



Cranial Nerves

By Elmira Imadova and Sayeh Mirshojae

O: olfactory nerve (CN I)
O: optic nerve (CN II)
O: oculomotor nerve (CN III)
T: trochlear nerve (CN IV)
T: trigeminal nerve (CN V)
A: abducens nerve (CN VI)

whoever named the nervous system
got it 100% right, that thing is nervous



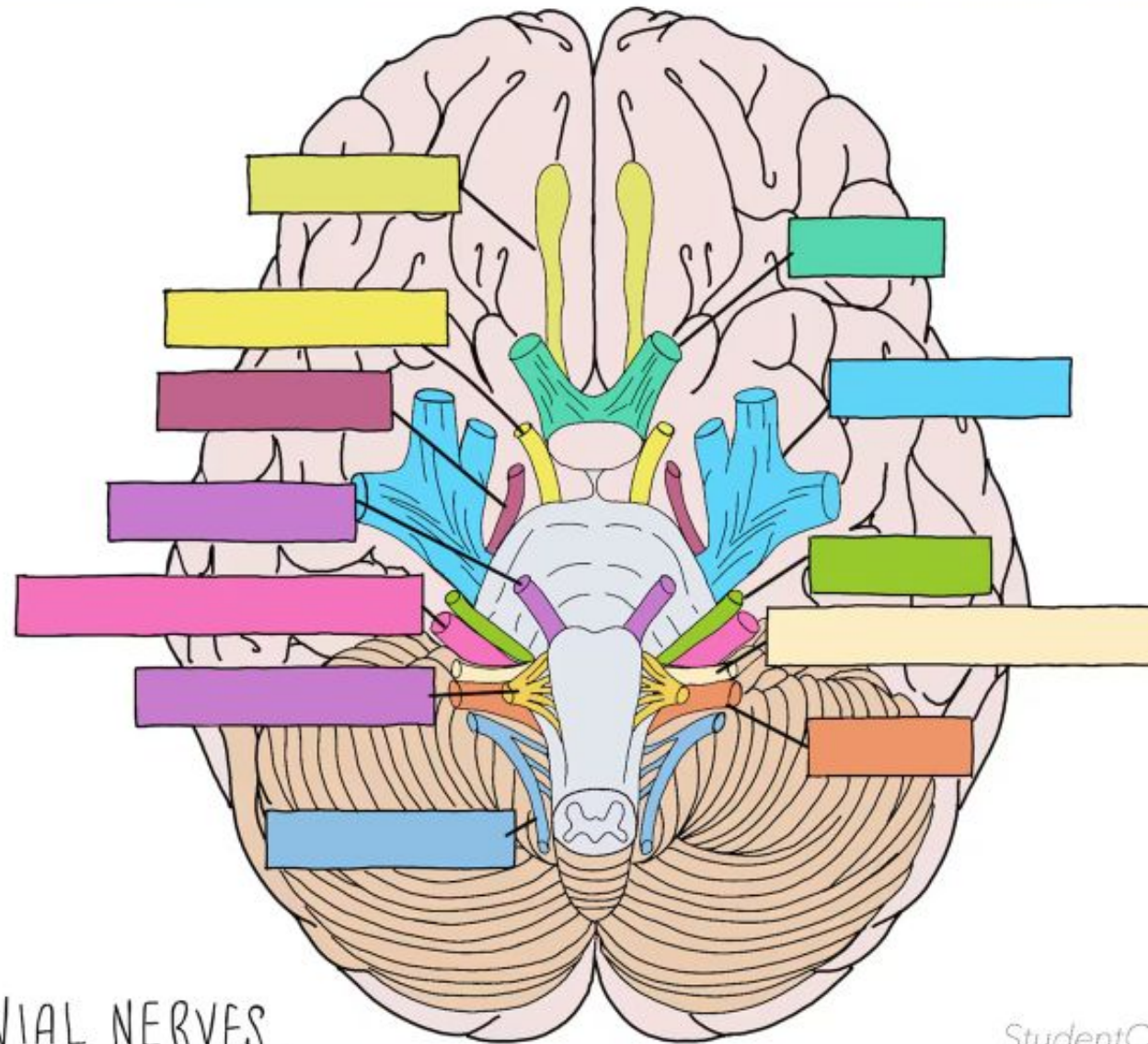
Ooh, **O**oh, **O**oh, **t**o **t**ouch **a**nd **f**eel
very **g**ood **v**elvet. **S**uch (**A**h)
heaven!

F: facial nerve (CN VII)
V: auditory (or vestibulocochlear) nerve (CN VIII)
G: glossopharyngeal nerve (CN IX)
V: vagus nerve (CN X)
S/A: spinal accessory nerve (CN XI)
H: hypoglossal nerve (CN XII)

Afferent Arrives, Efferent Exits

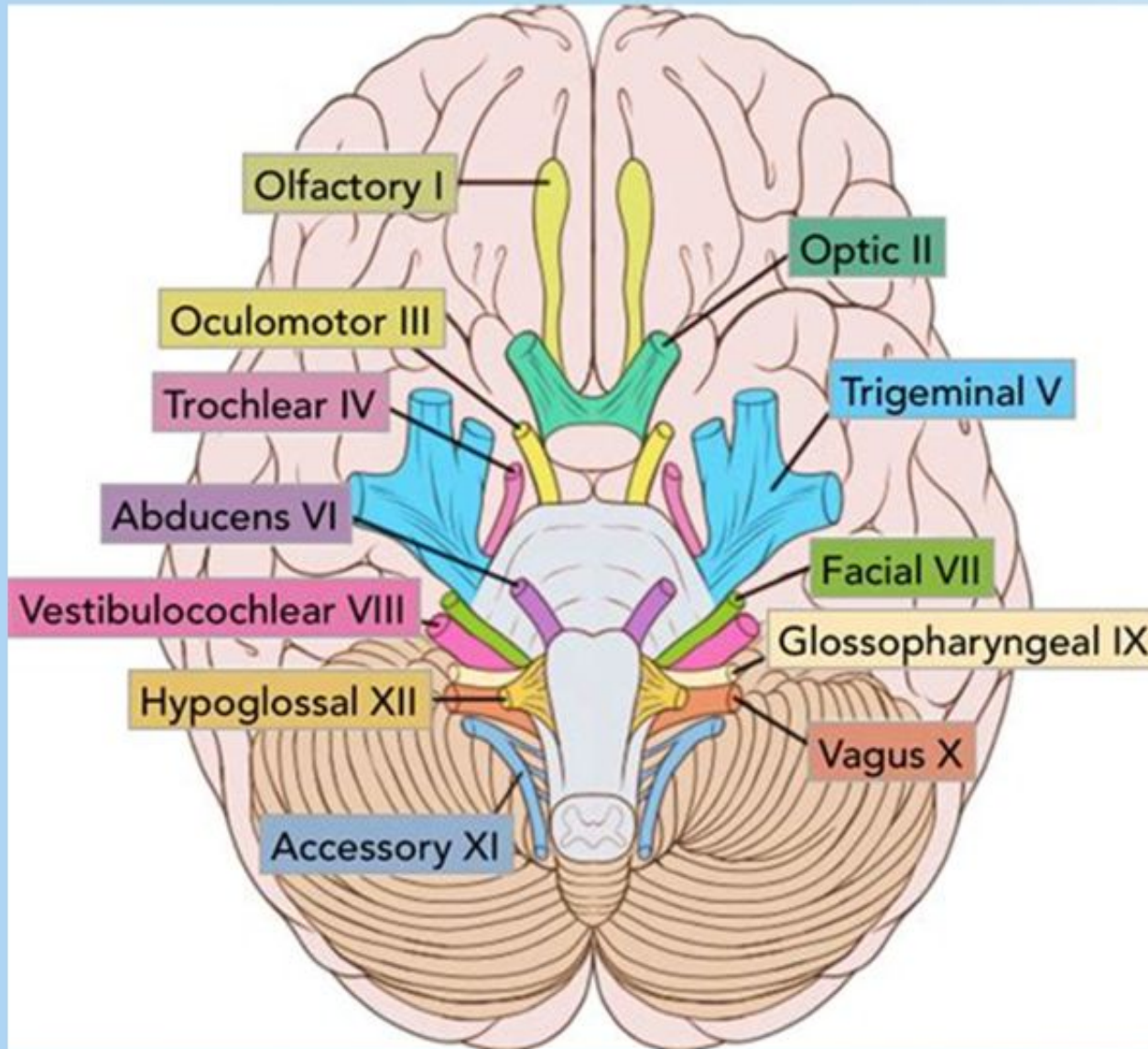
Cranial nerve reflexes

REFLEX	AFFERENT	EFFERENT
Accommodation	II	III
Corneal	V ₁ ophthalmic (nasociliary branch)	Bilateral VII (temporal and zygomatic branches—orbicularis oculi)
Cough	X	X (also phrenic and spinal nerves)
Gag	IX	X
Jaw jerk	V ₃ (sensory—muscle spindle from masseter)	V ₃ (motor—masseter)
Lacrimation	V ₁ (loss of reflex does not preclude emotional tears)	VII
Pupillary	II	III



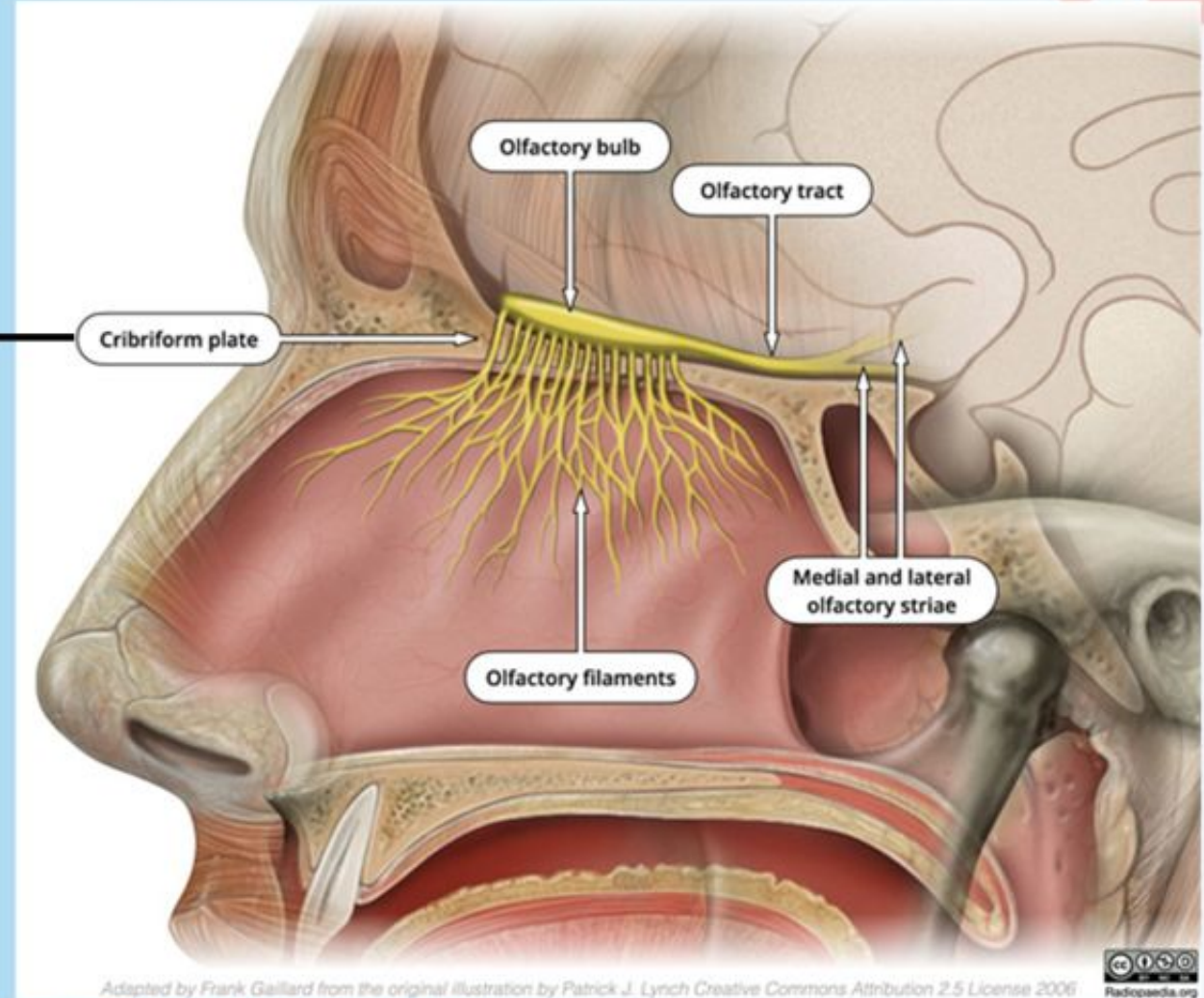
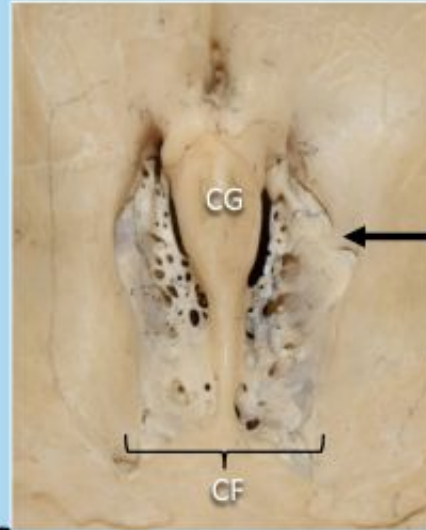
CRANIAL NERVES

StudentODPlife



Cranial Nerve #1-Olfactory

- enters cribriform (small holes) plate of ethmoid
- olfactory bulb located in anterior cranial fossa
- olfactory mucosa contains pseudostratified columnar epithelium

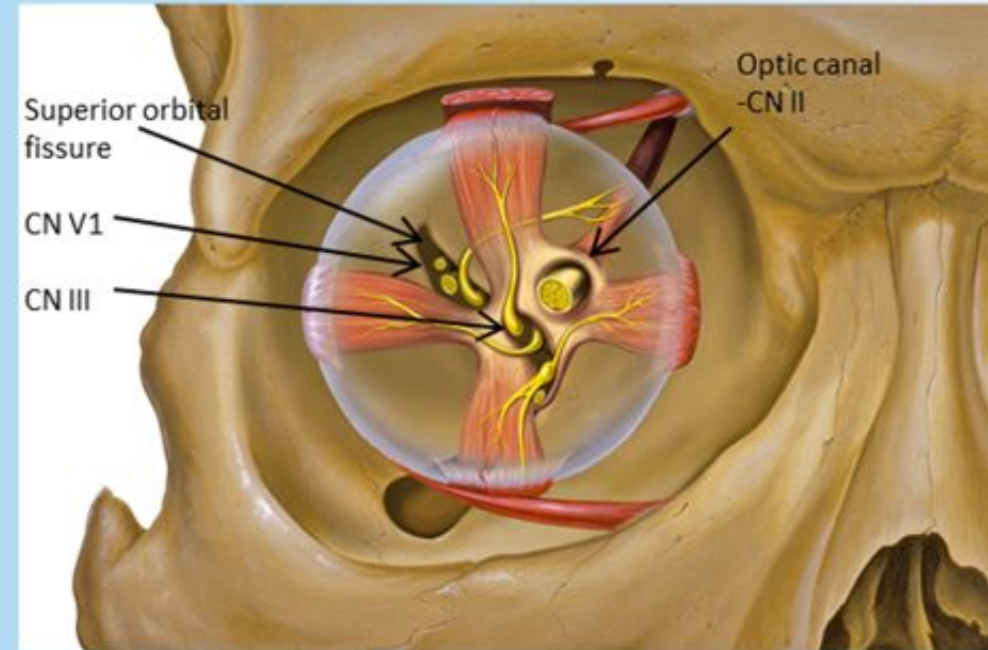
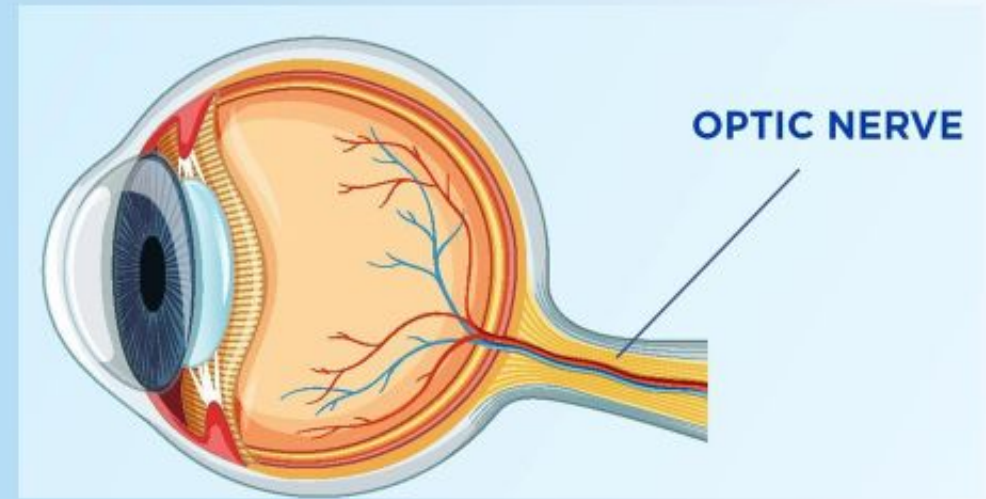


Problem with smelling=problem with the nerve

↓
Anosmia

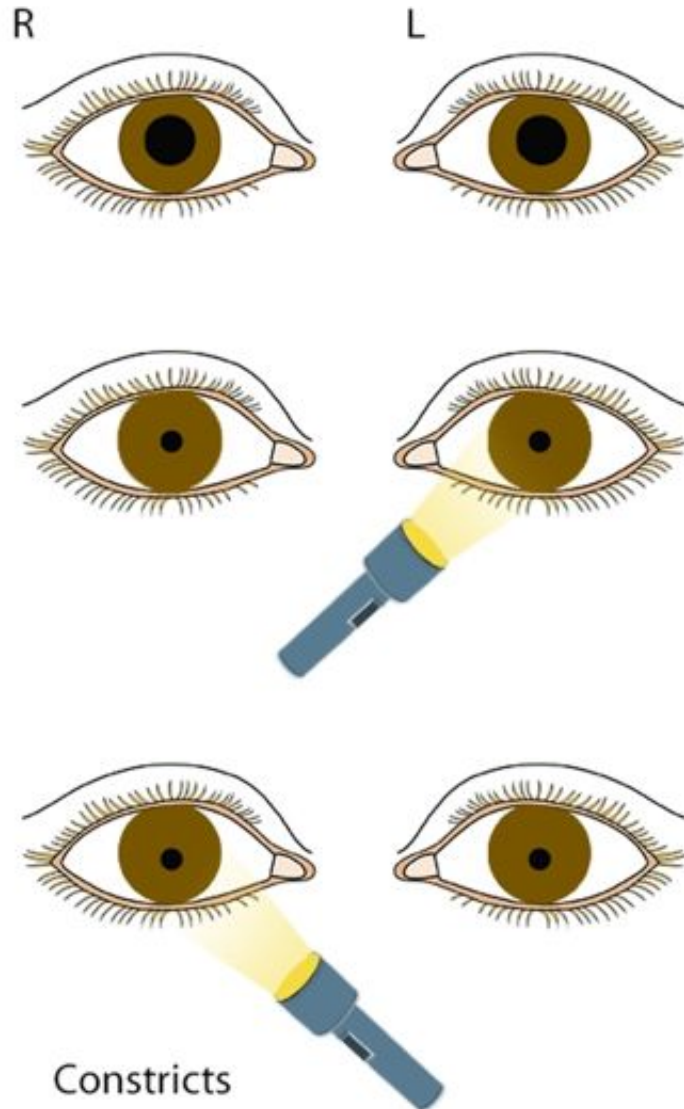
Cranial Nerve #2-Optic

- vision
- exits through optic canal
- pass through tendinous ring
- consensual constriction together with IIIrd
- afferent limb of pupillary reflex and accommodation (changing shape according to objects distance)
 - lesion to the nerve=no accommodation

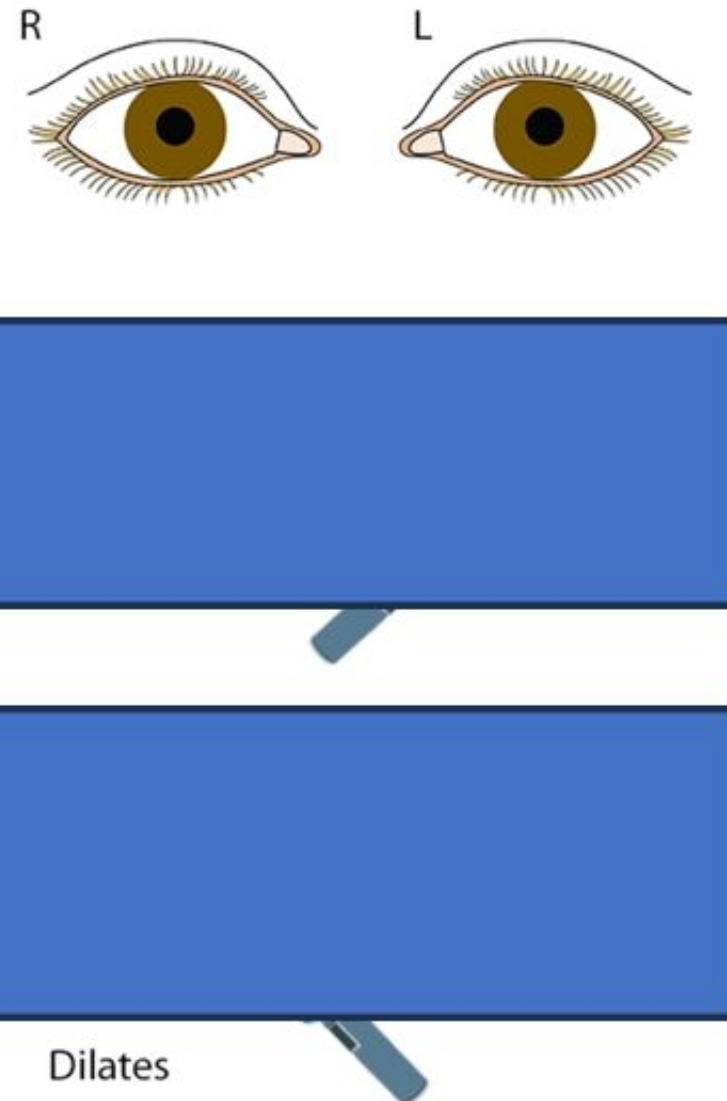


! NOT IV !

Normal

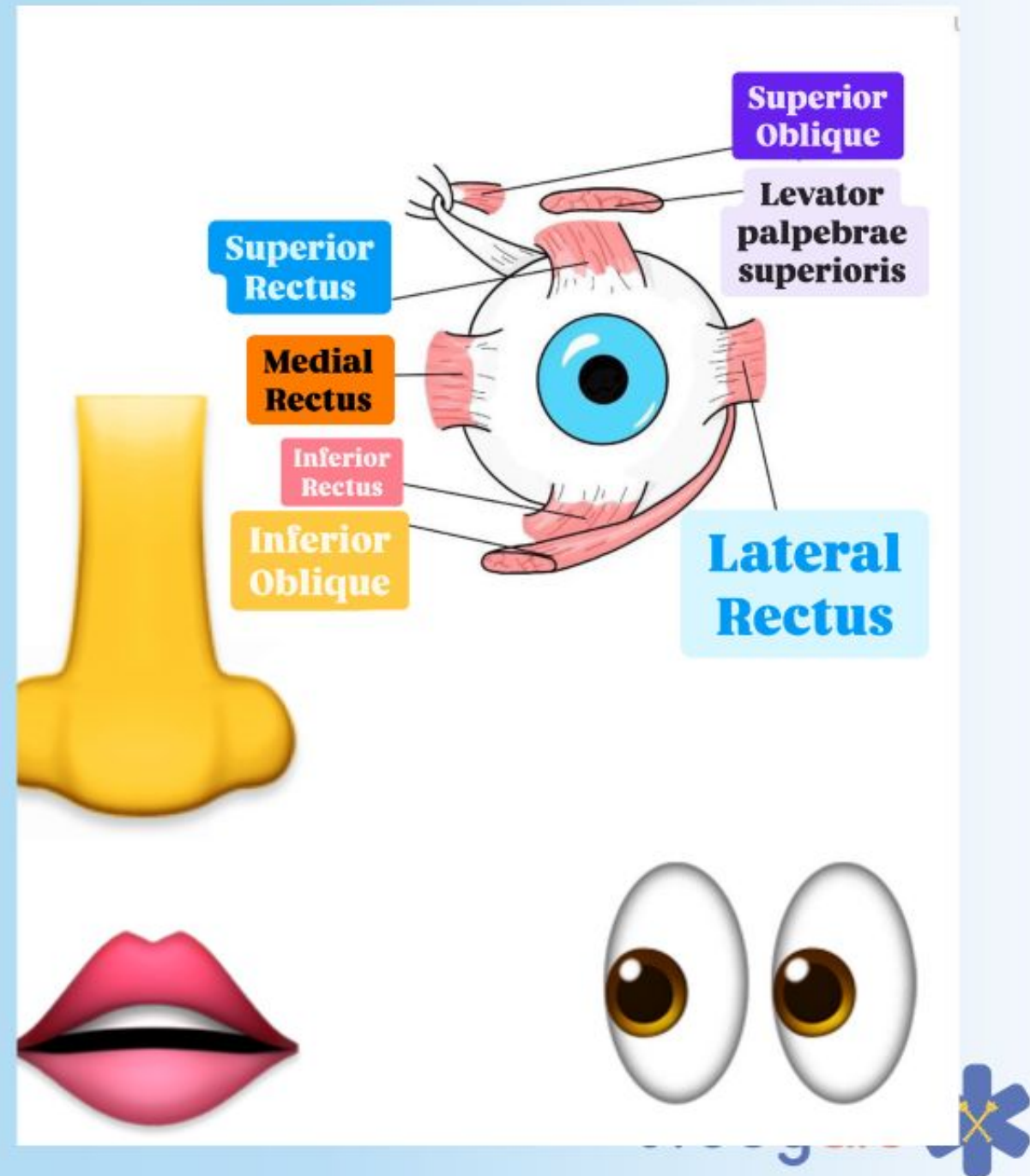


Right relative afferent pupillary defect

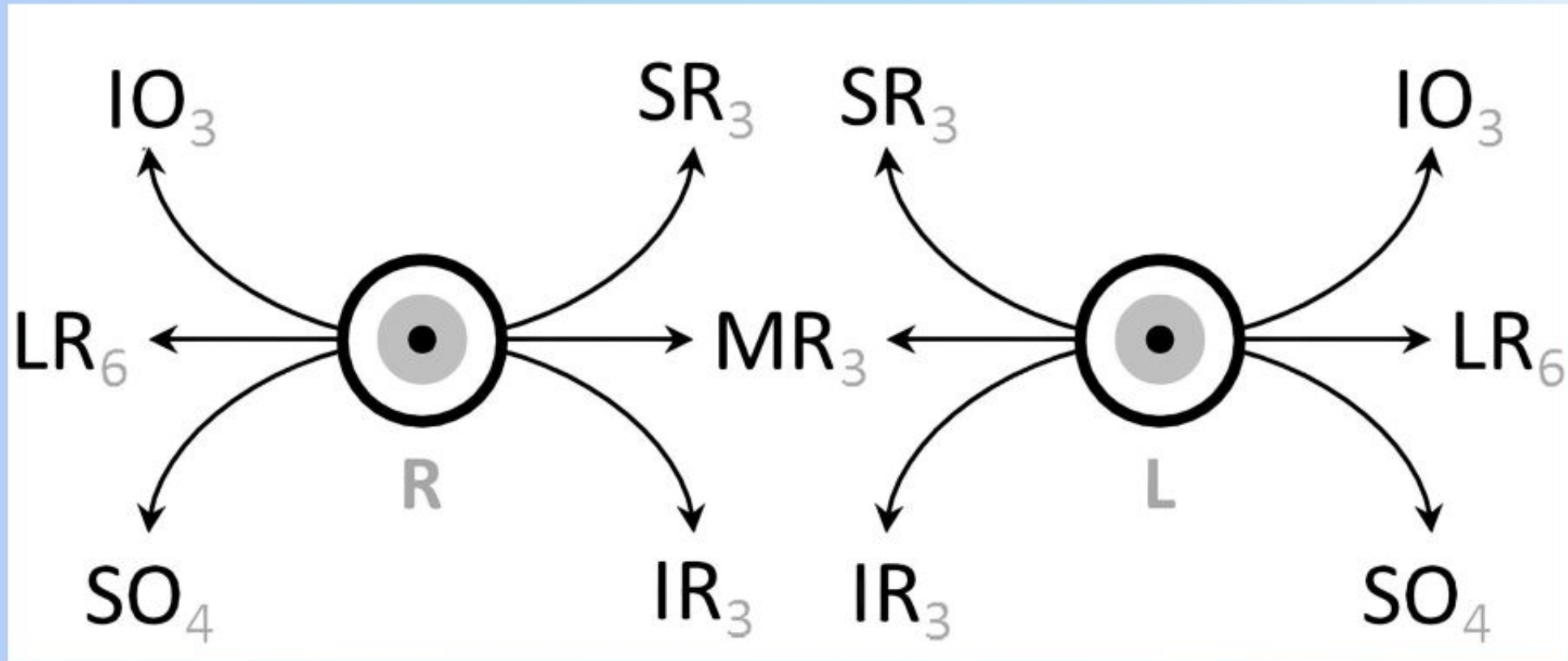


Muscles of the Eye

- 7 muscles
- **R**ectus=**R**ight way
- **O**blique=**O**pposite
- Superior **O**blique=**O**pposite
 - =>down and in
- Inferior **O**blique=**O**pposite
 - =>up and out



Muscles, Innervations & Directions



CRANIAL NERVES



Nerves Of The Eye

Formula:

LR6 S04 03

What does it mean?

Lateral Rectus

Superior Oblique

Others

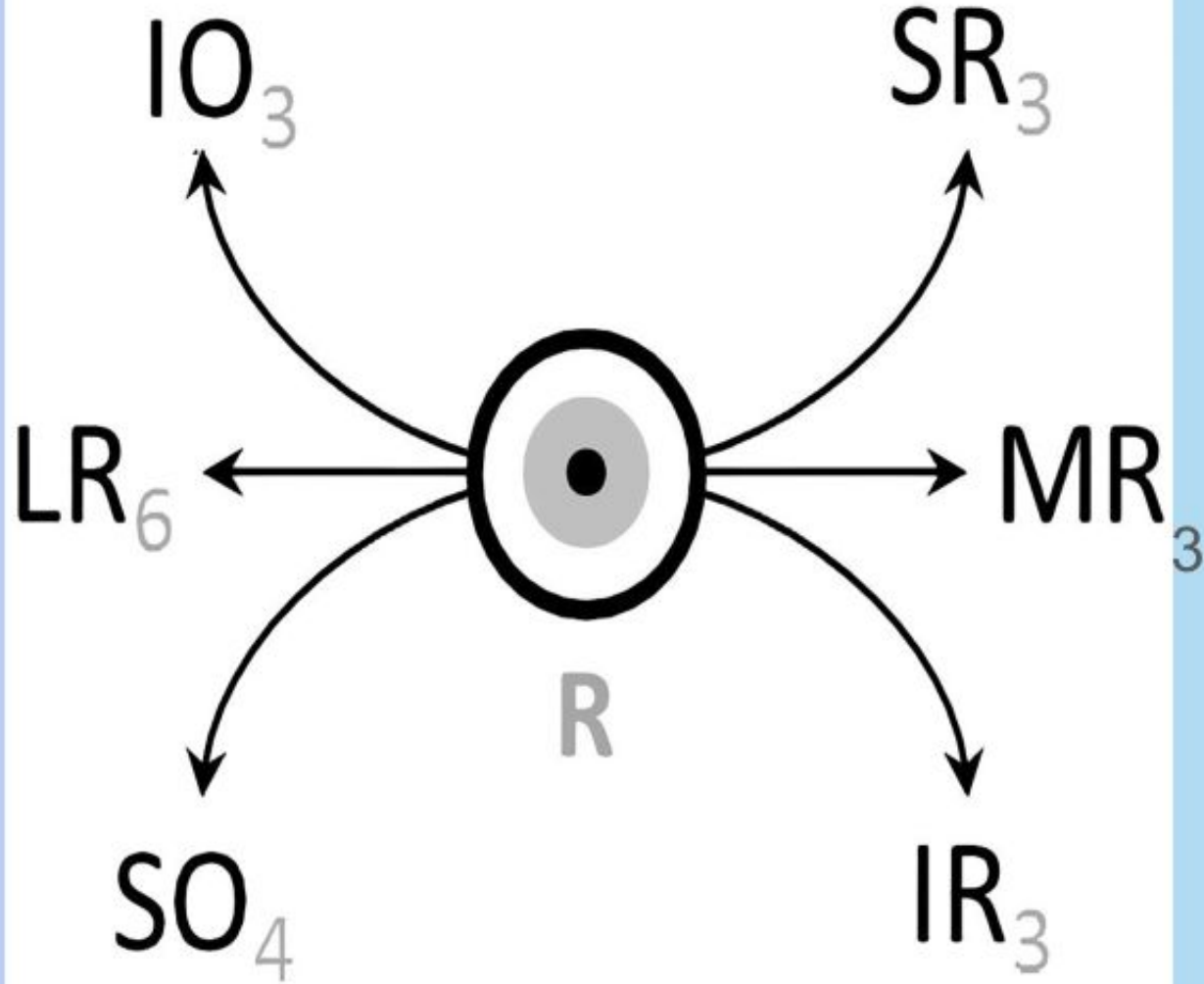
6th Cranial N **Abducent**

4th Cranial N **Trochlear**

3rd Cranial N **Oculomotor**

- Down out - oculomotor III nerve affected
- Eye going towards nose -abducens VI affected
- Up and out- trochlear IV affected

Cranial Nerves & Muscles



Lateral Rectus, Medial Rectus, Superior Rectus, Inferior Rectus, Superior Oblique, Inferior Oblique



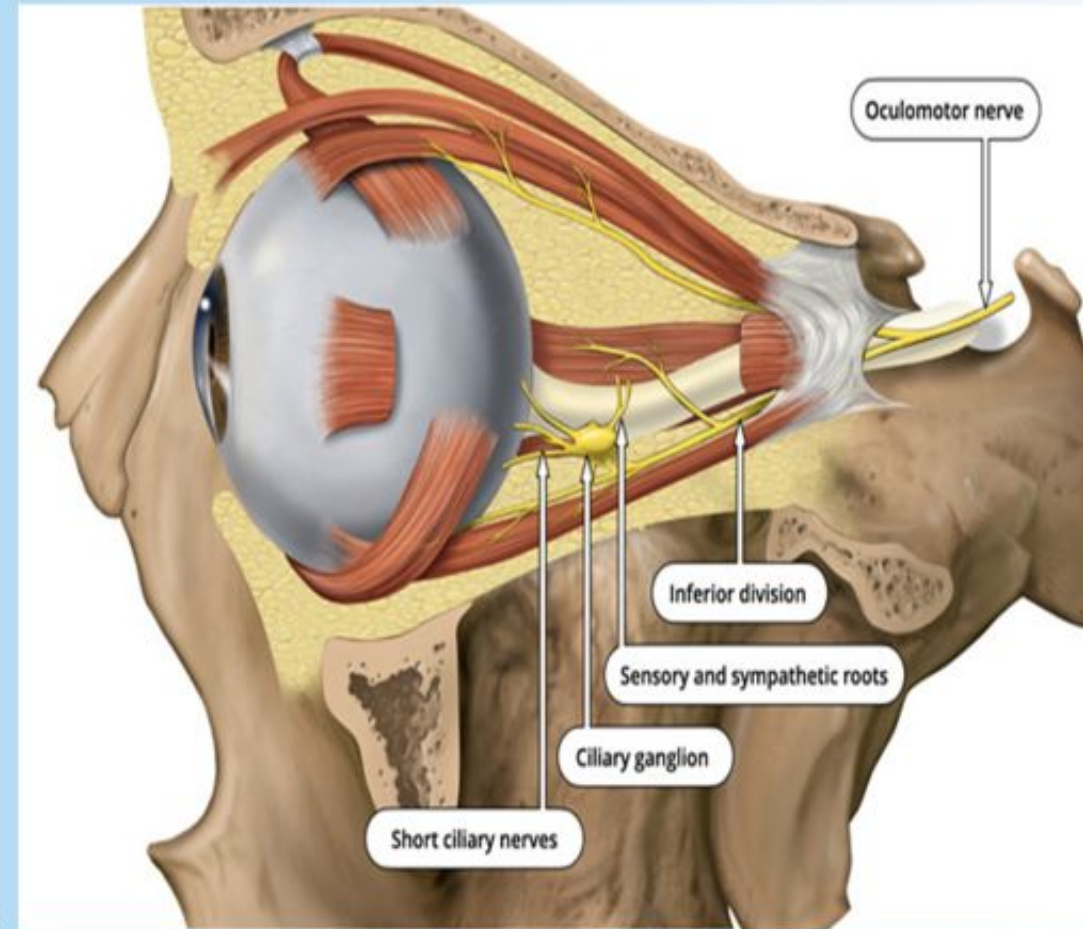
LR, MR, IR, SR, SO, IO

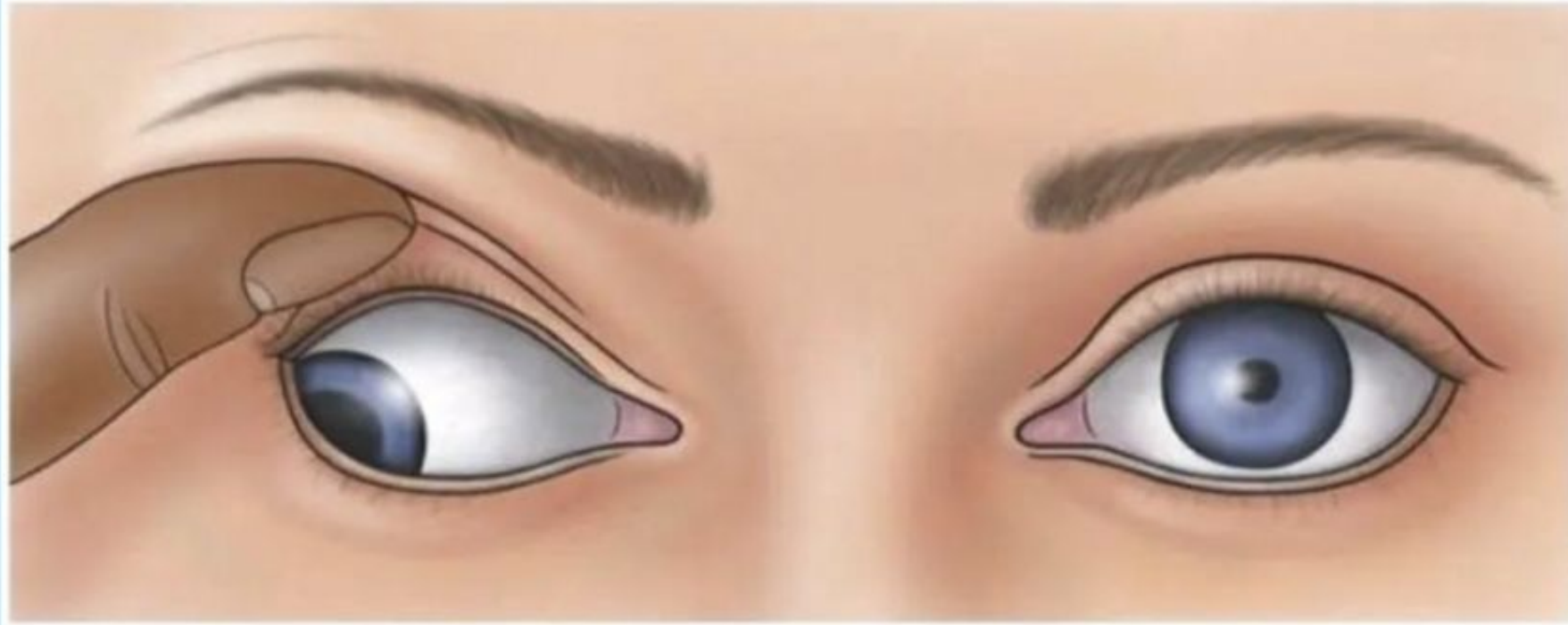


LR₆, MR₃, SR₃, IR₃, SO₄, IO₃

Cranial Nerve #3-Oculomotor

- Efferent limb of pupillary reflex
- Ciliary muscles-accommodation (efferent)
- Sphincter pupillae and dilator pupillae
- Levator palpebrae superioris (ptosis)
 - levator=elevates
- Edinger-Westphal ganglion (parasympathetic root of the ciliary ganglion)





Right eye: Downward and outward gaze, dilated pupil, eyelid manually elevated due to ptosis

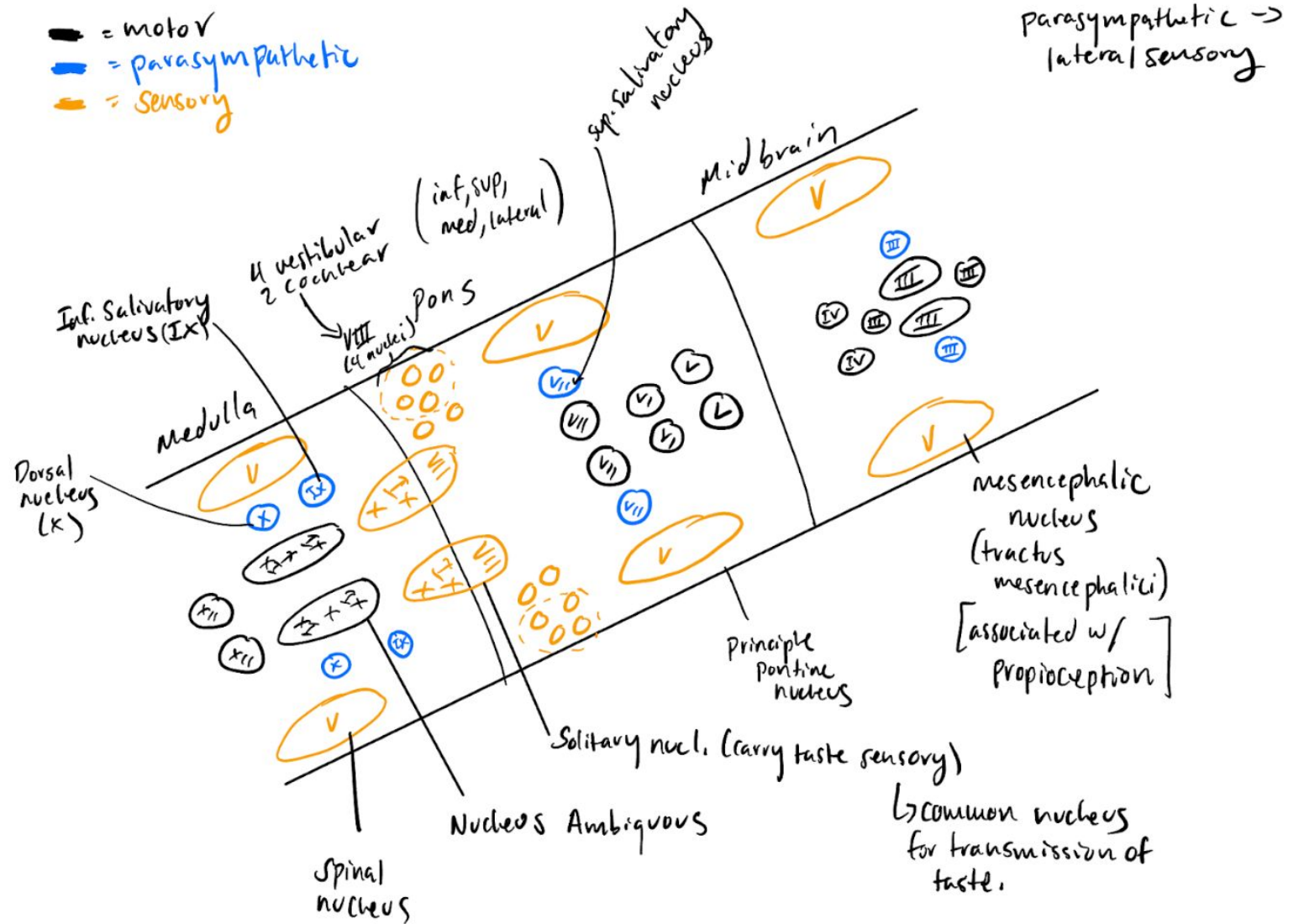
Left: Normal

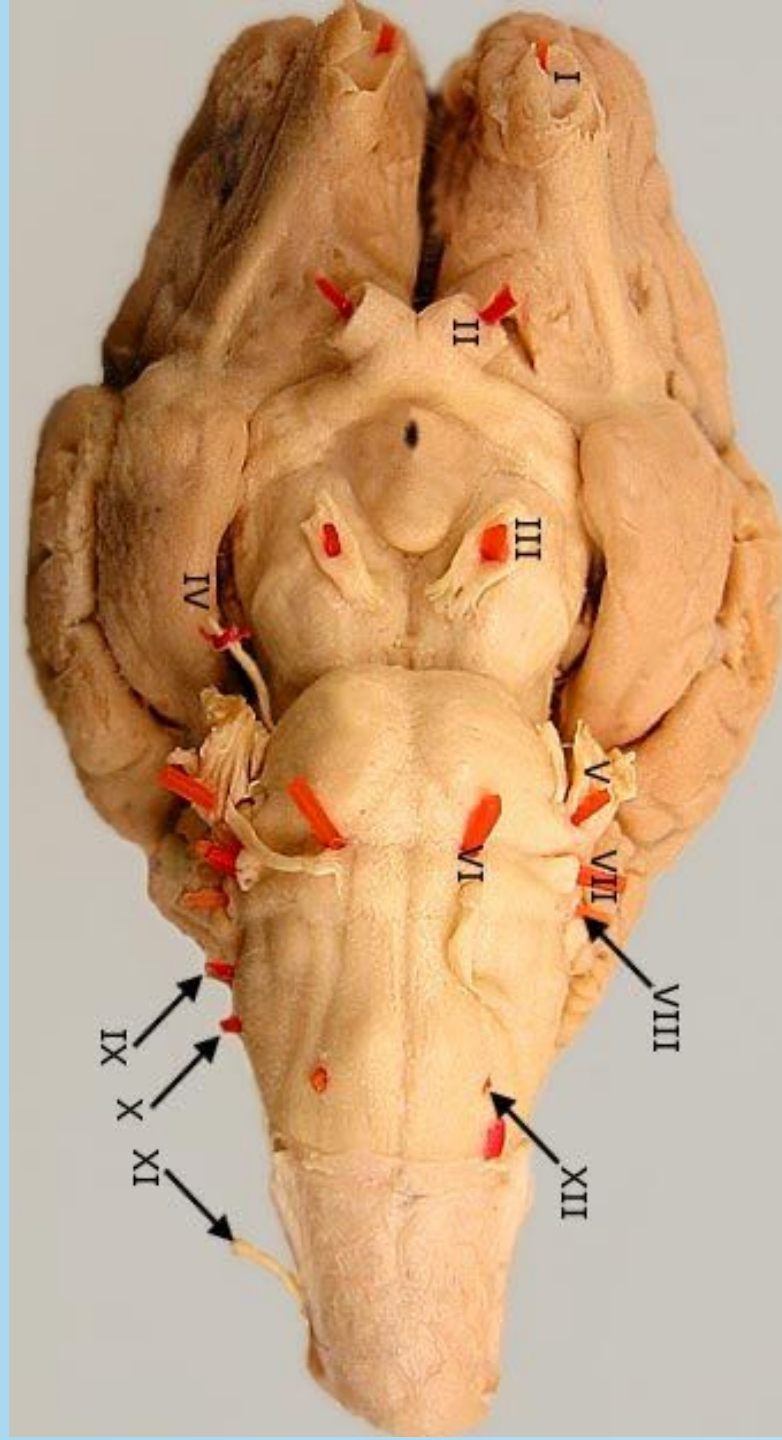
Cranial Nerve Locations

Rule of 4's

Medial Motor	Lateral Sensory	
3		Midbrain
4		
6	5, 7, 8	Pons
12	9, 10, 11	Medulla

Brainstem: Dorsal, Superior View





CRANIAL NERVE PATHWAYS: START TO FINISH

1. MOTOR (EFFERENT)

GENERAL PATHWAY:

Nucleus → EXIT skull
→ Target muscle

ORIGIN (BRAINSTEM)



Motor nucleus



EXIT FROM SKULL (Foramen)



Nerve exits through foramen



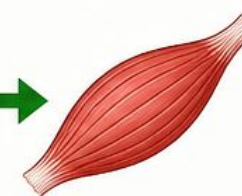
PERIPHERAL NERVE



Nerve travels in periphery



TARGET



Innervates muscle

EXAMPLE:

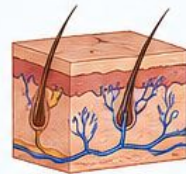
CN VI (Abducens)
Abducens nucleus
→ Superior orbital fissure → Lateral rectus muscle

2. SENSORY (AFFERENT)

GENERAL PATHWAY:

Receptor → ENTER skull
→ Ganglion → Nucleus

RECEPTOR



Detects stimulus (e.g., touch, pain, temperature, taste)



ENTER SKULL (Foramen)



Nerve enters through foramen



GANGLION



Cell body of sensory neuron



END IN NUCLEUS (BRAINSTEM)



Signal ends in brainstem nucleus

EXAMPLE:

CN V (Trigeminal)
Face receptors → Foramen ovale/rotundum/superior orbital fissure → Trigeminal ganglion → Trigeminal nuclei

3. PARASYMPATHETIC (AUTONOMIC)

GENERAL PATHWAY:

Nucleus → EXIT skull
→ Ganglion → Target organ

ORIGIN (BRAINSTEM)



Parasympathetic nucleus



EXIT FROM SKULL (Foramen)



Nerve exits through foramen



GANGLION (Peripheral)



Synapse in peripheral ganglion



TARGET ORGAN



Innervates gland or organ

EXAMPLE:

CN VII (Facial)
Superior salivatory nucleus → Facial nerve → Submandibular ganglion → Salivary glands

KEY POINTS

- Motor fibers EXIT the CNS to go to muscles.
- Sensory fibers ENTER the CNS and END in a nucleus.
- Parasympathetic fibers EXIT the CNS, synapse in a ganglion, then go to organs.

MASTER PATTERN (QUICK REFERENCE)

MOTOR	Nucleus → EXIT → Muscle
SENSORY	Receptor → ENTER → Ganglion → Nucleus
PARASYMPATHETIC	Nucleus → EXIT → Ganglion → Organ

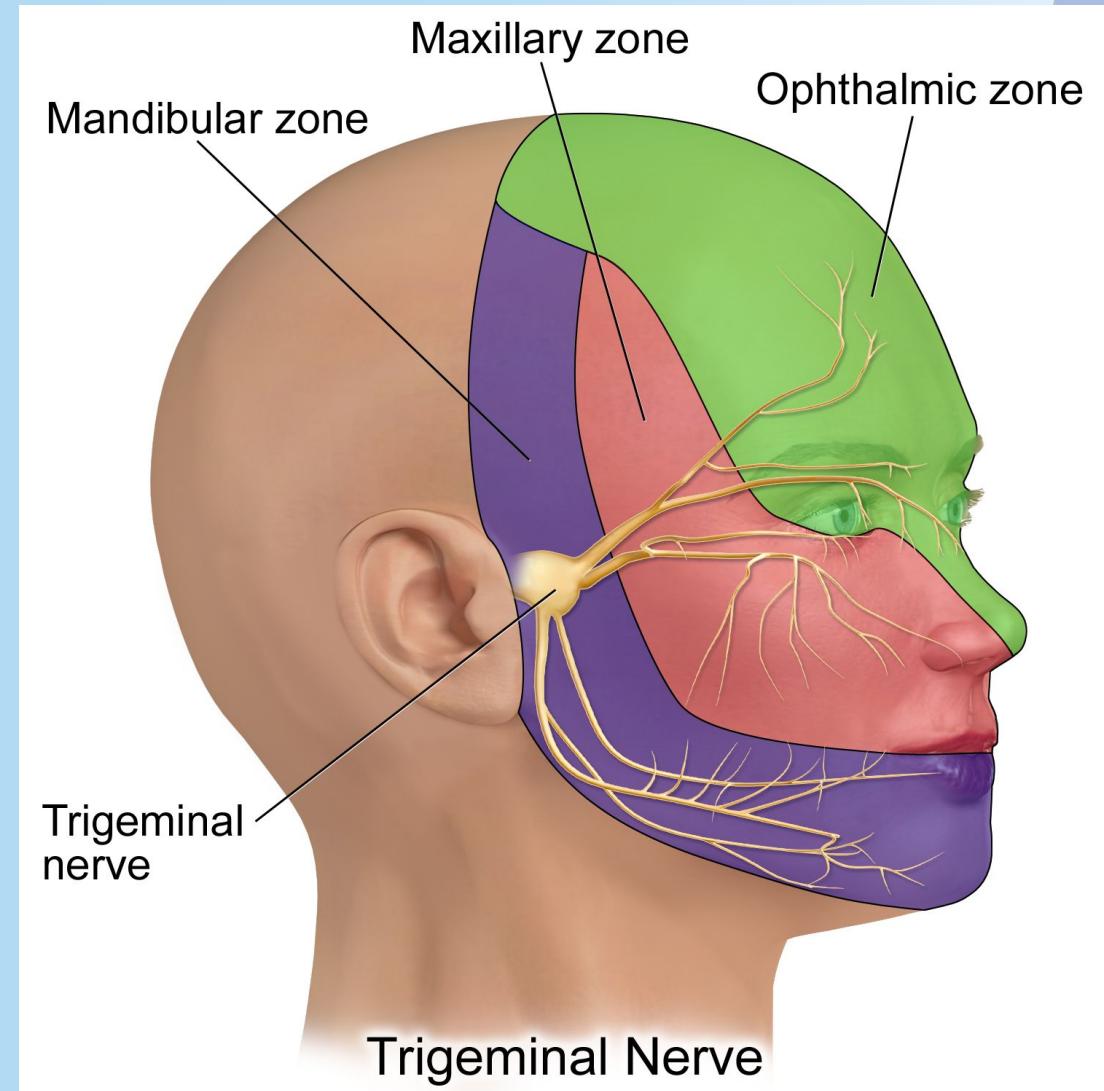
REMEMBER:

MOTOR EXITS
SENSORY ENTERS
PARASYMPATHETIC
EXITS THEN SYNAPSES

CN V: Trigeminal Nerve

Divided into 3 branches:

- V1 ophthalmic (S)
- V2 maxillary (S)
- V3 mandibular (M)

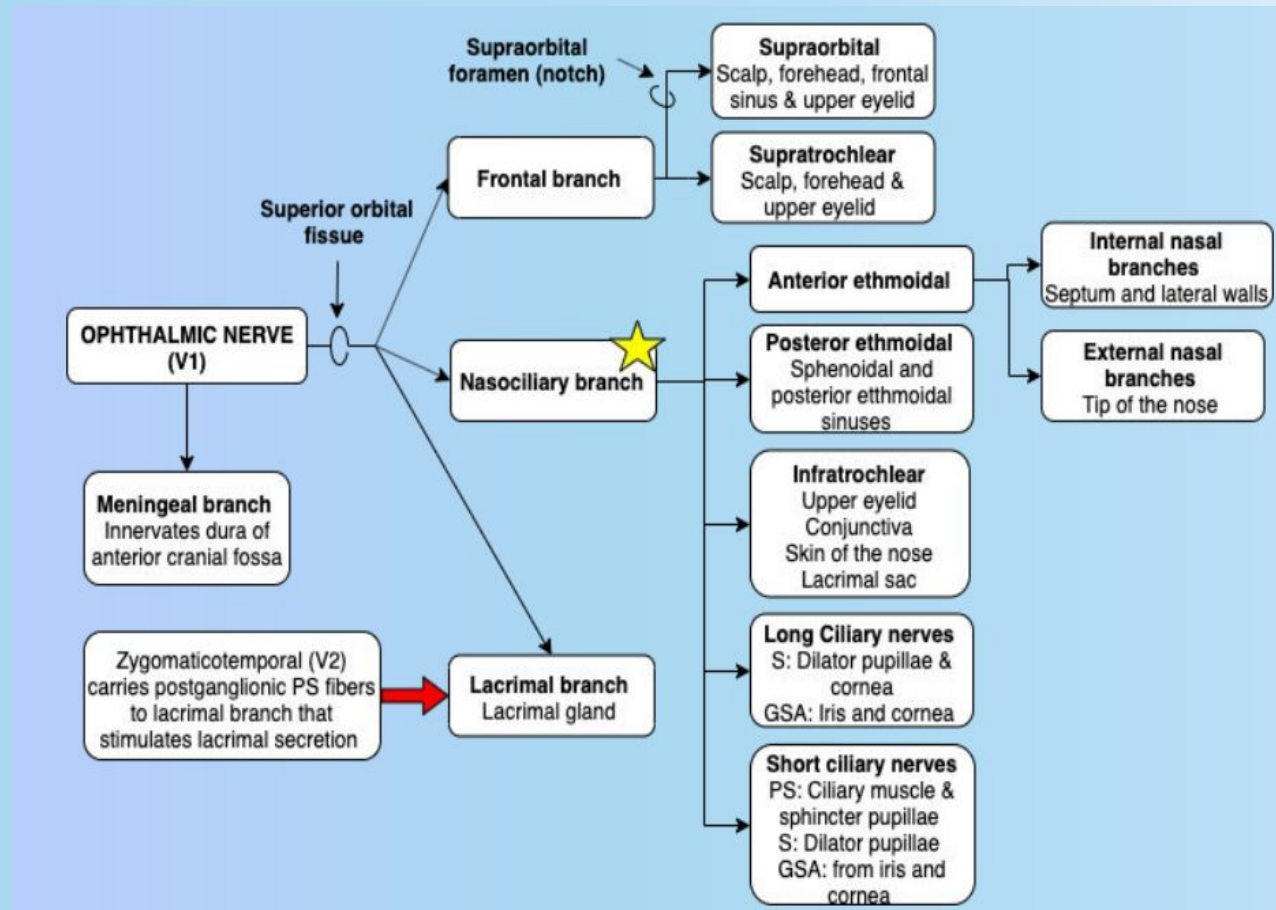


CN V1: Ophthalmic Branch

Function: Sensory innervation eyeball, tip of nose, skin of face above the eyes

Course: Face receptors → Enter Superior orbital fissure → Trigeminal ganglion → Principal (touch) + Spinal Trigeminal nuclei (pain/temp)

Fibers: GSA

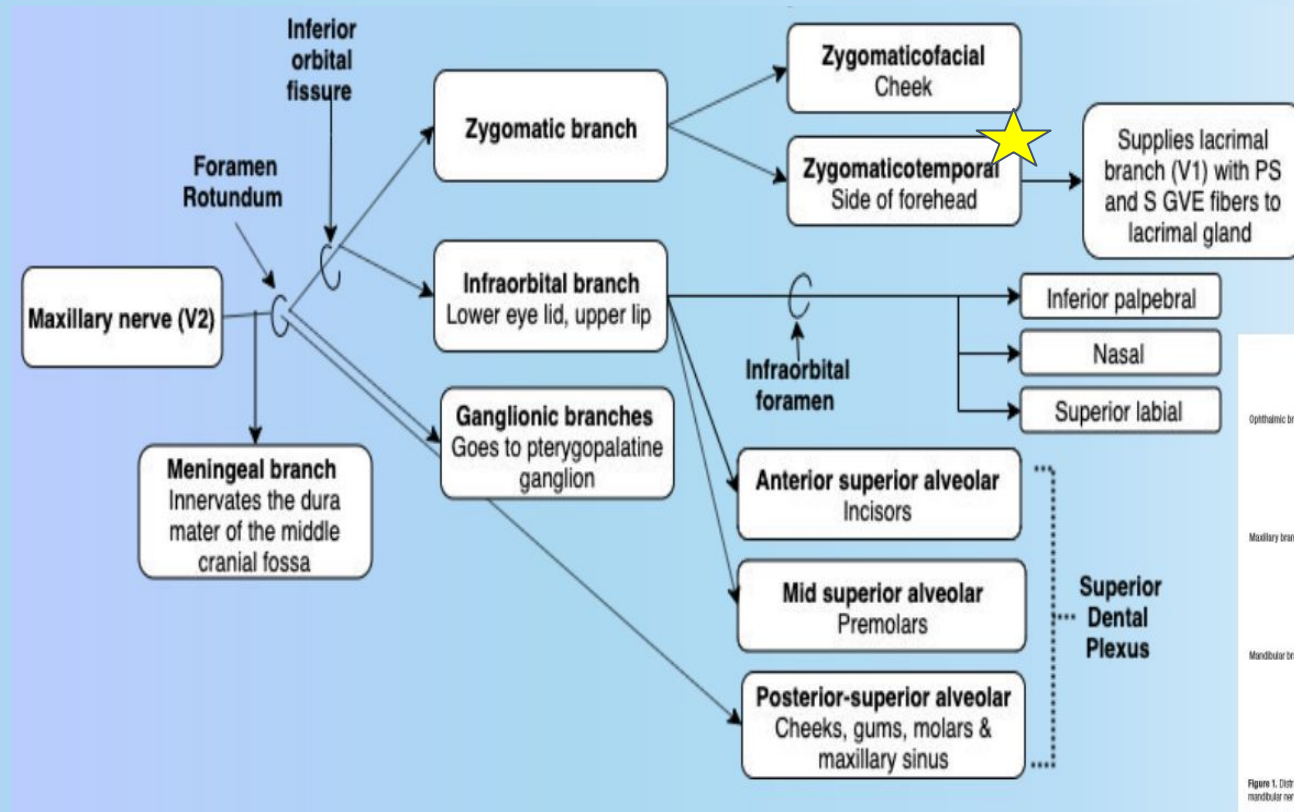


CN V2: Maxillary Branch

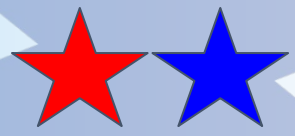
Function: Sensory innervation palate, paranasal sinuses, maxillary teeth, skin of face between eye and upper lip

Course: Face receptors → Enter Foramen Rotundum → Trigeminal ganglion → Principal (touch) + Spinal Trigeminal (pain/temp) nuclei

Fibers: GSA



CN V3: Mandibular Branch



Function: Motor innervation muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatini, and tensor tympani muscles

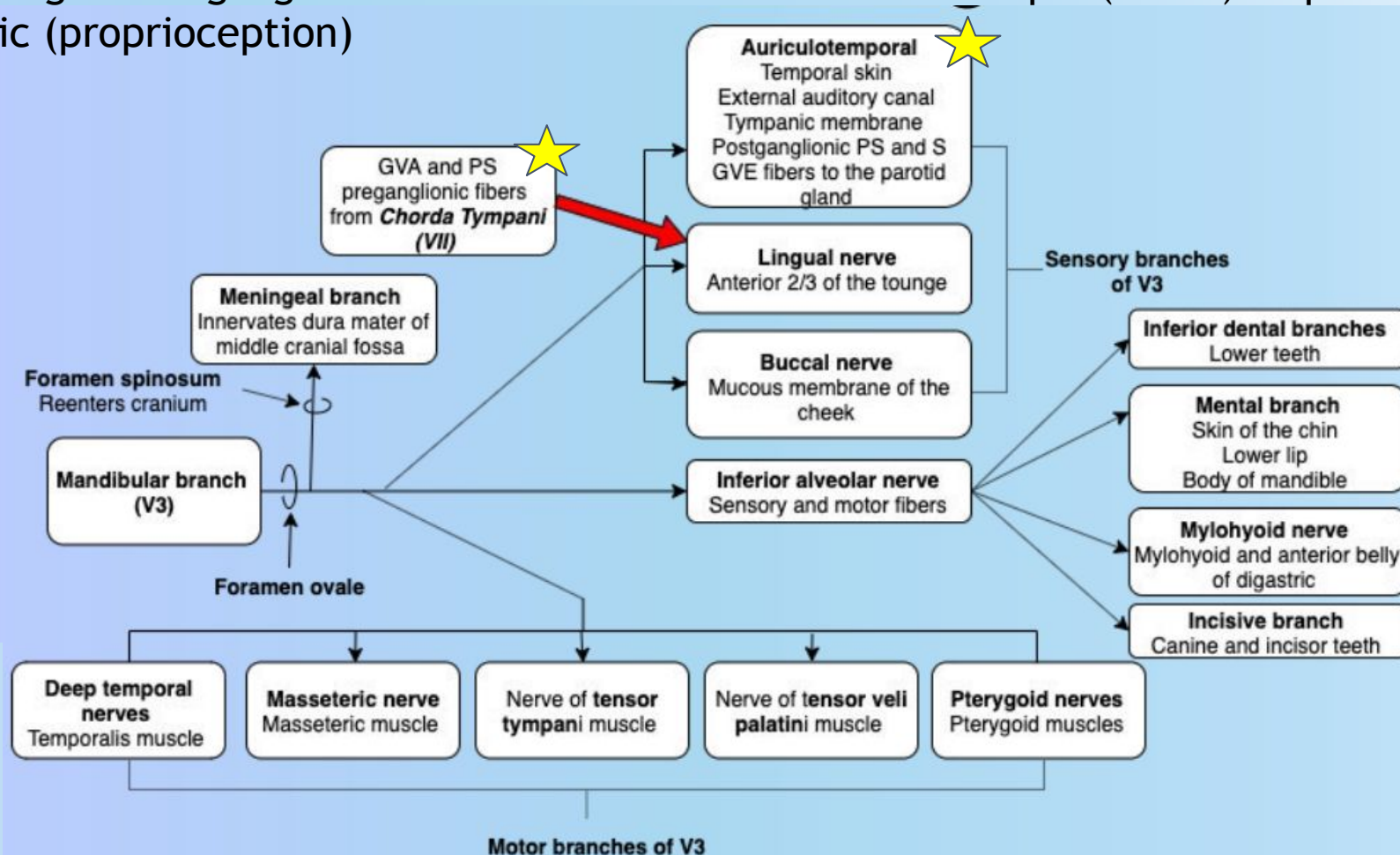
Course:

Motor: Motor nucleus of V (mastication) → Exits Foramen ovale → muscles of mastication

Sensory: Face receptors → Trigeminal ganglion → Enters Foramen ovale → Principal (touch) + Spinal trigeminal (pain/temp) + Mesencephalic (proprioception)

Fibers: GSA, SVE

1st Pharyngeal Arch



Masseter	Moves the mandible UP (closes the mouth)
Medial Pterygoid	
TeMporalis	
Lateral Pterygoid	Lowers the mandible (open mouth)

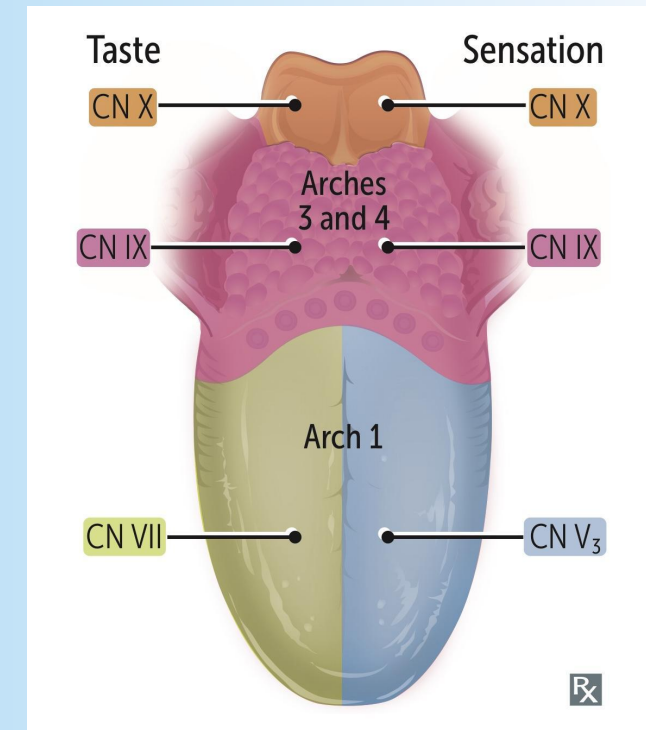
CN V: Trigeminal Nerve

Effect of nerve injury:

- Sensory loss on face
- Loss of mastication
- Jaw deviation toward side of lesion
- Loss of afferent limb of corneal and sneeze reflexes
- Paralysis of tensor tympani leading to hyperacusis = partial deafness to low-pitched sounds
- Trigeminal neuralgia

Lesion site:

- Lesion of pons
- Fracture or tumor in region of trigeminal ganglion



Trigeminal Nerve: 7 Communications

1. With oculomotor nerve

→ via **ciliary ganglion (V1)**

- **Carries:** postganglionic parasympathetic fibers
- **Function:** pupil constriction & accommodation
- ★ **Significance:** trigeminal delivers CN III parasympathetics to the eye

2. With trochlear nerve

→ orbital communication (V1)

- **Carries:** proprioceptive sensory fibers
- **Function:** feedback from extraocular muscles
- ★ **Significance:** helps coordinate eye movement

3. With abducens nerve

→ cavernous sinus/orbit (V1)

- **Carries:** proprioceptive sensory fibers
- **Function:** eye position awareness
- ★ **Significance:** contributes to coordinated gaze

4. With facial nerve (via V2)

→ **pterygopalatine ganglion**

- **Carries:** parasympathetic fibers
- **Function:** lacrimal, nasal, palatal gland secretion
- ★ **Significance:** trigeminal distributes CN VII fibers for tearing & nasal secretions

5. With facial nerve (via V3)

→ **chorda tympani** → **lingual nerve**

- **Carries:**
 - taste (anterior 2/3 tongue)
 - parasympathetic fibers
- **Function:** salivation (submandibular & sublingual glands)
- ★ **Significance:** trigeminal enables taste + salivary secretion

6. With glossopharyngeal nerve

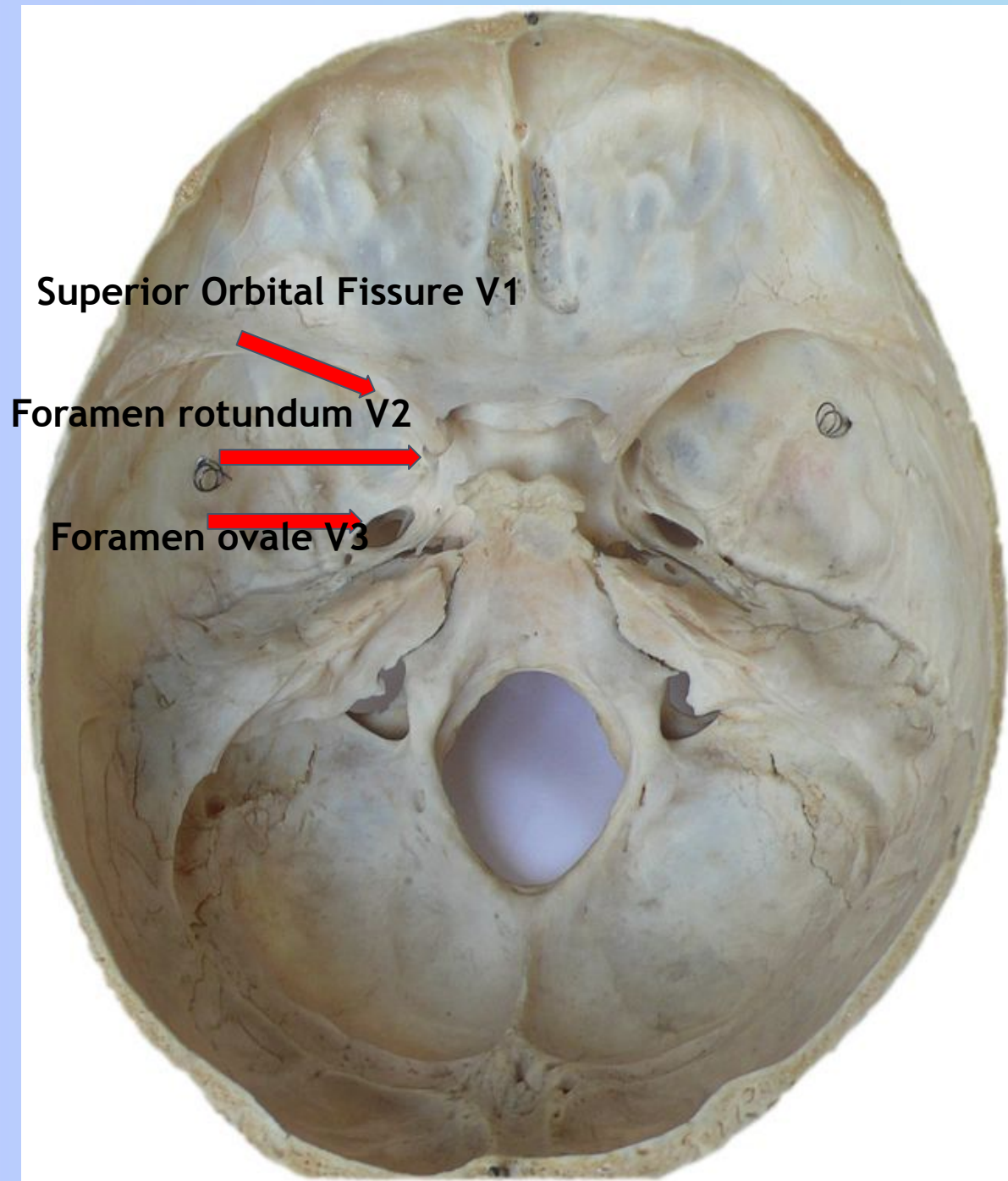
→ **otic ganglion** → **auriculotemporal nerve (V3)**

- **Carries:** parasympathetic fibers
- **Function:** parotid gland secretion
- ★ **Significance:** trigeminal distributes CN IX fibers

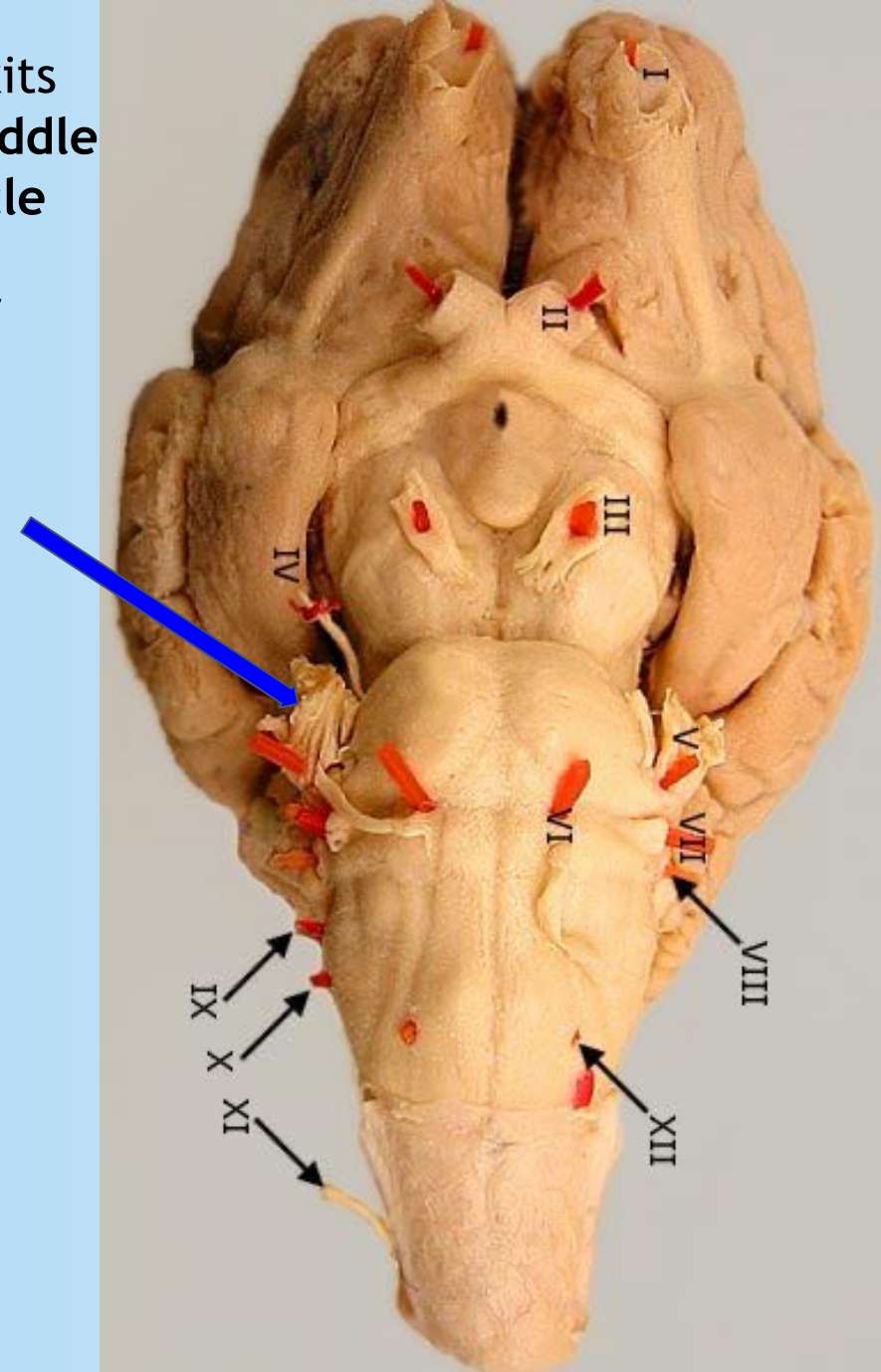
7. With sympathetic nervous system

→ via carotid plexus → V1, V2, V3

- **Carries:** sympathetic fibers
- **Function:** vasoconstriction, sweating, pupil dilation pathways
- ★ **Significance:** trigeminal spreads sympathetic supply to the face



Brainstem Exit: Exits anterior to the middle cerebellar peduncle and lateral to the basal eminence of pons



CN VII: Facial Nerve

Function: Muscle of facial expression, posterior belly of digastric, stylohyoid, and stapedius muscle; Lacrimal and salivary secretion; Taste from anterior $\frac{2}{3}$ of tongue and palate; Sensation from palate; Auricle and external acoustic meatus

Course:

Motor: Facial motor nucleus (facial expression) → Exit Internal acoustic meatus → through facial canal → exit skull through stylomastoid foramen → Target muscles

Sensory: Taste from anterior $\frac{2}{3}$ of tongue and palate → through chorda tympani + **lingual nerve (V3)** → Enter Internal acoustic meatus → Geniculate ganglion → Solitarius nucleus (taste)

Parasympathetic:

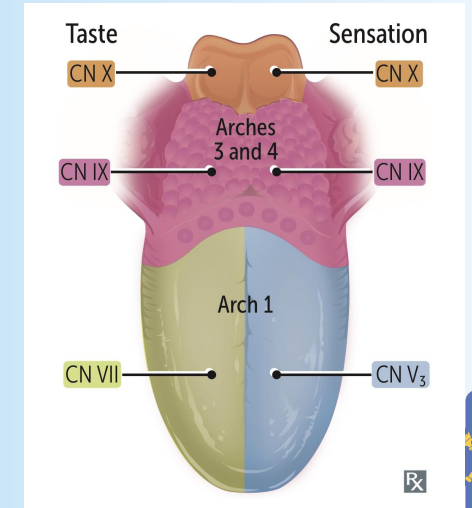
Superior salivatory nucleus (parasympathetic) →

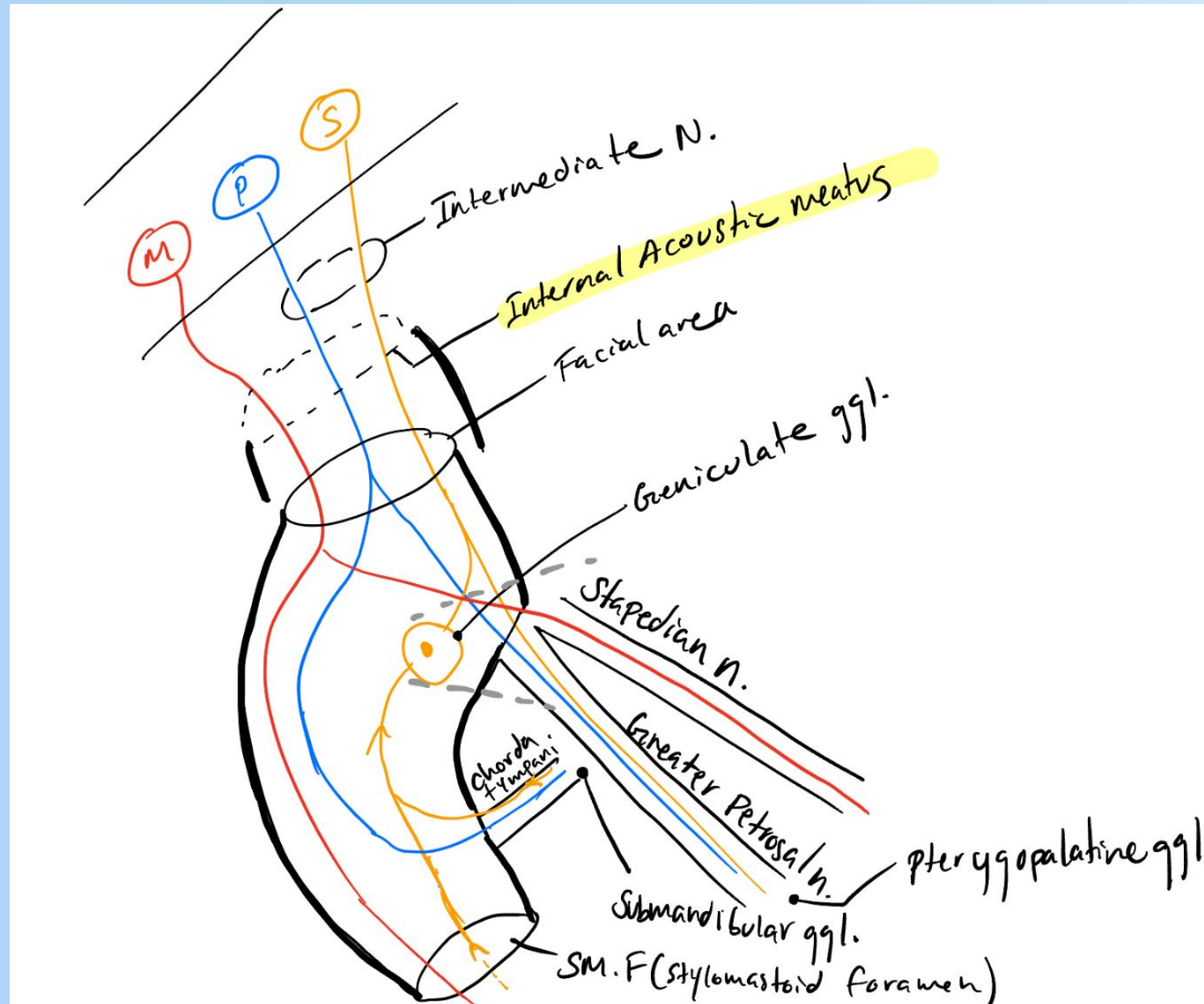
1. Greater petrosal nerve → Exits Hiatus of greater petrosal nerve → pterygopalatine ganglion → lacrimal gland (**Via V2, V1**)

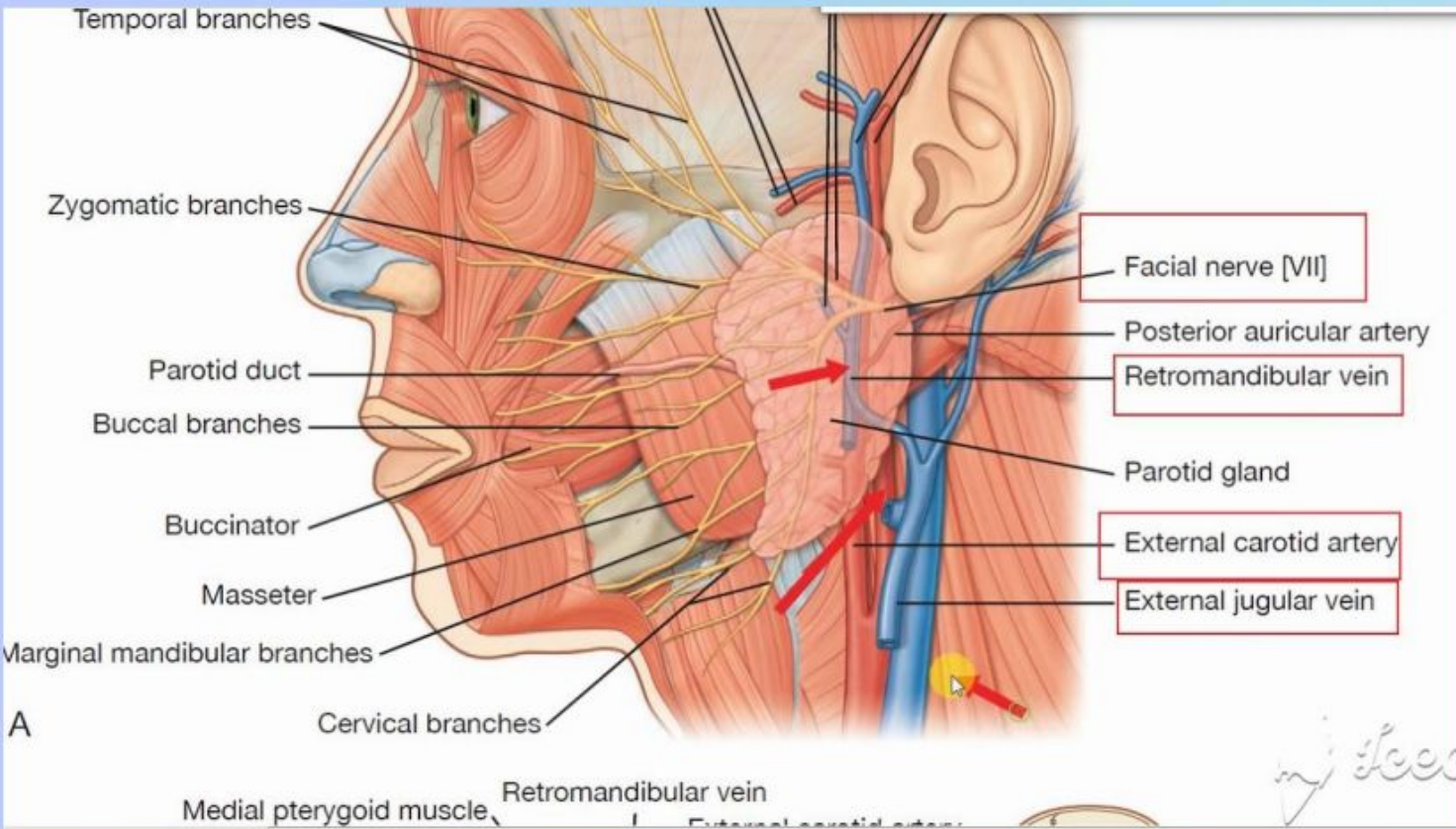
2. Chorda tympani → Exits petrotympanic fissure → **joins lingual nerve (V3)** → submandibular ganglion → submandibular and sublingual glands

Fibers: SVE, GVE, SVA

2nd Pharyngeal arch







CLINICAL CORRELATION

Facial nerve passes through the **parotid gland** after exiting from the stylomastoid foramen. BUT it **does not** innervate the parotid gland.

This means that damage to the parotid gland, or a tumor of the parotid can damage the facial nerve.

Other structures that can be damaged are highlighted in red.

Note: Posterior Auricular n. does not enter the parotid gland. Runs immediately behind the auricle.

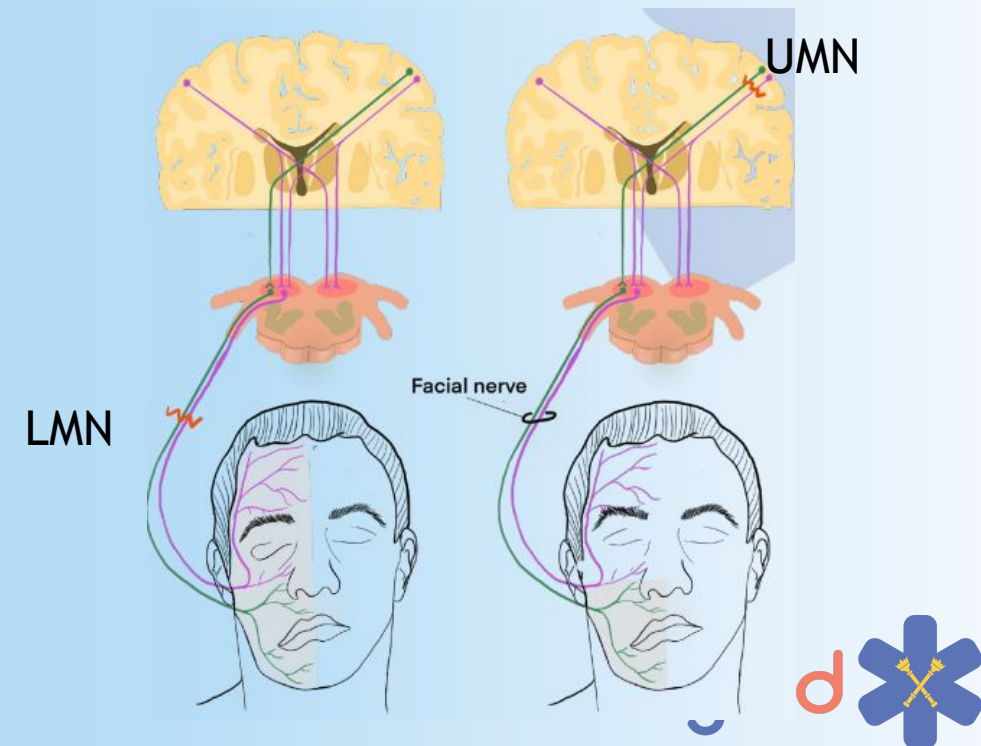
CN VII: Facial Nerve

Effect of nerve injury:

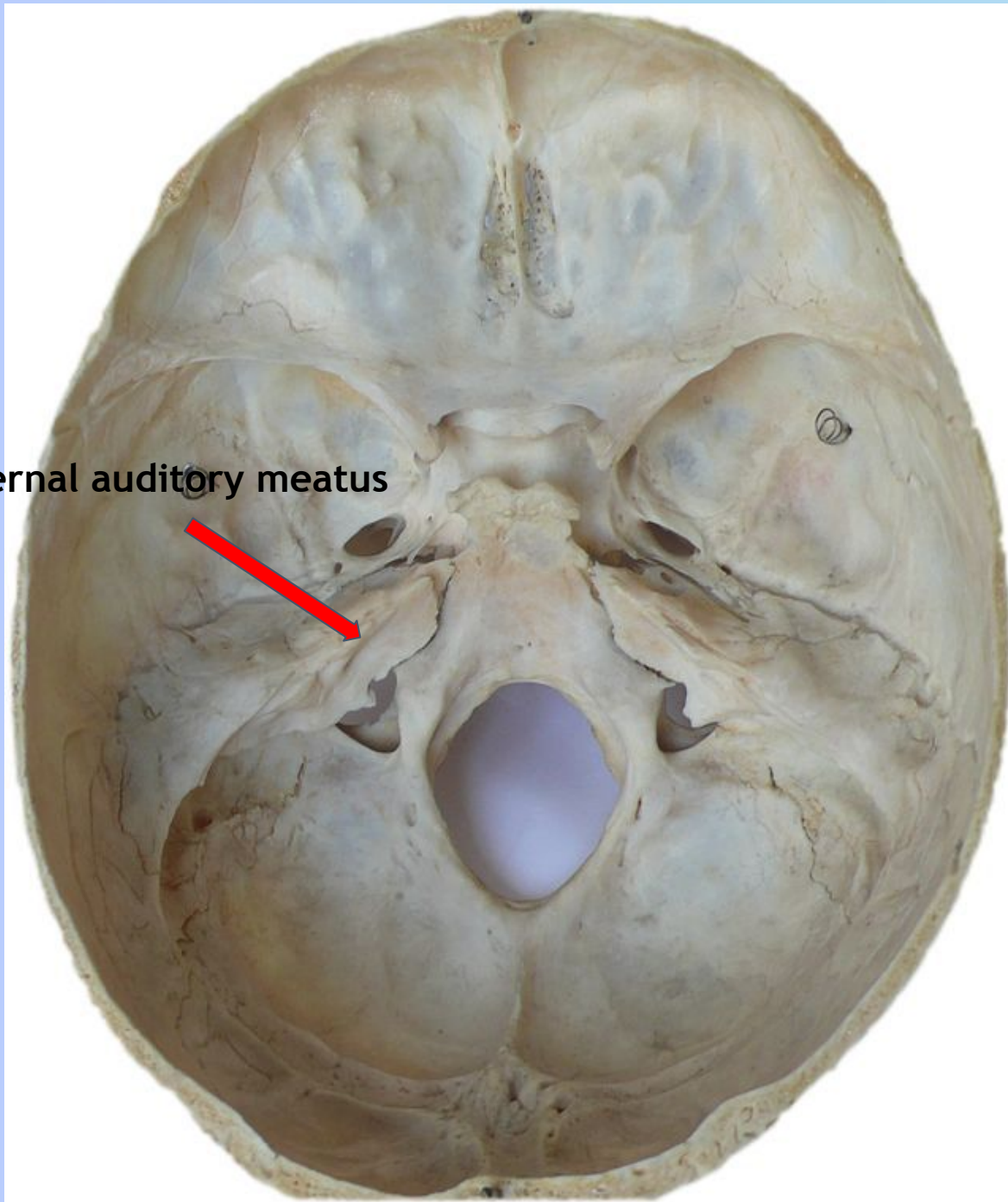
- Facial paralysis (Bell palsy) (upper and lower face)
- Loss of efferent limb of corneal reflex
- Loss of taste to anterior $\frac{2}{3}$ of tongue
- Loss of secretion of lacrimal, submandibular, sublingual, nasal and palatine glands
- Hyperacusis (increased acuity to sound), due to stapedius paralysis

Lesion site:

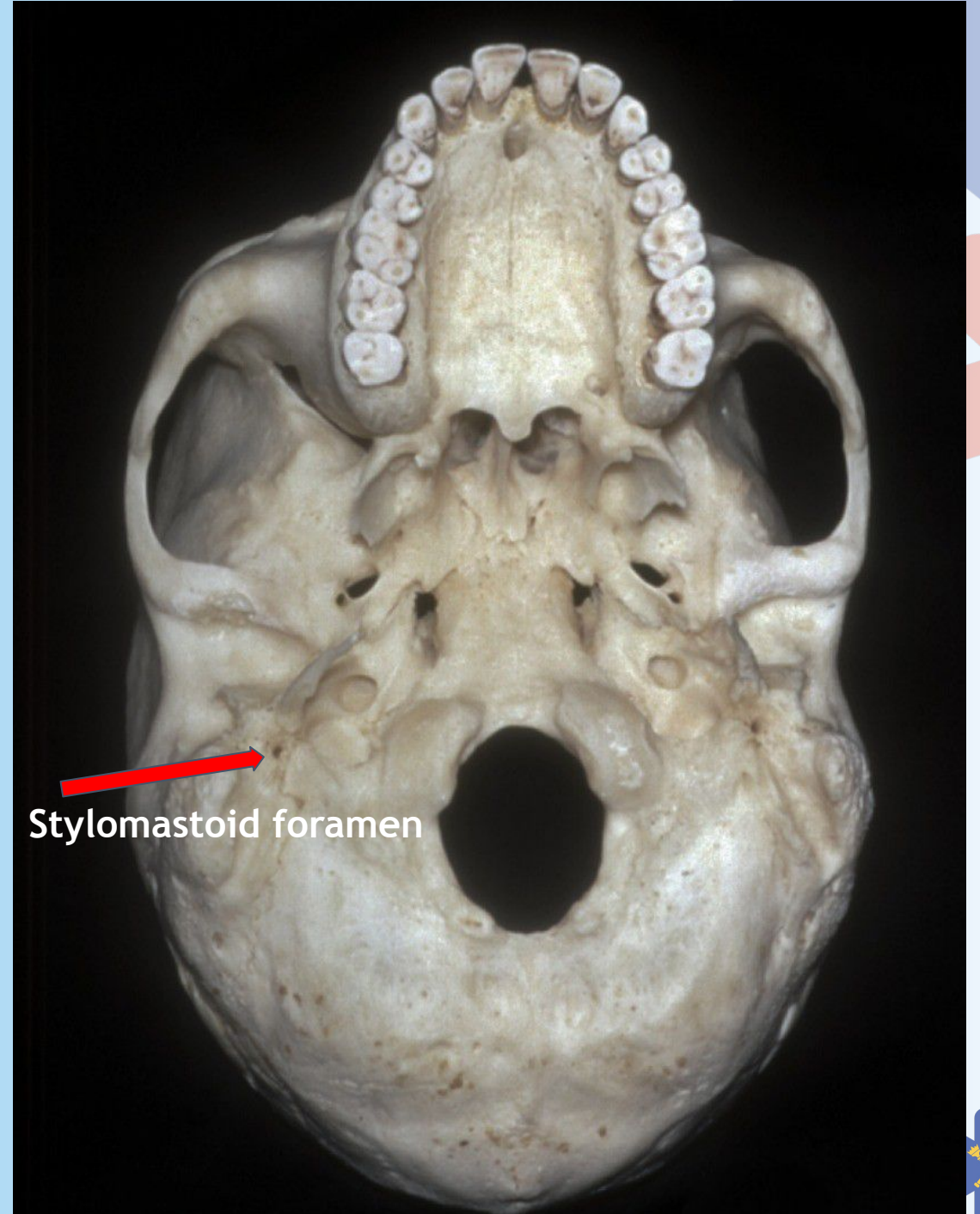
- Lesion of pons/cerebellopontine angle
- Injury to internal auditory meatus
- Laceration in parotid region
- Fracture of temporal bone



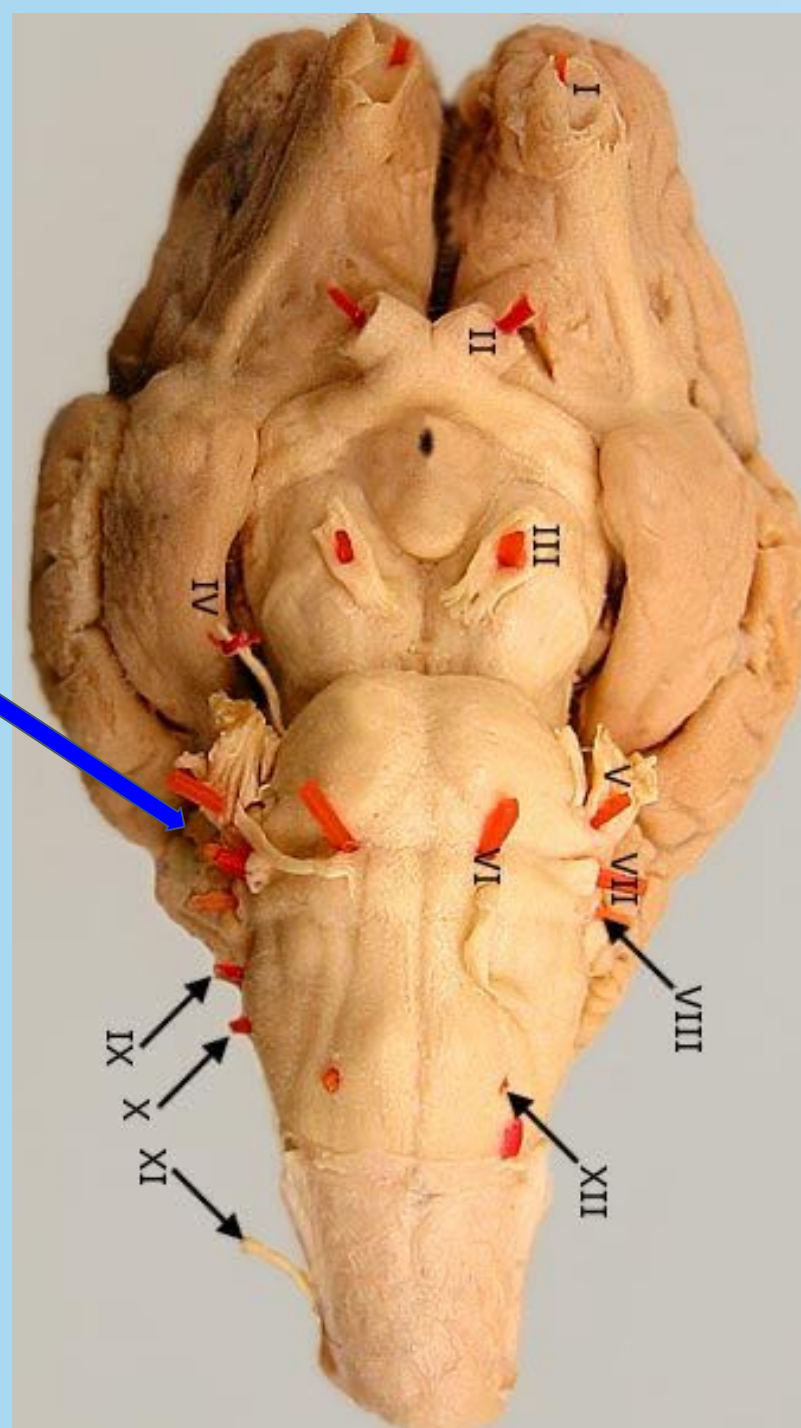
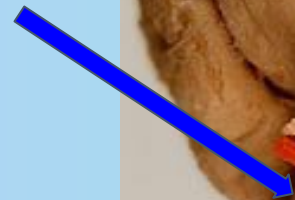
Internal auditory meatus



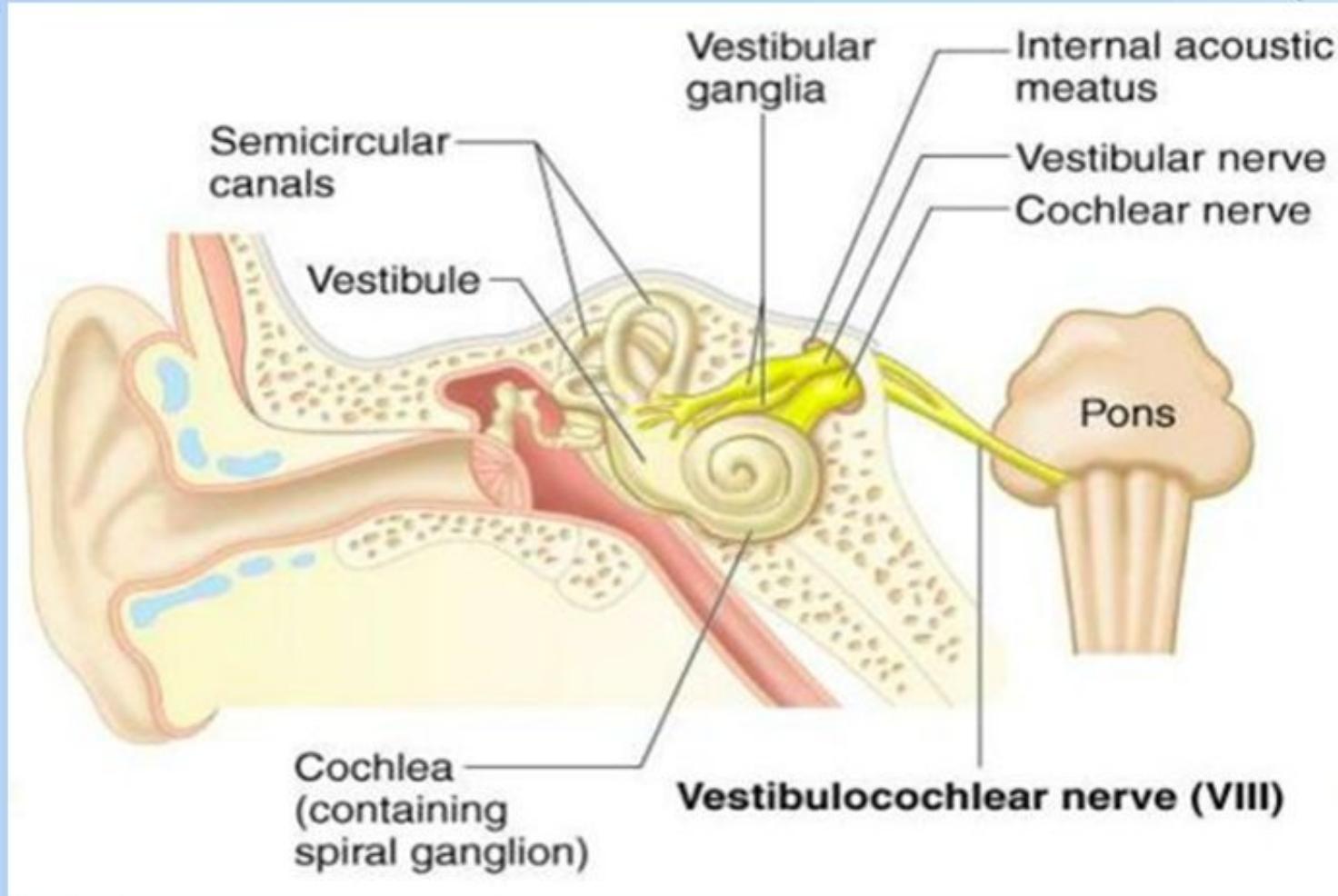
Stylomastoid foramen



Brainstem Exit: Cerebellopontine angle



Cranial Nerve #8-Vestibulocochlear (Auditory)



-sound and equilibrium (balance) information from the inner ear to the brain

Ear,
Equilibrium=
Eight

- pons (rule of 4s)
- exit the brainstem at the cerebellopontine angle
- internal auditory meatus
- LOSS of balance

CN IX: Glossopharyngeal Nerve



Function: Elevation of pharynx (stylopharyngeus muscle); Secretion of saliva (parotid gland); Carotid sinus and body, tongue, pharynx, and middle ear; Taste from posterior $\frac{1}{3}$ of tongue; External ear.

Course:

Motor: Nucleus ambiguus (swallowing) → exit through jugular foramen → Stylopharyngeus muscle

Sensory:

1. Posterior $\frac{1}{3}$ of the tongue, carotid body, and carotid sinus → Jugular foramen → Inferior (Petrosal) ganglion → Solitarius nucleus (taste/visceral)

2. Receptors of posterior tongue, pharynx, middle ear → Jugular foramen → Superior ganglion (general sensory) → Spinal trigeminal nucleus (pain/temp)

Parasympathetic: Inferior salivatory nucleus (parotid) → exit through jugular foramen → tympanic nerve → reenters middle ear cavity → tympanic plexus and lesser petrosal nerve → exit foramen ovale → otic ganglion → Parotid gland (via V3 auriculotemporal nerve)

Fibers: GSA, GVA, GVE, SVA, SVE

High-yield: Afferent gag reflex, afferent limb of carotid sinus

3rd Pharyngeal arch

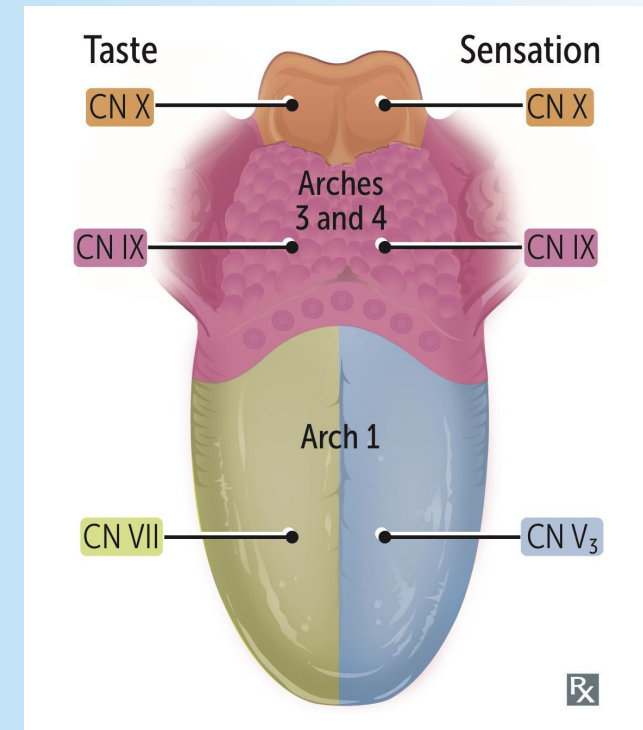
CN IX: Glossopharyngeal Nerve

Effect of nerve injury:

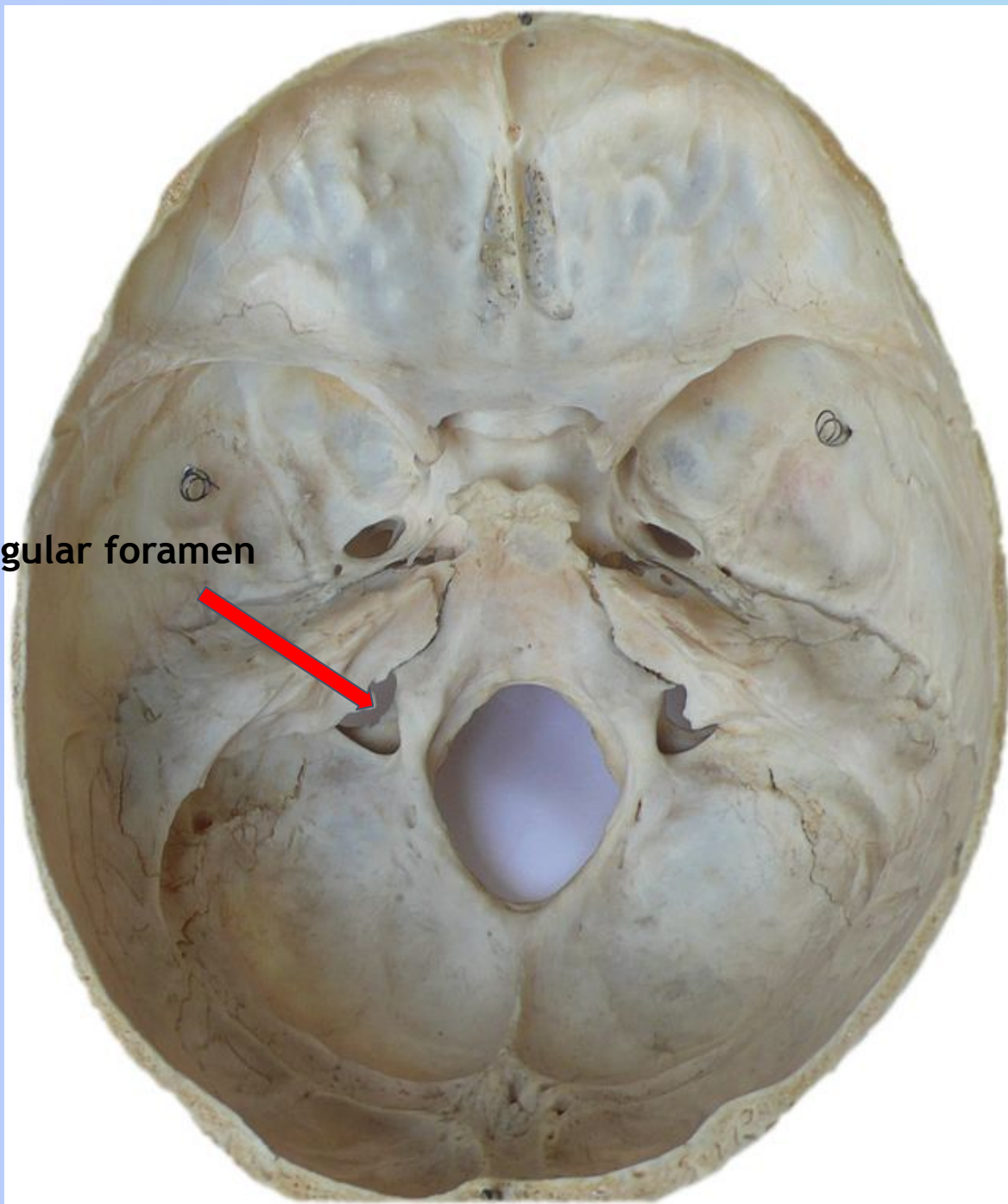
- Loss of taste to posterior $\frac{1}{3}$ of tongue
- Loss of receptors in carotid body and sinus
- Loss of parotid gland secretion
- Paralysis of stylopharyngeus muscle
- Loss of afferent limb of gag reflex
- Glossopharyngeal neuralgia

Lesion site:

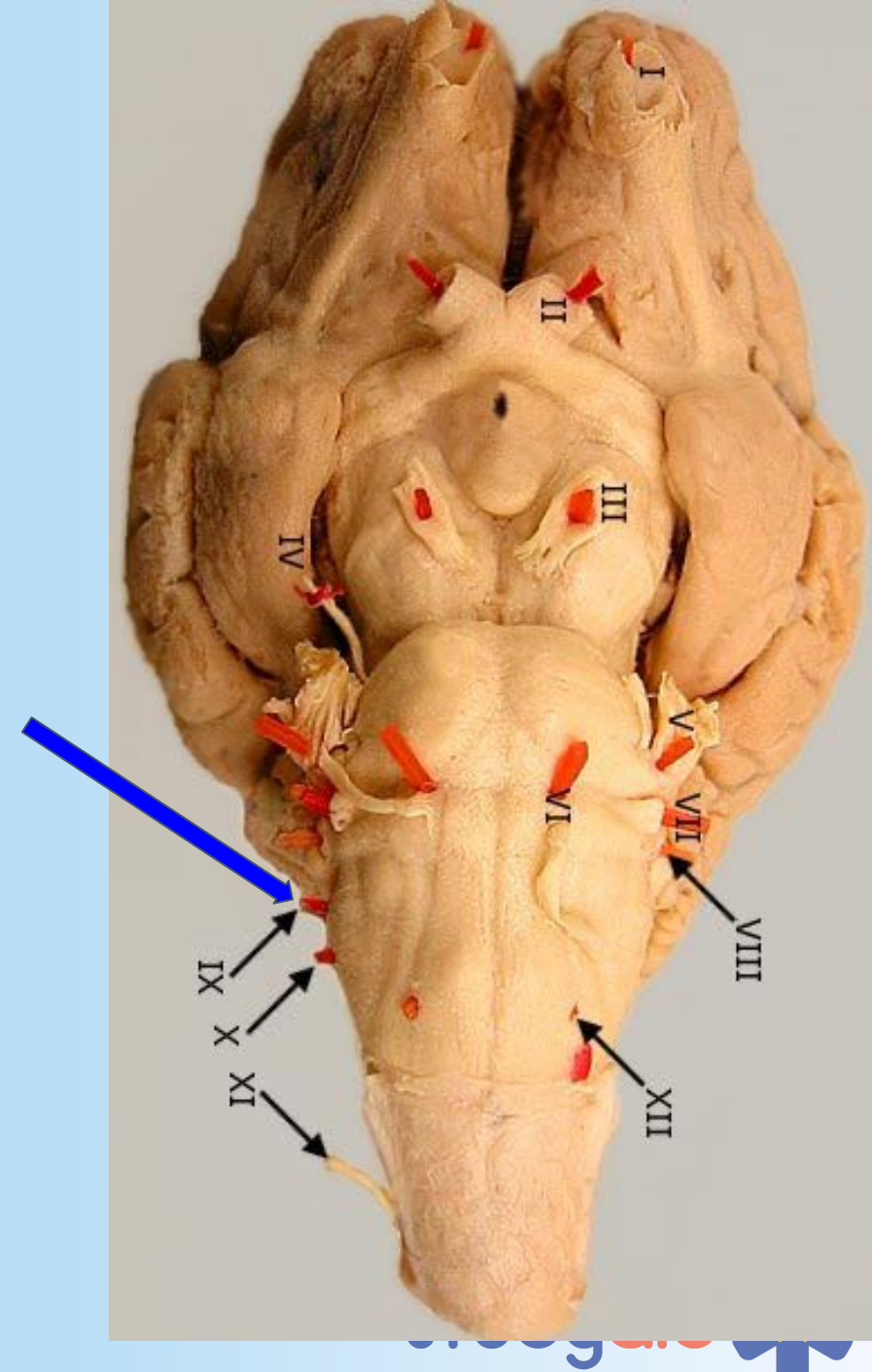
- Brainstem lesion
- Penetrating neck lesion



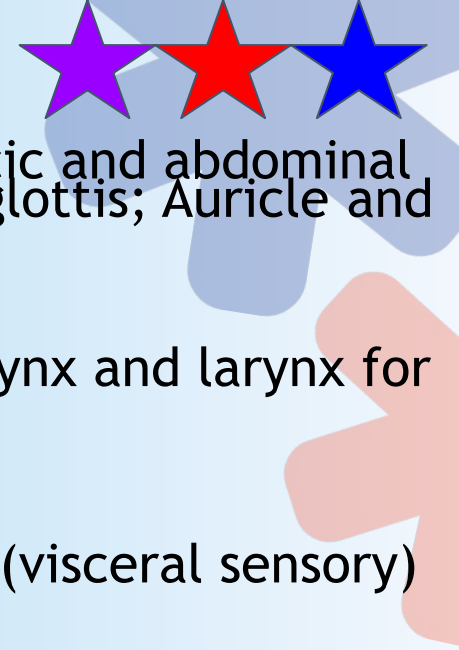
Jugular foramen



Brainstem Exit:
Postolivary sulcus



CN X: Vagus Nerve



Function: Muscle of pharynx, larynx, and palate; Smooth muscles and glands in thoracic and abdominal viscera; Sensation in lower pharynx, larynx, trachea, and other viscerae; Taste on epiglottis; Auricle and external acoustic meatus.

Course:

Motor: Nucleus ambiguus (speech/swallowing) → Jugular foramen → muscles of pharynx and larynx for swallowing and speech

Sensory:

1. Thorax/abdomen/epiglottis → Enter Jugular foramen → Inferior (nodose) ganglion (visceral sensory) → Nucleus solitarius (visceral/taste)

2. Thorax/abdomen/epiglottis → Enter Jugular foramen → Superior ganglion (pain/temp) → Spinal trigeminal nucleus (pain/temp) (visceral/taste)

Parasympathetic: Dorsal motor nucleus of X (parasympathetic) → exit through jugular foramen → heart/lungs/GI tract → terminal ganglia in organs

Fibers: GSA, GVA, GVE, SVA, SVE

High-yield: Efferent limb of carotid sinus

4th & 6th Pharyngeal Arches

CN X: Vagus Nerve

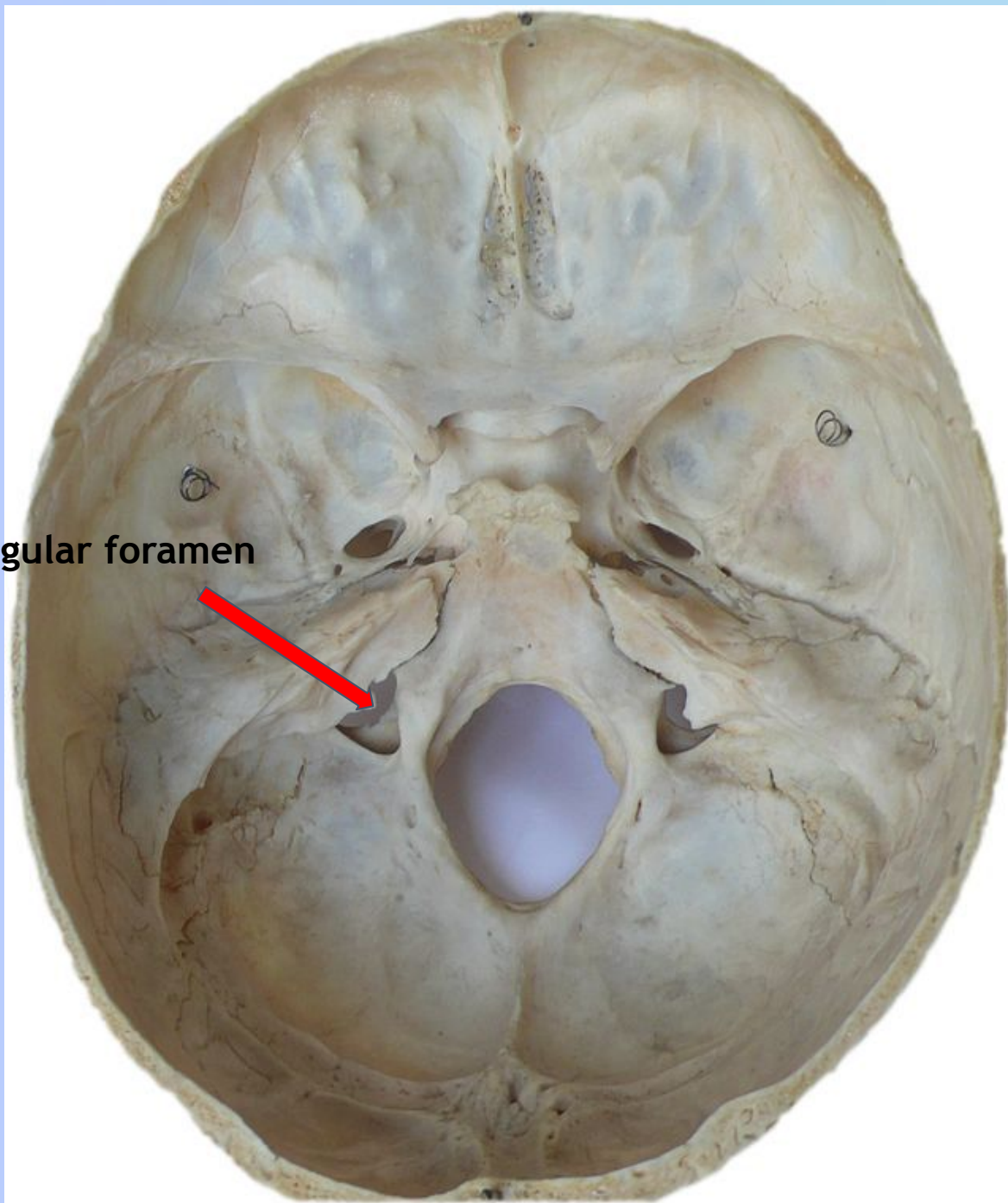
Effect of nerve injury:

- Loss of efferent limbs, gag, sneeze, and both limbs of cough reflex
- Deviation of uvula toward normal side
- Vocal cord paralysis (left recurrent laryngeal nerve)
 - Thyroidectomy
- Paralysis of palate, pharynx, and larynx
- Loss of receptors in aortic body and arch

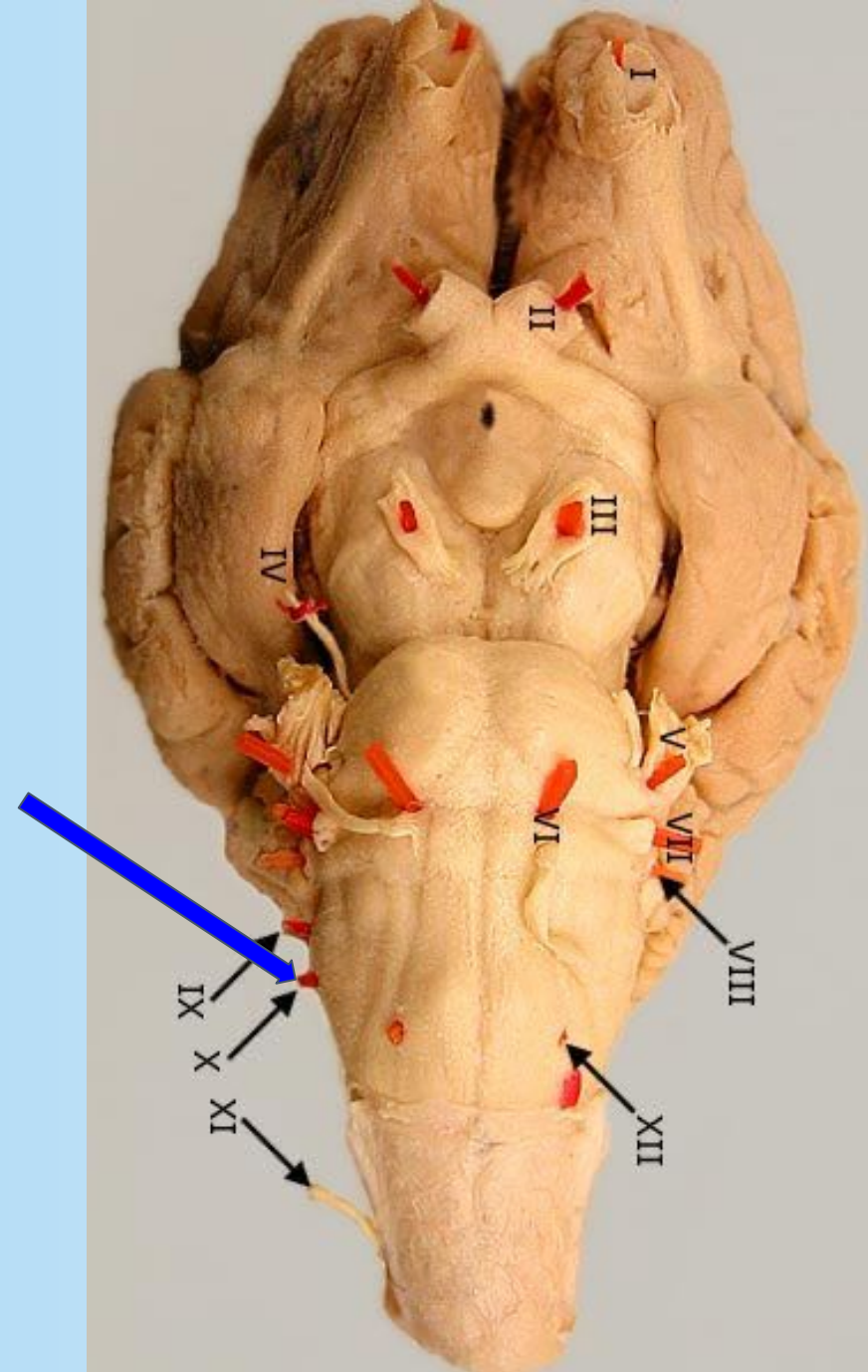
Lesion site:

- Brainstem lesion
- Penetrating neck injury
- Skull base fracture

Jugular foramen



Brainstem Exit:
Postolivary sulcus

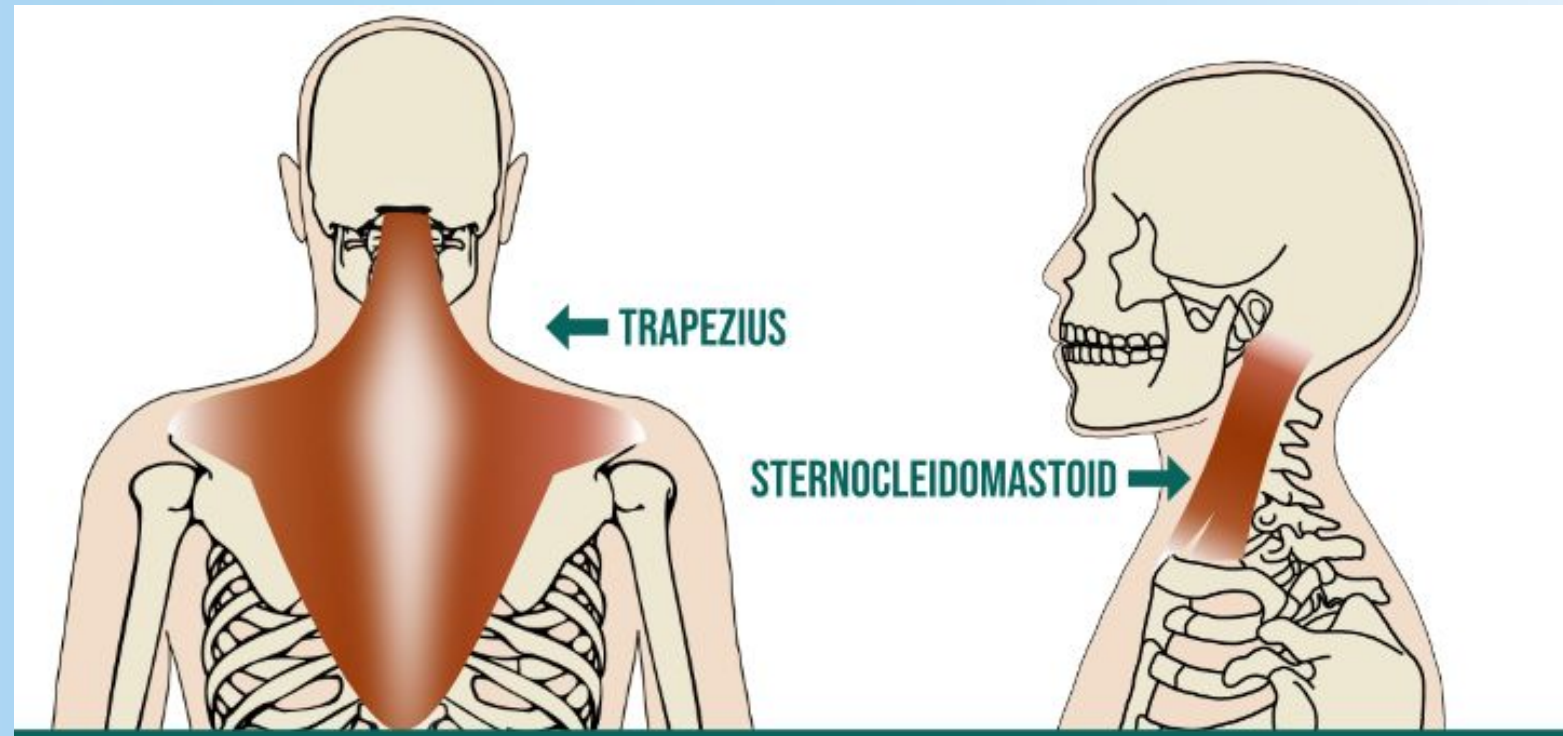


CN XI: Accessory Nerve

Function: SCM, trapezius

Course: Motor: Spinal accessory nucleus C1-C5 → foramen magnum → exits through jugular foramen → SCM and Trapezius

Fibers: SVE



CN XI: Accessory Nerve

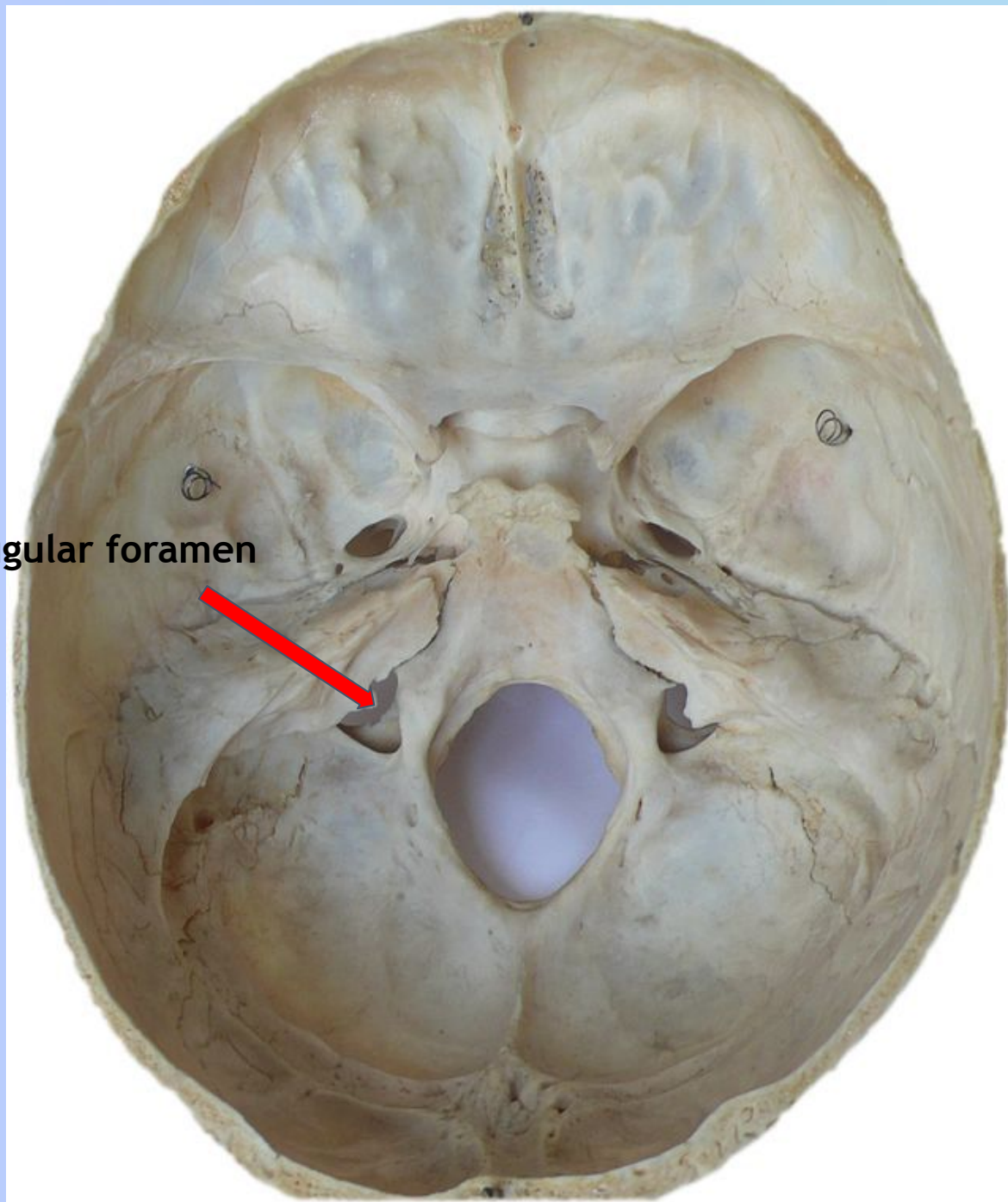
Effect of nerve injury:

- Inability to shrug shoulder
- Difficulty in turning head to opposite side

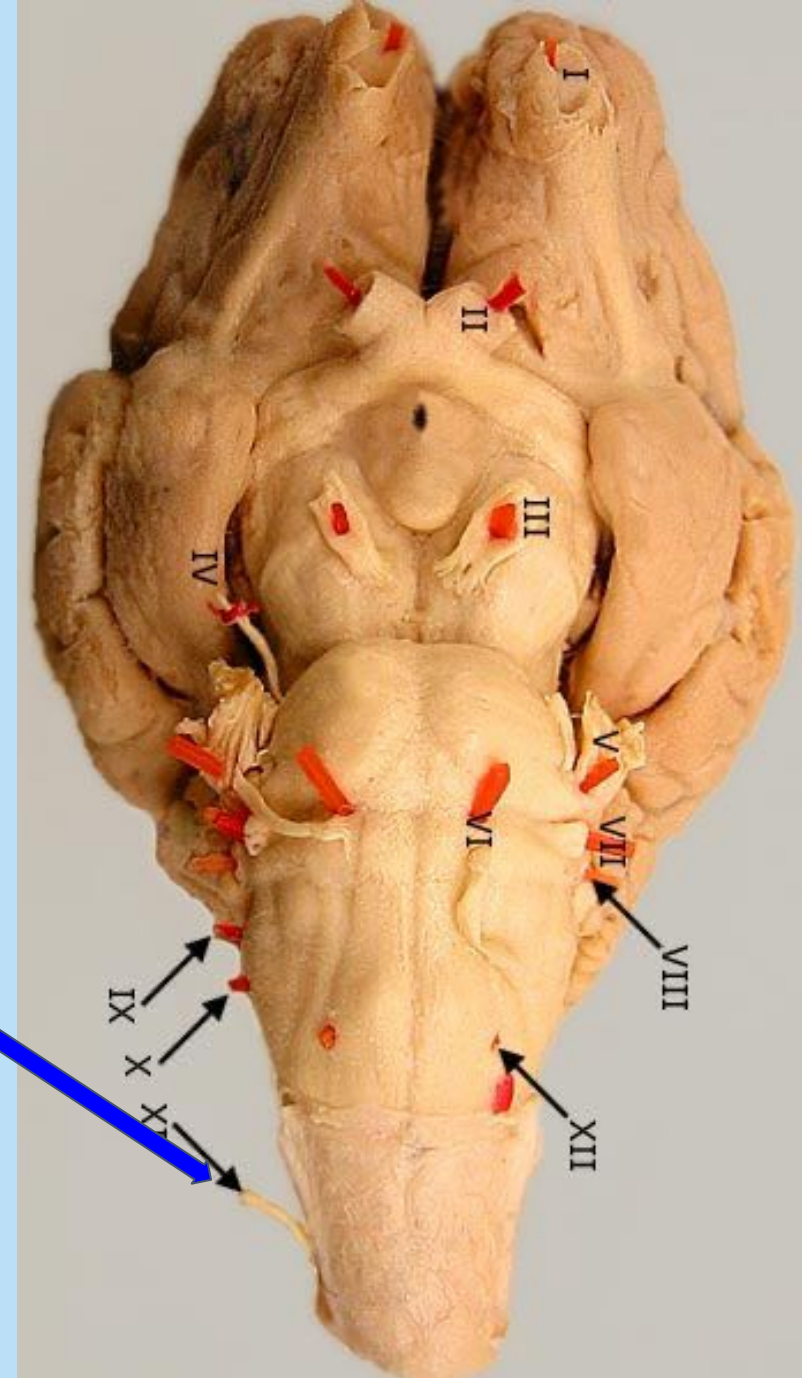
Lesion site:

- Penetrating injury to posterior cervical triangle
- Skull base fracture

Jugular foramen



Brainstem Exit:
Postolivary sulcus



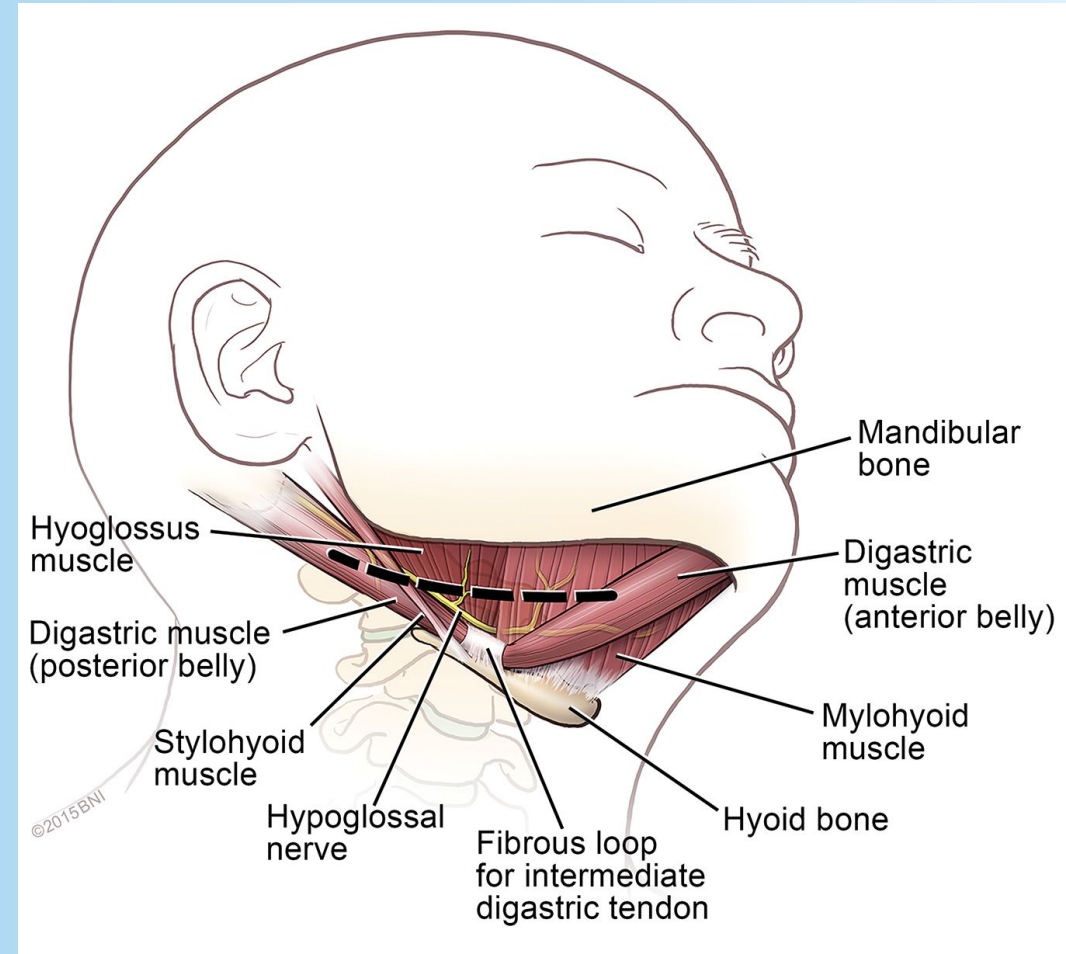
CN XII: Hypoglossal Nerve



Function: Tongue movement

Course: Motor: Hypoglossal nucleus → exits through the hypoglossal canal → intrinsic and extrinsic muscles of the tongue

Fibers: GSE



CN XII: Hypoglossal Nerve

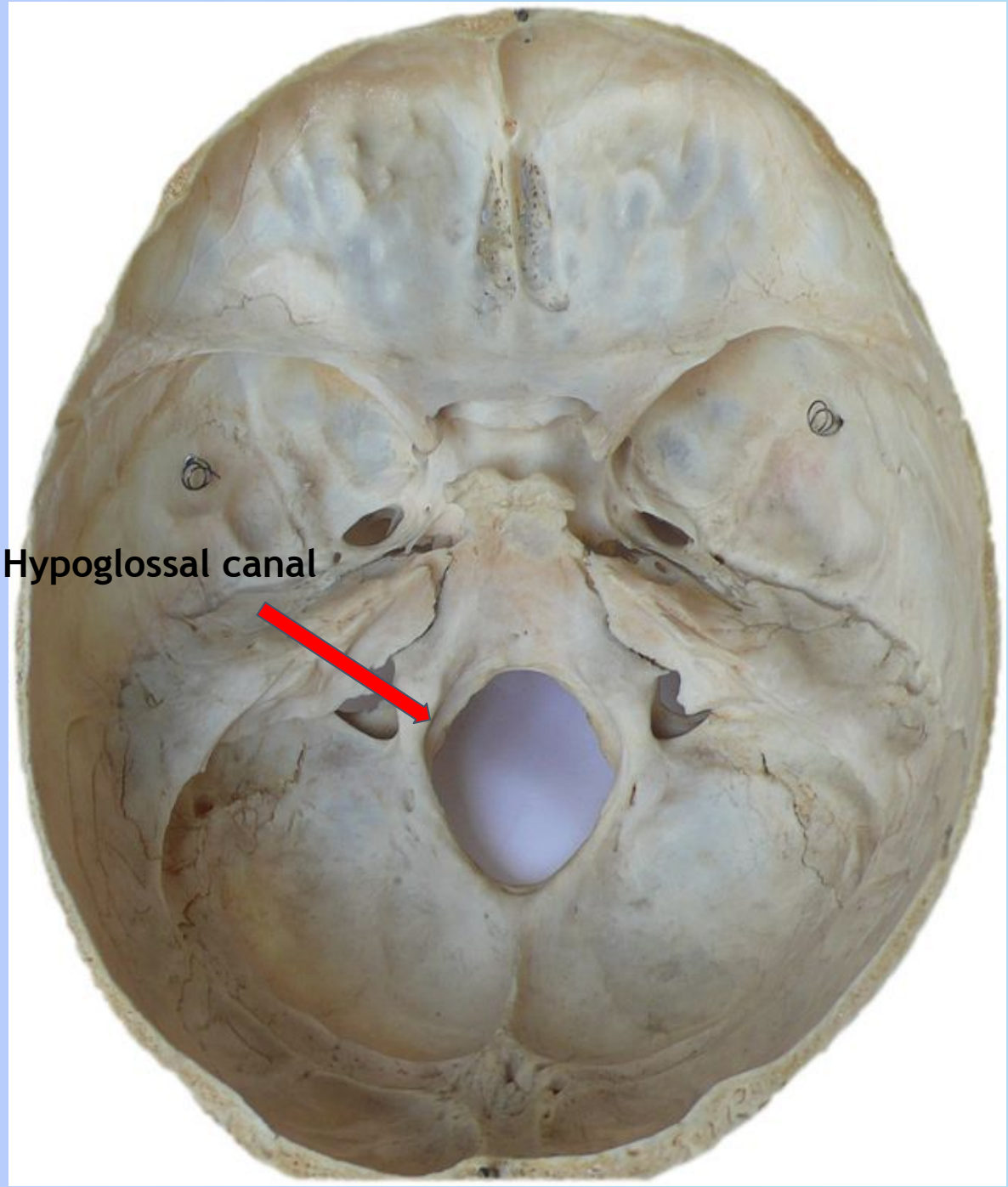
Effect of nerve injury:

- Loss of tongue movements
- Tongue deviation toward lesion side (genioglossus m.)

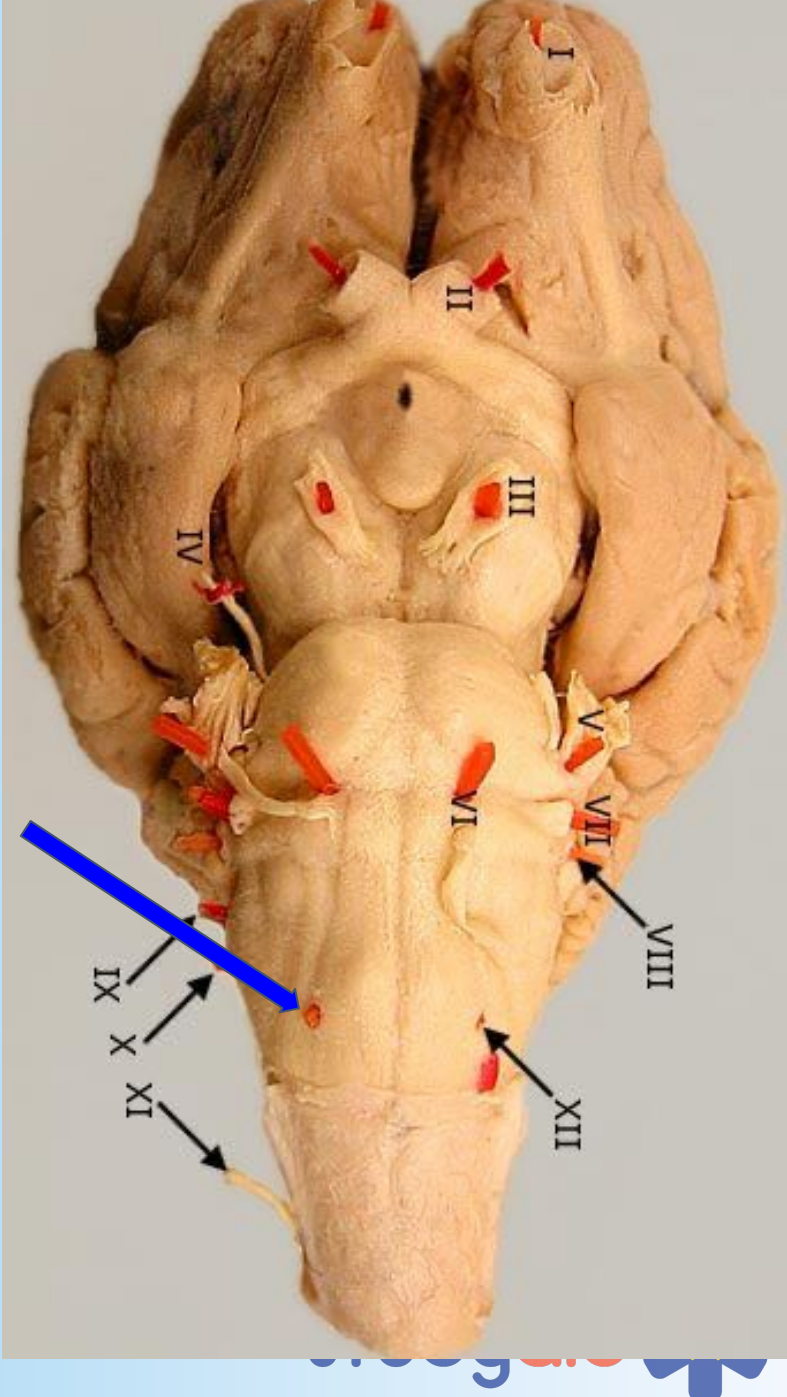
Lesion site:

- Deep laceration of neck
- Basal skull fracture





Hypoglossal canal



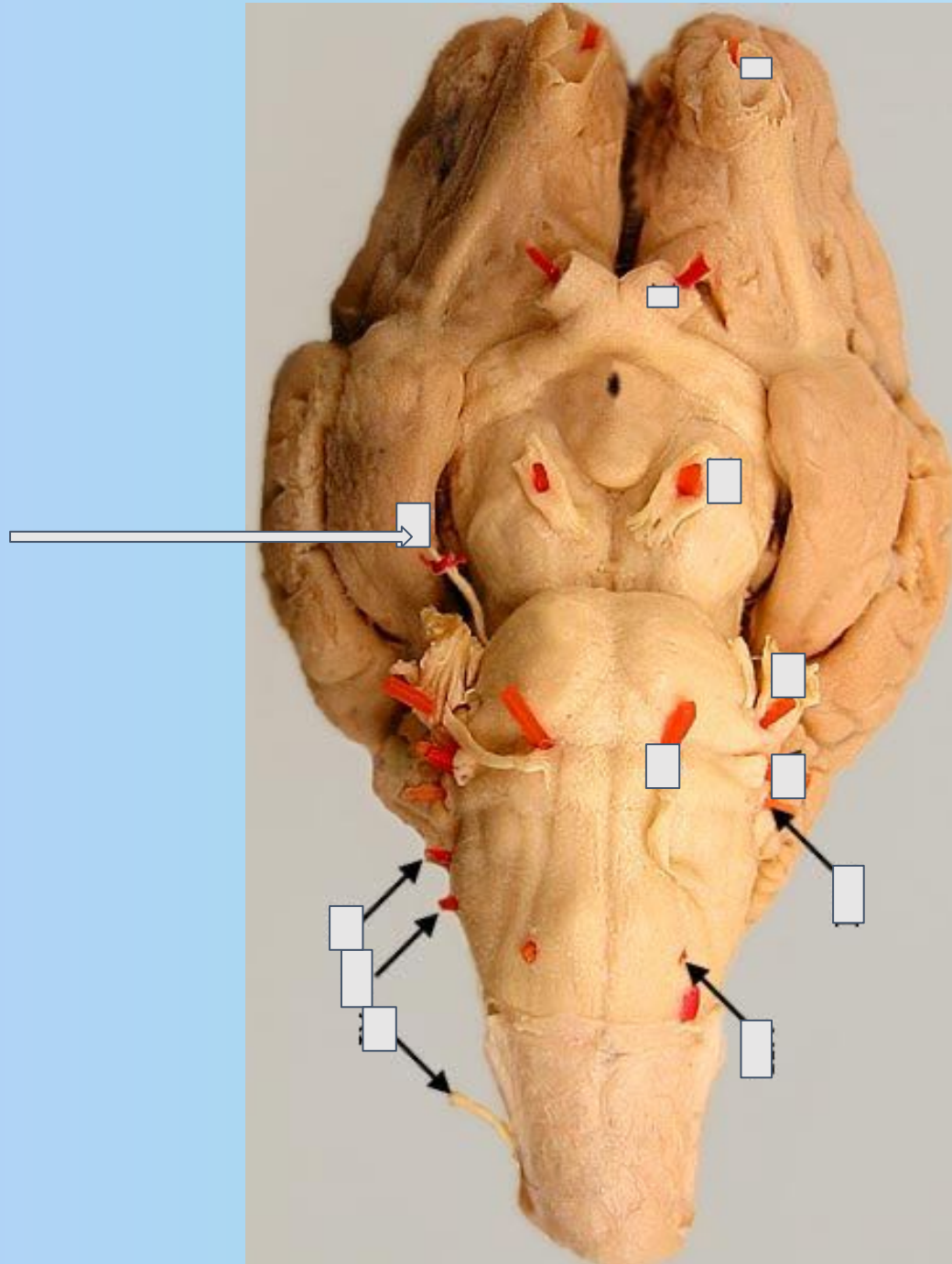
Brainstem Exit:
Preolivary sulcus

Functional Components of CN

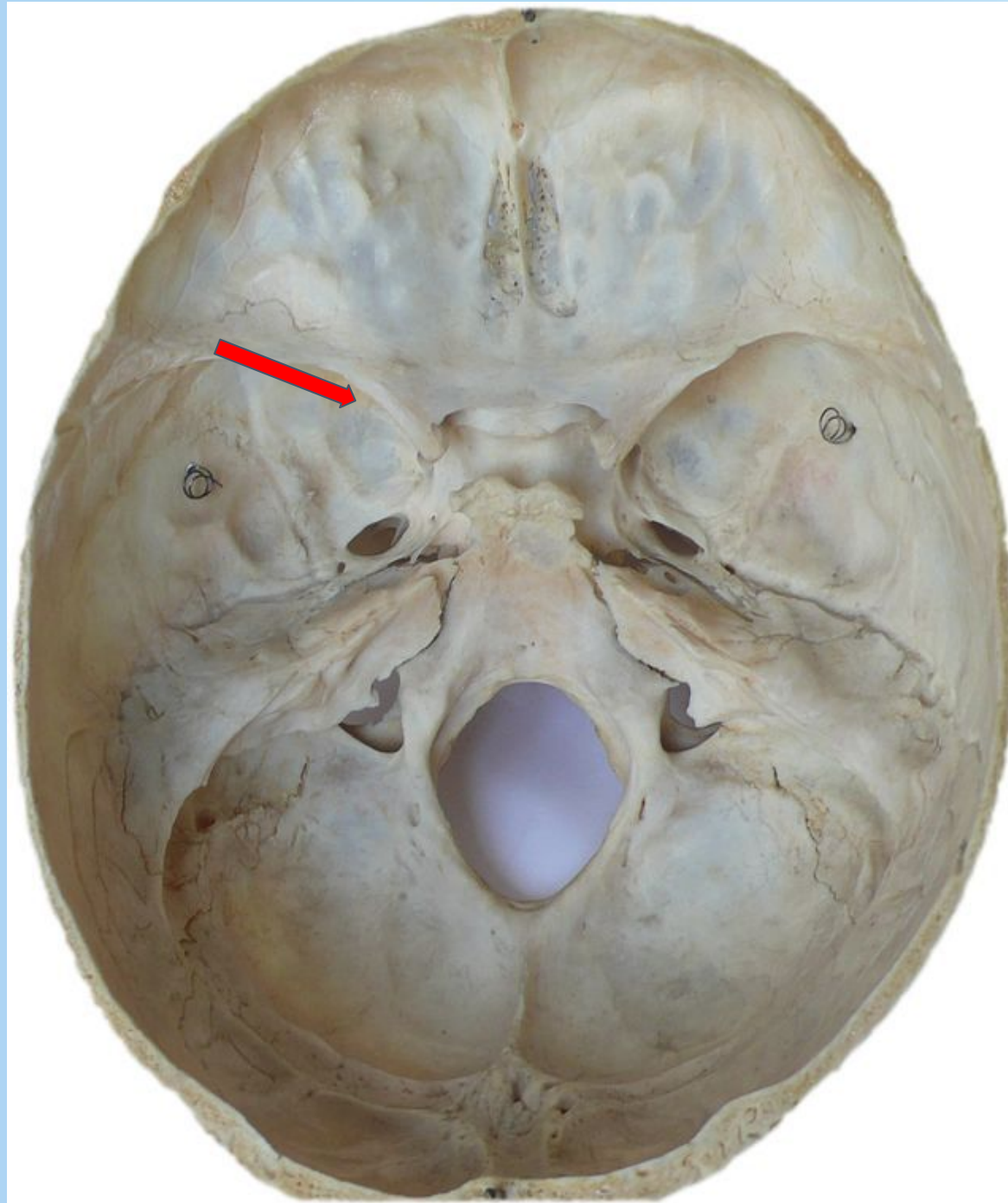
Functional Component	Type of Information Carried	Cranial Nerves
GSA	Pain, temperature, touch proprioception	V, VII, IX, X
GSE	Motor to skeletal muscle of the eye and tongue	III, IV, VI, XII
GVA	Sensory from visceral organs	VII, IX, X
GVE	Autonomic motor fibers to smooth muscle, cardiac muscle, glands	III, VII, IX, X
SSA	Vision, hearing, equilibrium	II, VIII
SVA	Smell and taste	I, VII, IX, X
SVE or branchial efferent	Motor to skeletal muscles for mastication, facial expression, movement of the pharynx and larynx	V, VII, IX, X, XI

CN	Nuclei (Function)	Ganglia (Function)
I – Olfactory	Olfactory bulb* → smell processing (*technically CNS relay, not classic brainstem nucleus)	✗ None
II – Optic	Lateral geniculate nucleus → vision relay (thalamus)	✗ None
III – Oculomotor	Oculomotor nucleus → eye movement Edinger–Westphal → parasympathetic (pupil constriction)	Ciliary ganglion → pupil constriction
IV – Trochlear	Trochlear nucleus → superior oblique muscle	✗ None
V – Trigeminal	Mesencephalic → proprioception Principal sensory → touch Spinal trigeminal → pain/temp Motor V → mastication	Trigeminal ganglion → facial sensation
VI – Abducens	Abducens nucleus → lateral rectus	✗ None
VII – Facial	Facial motor → facial expression Superior salivatory → parasympathetic Solitarius → taste	Geniculate → sensory/taste Pterygopalatine → lacrimal gland Submandibular → salivary glands
VIII – Vestibulocochlear	Cochlear → hearing Vestibular → balance	Spiral → hearing Vestibular → balance
IX – Glossopharyngeal	Ambiguus → swallowing Inferior salivatory → parotid Solitarius → taste/visceral Spinal trigeminal → pain/temp	Superior → general sensory Inferior (petrosal) → taste/visceral Otic → parotid gland
X – Vagus	Ambiguus → phonation/swallowing Dorsal motor → parasympathetic Solitarius → visceral/taste Spinal trigeminal → pain/temp	Superior → somatic sensory Inferior (nodose) → visceral sensory
XI – Accessory	Spinal accessory → SCM, trapezius	✗ None
XII – Hypoglossal	Hypoglossal → tongue movement	✗ None

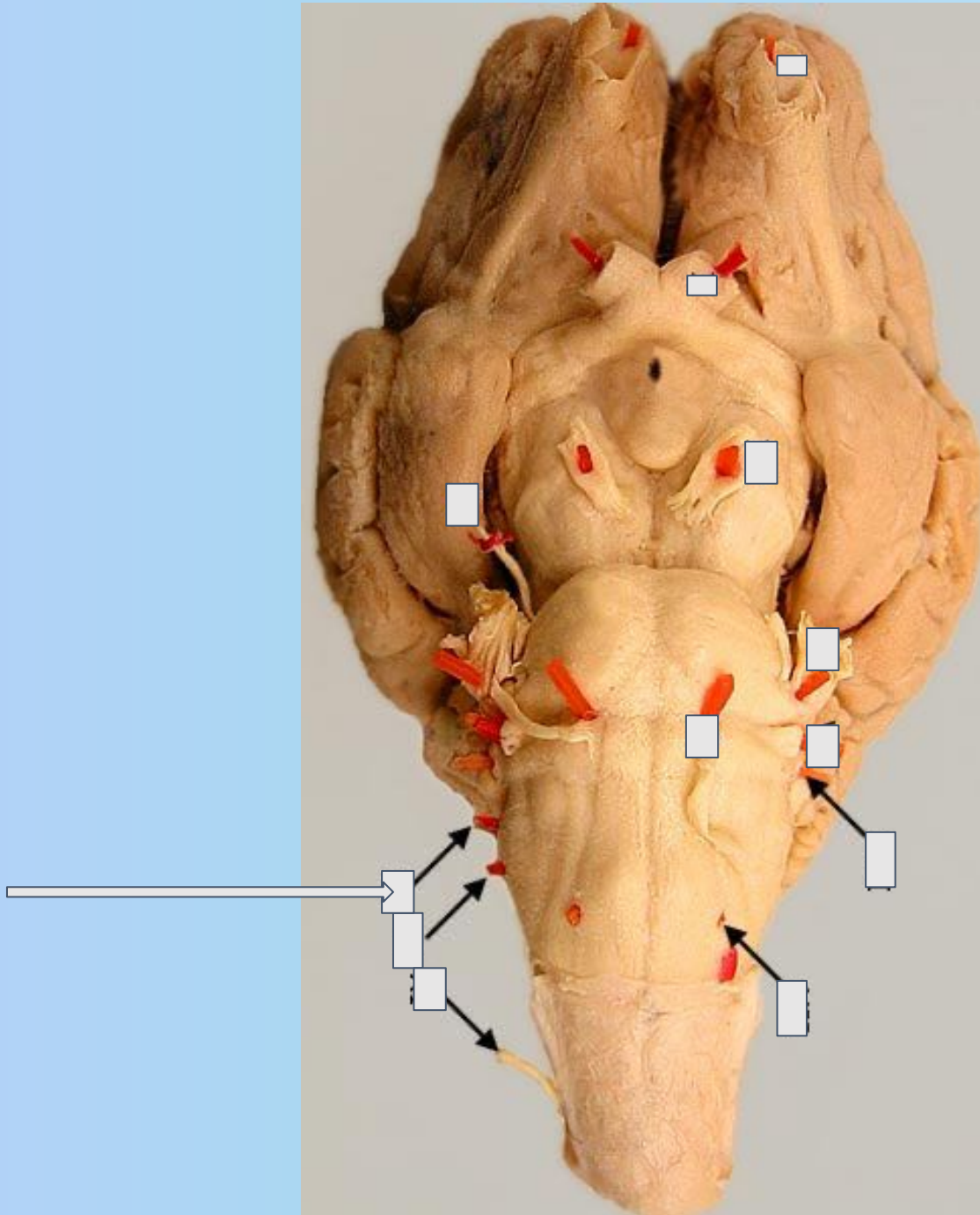
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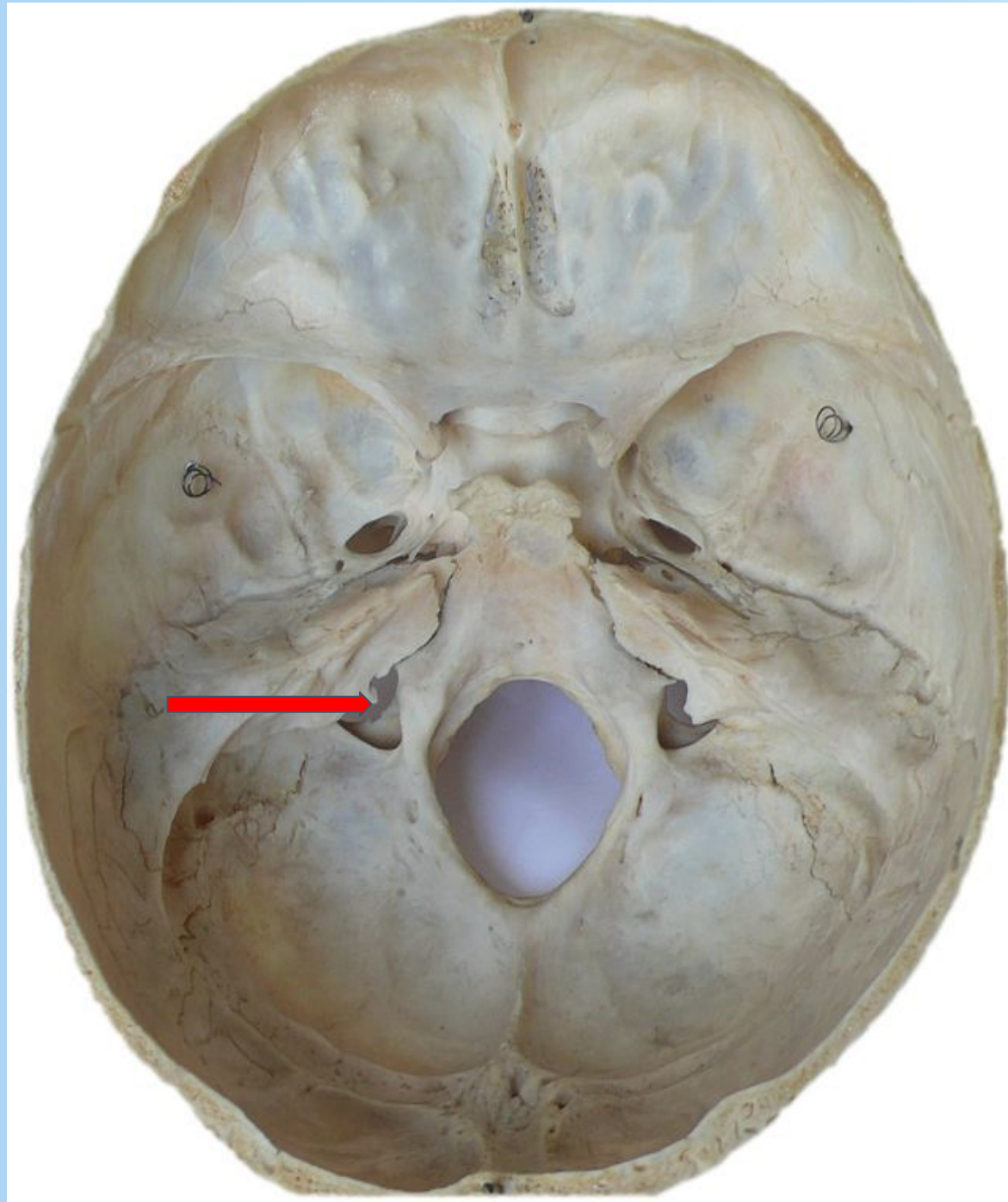
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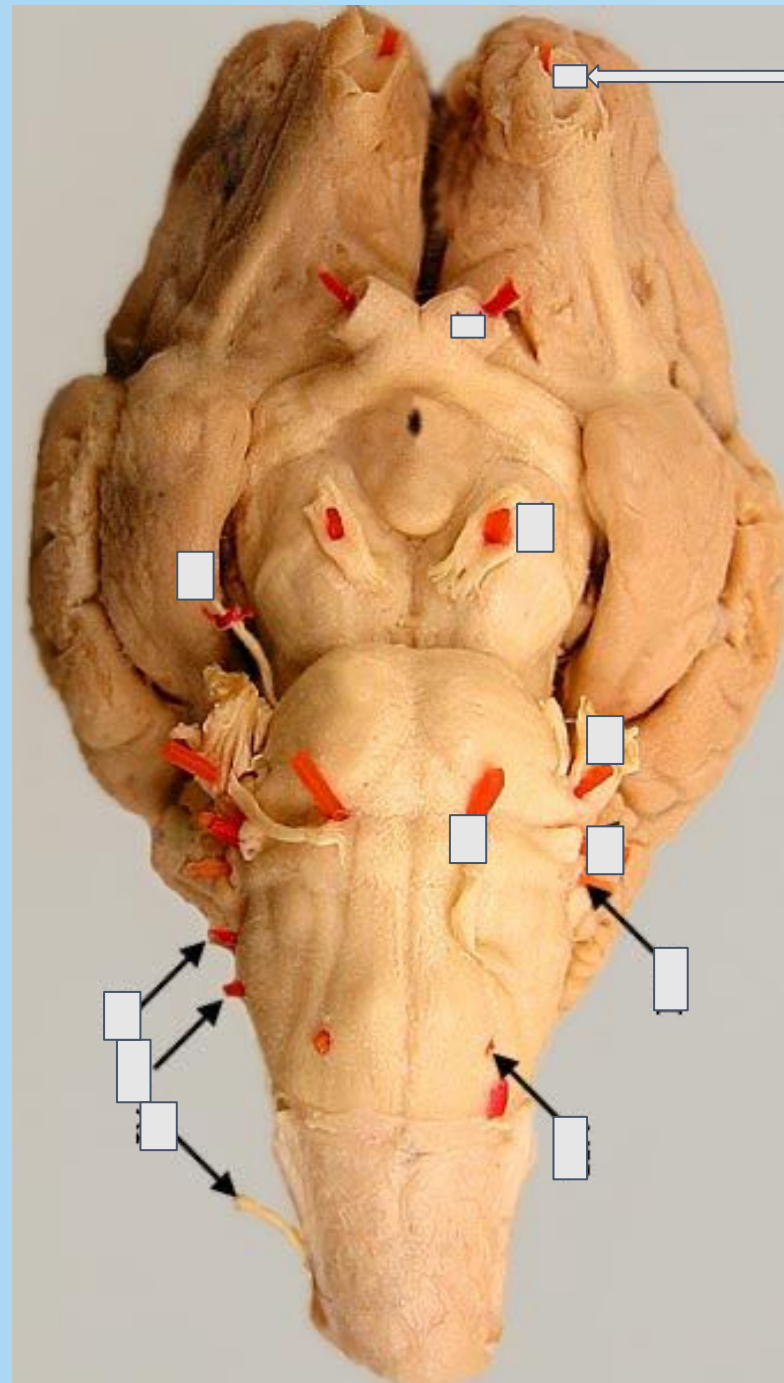
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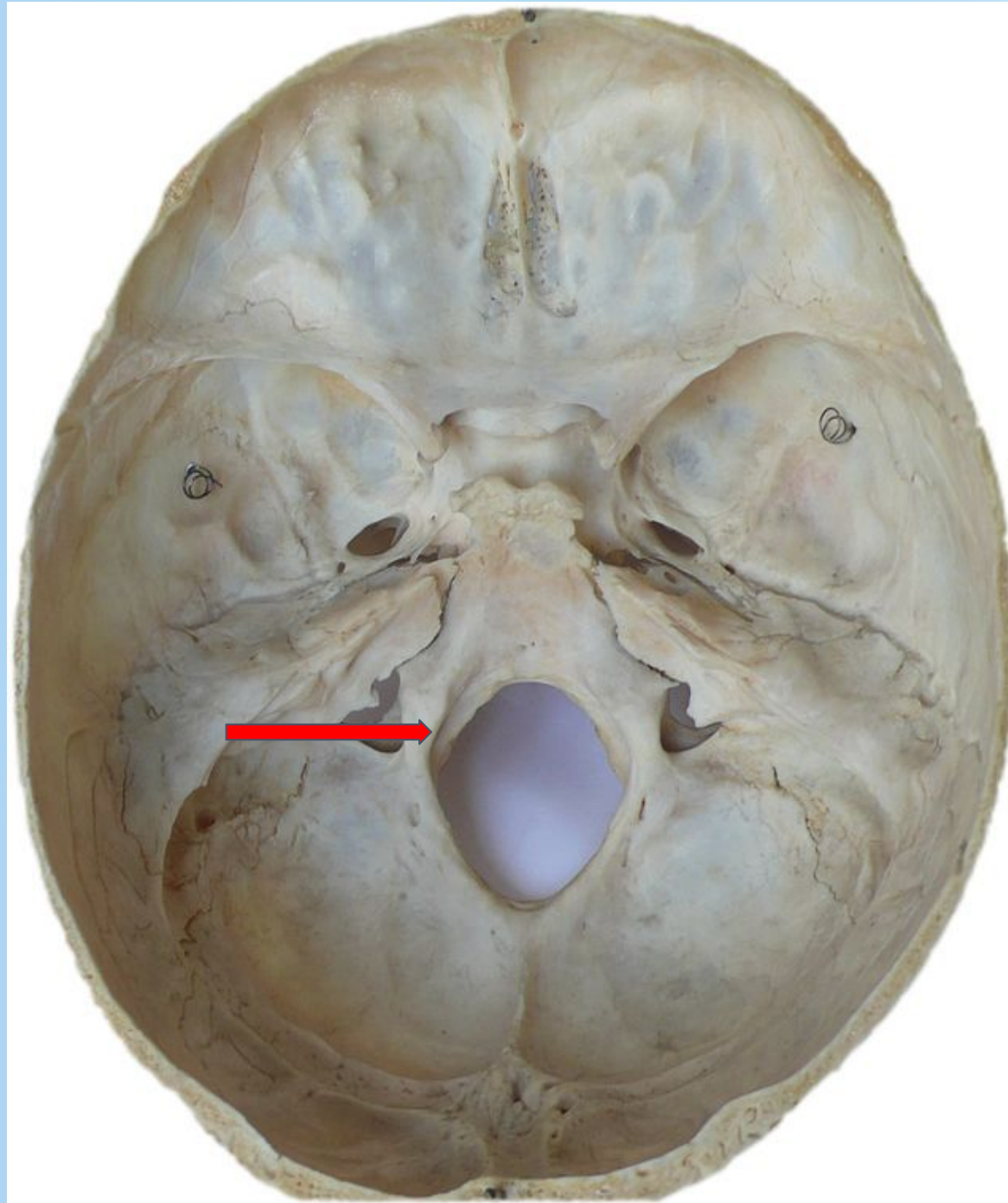
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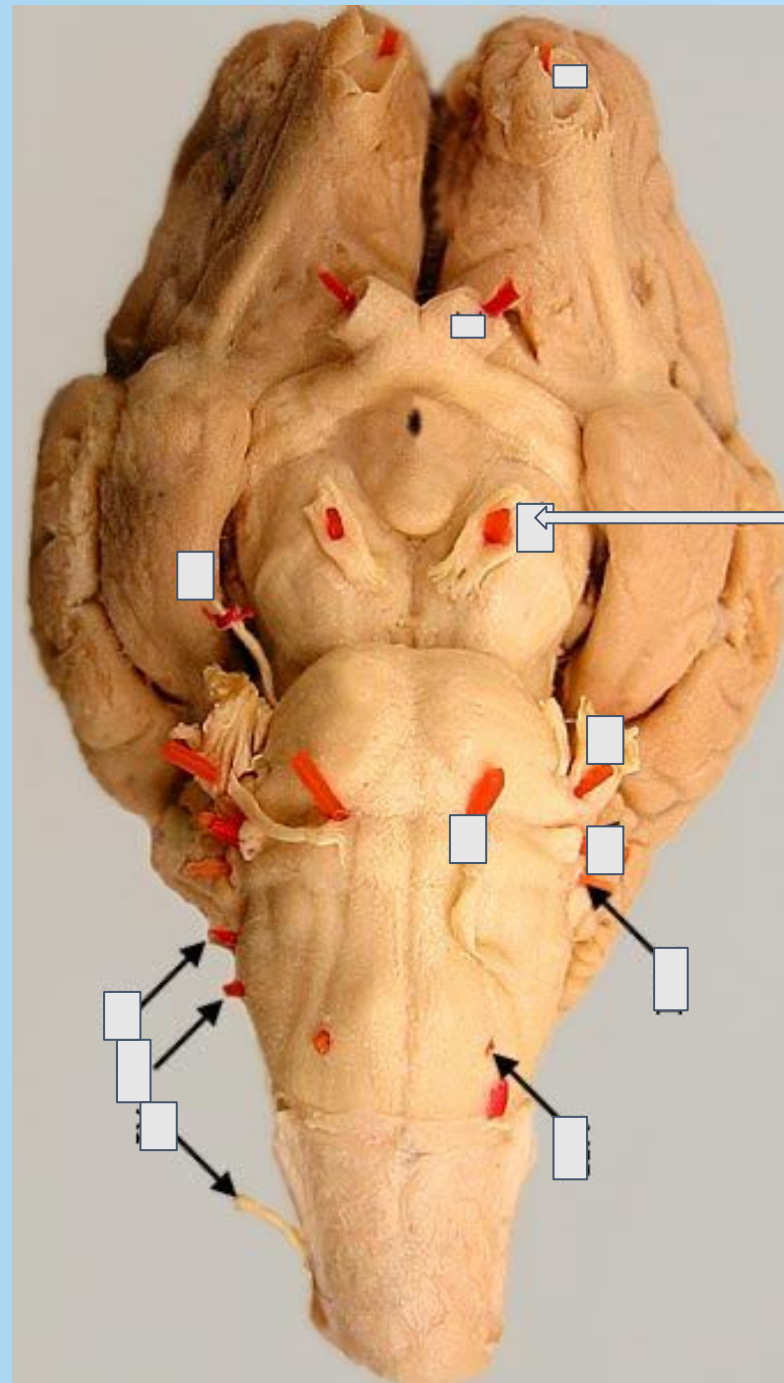
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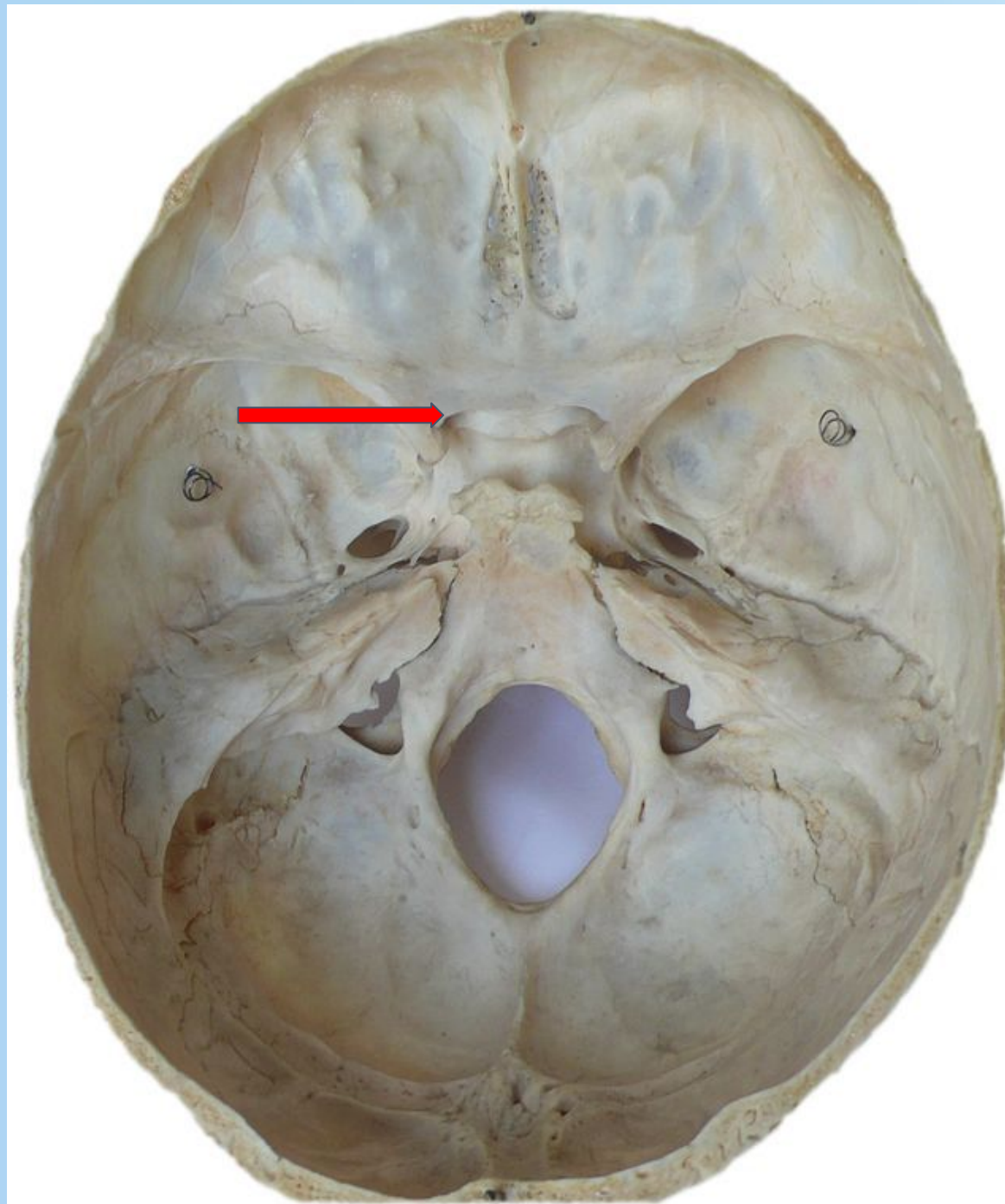
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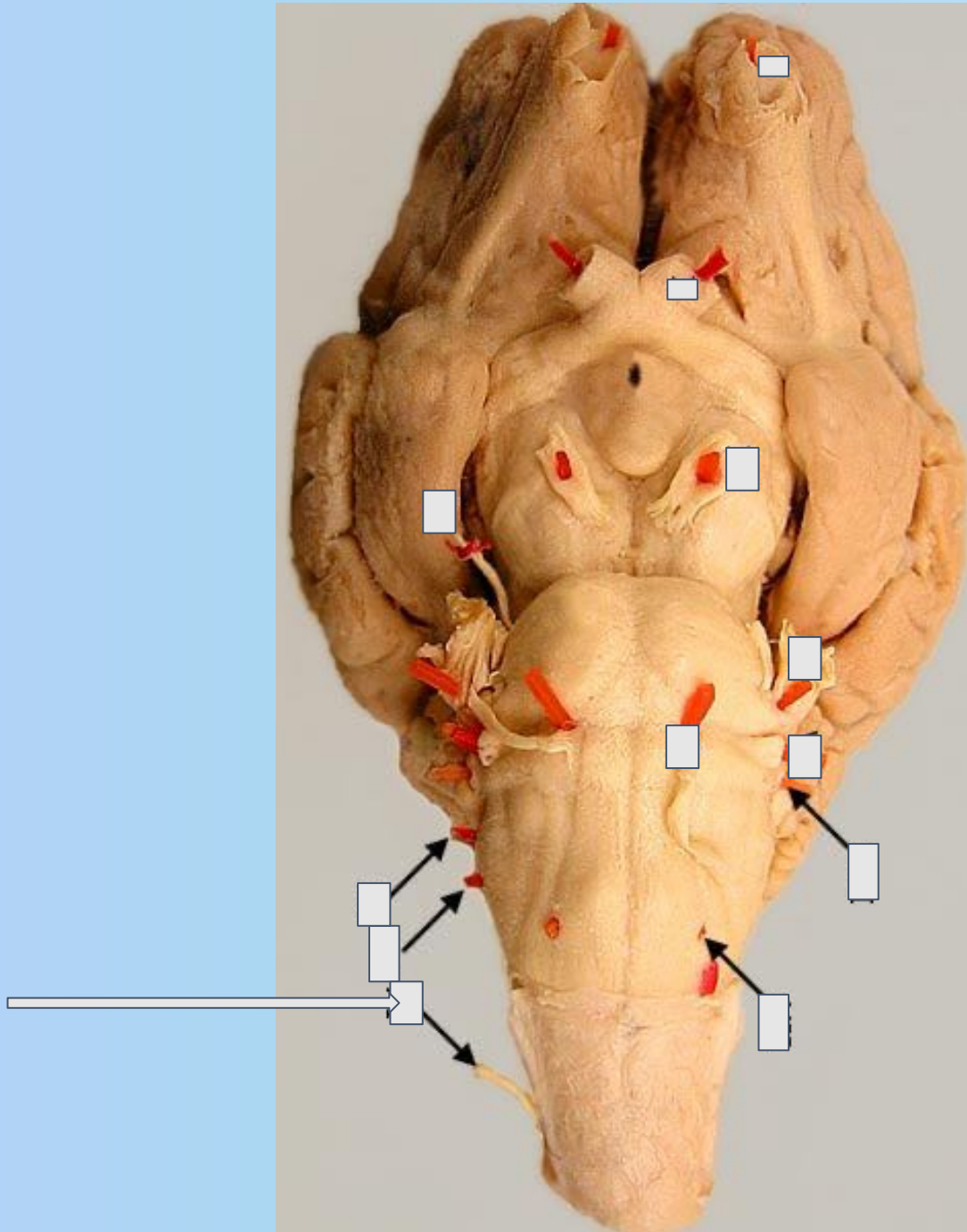
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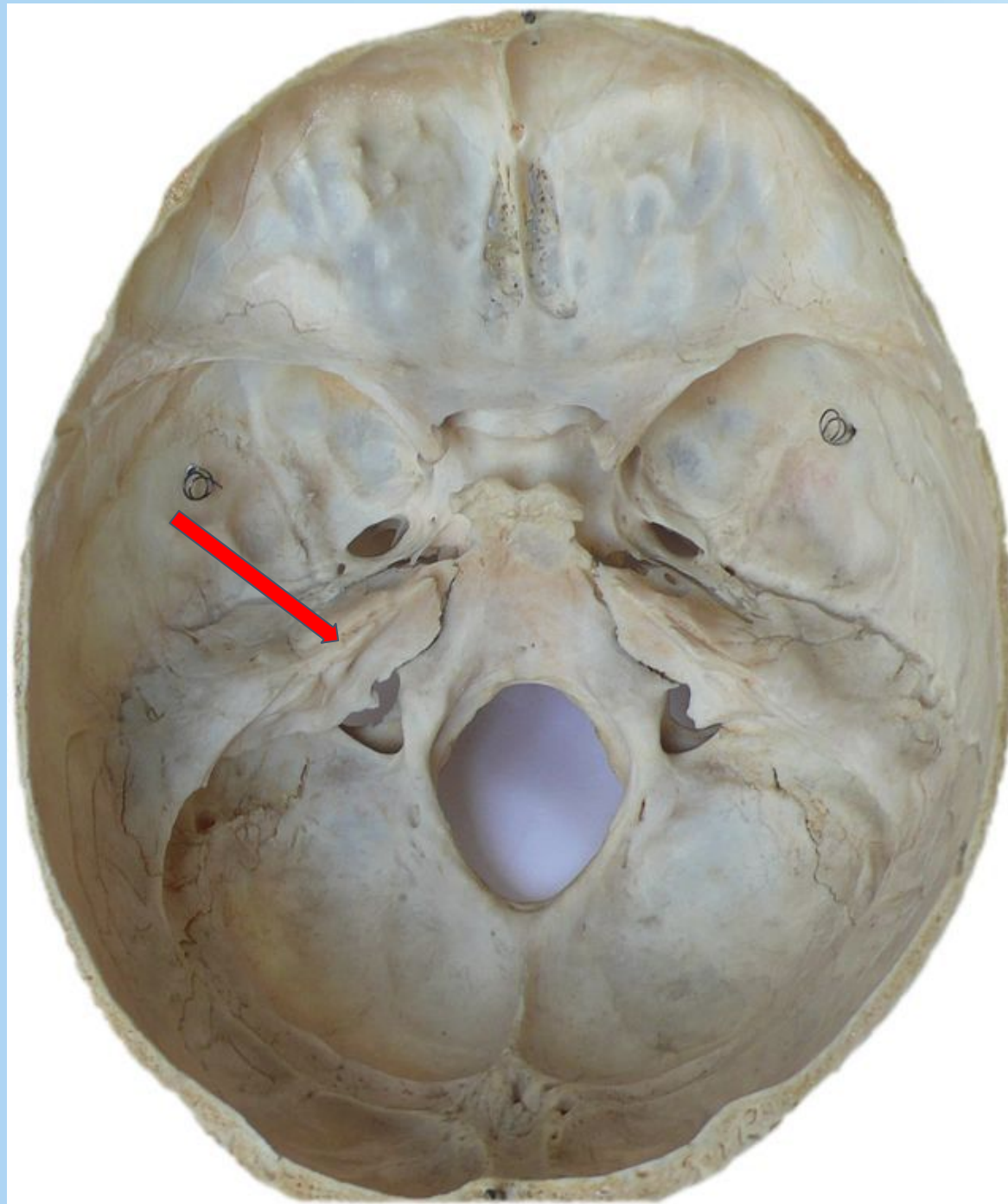
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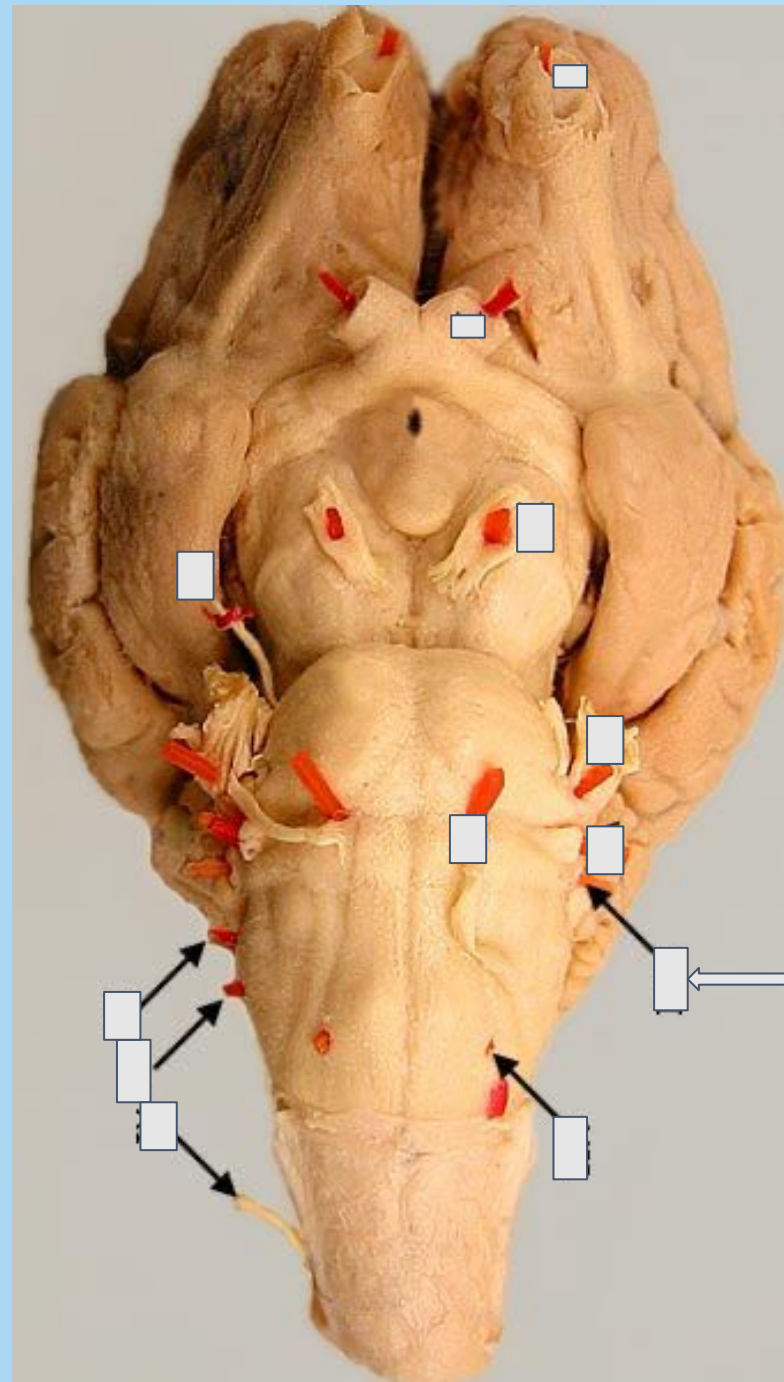
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K

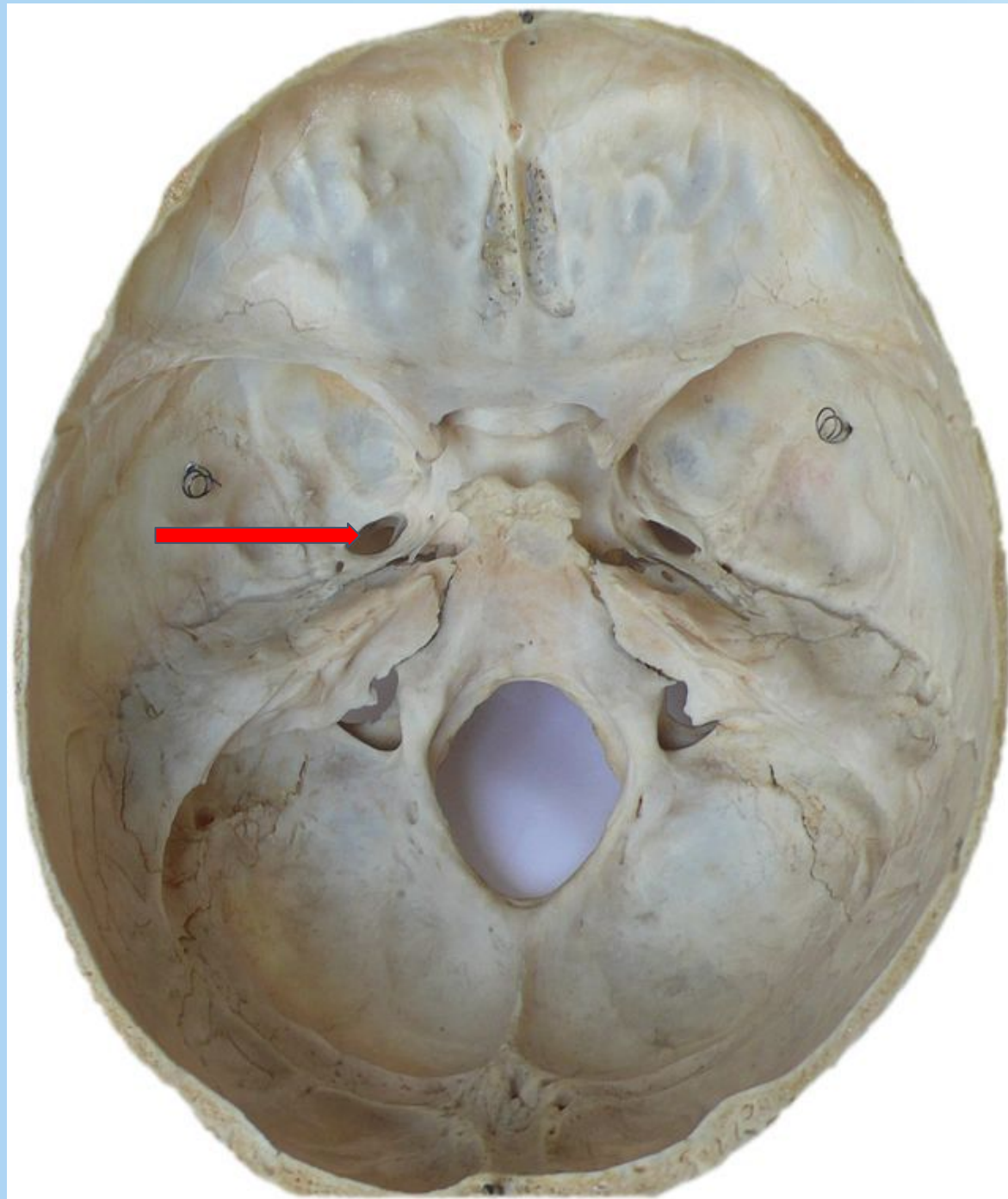


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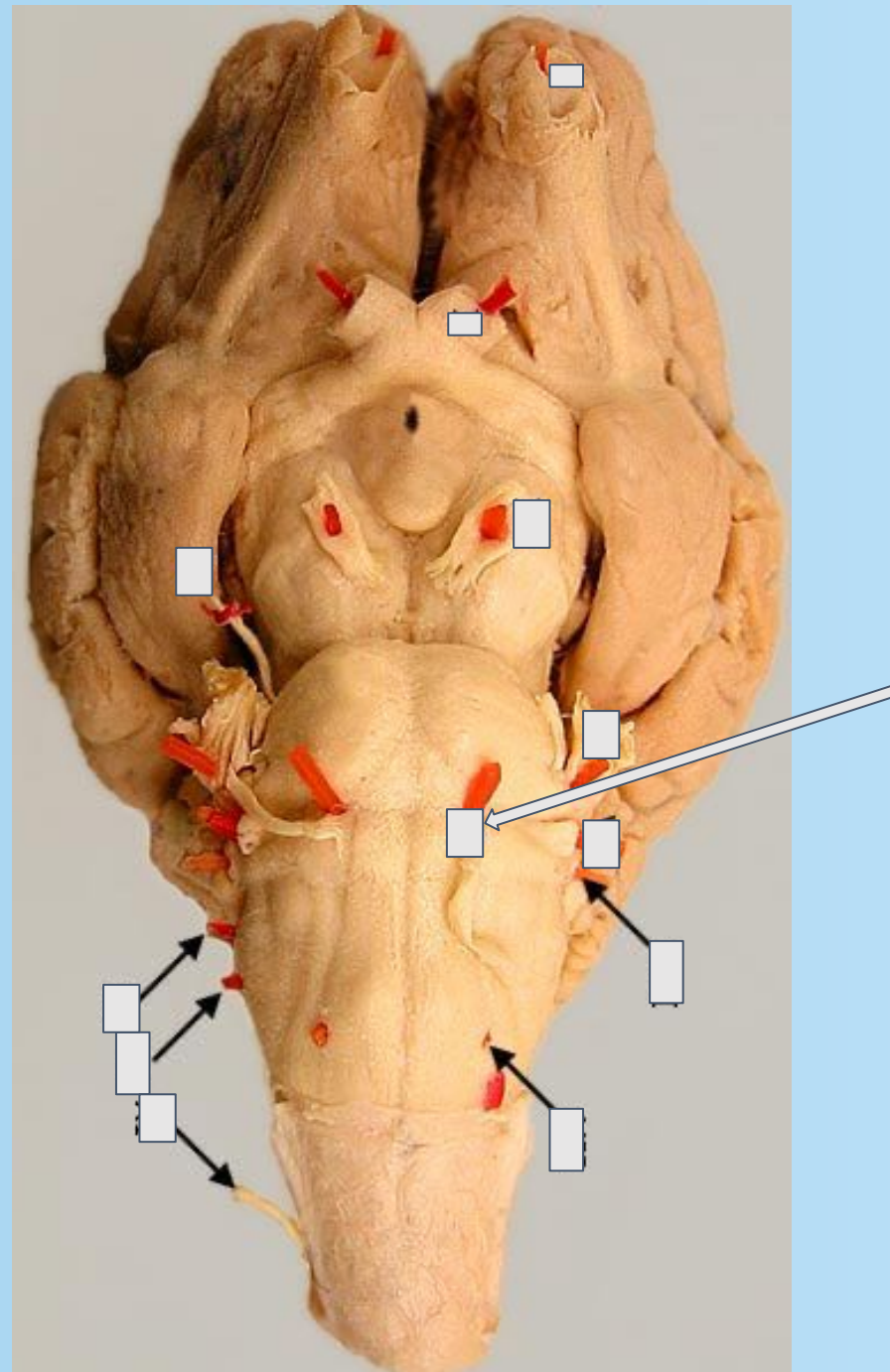




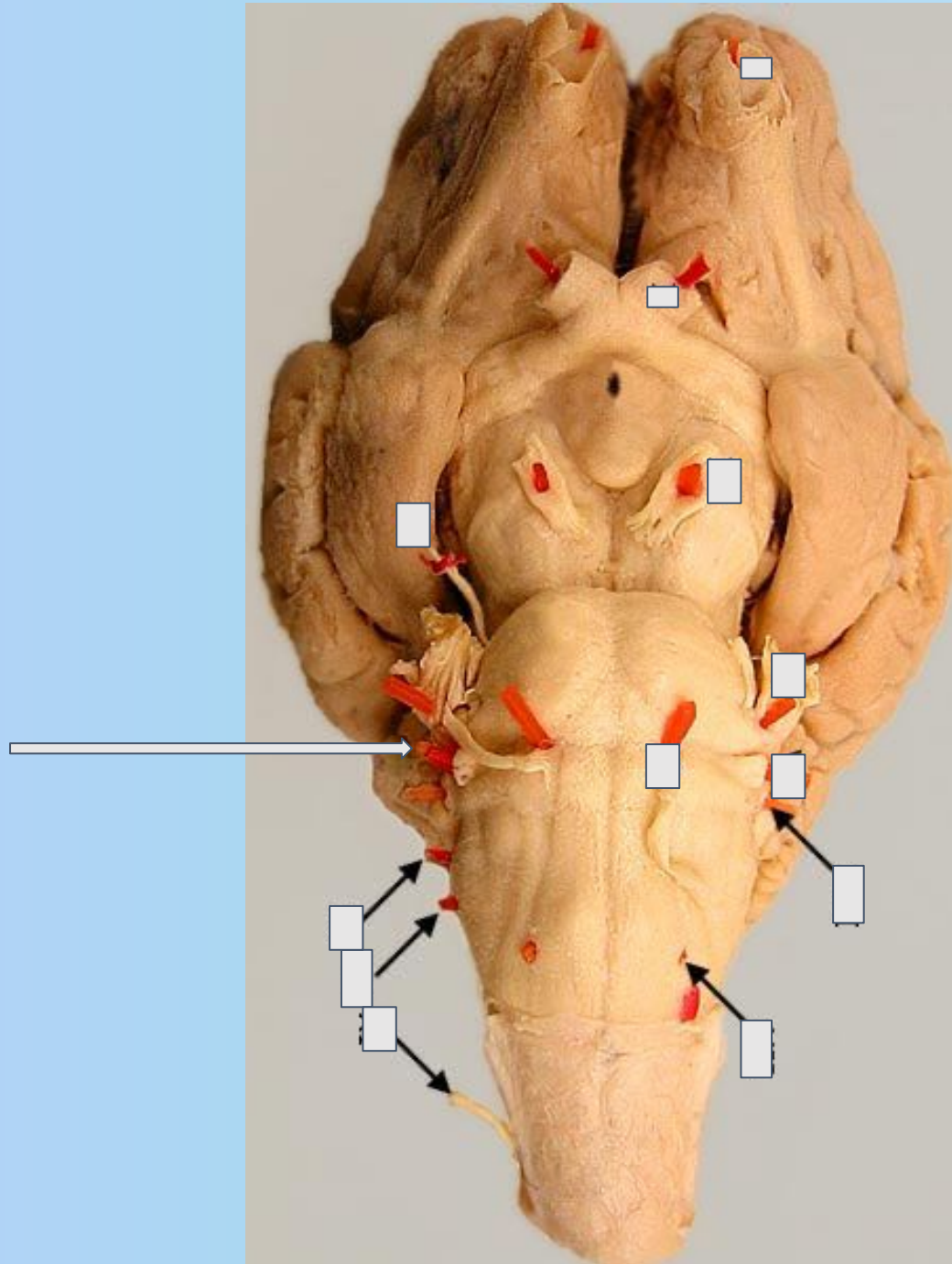
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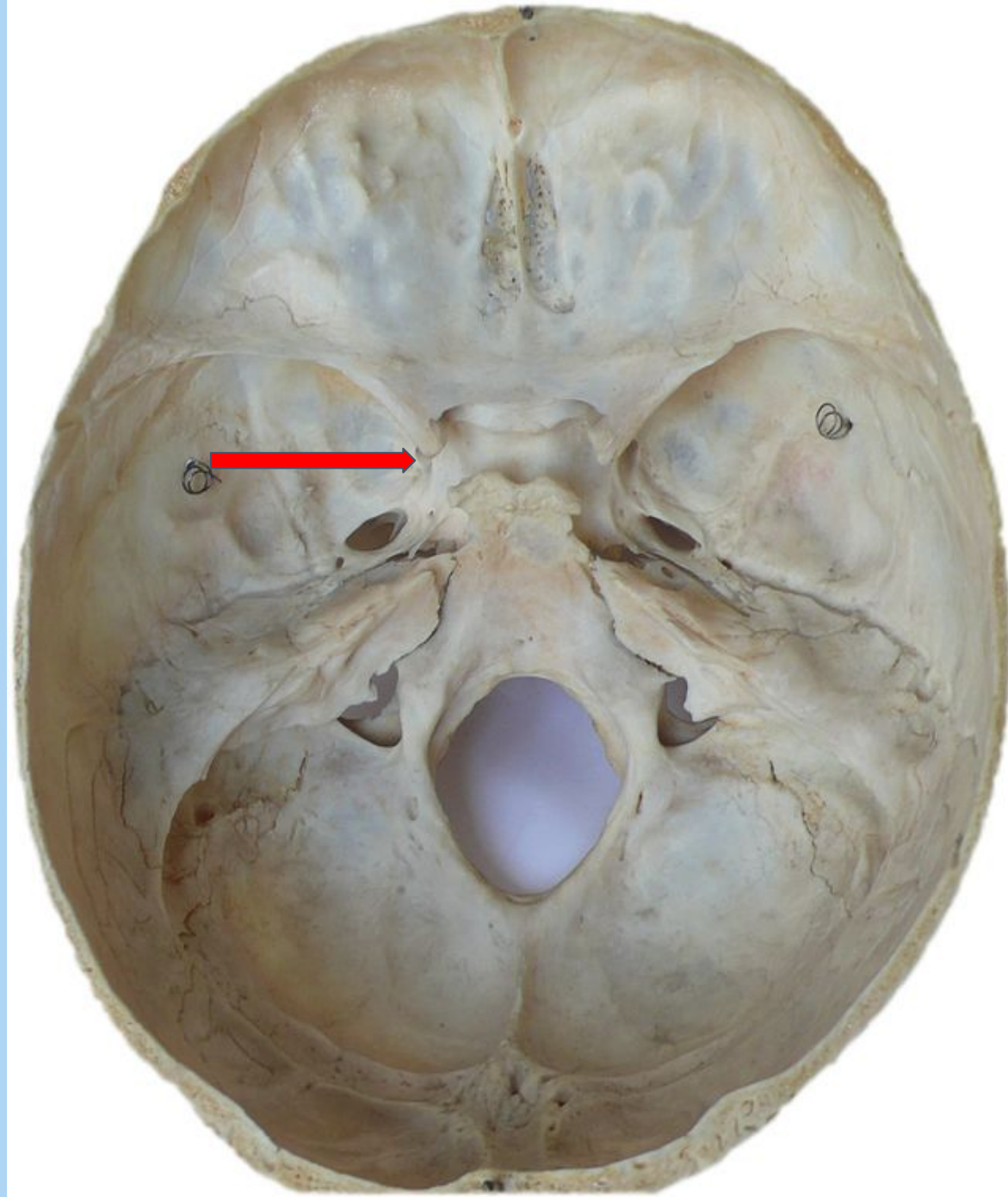
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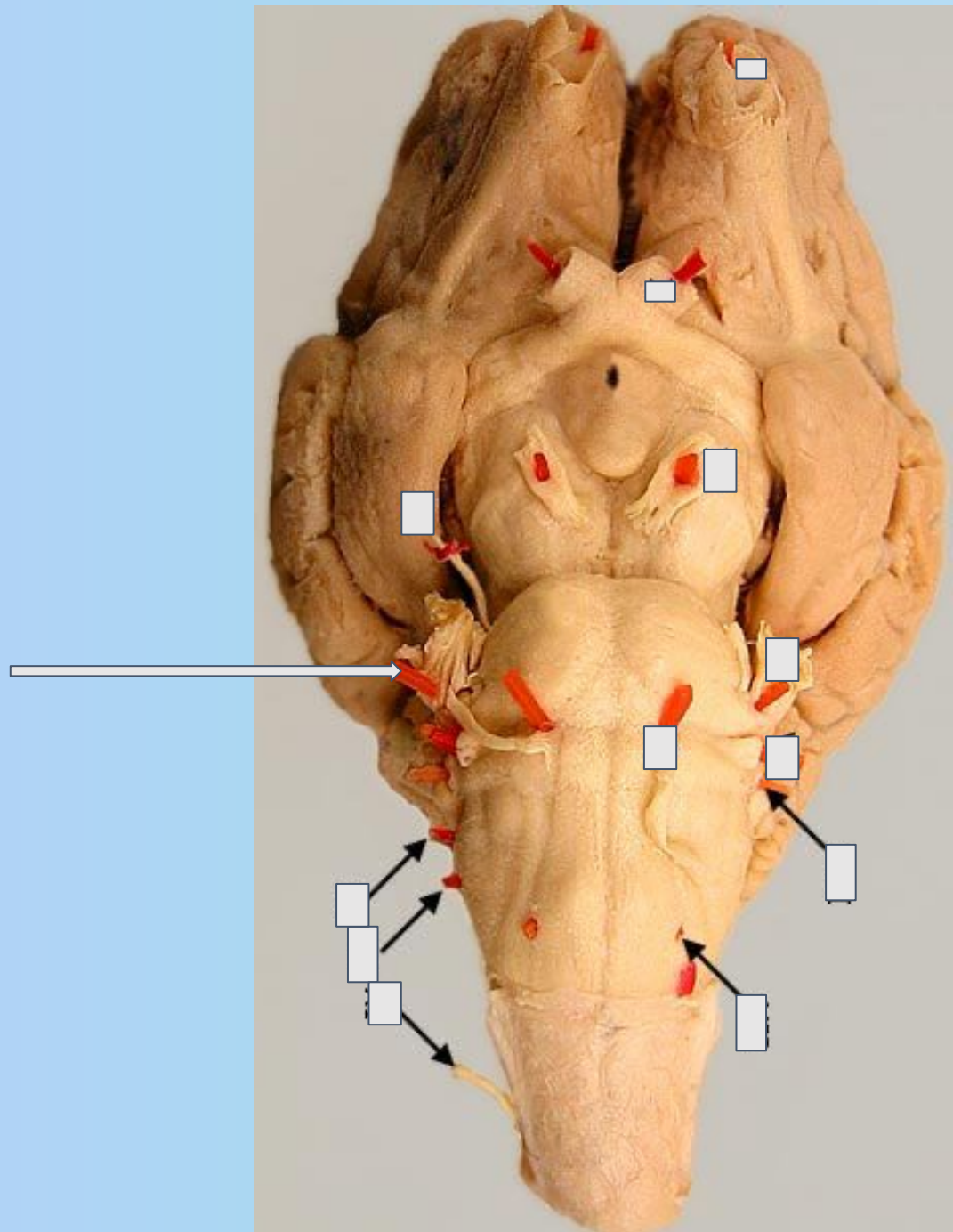
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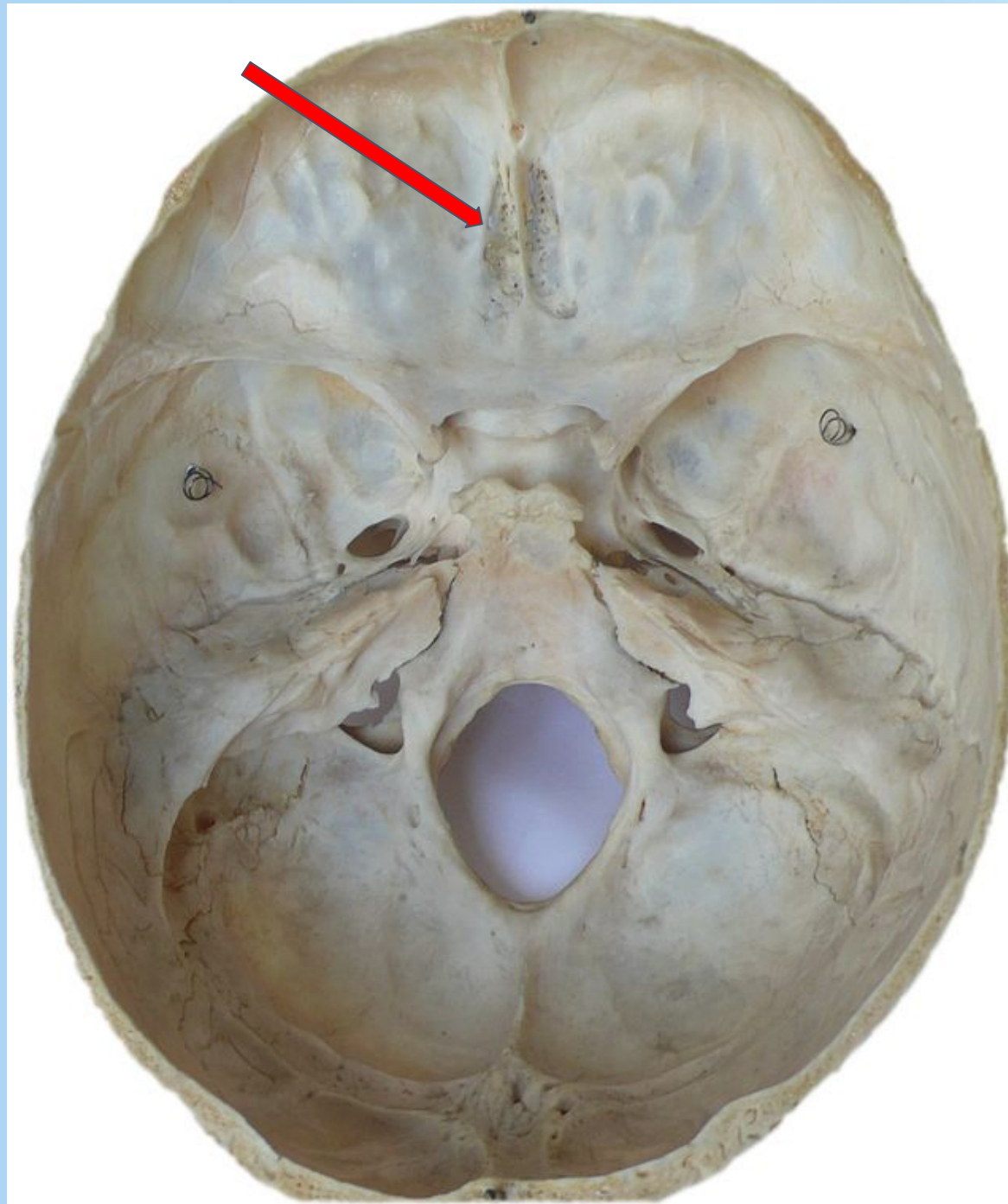
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S



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