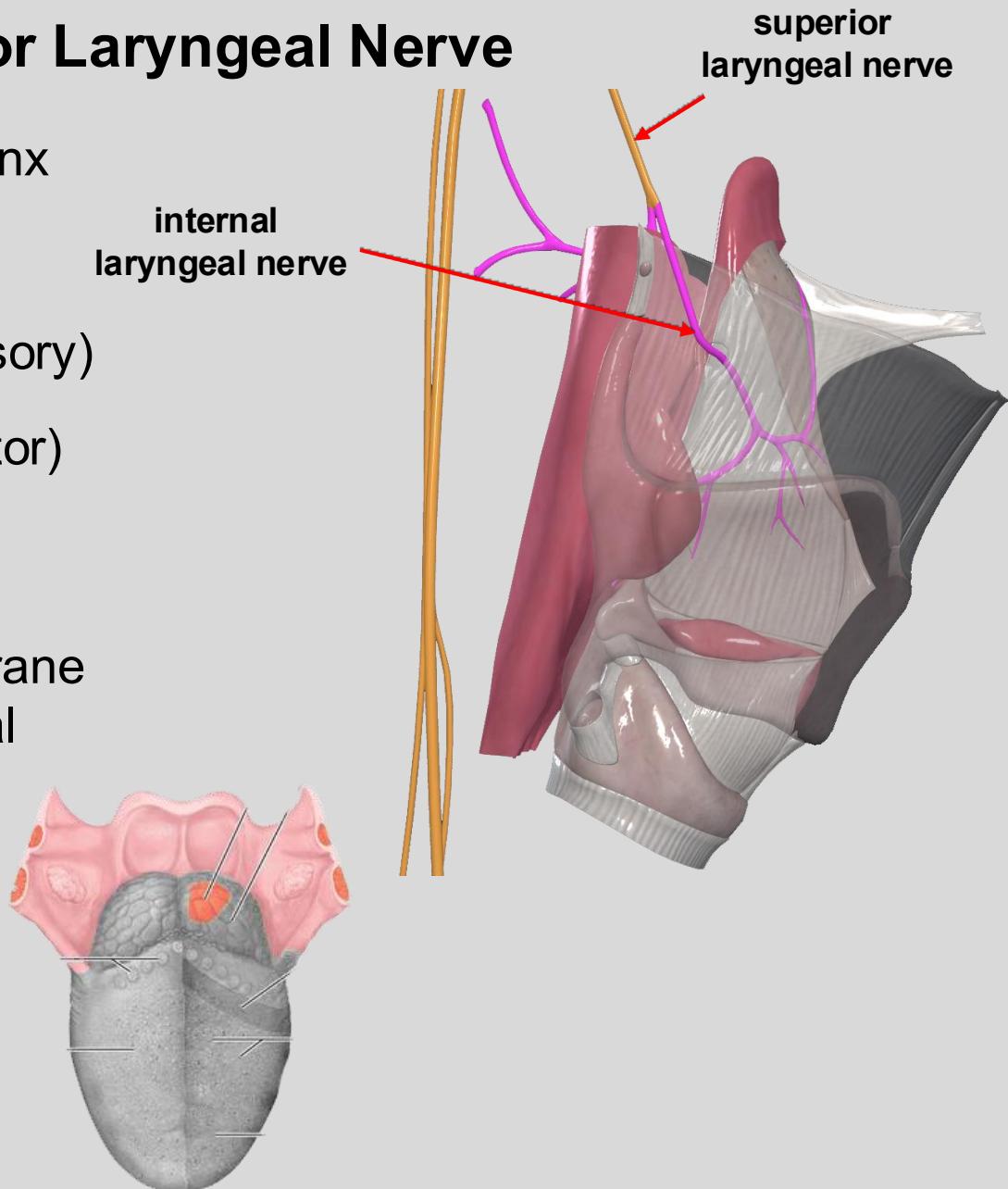
Divides into 2 branches

1. Internal laryngeal nerve (sensory)
2. External laryngeal nerve (motor)

Internal laryngeal

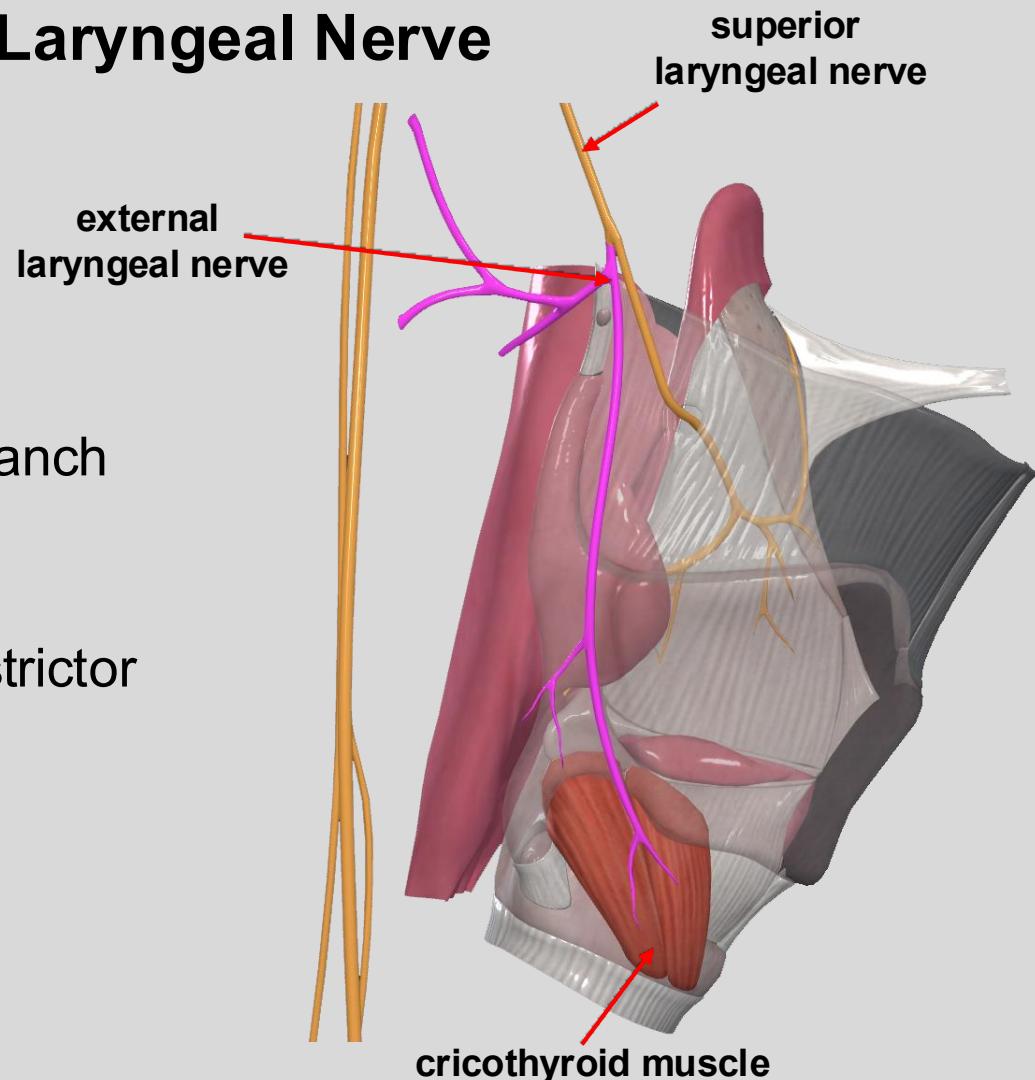
Goes through thyrohyoid membrane
to innervate mucosa above vocal
folds

Small branch will provide taste
sensation to parts of the tongue,
pharynx and soft palate



CN X — Vagus

Superior Laryngeal Nerve



External laryngeal is the smaller branch

Provides motor innervation to:

portion of inferior pharyngeal constrictor
cricothyroid muscle

Cricothyroid is the only intrinsic larynx muscle innervated by superior laryngeal

CN X — Vagus

Recurrent Laryngeal Nerve

Final branch of vagus to go to the head and neck. Branches off in thorax

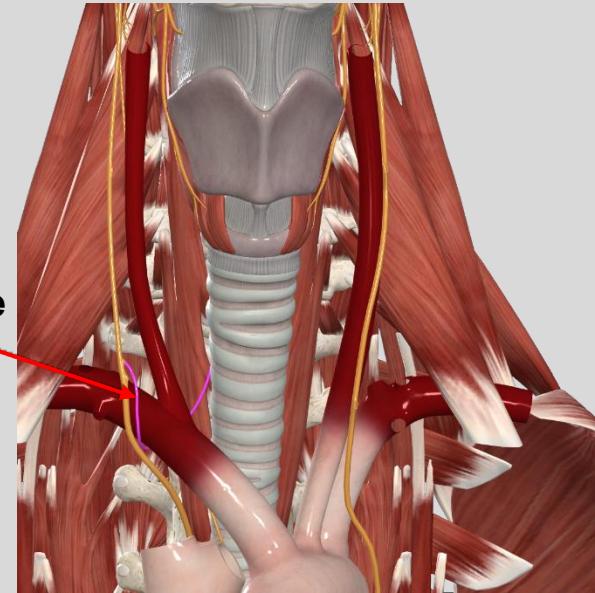
Left recurrent wraps around aortic arch (ligamentum arteriosum)

Right recurrent wraps around the right subclavian artery

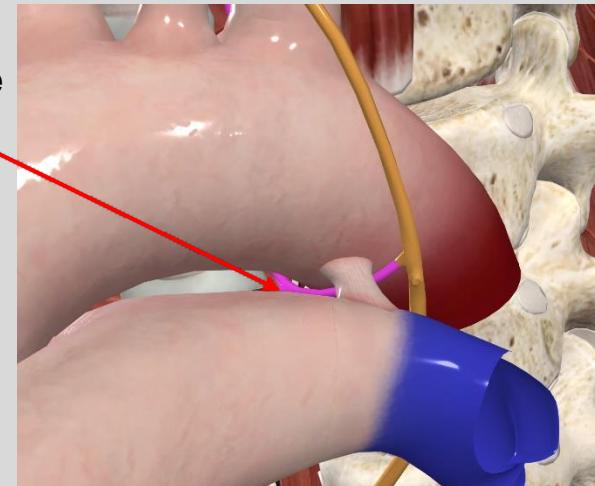
Both sides ascend to larynx in the tracheo-esophageal groove, providing sensory innervation to trachea and esophagus

At the level of the larynx, recurrent laryngeal changes to inferior laryngeal

right recurrent laryngeal nerve



left recurrent laryngeal nerve



CN X — Vagus

Inferior Laryngeal Nerve

Main innervation for the larynx

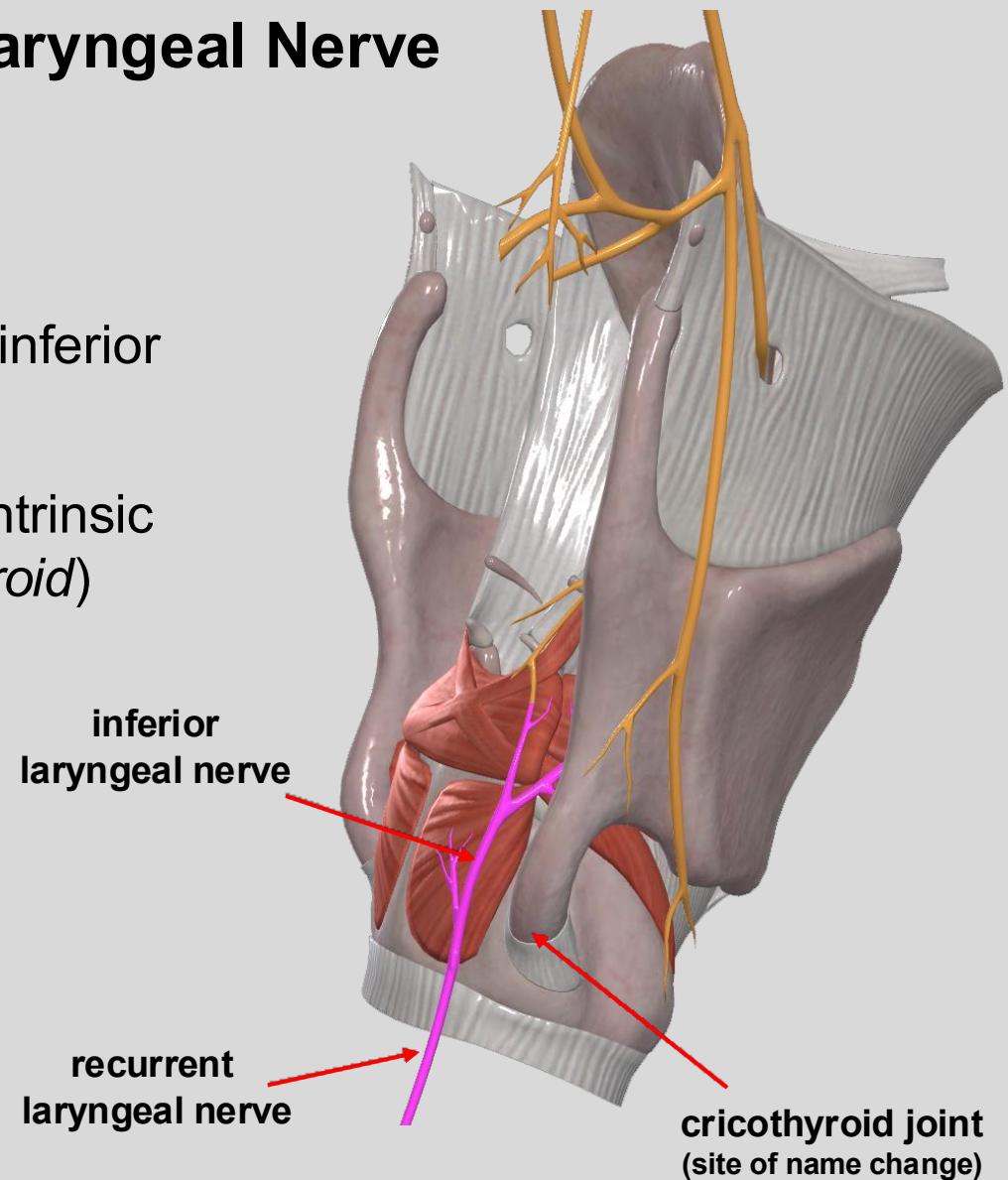
Afferent component = sensation to inferior glottic cavity

Efferent component = motor to all intrinsic laryngeal muscles (*except cricothyroid*)

Divides into 2 terminal branches

Anterior branch

Posterior branch



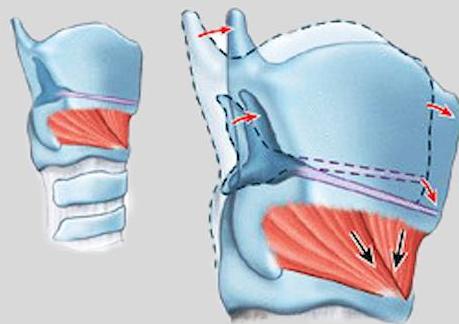
Note: You do not need to know which branch innervates which muscle

Laryngeal Muscles

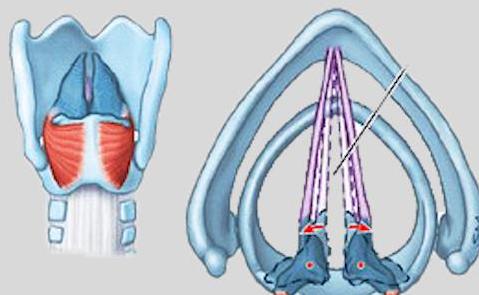
Posterior crico-arytenoids are *the only* muscles that A-B-duct the vocal folds

Cricothyroid is *the only* intrinsic laryngeal muscle innervated by the superior laryngeal nerve

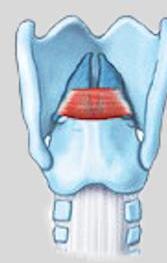
Moores Fig. 9.39



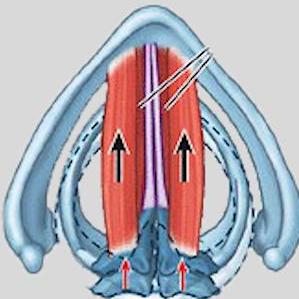
(A) Lateral view
Cricothyroid



(C) Superior view
Posterior crico-arytenoid



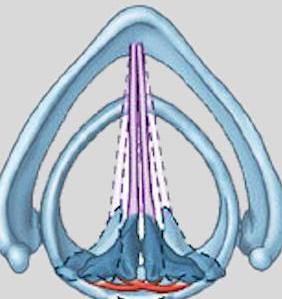
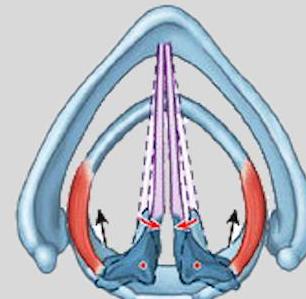
(E) Superior view
Transverse arytenoid



(B) Superior view
Thyro-arytenoid



(D) Superior view
Lateral crico-arytenoid



(F) Superior view
Oblique arytenoid

CN X — Vagus

Clinical Correlates

Recurrent laryngeal nerve damage

Result of surgical accidents

e.g. thyroid tumour removal

Consequence of compression from tumours or aneurysms

Lesion produces partial / total paralysis of most laryngeal muscles

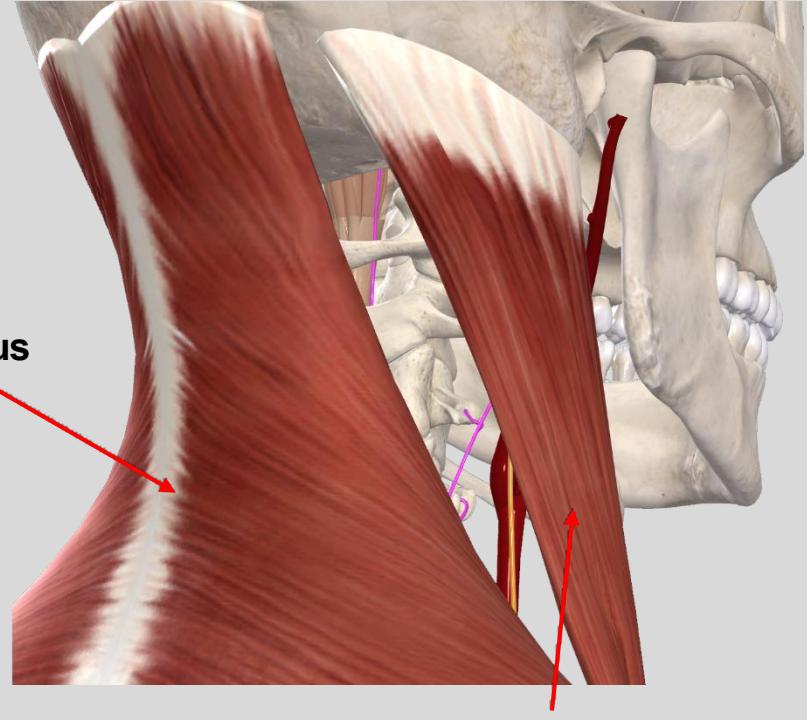
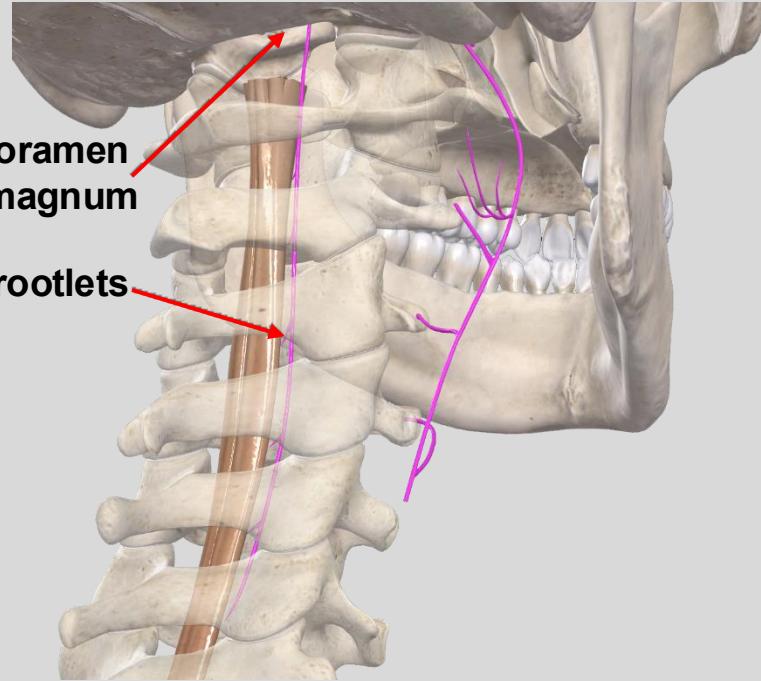
Unilateral lesion result in a voice that sounds hoarse

Bilateral lesion produces muteness and trouble breathing (vocal folds can't abduct)



Only muscle left unaffected is the cricothyroid

CN XI — Spinal Accessory



Starts as rootlets from first 5–6 cervical segments of spinal cord

Enters the endocranum through the foramen magnum

Exits the endocranum and skull through the jugular foramen

Parallel to the internal carotid before branching off to innervate sternocleidomastoid and trapezius

CN XI — Spinal Accessory

Clinical Correlates

CN XI can be damaged in whiplash accidents or during birth

Shoulder drop



Trapezius weakness / paralysis
Shoulder slopes towards side of lesion

Torticollis



Sternocleidomastoid hypertonicity or entrapment
Head tilts towards lesion. Face turns away

CN XII — Hypoglossal

Main motor nerve for the tongue

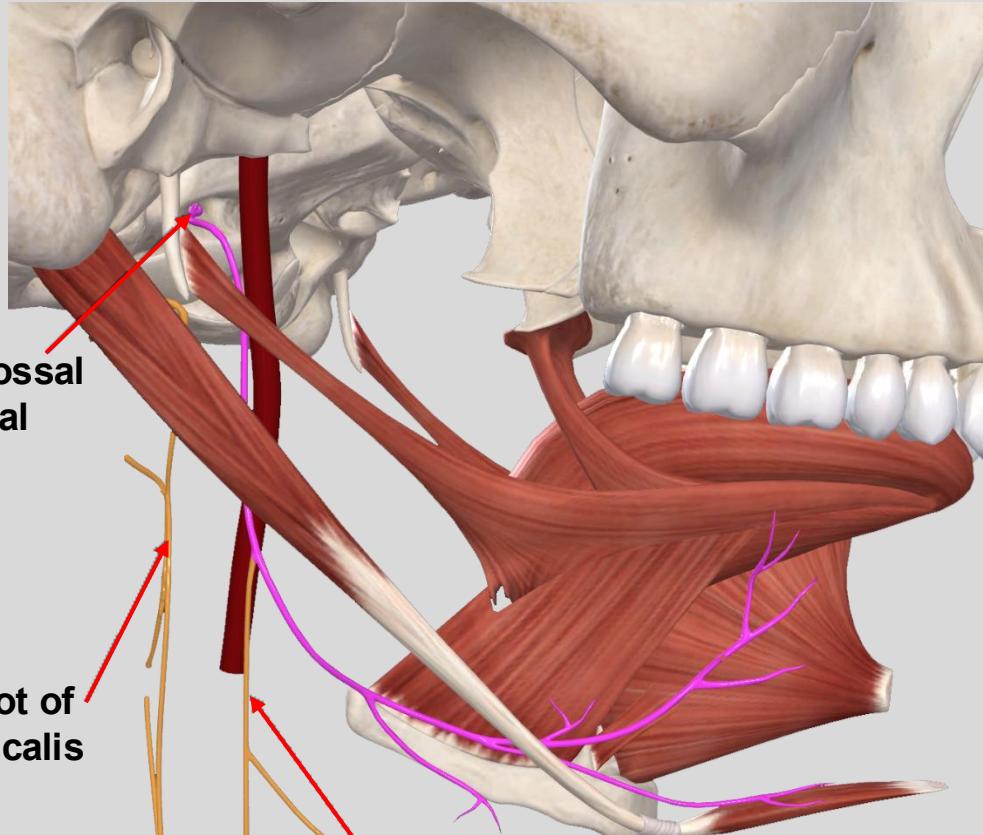
Innervates all tongue muscle
except for palatoglossus

Exits the endocranum & skull
through the hypoglossal canal

Crosses anteriorly between internal carotid artery and internal jugular vein

Cervical plexus nerves (C1 & C2) “hitch a ride”
with CN XII to their destination (superior root of ansa cervicalis)

Enters tongue from inferolateral direction



CN XII — Hypoglossal Tongue Muscles

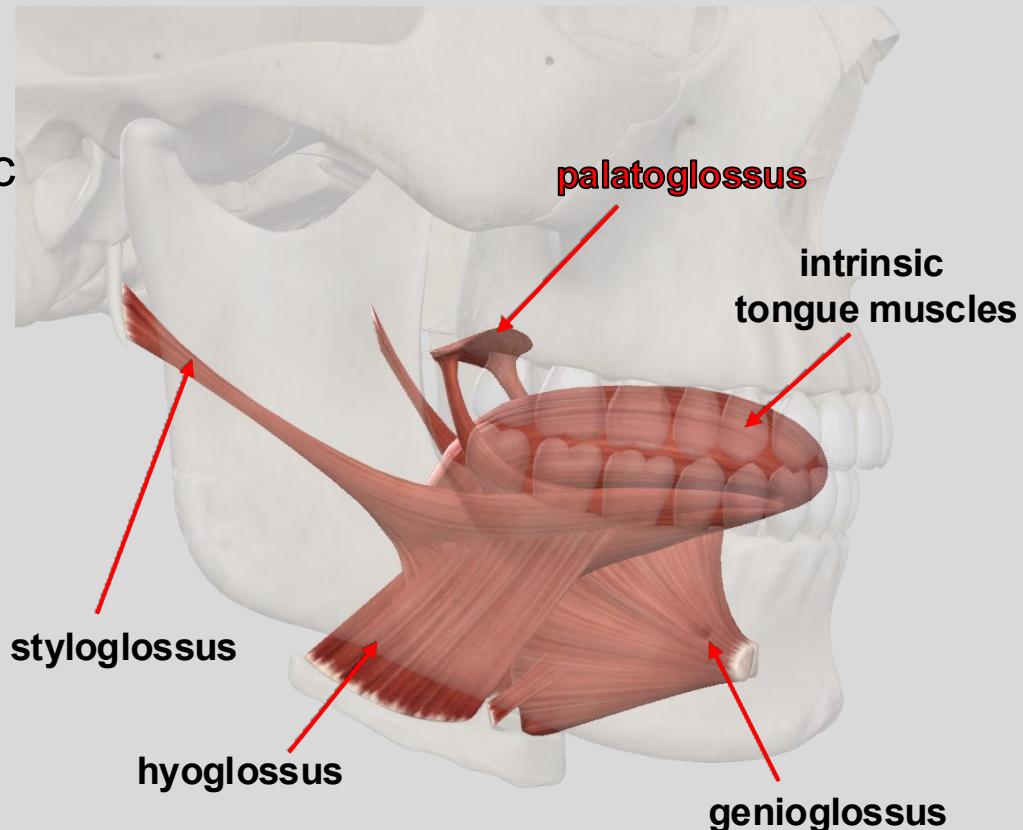
All the *glossus muscles are extrinsic

Genioglossus extends

Hyoglossus retracts & depresses

Styloglossus retracts and elevates

Palatoglossus elevates



Palatoglossus is *the only muscle not innervated* by hypoglossal

Stern's Law

Two muscles of the palate and tongue region have innervation exceptions
tensor veli palatini and palatoglossus

Jack Stern came up with a helpful way to remember this relationship

Stern's Law



-tensor = CN V₃

-palate = CN X

-glossus = CN XII

CN XII — Hypoglossal

Clinical Correlate

Hypoglossal lesion test (Genioglossus test)

Lesions to hypoglossal present as weakness or paralysis of most tongue muscles

A common test for hypoglossal damage is to have patient stick out tongue

Weakened / paralyzed genioglossus will present asymmetric activation

Results in the tongue deviating to the lesion side



Most behaviours of the head and neck require cranial nerves to work together and with proper timing

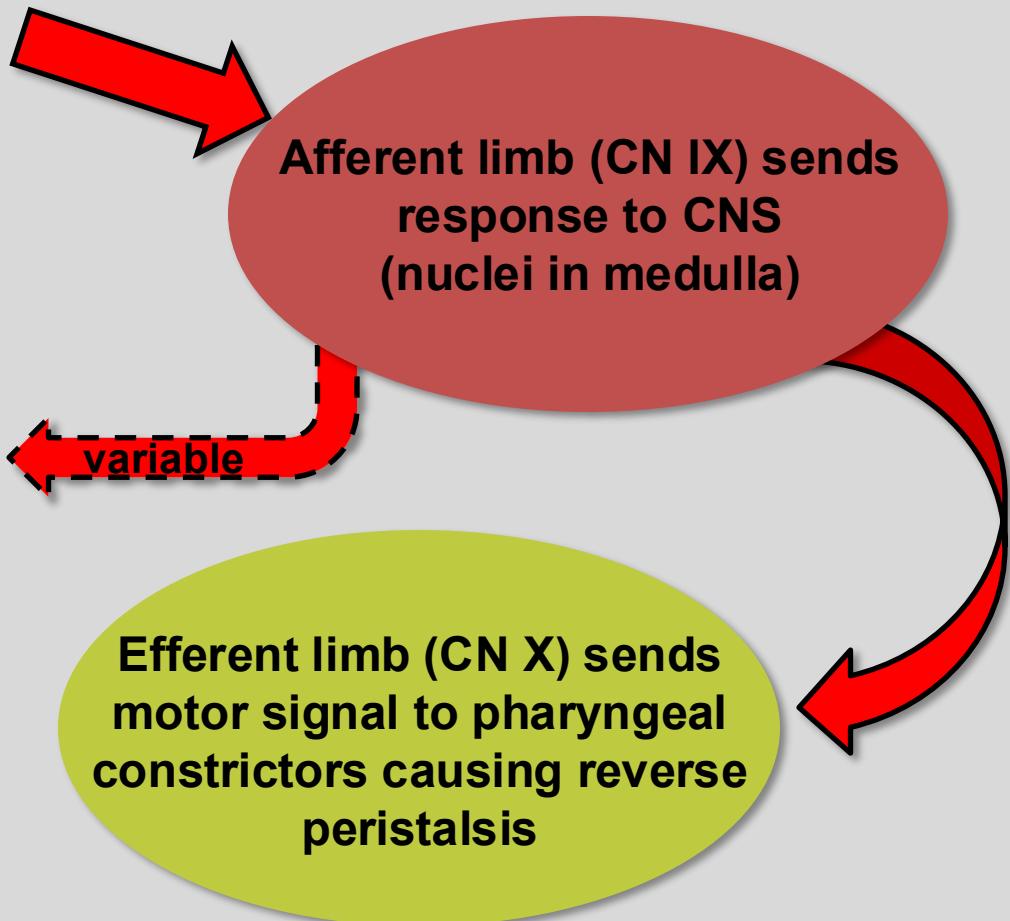
Let's briefly compare two examples:

- 1. Gag reflex**
- 2. Deglutition (swallowing)**

Gag Reflex

Gag reflex contributions vary between individuals but stay consistent within individuals

Unexpected object touches the pharynx



Jaw opens (CN V₃) and tongue lowers (CN XII) expelling food

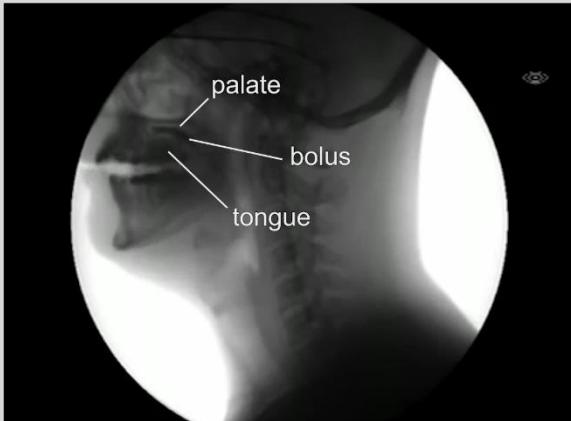
37% of people lack an appreciable gag reflex

Swallowing (Deglutition)

3 stages to swallowing

Stage 1 — CN XII

Tongue pushes food bolus to back of mouth



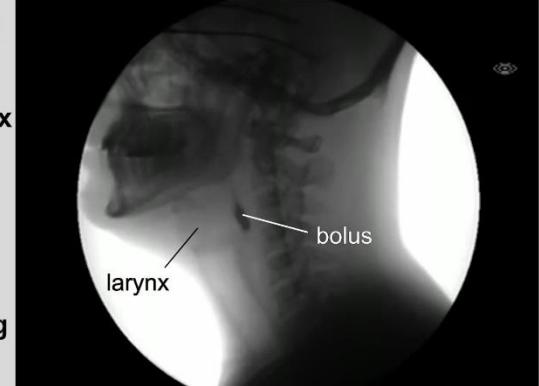
Michael Farnan (YouTube)

Stage 2 — CN V₃, IX, X

Soft palate is lifted sealing the nasopharynx
(CN V₃, X)

Pharynx is lifted and widened
(CN IX, X)

Epiglottis shuts, closing off trachea



Michael Farnan (YouTube)

Stage 3 — CN X

Rhythmic contraction of pharyngeal constrictors



Michael Farnan (YouTube)

Misfiring nerves produce dysphagia (trouble swallowing)

Ianessa Humbert (<https://shorturl.fm/jVAR9>)

Michael Farnan (<https://www.youtube.com/watch?v=umnnA50IDiY>)

Lecture Feedback Survey

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