

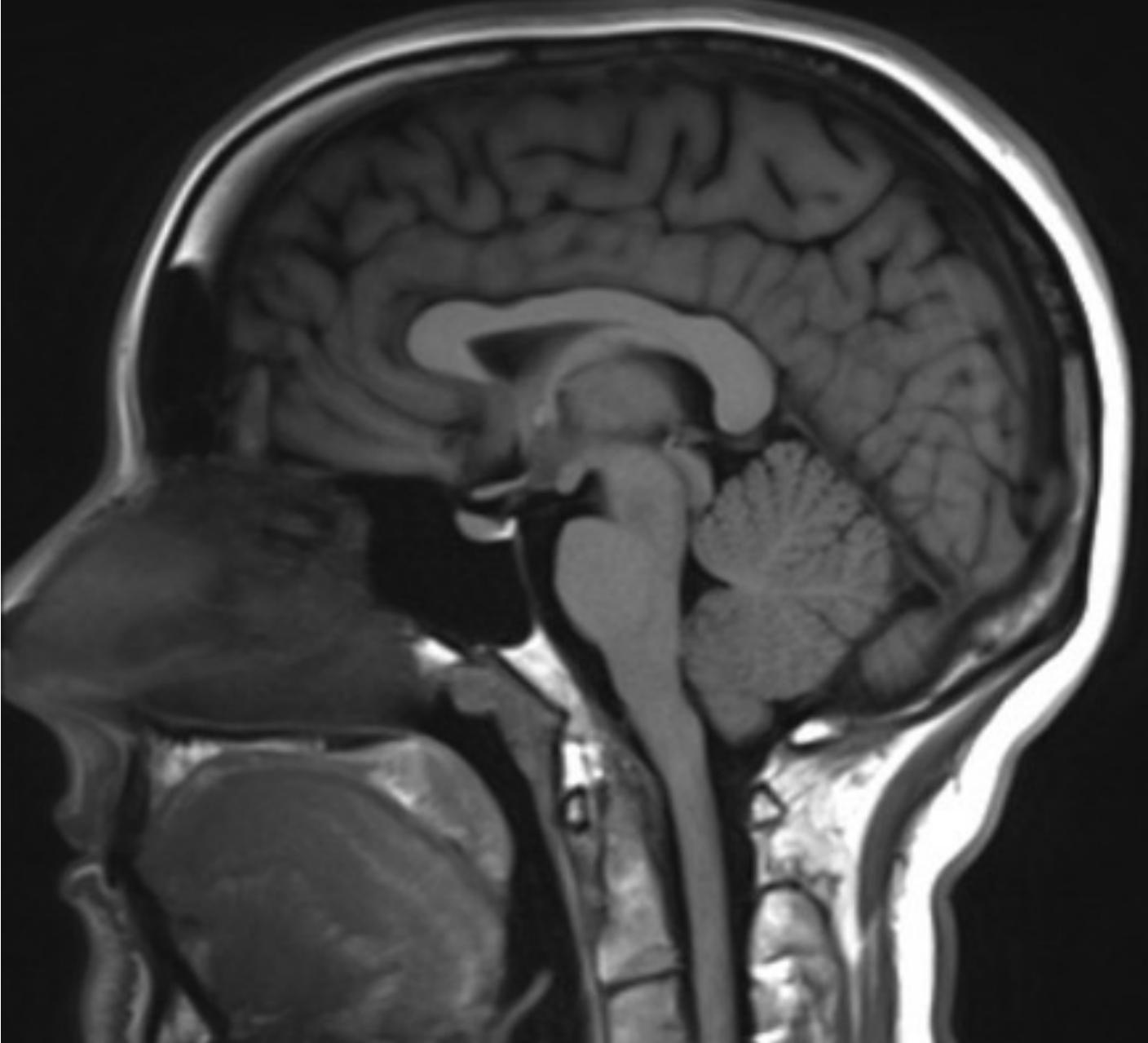
# BRAINSTEM

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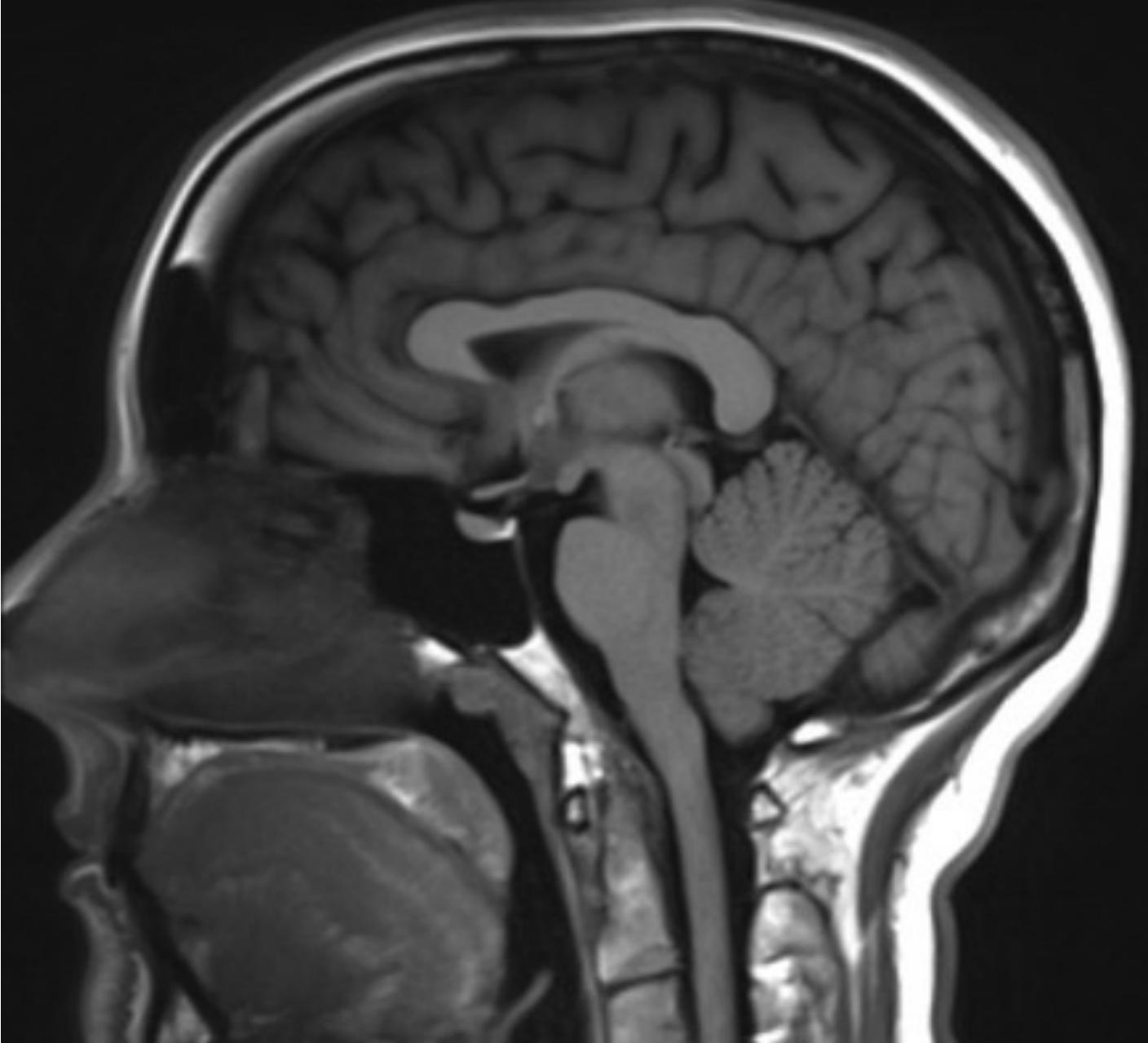
# THE BRAINSTEM



WHAT DO I NEED TO  
KNOW?

1. The big picture
2. 3 sections – midbrain, pons, medulla
  1. Cranial nerves/ nuclei
  2. Sensory/ motor pathways
3. Vascular anatomy
4. CSF spaces
3. Pathologies

# THE BRAINSTEM

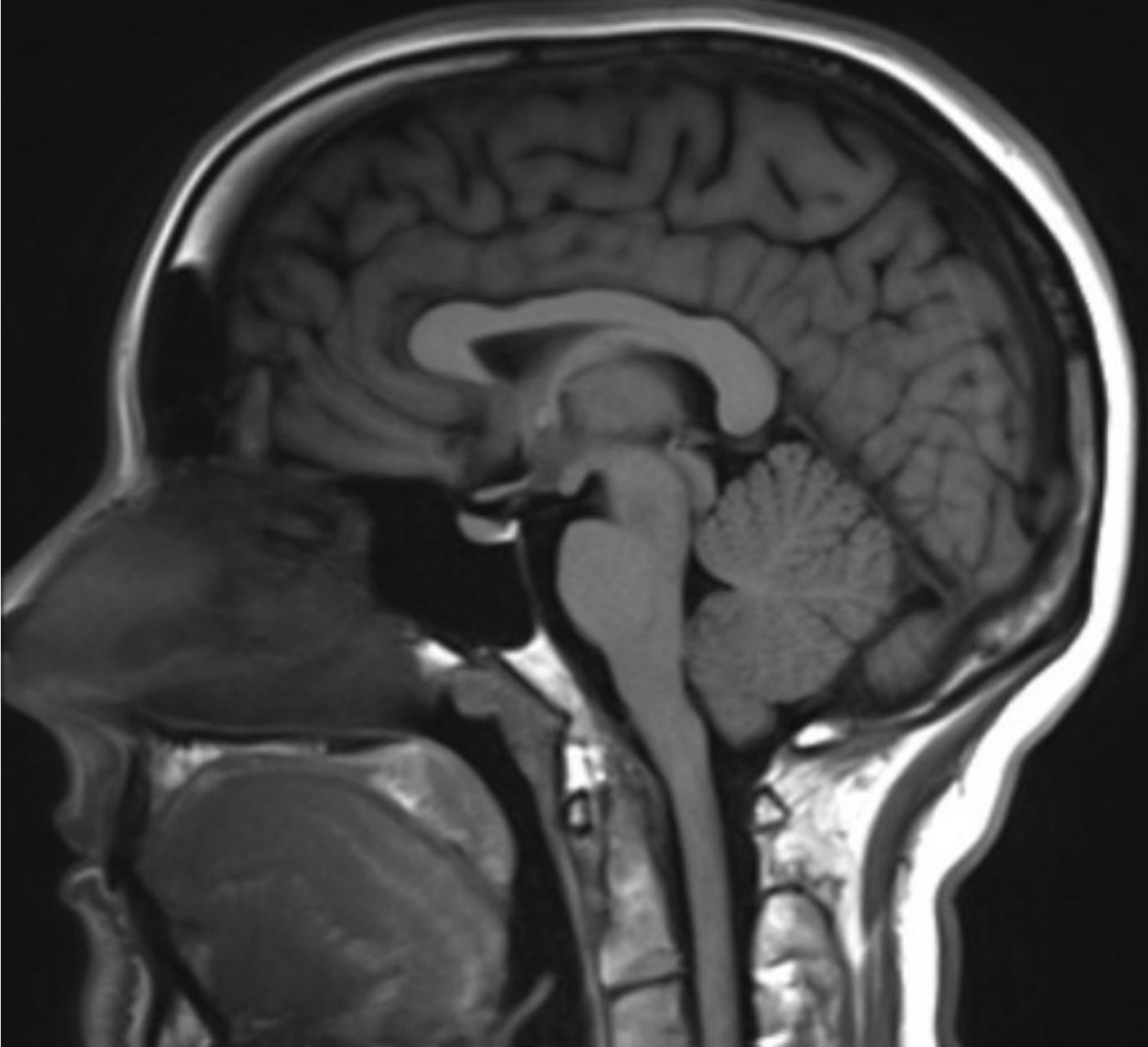


## THE BIG PICTURE

*Small but mighty—the brainstem is responsible for basic life functions:*

- Cardiorespiratory
- Consciousness
- Pain sensitivity
- Conduction

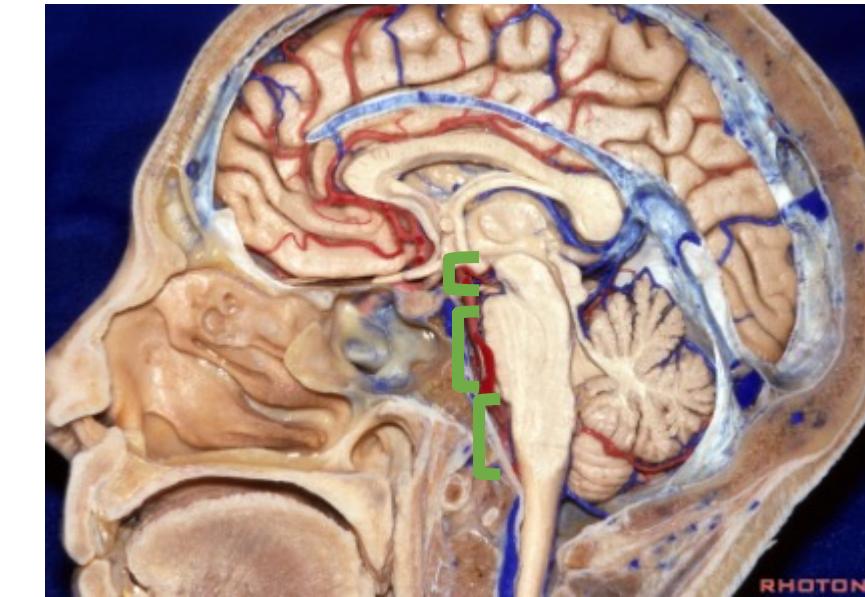
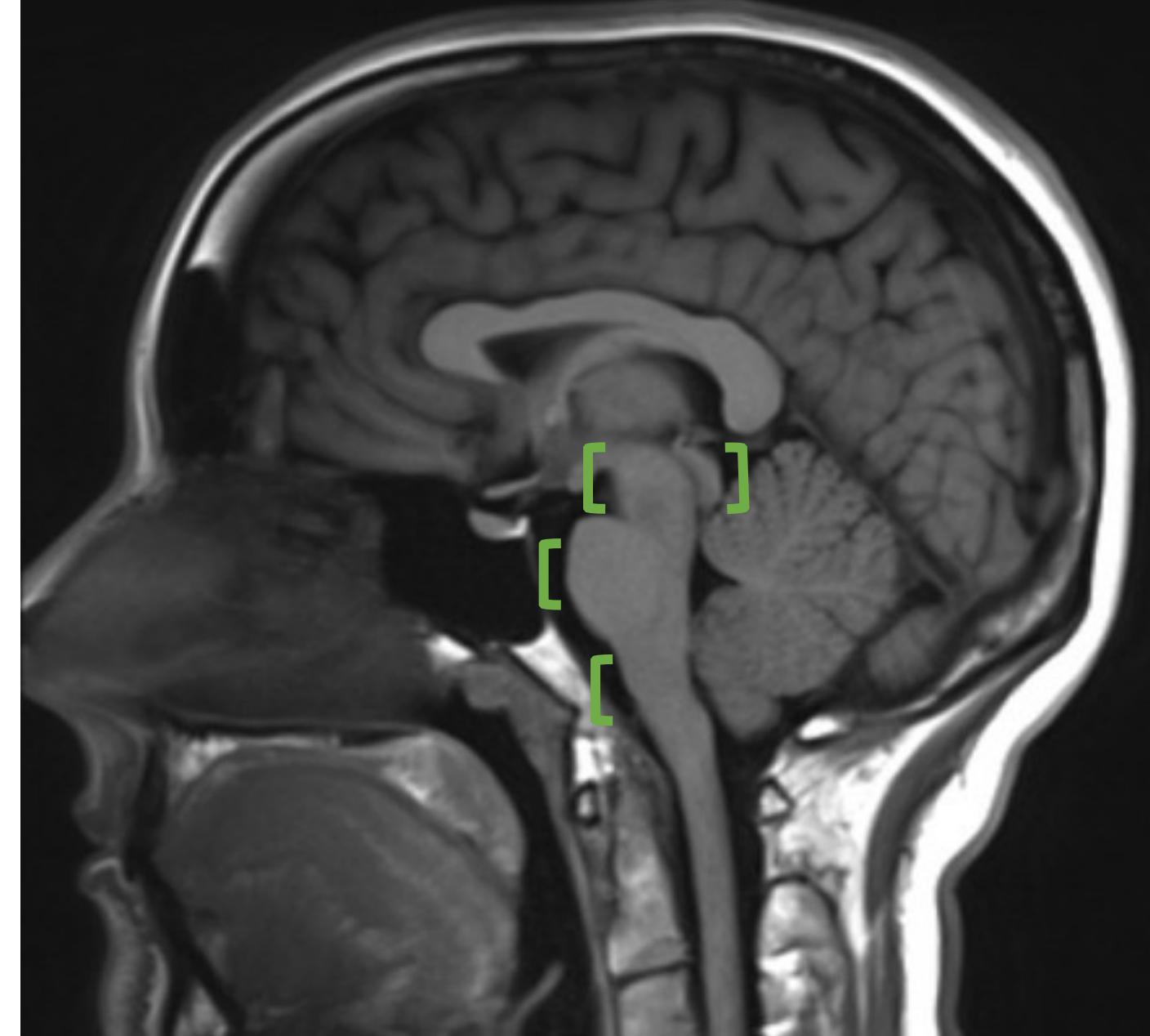
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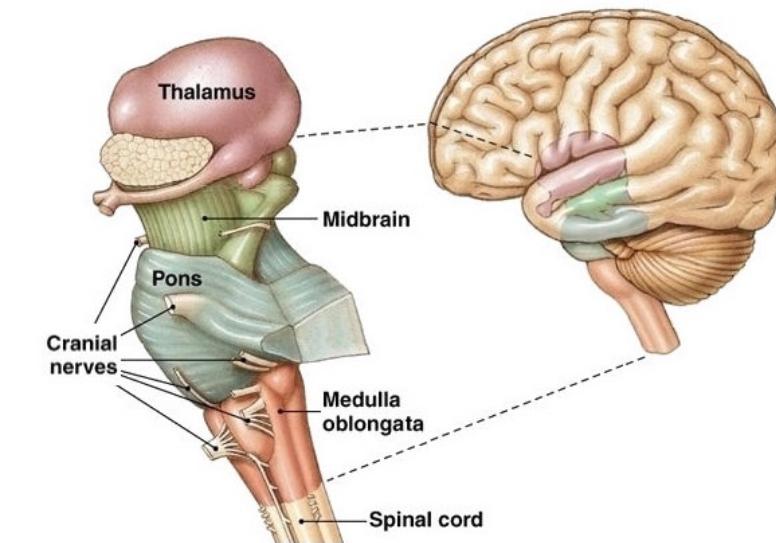
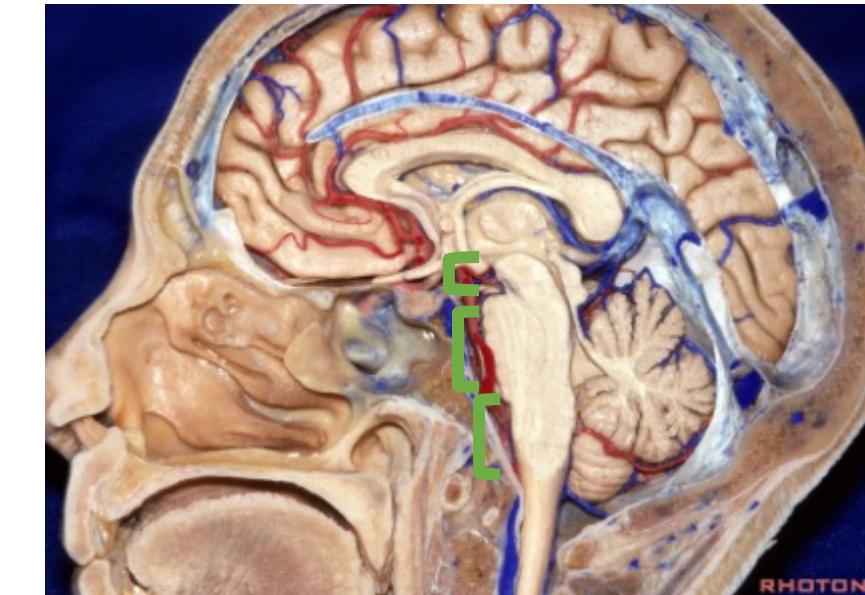
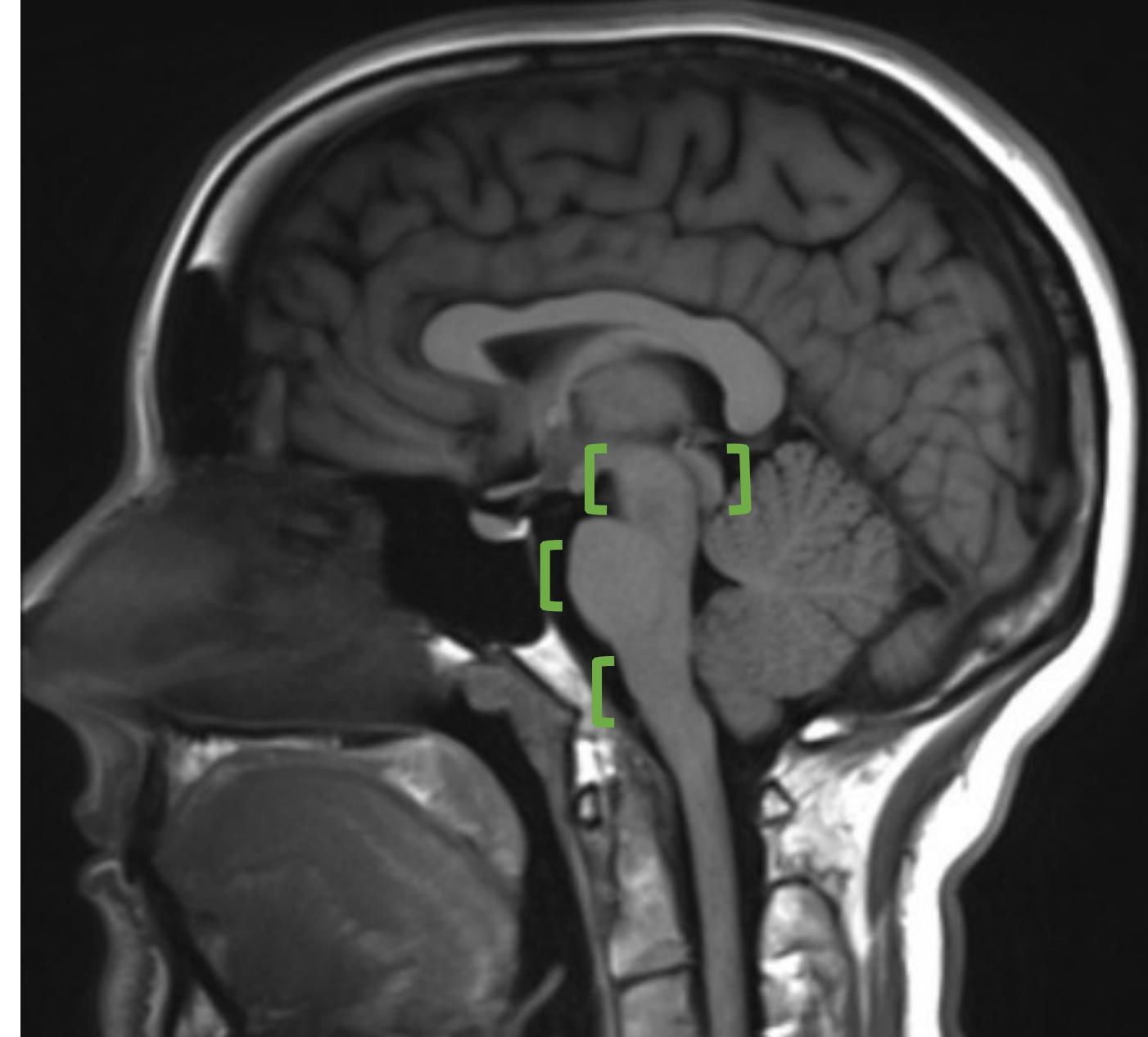
## THE BIG PICTURE

Brainstem pathologies vary from causing "mild" symptoms to devastating neurologic injuries.

# THE BRAINSTEM

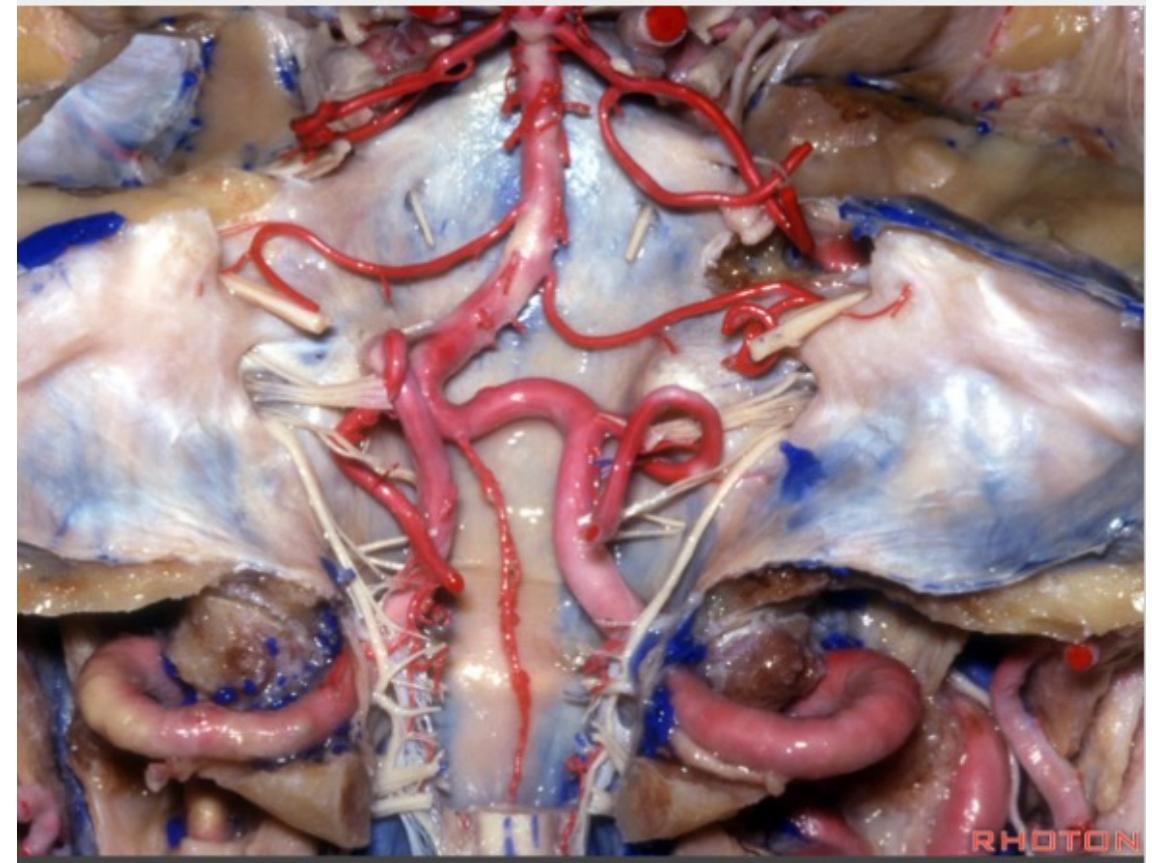
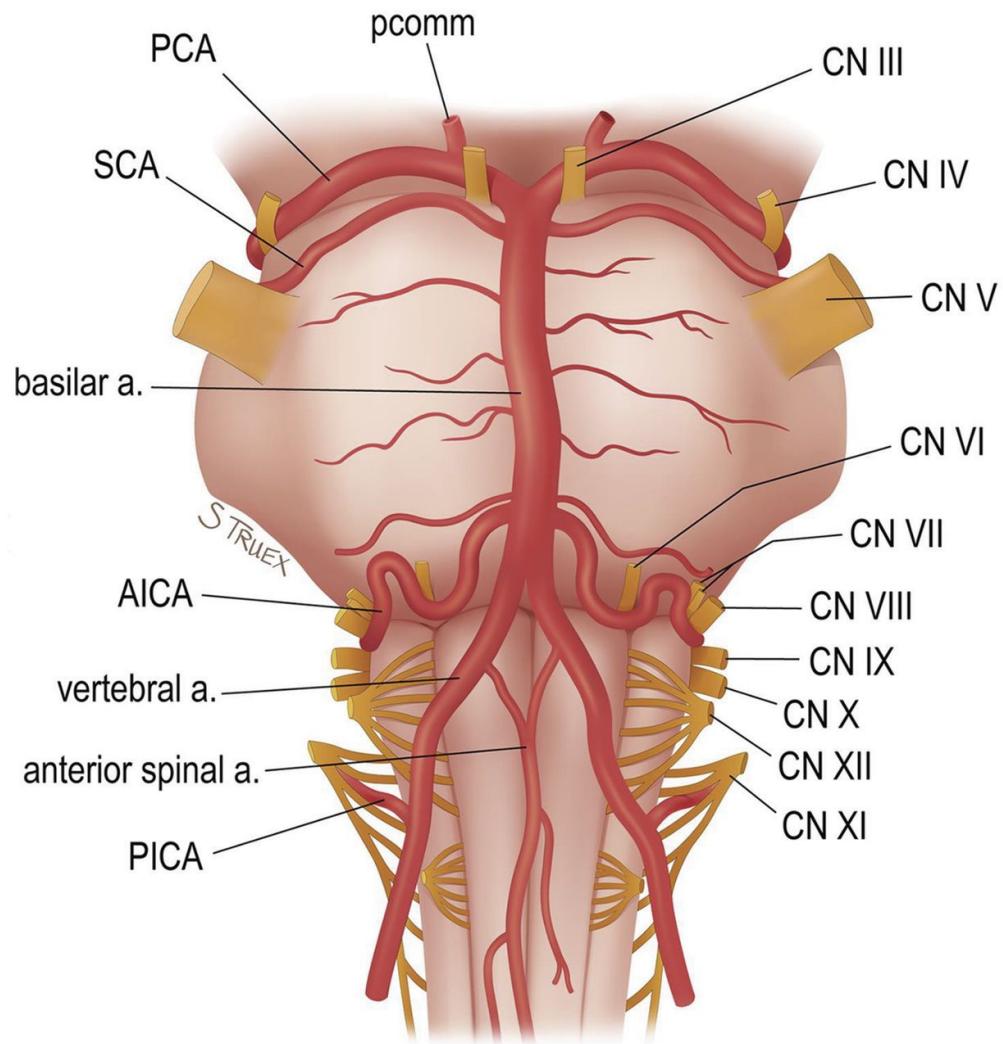


# THE BRAINSTEM



# VASCULAR ANATOMY

# Vascular Anatomy



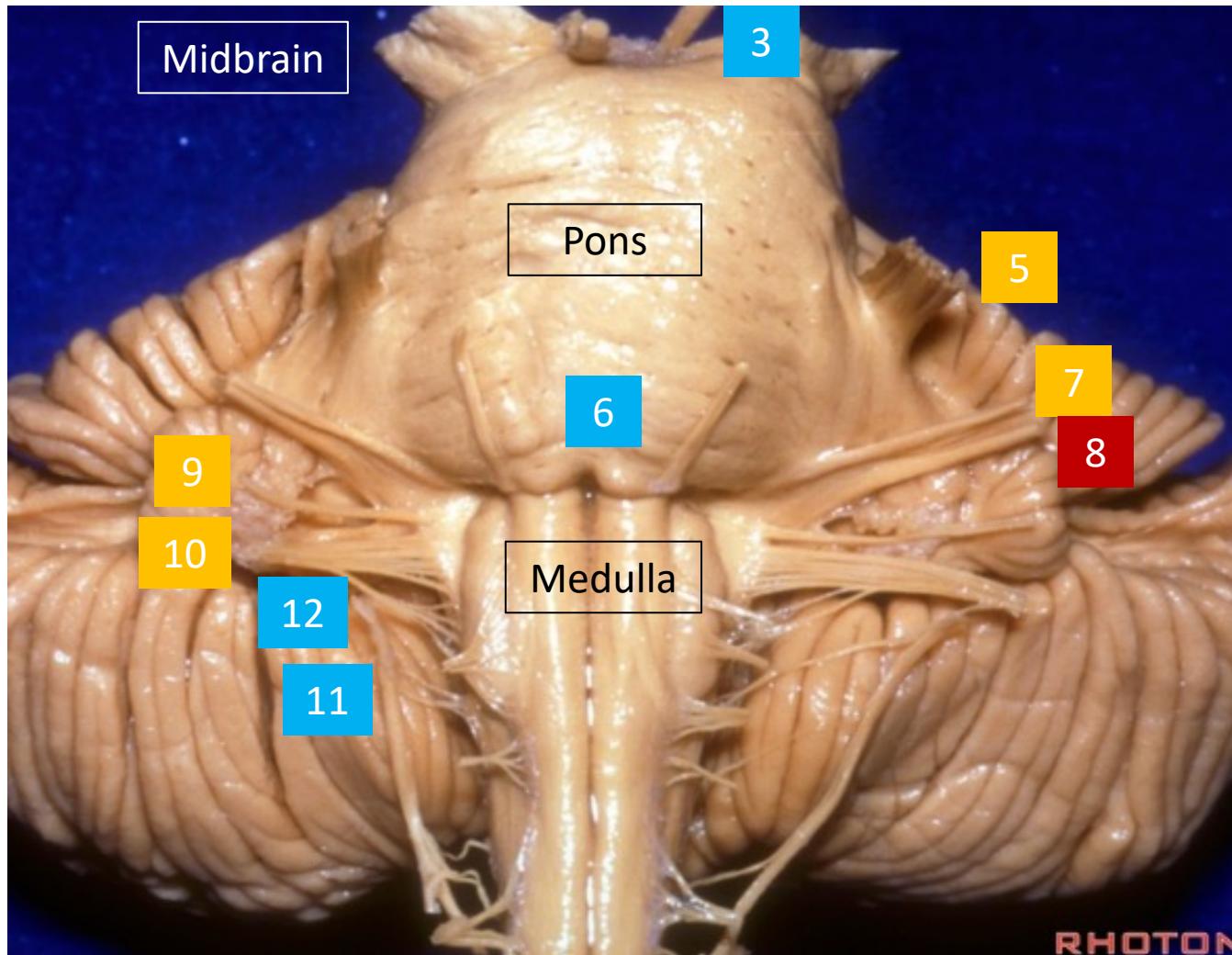
# CRANIAL NERVES

# Cranial nerves

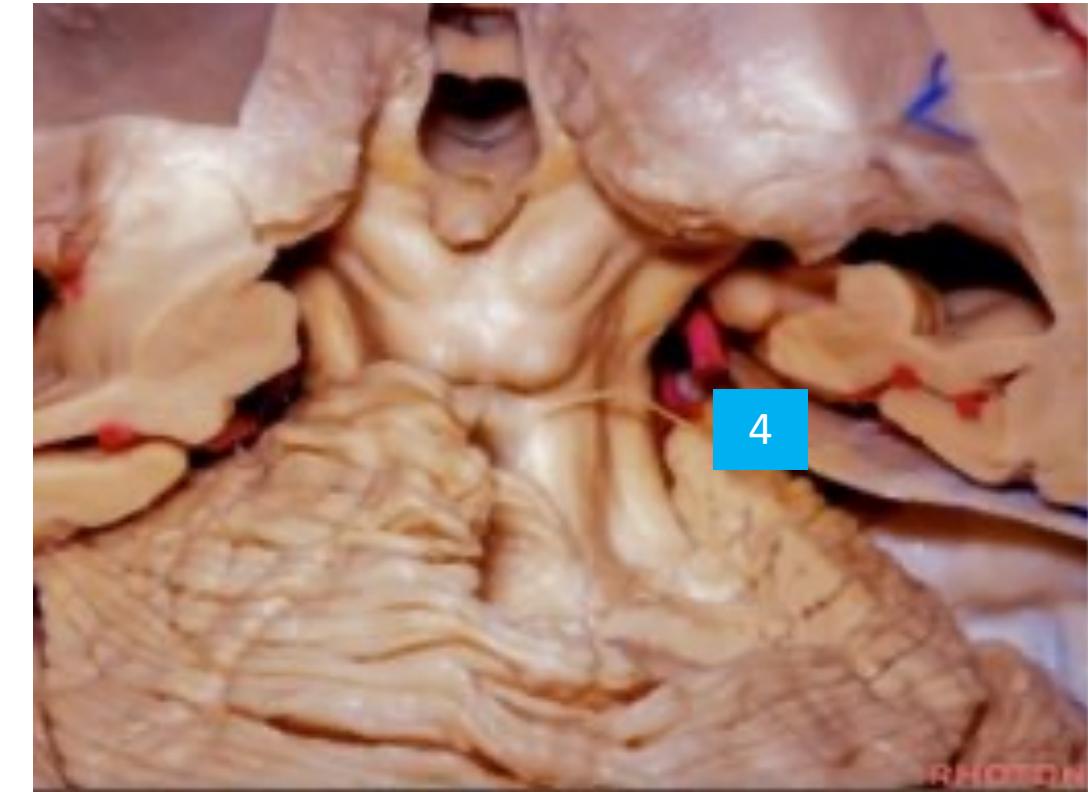
**TABLE A2 ■ The Cranial Nerves and Their Primary Functions**

Cranial nerve	Name	Sensory and/or motor	Major function	Location of cells whose axons form the nerve
I	Olfactory nerve	Sensory	Sense of smell	Nasal epithelium
II	Optic nerve	Sensory	Vision	Retina
III	Oculomotor nerve	Motor	Eye movements; pupillary constriction and accommodation; muscle of upper eyelid	Oculomotor nucleus in midbrain; Edinger-Westphal nucleus in midbrain
IV	Trochlear nerve	Motor	Eye movements (intorsion, downward gaze)	Trochlear nucleus in midbrain
V	Trigeminal nerve	Sensory and motor	Somatic sensation from face, mouth, cornea; muscles of mastication	Trigeminal motor nucleus in pons; trigeminal sensory ganglion (the gasserian ganglion)
VI	Abducens nerve	Motor	Eye movements (abduction or lateral movements)	Abducens nucleus in pons
VII	Facial nerve	Sensory and motor	Controls the muscles of facial expression; taste from anterior tongue; lacrimal and salivary glands	Facial motor nucleus in pons; superior salivatory nuclei in pons; geniculate ganglion
VIII	Vestibulocochlear (auditory) nerve	Sensory	Hearing; sense of balance	Spiral ganglion; vestibular (Scarpa's) ganglion
IX	Glossopharyngeal nerve	Sensory and motor	Sensation from posterior tongue and pharynx; taste from posterior tongue; carotid baroreceptors and chemoreceptors; salivary gland	Nucleus ambiguus in medulla; inferior salivatory nucleus in pons; glossopharyngeal ganglia
X	Vagus nerve	Sensory and motor	Autonomic functions of gut; cardiac inhibition; sensation from larynx and pharynx; muscles of vocal cords; swallowing	Dorsal motor nucleus of vagus; nucleus ambiguus; vagal nerve ganglion
XI	Spinal accessory nerve	Motor	Shoulder and neck muscles	Spinal accessory nucleus in superior cervical cord
XII	Hypoglossal nerve	Motor	Movements of tongue	Hypoglossal nucleus in medulla

# Cranial nerves



Ventral



Dorsal

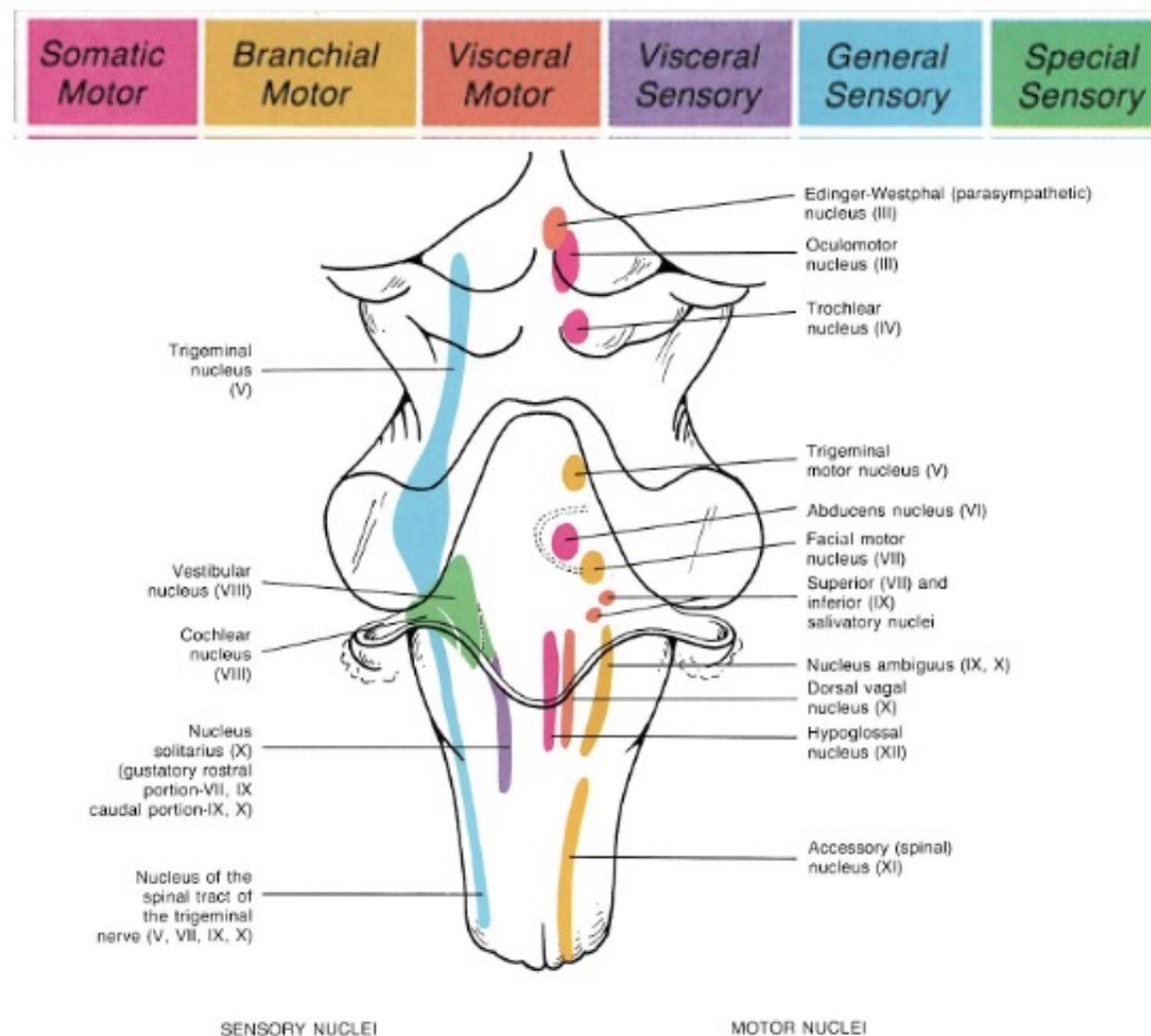
Sensory, Motor, or Both?  
Some Say Money Matters But My Brother Says Big  
Brains Matter More

# Cranial nerve nuclei

**TABLE A3** Classification and Location of the Cranial Nerve Nuclei<sup>a</sup>

Location	Somatic motor	Branchial motor	Visceral motor	General sensory	Special sensory	Visceral sensory
Midbrain	Oculomotor nucleus (III)		Edinger-Westphal nucleus (III)	Trigeminal sensory: mesencephalic nucleus (V, VII, IX, X)		
	Trochlear nucleus (IV)					
Pons	Abducens nucleus (VI)	Trigeminal motor nucleus (V)	Superior salivatory nucleus (VII)	Trigeminal sensory: principal nucleus (V, VII, IX, X)	Vestibular nuclei (VIII)	Nucleus of the solitary tract (VII, IX, X)
		Facial nucleus (VII)	Inferior salivatory nucleus (IX)		Cochlear nuclei (VIII)	
Medulla	Hypoglossal nucleus (XII)	Nucleus ambiguus (IX, X)	Dorsal motor nucleus of vagus (X)	Trigeminal sensory: spinal nucleus (V, VII, IX, X)		
		Spinal accessory nucleus (XI)	Nucleus ambiguus (X)			

<sup>a</sup> Associated cranial nerves are shown in parentheses.

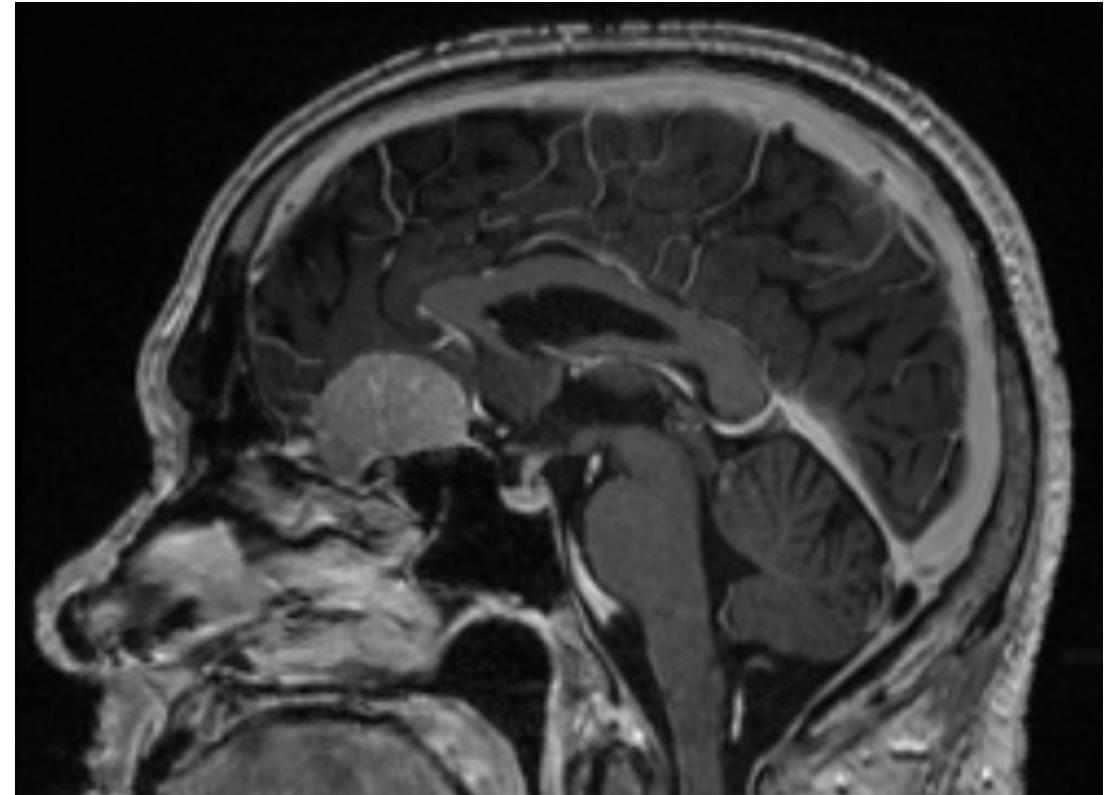
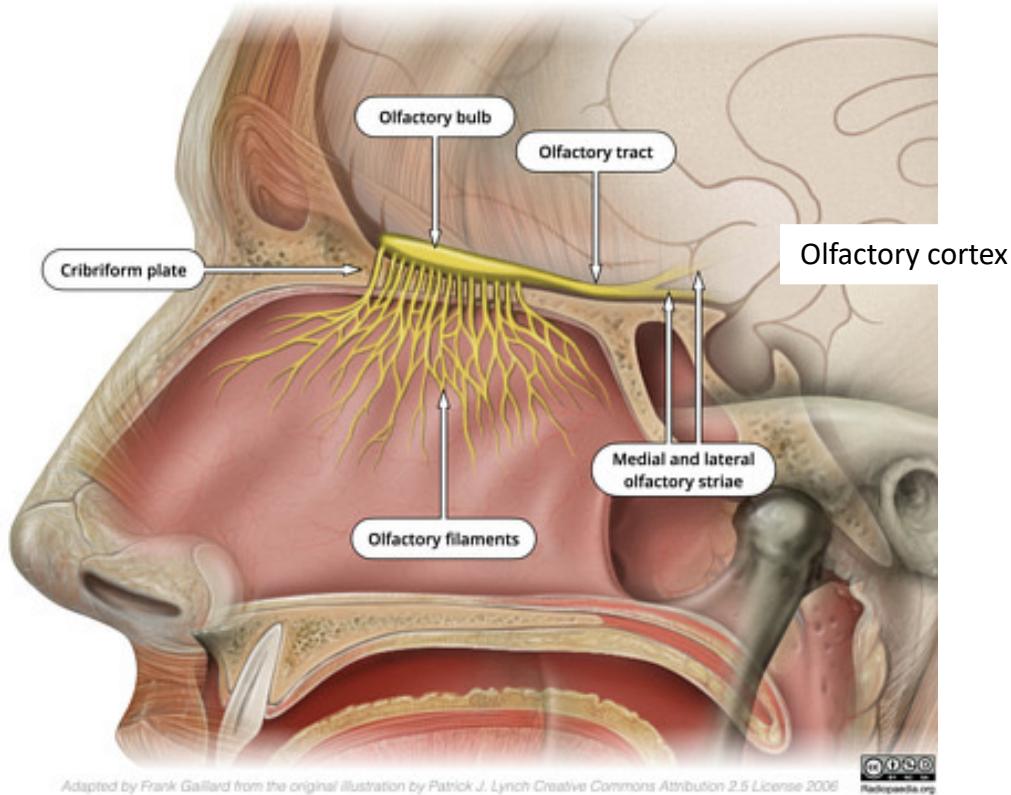


# CN 1: Olfactory nerve (sensory)

Function: sense of smell

Dysfunction: anosmia

Sample pathologies: trauma, COVID-19, olfactory groove meningioma

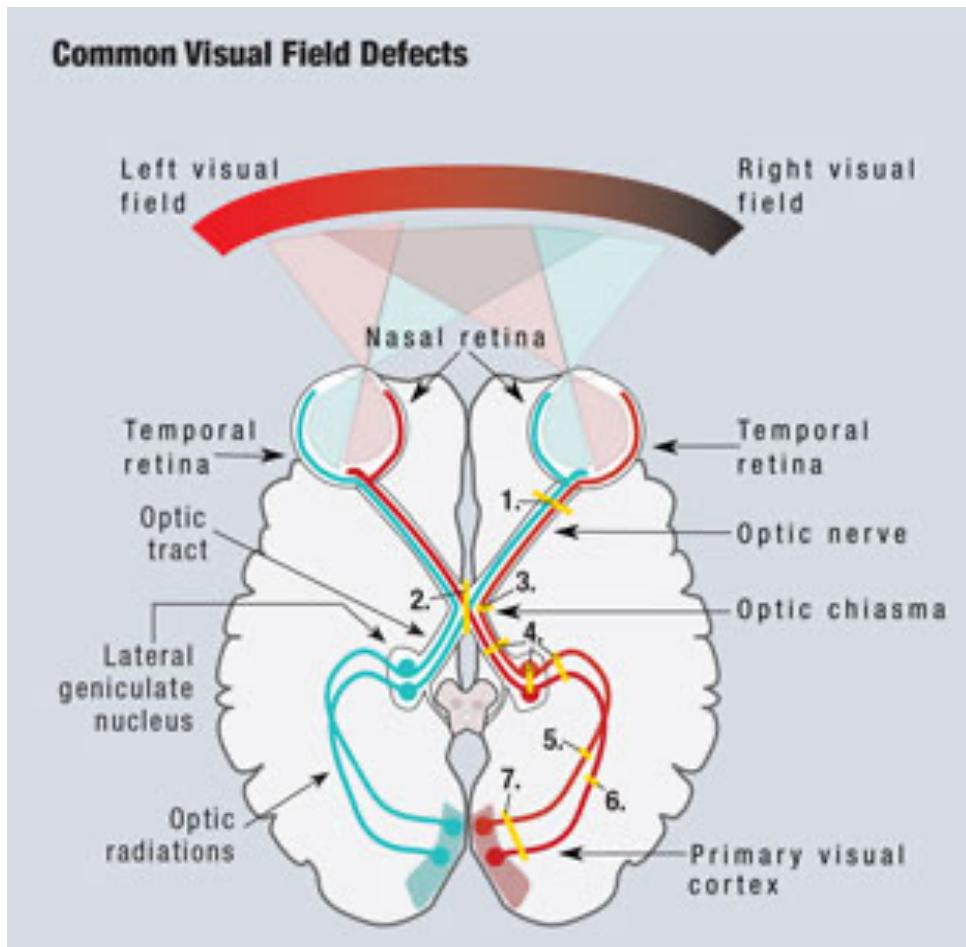


# CN 2: Optic nerve (sensory)

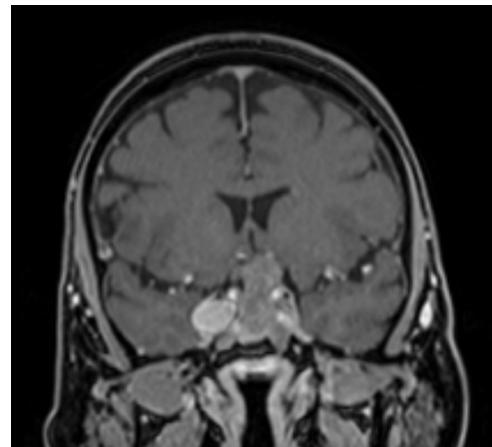
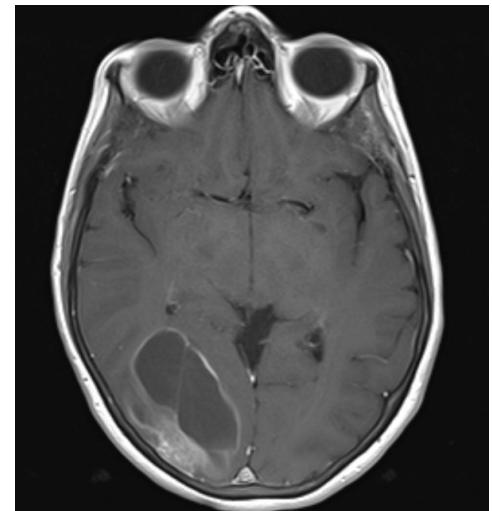
Function: visual information, pupillary light reflex (w/ CN3)

Dysfunction: visual field deficits/ vision loss

Sample pathologies: optic nerve glioma (neurofibromatosis 1), pituitary adenoma/ apoplexy, stroke, cortical tumors



L	R	
1.	Monocular vision loss	1. Optic nerve
2.	Bitemporal hemianopia	2. Optic chiasma
3.	Monocular nasal hemianopia	3. Optic tract
4.	Homonymous hemianopia	4. Optic radiation
5.	Inferior homonymous quadrantanopia (parietal optic radiations)	5. Optic radiation
6.	Superior homonymous quadrantanopia (temporal optic radiations AKA Meyer's loop)	6. Optic radiation
7.	Homonymous hemianopia w/ macular sparing	7. Primary visual cortex

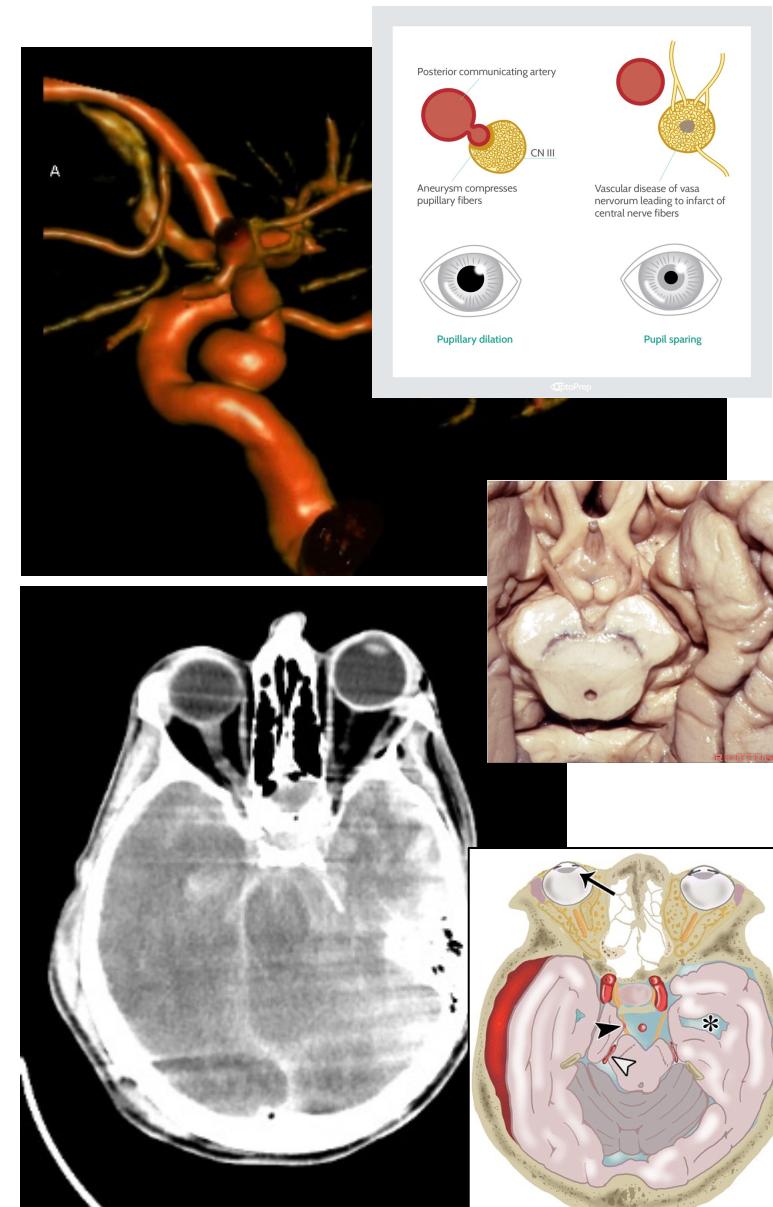
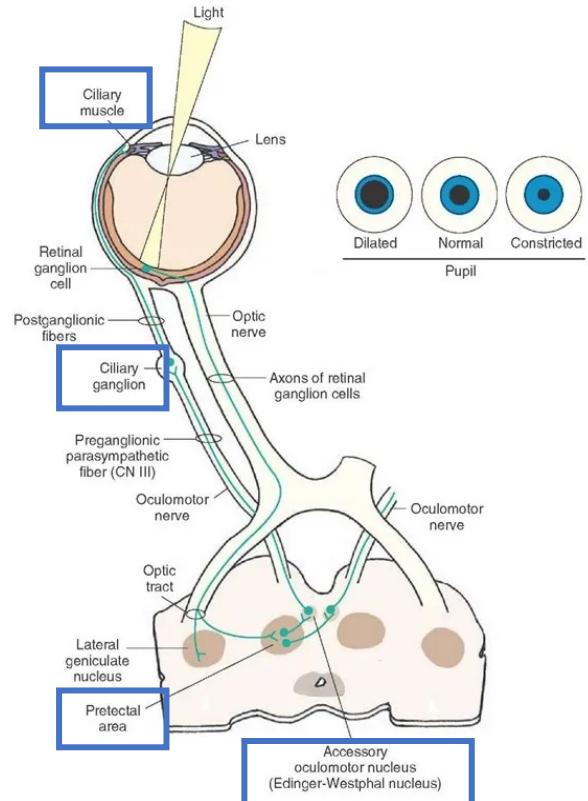
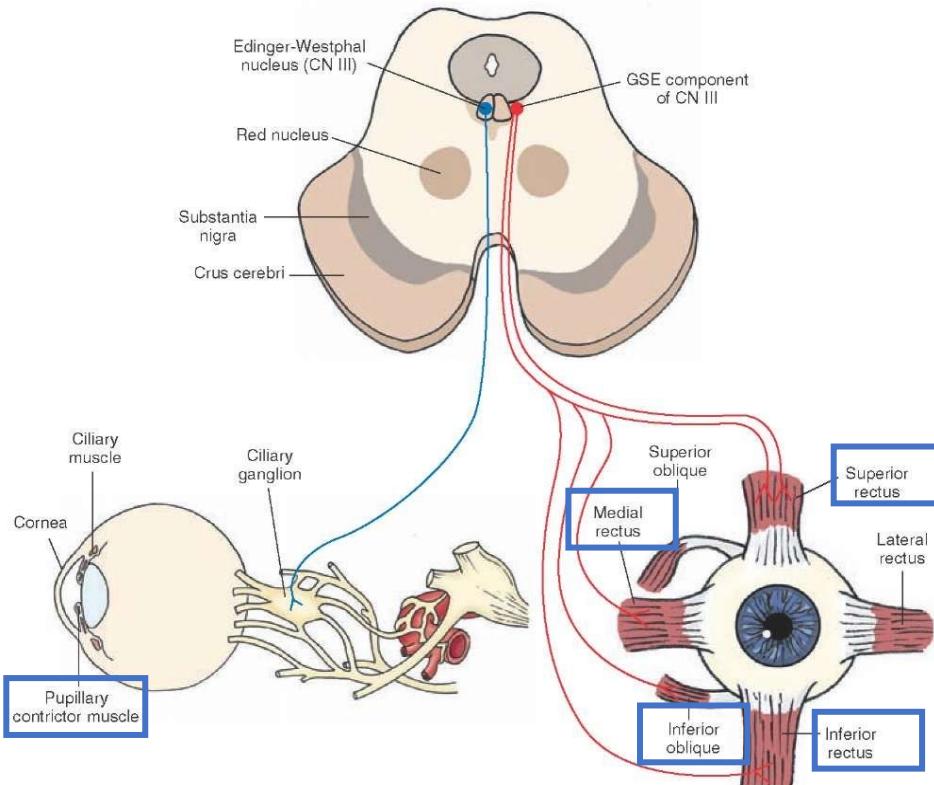


# CN 3: Oculomotor nerve (motor)

Function: eye movements (somatomotor), pupillary light reflex (visceromotor)

Dysfunction: EOM palsy (down + out), ptosis, mydriasis

Sample pathologies: PComm aneurysm, uncal herniation, ischemia



Extraocular muscles: Superior rectus, inferior rectus, inferior oblique, medial rectus, levator palpebrae

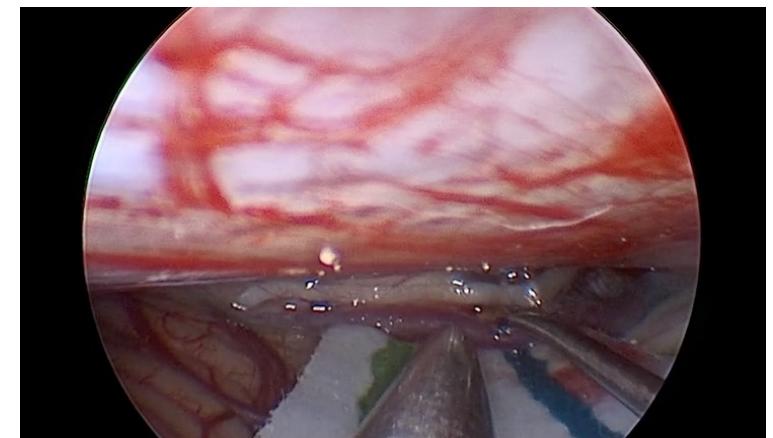
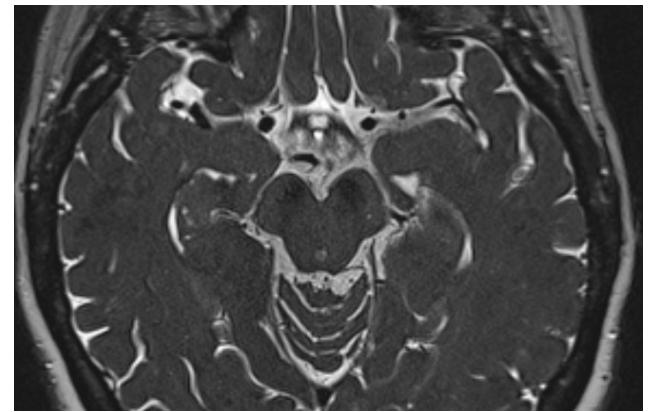
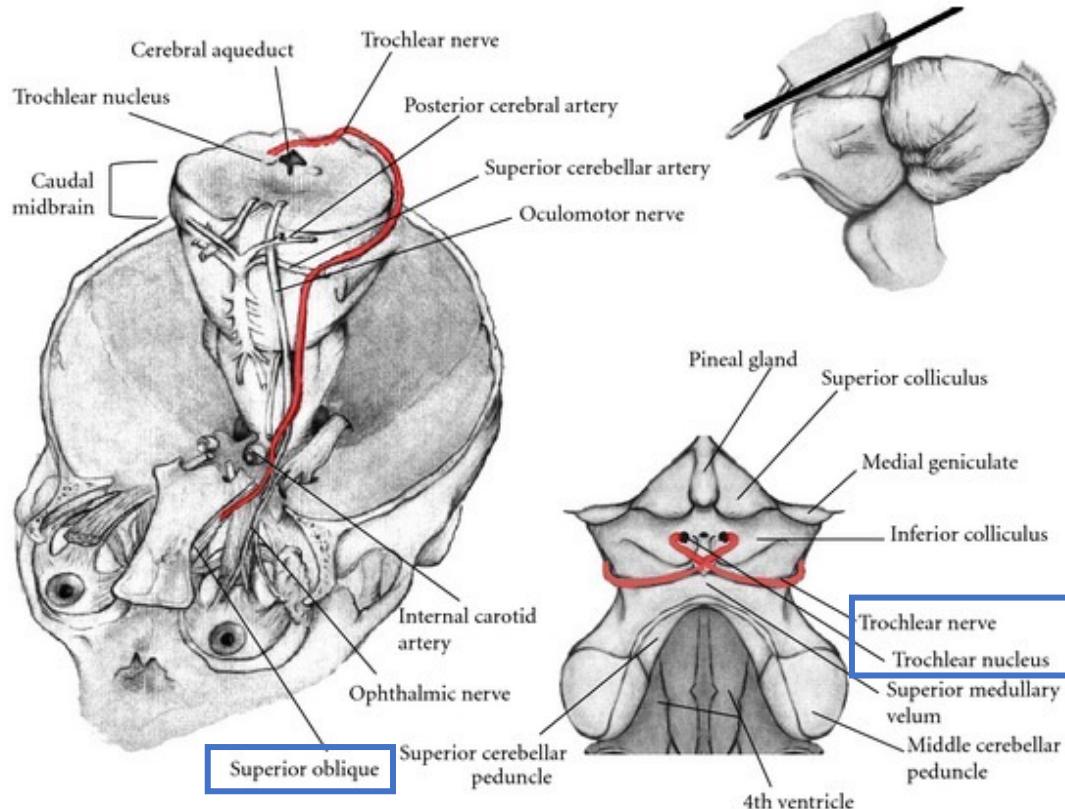
Autonomic muscles: pupillary sphincter and ciliary muscles

# CN 4: Trochlear nerve (motor)

**Function:** Superior oblique muscle (intort/ depress/ abduct globe)

**Dysfunction:** inability to move eye in inward rotation/ down/ lateral

**Sample pathologies:** idiopathic, trauma, ischemia, tumor, intracranial hypertension, superior oblique myokymia

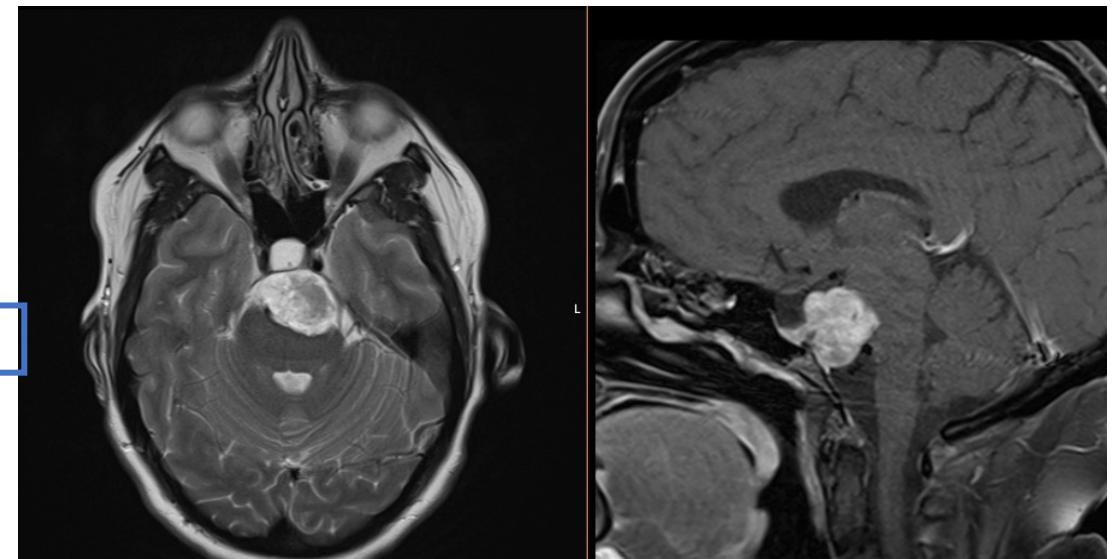
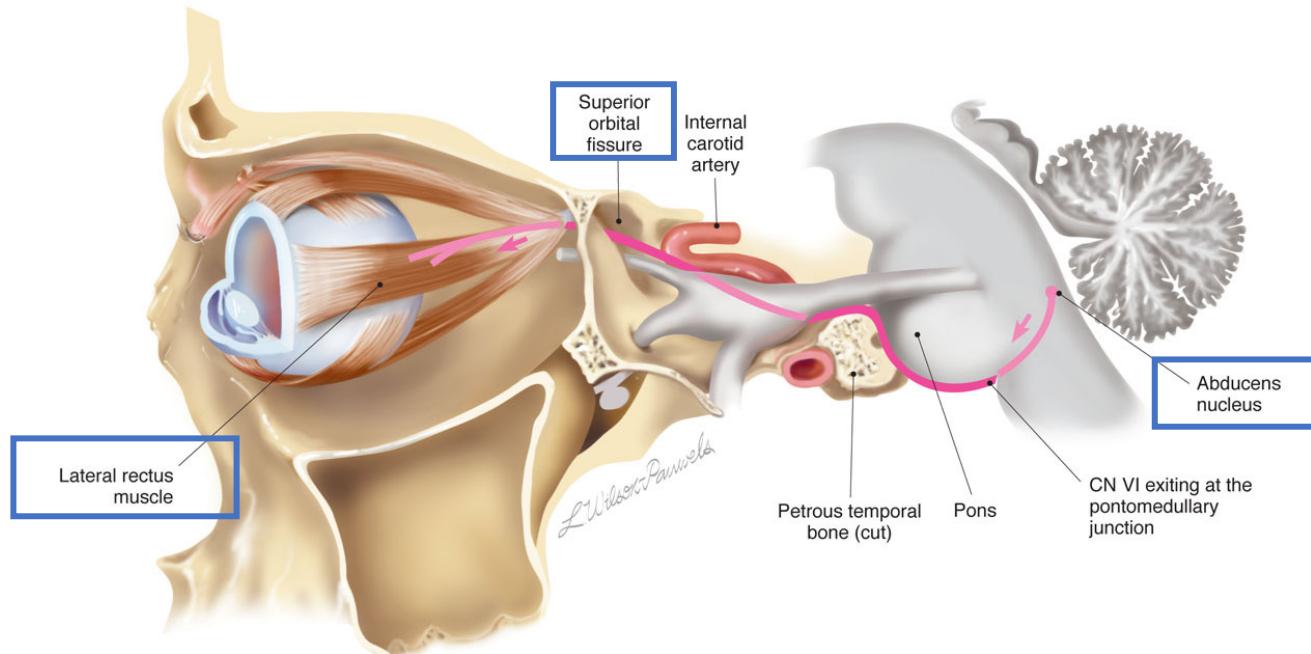


# CN 6: Abducens nerve (motor)

Function: Lateral rectus muscle

Dysfunction: inability to move eye laterally

Sample pathologies: trauma, intracranial hypertension, cavernous sinus lesion, tumor, ischemia



**Figure VI-1** Overview of the abducens nerve.

From Cranial Nerves 3rd Ed. ©2010 Wilson-Pauwels, Stewart, Akesson, Spacey, PMPH-USA

# CN 3/4/6 palsies

**Extraocular Movement**

Normal

For deficit affecting the **RIGHT** eye:

**CN III Palsy**  
Lateral deviation  
Downward deviation  
Ptosis

**CN IV Palsy**  
Upward deviation

**CN VI Palsy**  
Medial deviation

← Look Right      Look Straight      Look Left →

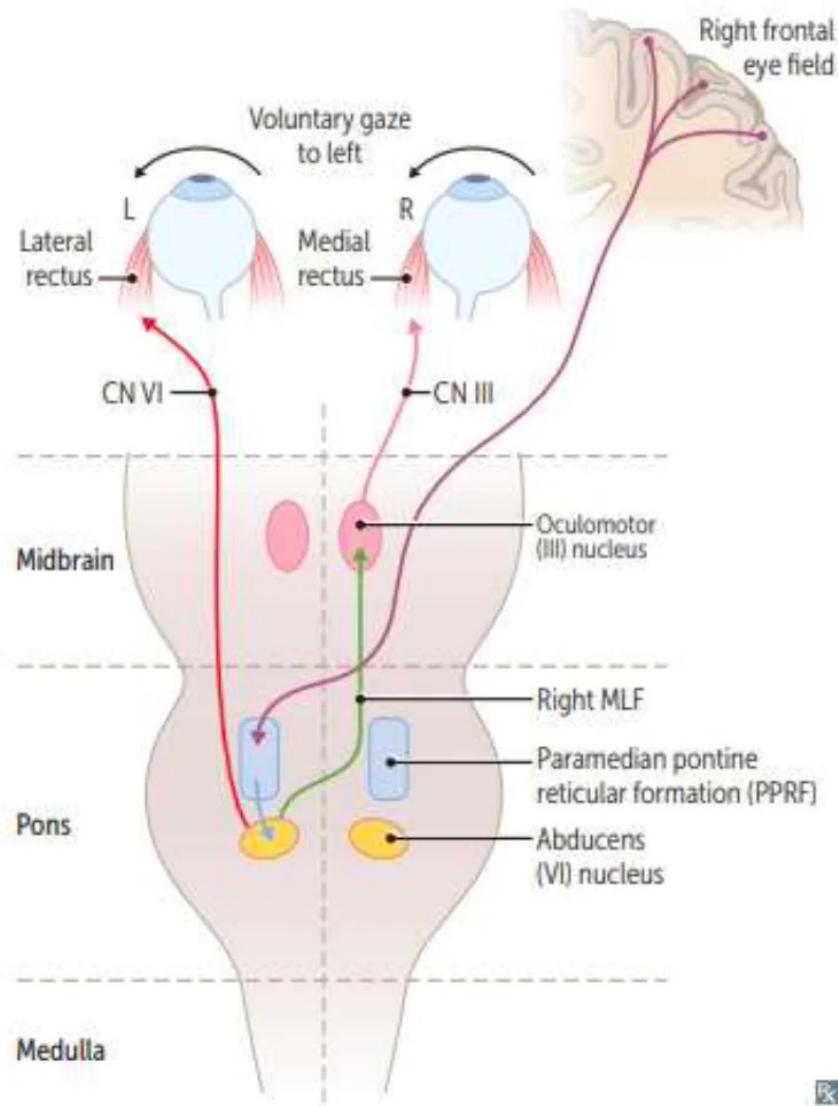
The diagram illustrates the extraocular muscles and their insertions on the eye globe. It shows three positions: 'Look Right' (left gaze), 'Look Straight' (mid-gaze), and 'Look Left' (right gaze). The muscles are labeled as follows:

- Look Right:** Superior Rectus (SR), Superior Oblique (SO), Lateral Rectus (LR), Medial Rectus (MR), Inferior Oblique (IO), Inferior Rectus (IR).
- Look Straight:** Superior Rectus (SR), Superior Oblique (SO), Lateral Rectus (LR), Medial Rectus (MR), Inferior Oblique (IO), Inferior Rectus (IR).
- Look Left:** Superior Rectus (SR), Superior Oblique (SO), Lateral Rectus (LR), Medial Rectus (MR), Inferior Oblique (IO), Inferior Rectus (IR).

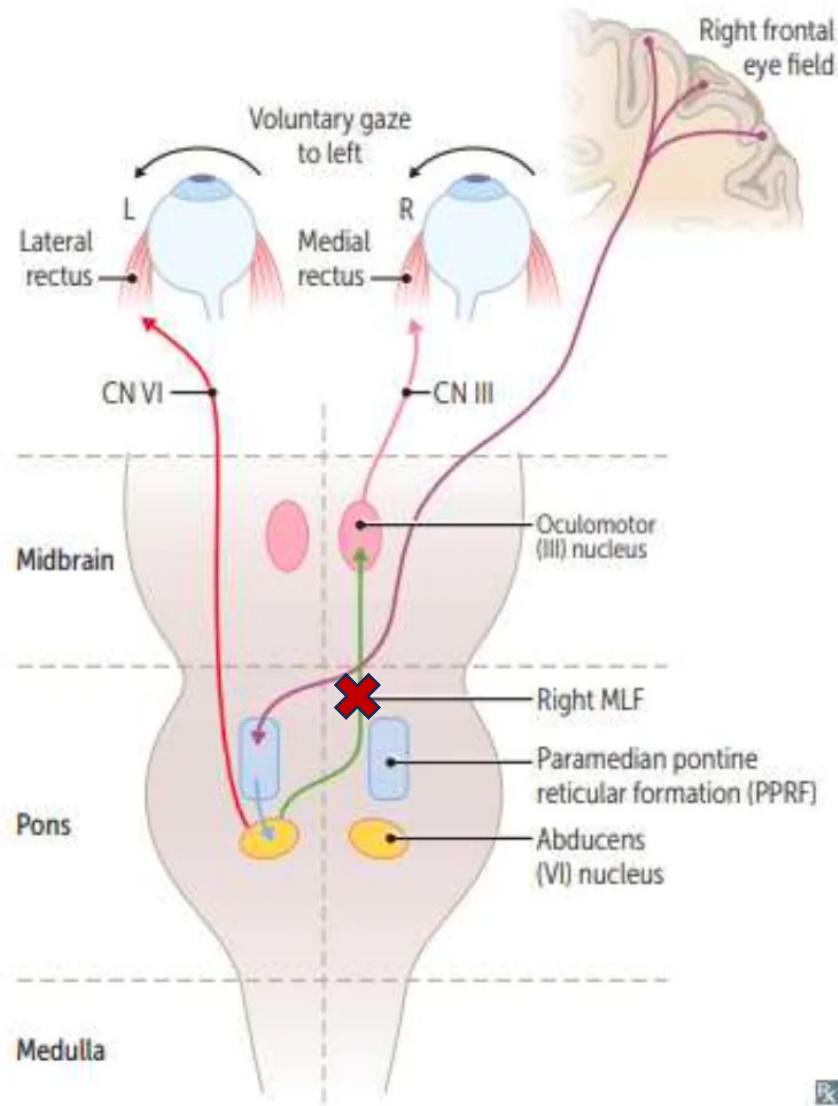
Below the diagrams, three rows of eye images show the effects of palsies on each eye's movement.

[fpnotebook.com](http://fpnotebook.com)

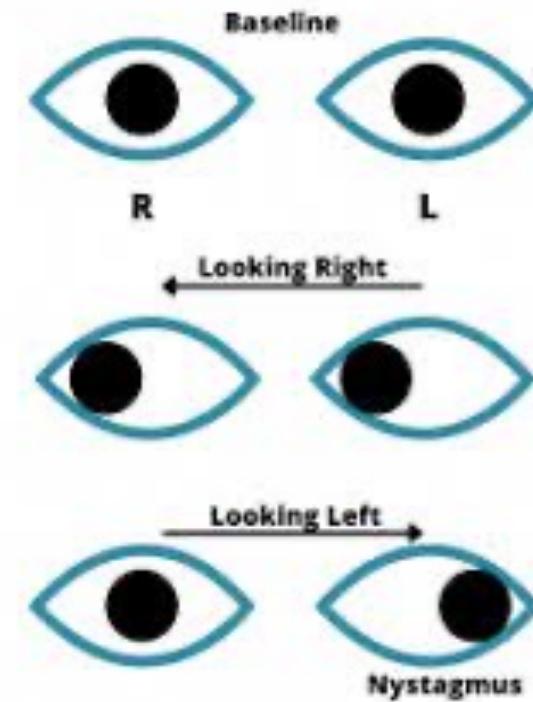
# CN 3+6 work together



# CN 3+6 work together



**INTERNUCLEAR OPHTHALMOPLEGIA:**  
*LESION OF RIGHT MEDIAL LONGITUDINAL FASCICULUS*

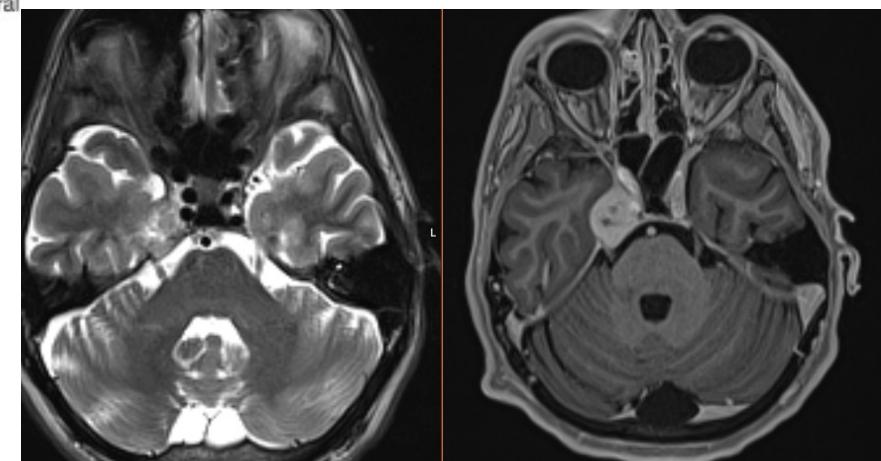
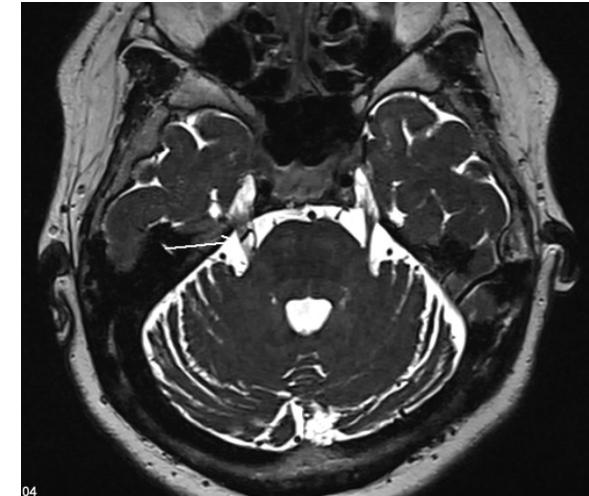
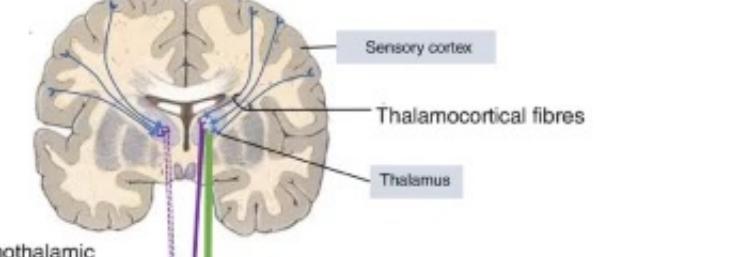
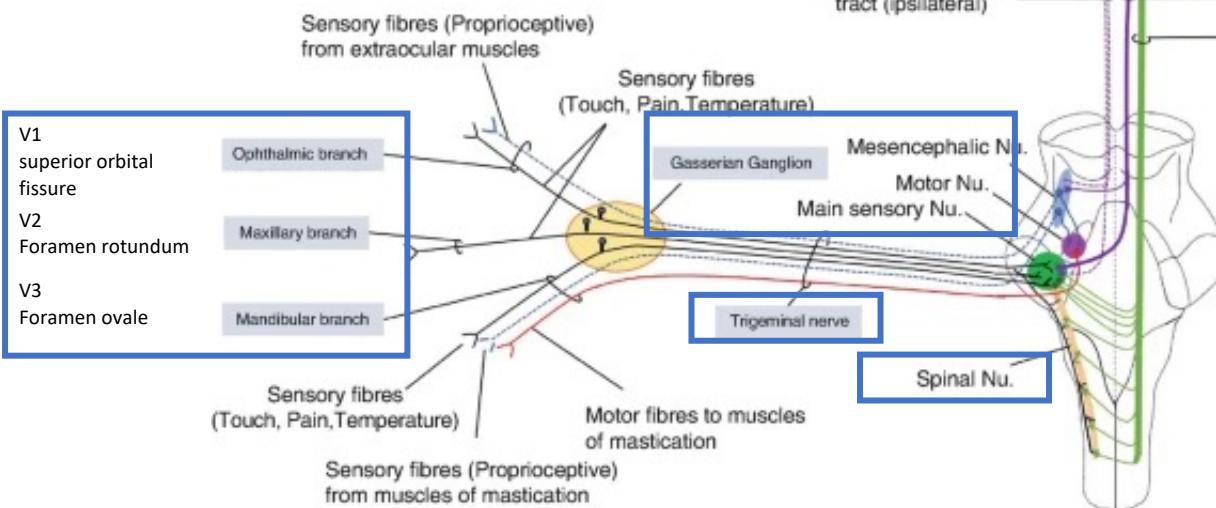
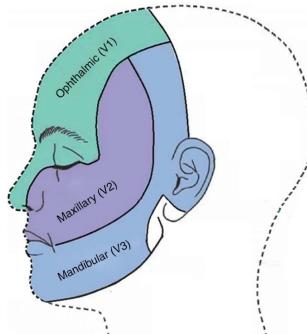


# CN 5: Trigeminal nerve (sensorimotor)

Function: Facial sensation, mastication muscles, corneal reflex (w/ CN7), jaw-jerk reflex

Dysfunction: facial numbness/ paresthesias, inability to chew

Sample pathologies: Trigeminal neuralgia, schwannoma



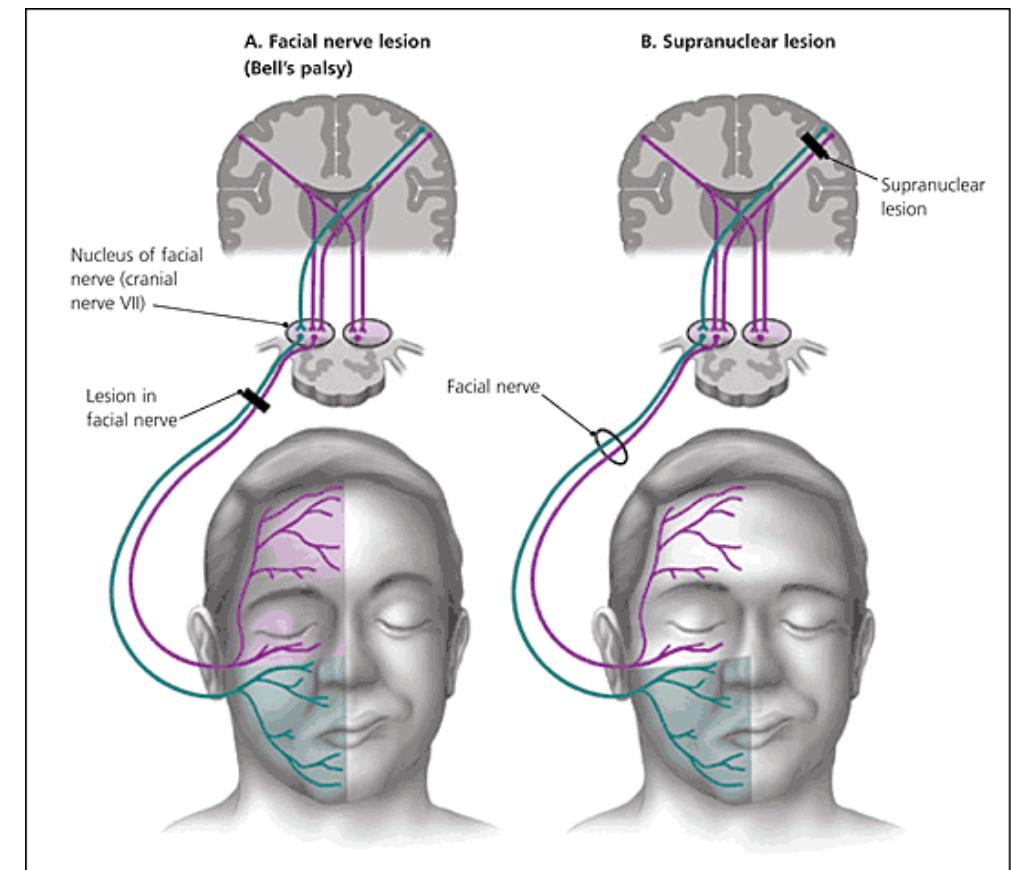
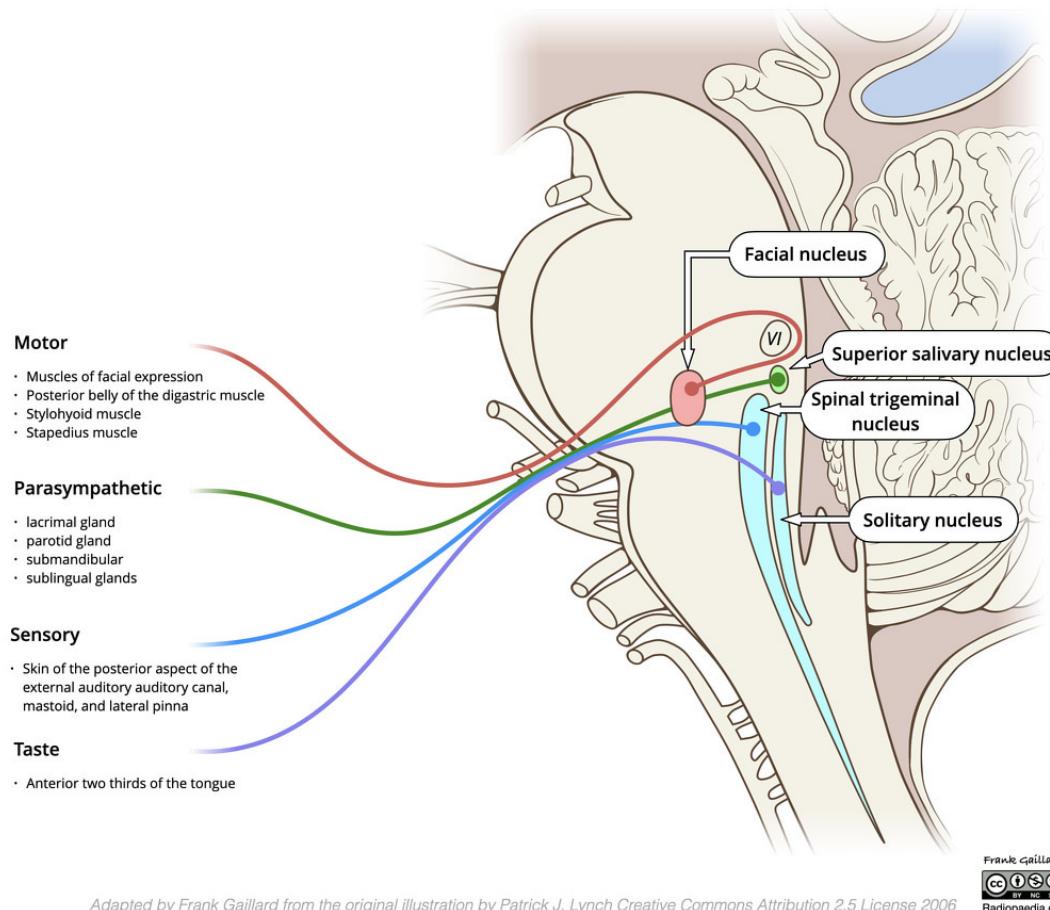
Motor supply: temporalis, masseter, pterygoids, anterior digastric; tensor tympani; tensory veli palatini

# CN 7: Facial nerve (sensorimotor)

Function: Muscles of facial expression, taste anterior 2/3 tongue, lacrimal/ salivary glands, corneal reflex (w/ CN 5)

Dysfunction: facial weakness, abnormal taste, absent lacrimation/ salivation

Sample pathologies: Hemifacial spasm, stroke, Bell's palsy, trauma, tumor

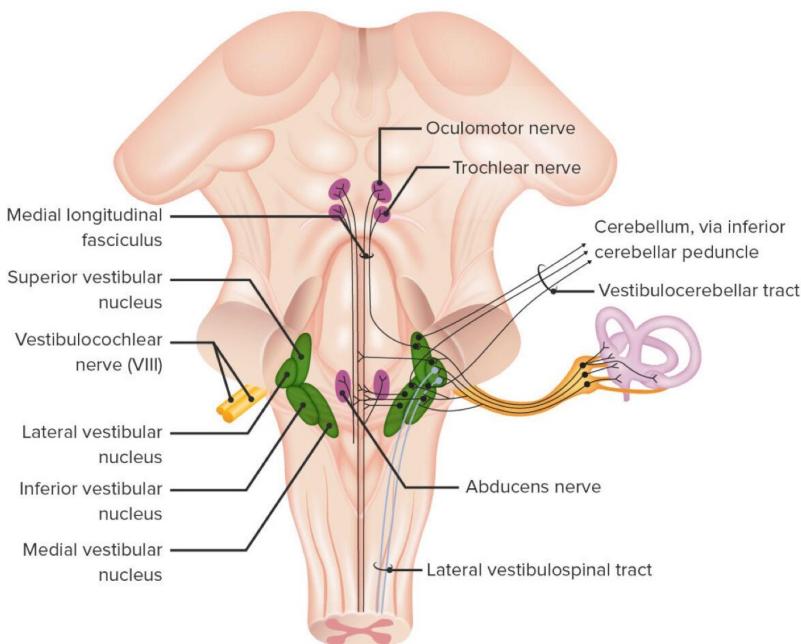
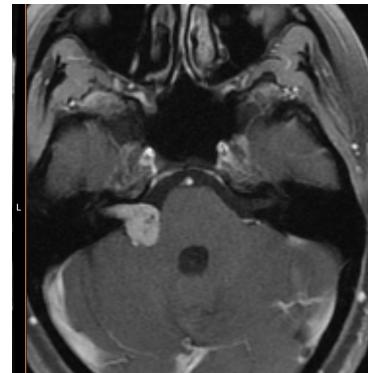


# CN 8: Vestibulocochlear nerve (sensory)

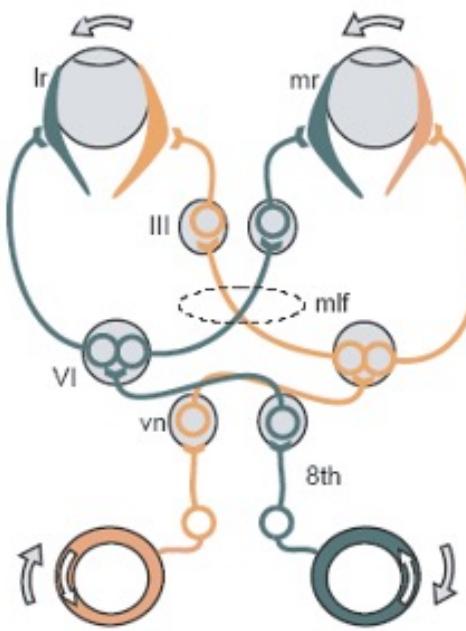
Function: Hearing, balance; vestibulo-ocular reflex

Dysfunction: Hearing loss, vertigo, tinnitus

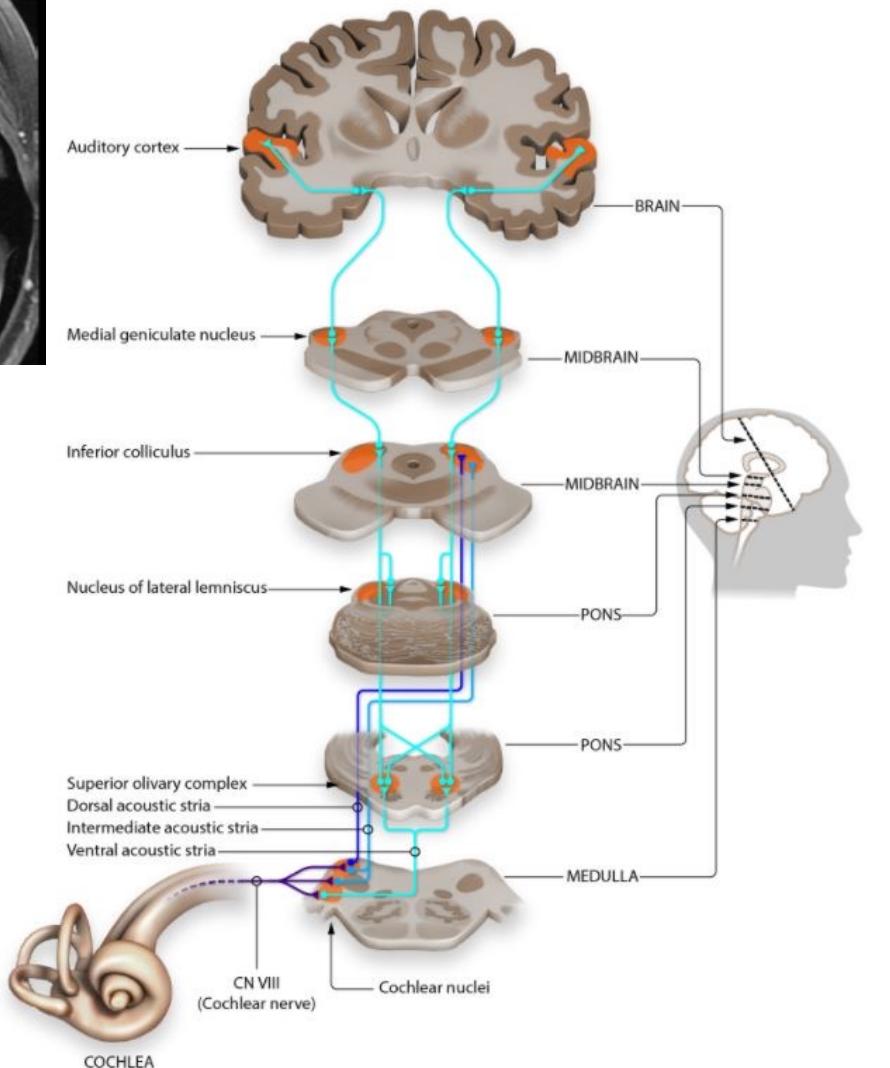
Sample pathologies: Vestibular schwannoma, stroke



Vestibular pathway



Vestibulo-ocular reflex



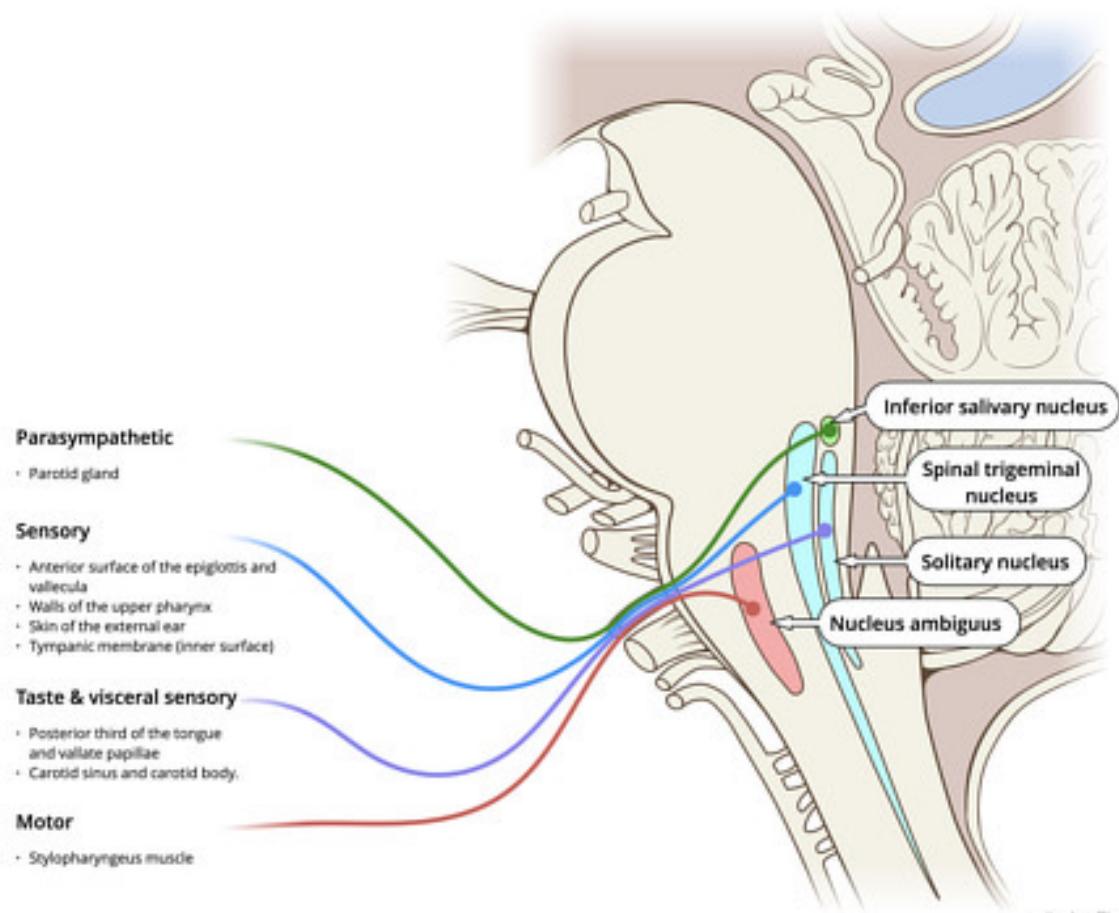
Auditory pathway (cochlear)

# CN 9: Glossopharyngeal nerve (sensorimotor)

**Function:** Sensation of posterior tongue/ pharynx, taste posterior 1/3 tongue, carotid baro/chemoreceptors, salivary gland, stylopharyngeus muscle, gag reflex (w/ CN X)

**Dysfunction:** dysphagia, abnormal taste/ tongue sensation, loss of carotid sinus reflex/ gag reflex

**Sample pathologies:** Glossopharyngeal neuralgia, stroke

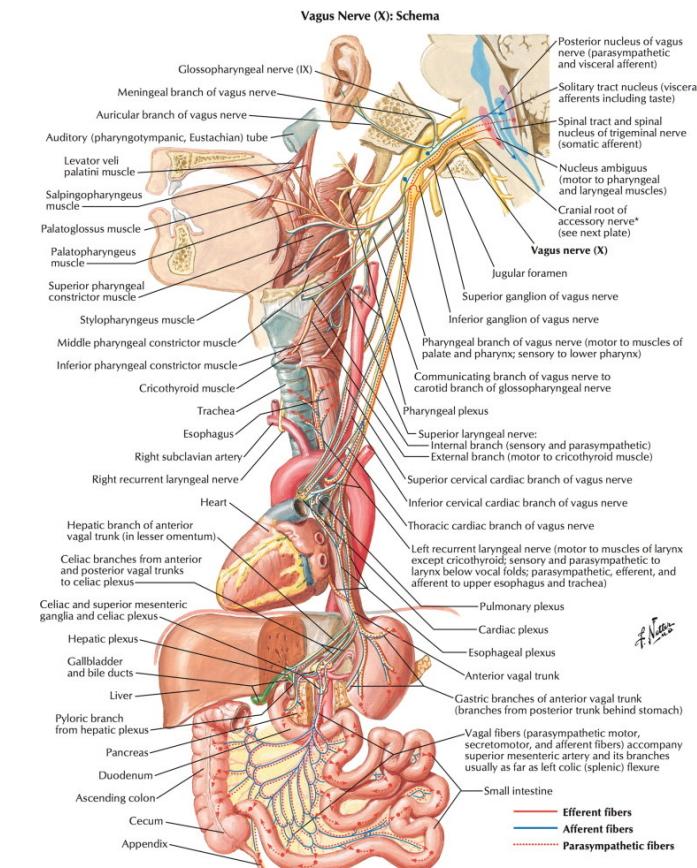
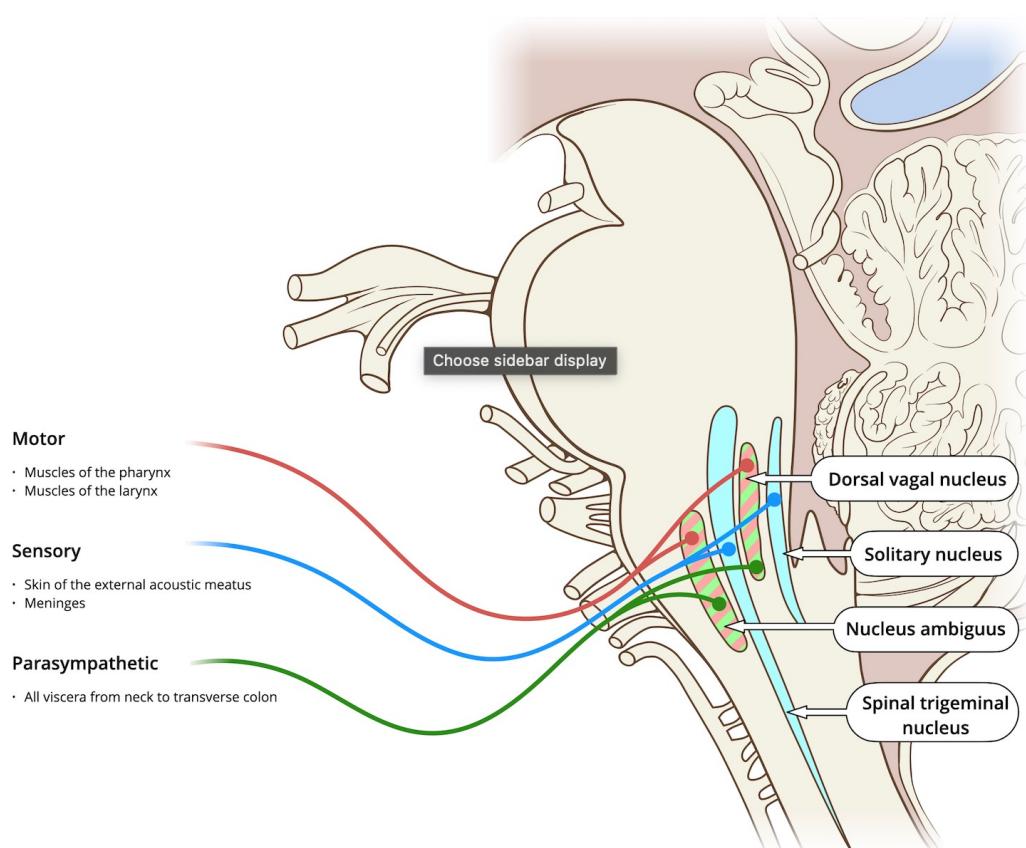


# CN 10: Vagus nerve (sensorimotor)

**Function:** Parasympathetic function (cardiac, respiratory, gut, pancreas, spleen, kidneys, adrenals), all other pharyngeal muscles, laryngeal muscles, gag reflex (w/ CN IX)

**Dysfunction:** dysphagia, dysarthria, hoarseness, autonomic dysfunction

**Sample pathologies:** carotid sheath lesions, stroke, seizure treatment

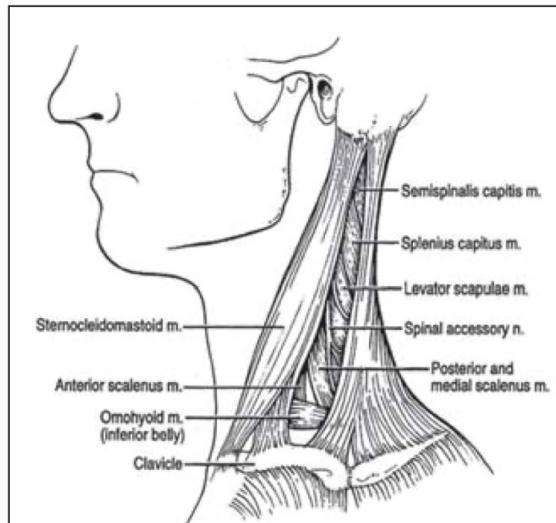
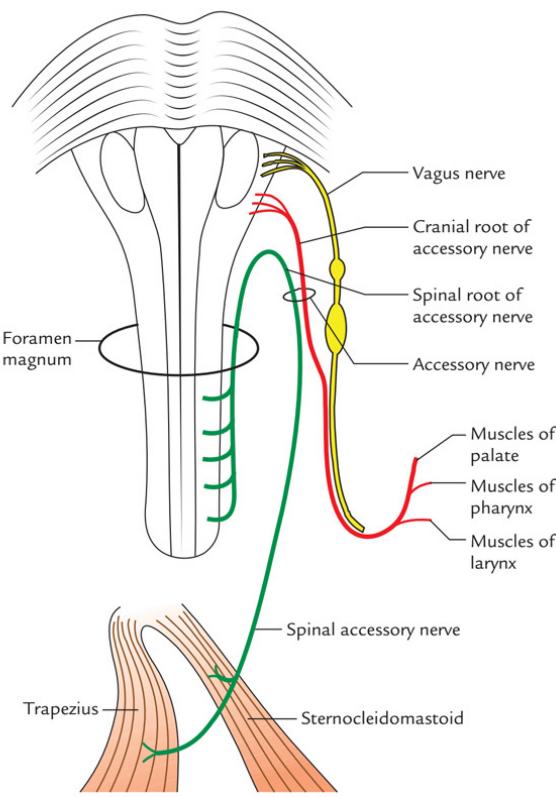


# CN 11: Spinal accessory nerve (motor)

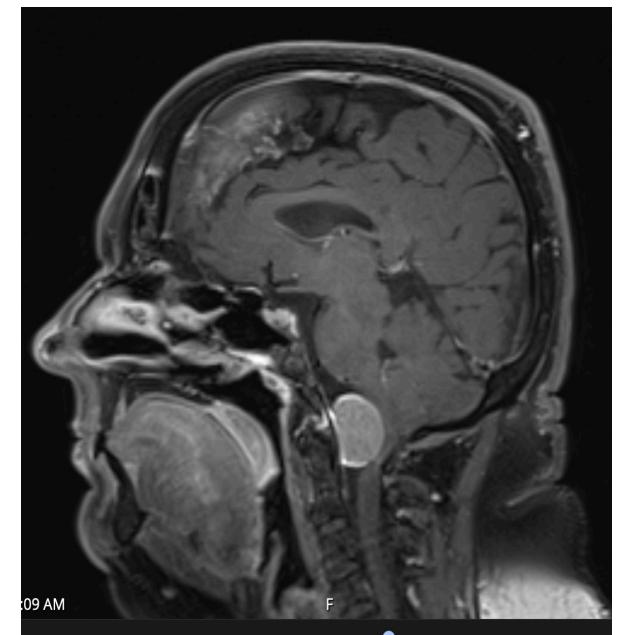
Function: Stenocleidomastoid and trapezius muscles

Dysfunction: limited shoulder abduction, pain

Sample pathologies: Trauma, iatrogenic injury, tumor



**FIGURE 1.** The spinal accessory nerve (SAN) crosses obliquely in the posterior triangle. (Reproduced with permission of Kuhn, JE. The scapulothoracic articulation: anatomy, biomechanics, pathophysiology and management. In: Iannotti JP, Williams GR, eds. *Disorders of the Shoulder: Diagnosis and Management*. Philadelphia, PA: Lippincott Williams & Wilkins; 1999).

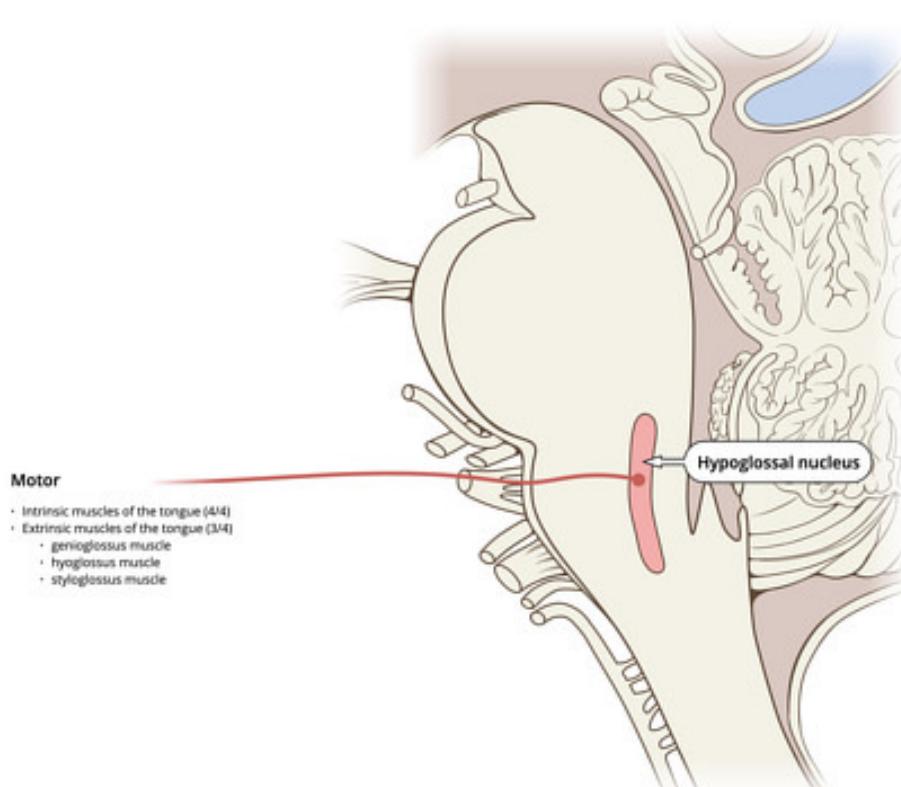


# CN 12: Hypoglossal nerve (motor)

Function: tongue muscles

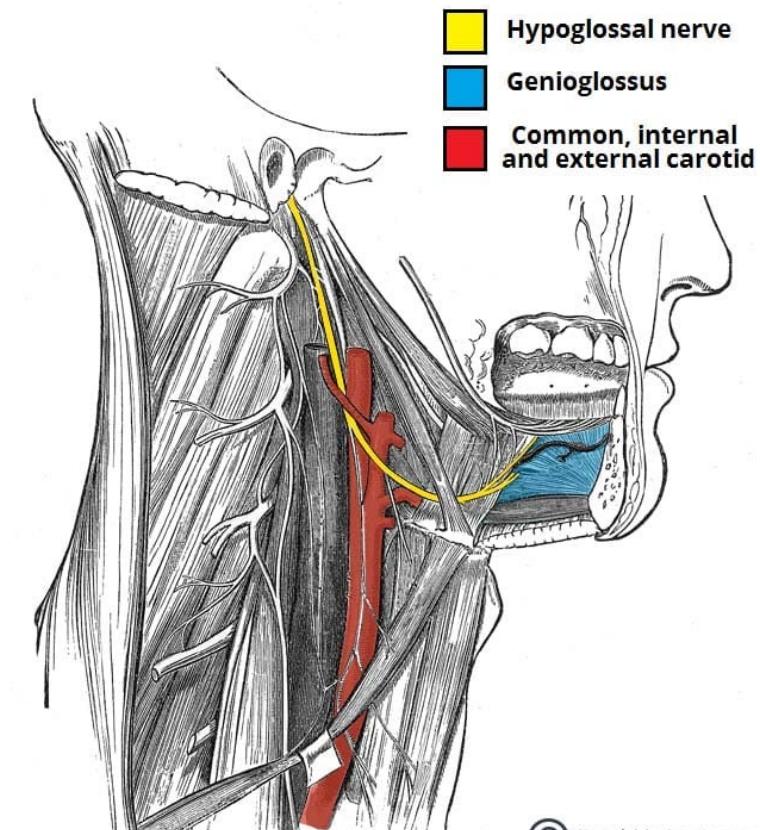
Dysfunction: ipsilateral tongue weakness (deviates to side of lesion)

Sample pathologies: Trauma, stroke, iatrogenic injury



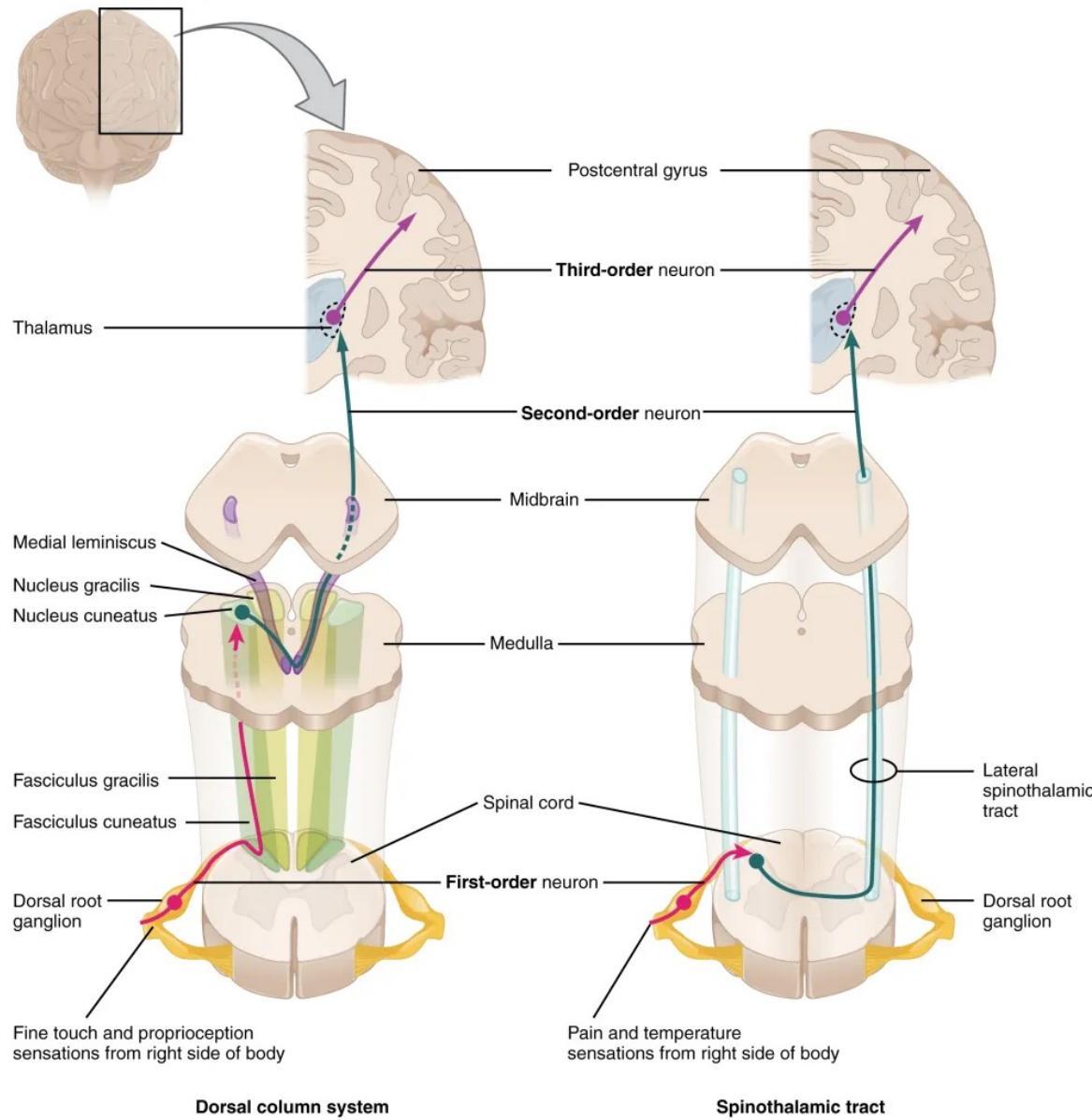
#### Motor

- Intrinsic muscles of the tongue (4/4)
- Extrinsic muscles of the tongue (3/4)
  - genioglossus muscle
  - hyoglossus muscle
  - styloglossus muscle

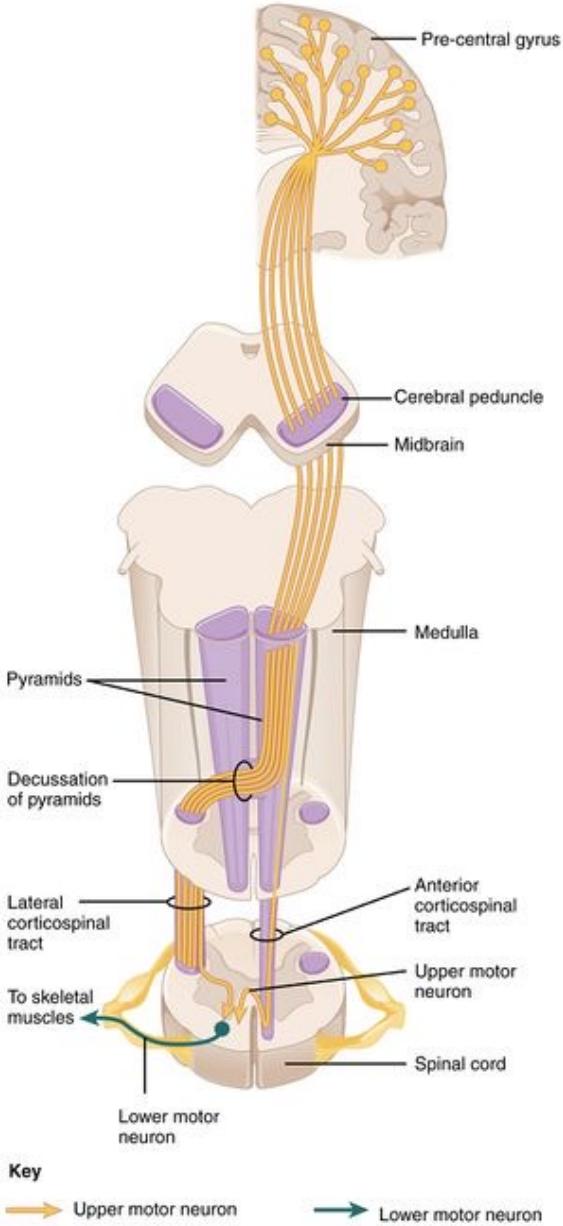


# SENSORIMOTOR PATHWAYS

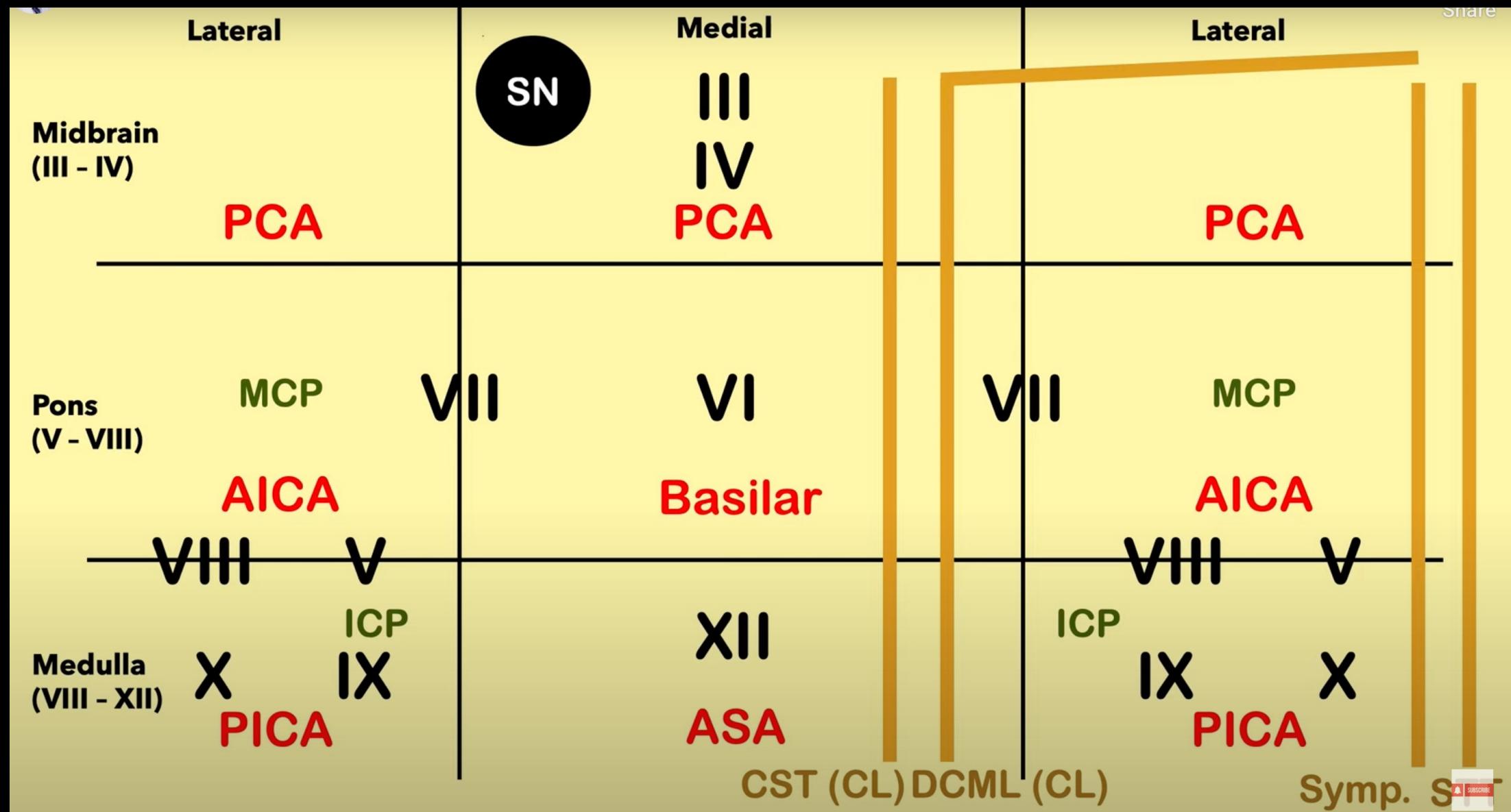
# Sensory pathways: *Dorsal column pathway & spinothalamic tract*



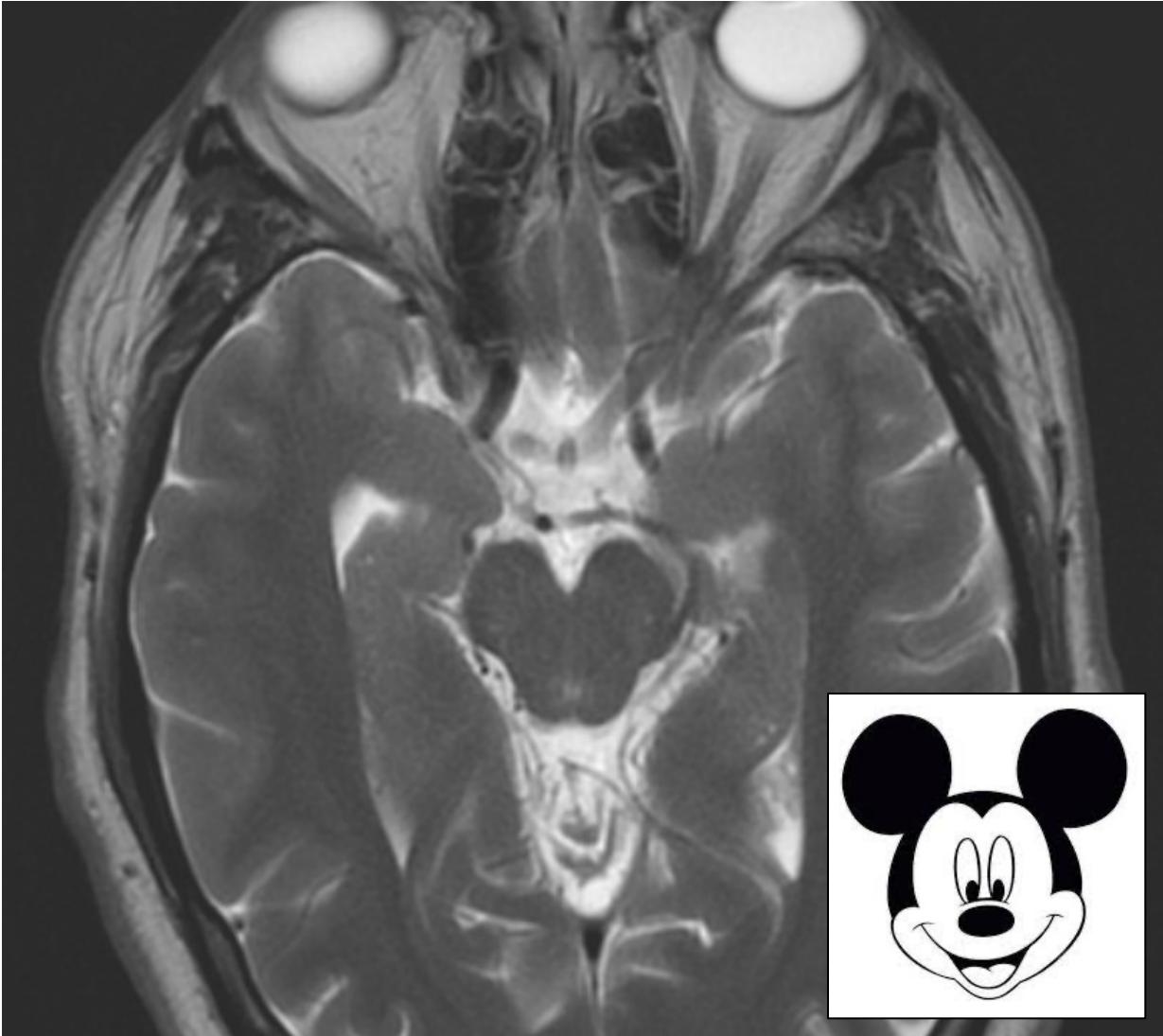
# Motor pathway: *Corticospinal tract*



# BRAINSTEM SECTIONS & STROKE SYNDROMES



# MIDBRAIN



**CN/ nuclei:** CN 3, 4; medial longitudinal fasciculus (MLF), Edinger-Westphal nucleus (EWN), superior colliculus

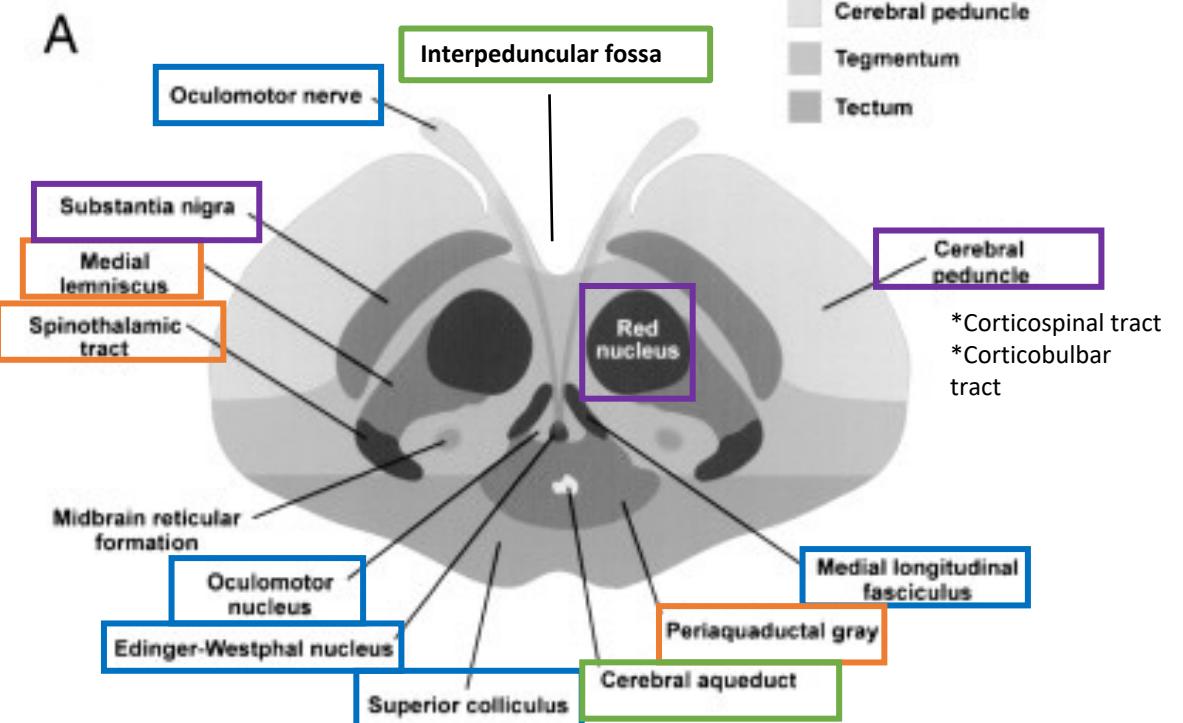
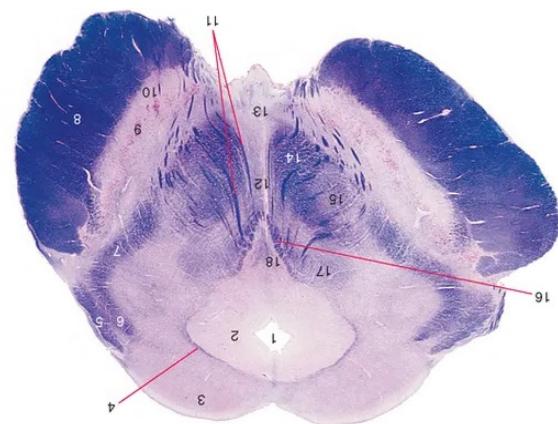
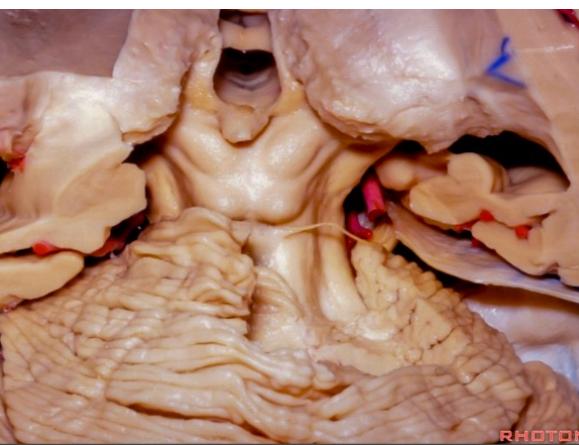
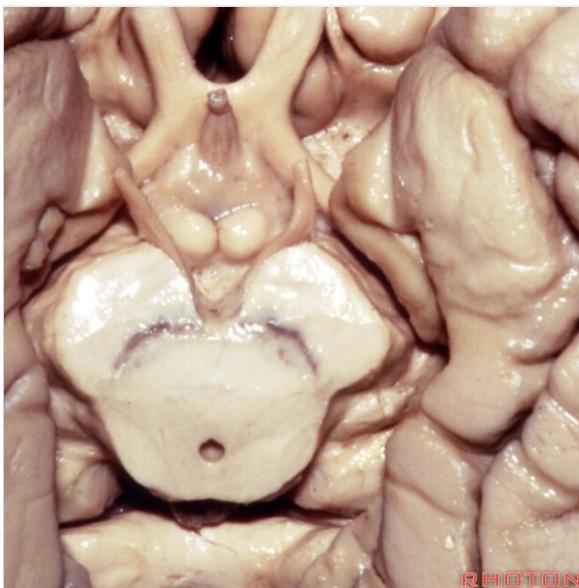
**Sensory:** Medial lemniscus, spinothalamic tract, periaqueductal gray

**Motor:** corticospinal tract, cerebral peduncle, red nucleus, substantia nigra

**CSF:** cerebral aqueduct, interpeduncular fossa

**Vascular:** posterior cerebral artery

# MIDBRAIN



# MIDBRAIN SYNDROME: BENEDIKT

## AREAS AFFECTED

Red nucleus

Medial lemniscus

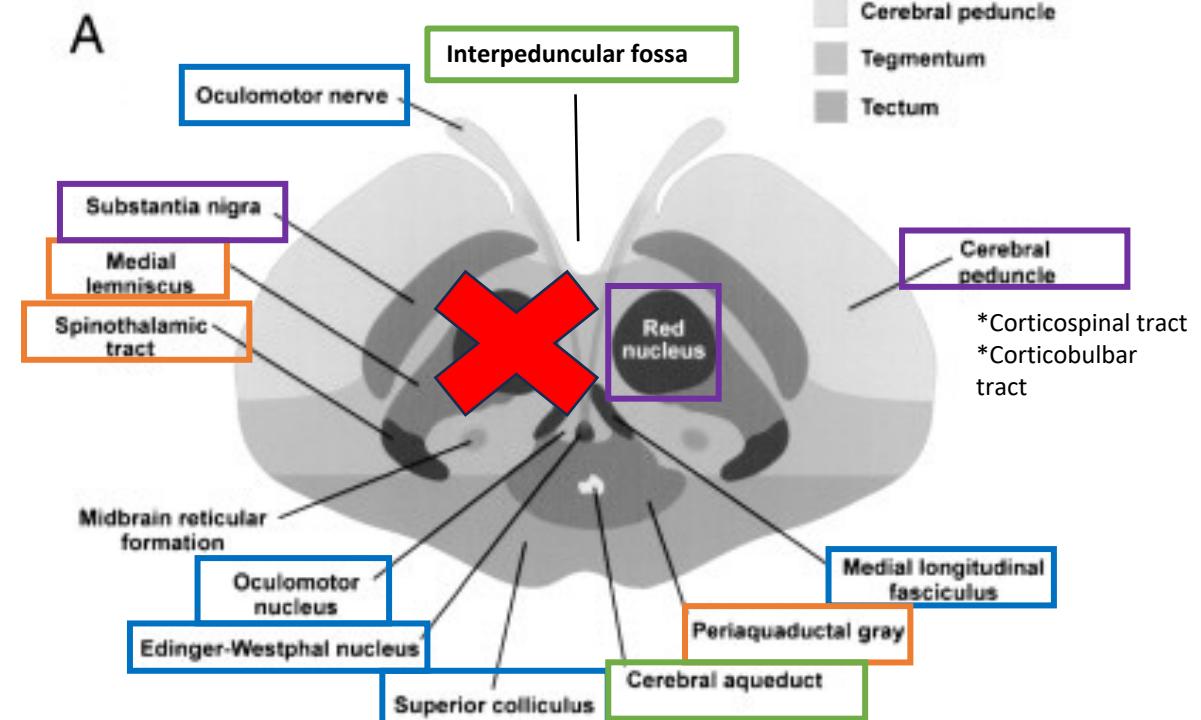
CN 3

## SYMPTOMS

Tremor/ ataxia

Contralateral loss-  
proprioception/ vibration

Oculomotor nerve palsy



**Posterior cerebral artery**

# MIDBRAIN SYNDROME: WEBER

## AREAS AFFECTED

Corticospinal tract

Corticobulbar tract

CN 3

## SYMPTOMS

Contralateral hemiparesis

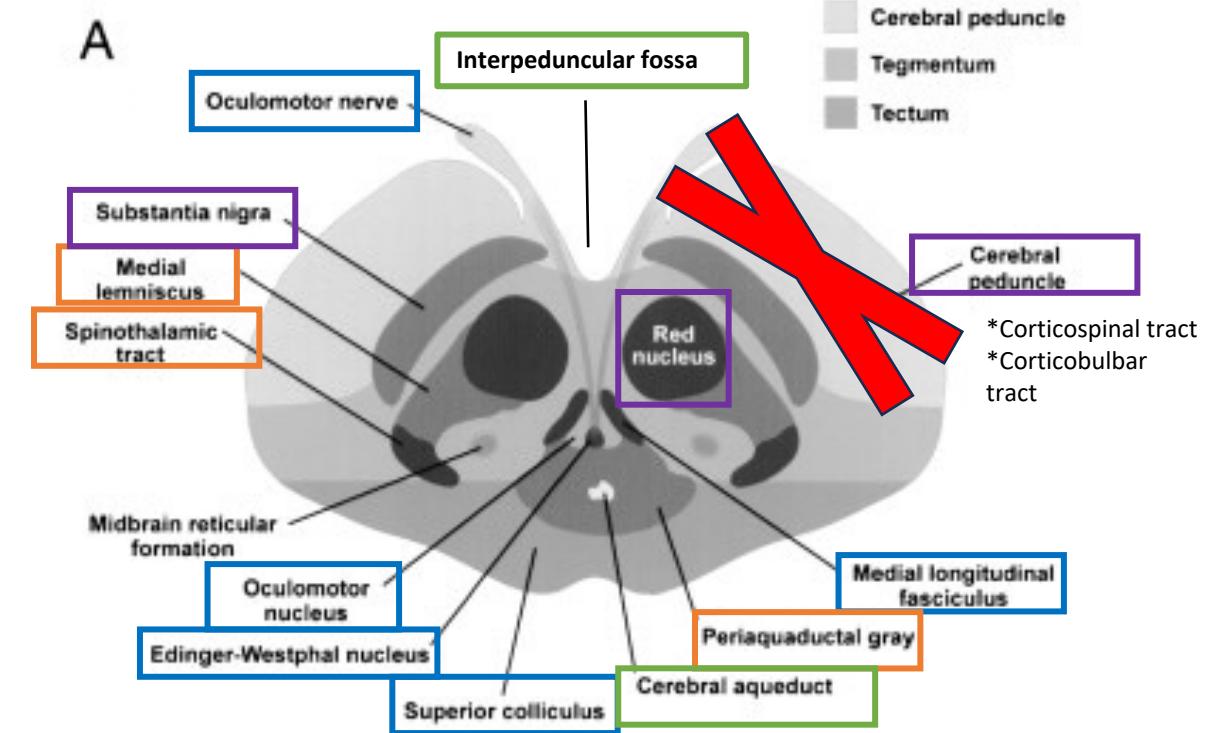
Pseudobulbar palsy\*

Oculomotor nerve palsy

## \*PSEUDOBULBAR PALSY

### UMN CN motor weakness:

- spastic dysarthria (harsh speech, hard to get words out)
- exaggerated gag reflex
- paralysis of lower face/ tongue



**Basilar or posterior cerebral artery**

# MIDBRAIN SYNDROME: PARINAUD

## AREAS AFFECTED

Superior colliculus

Pseudo Argyll  
Robertson pupil

\*Cerebral aqueduct

## SYMPTOMS

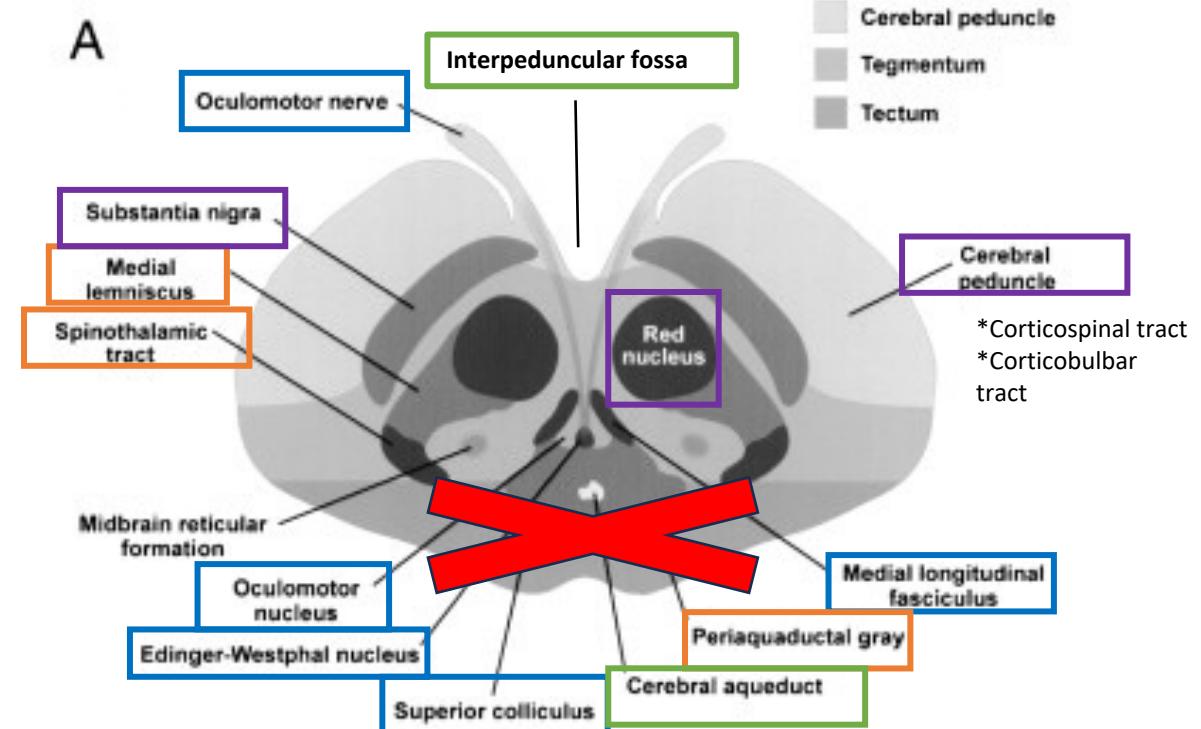
Vertical gaze palsy

No pupil constriction w/  
light; does constrict to  
accommodation

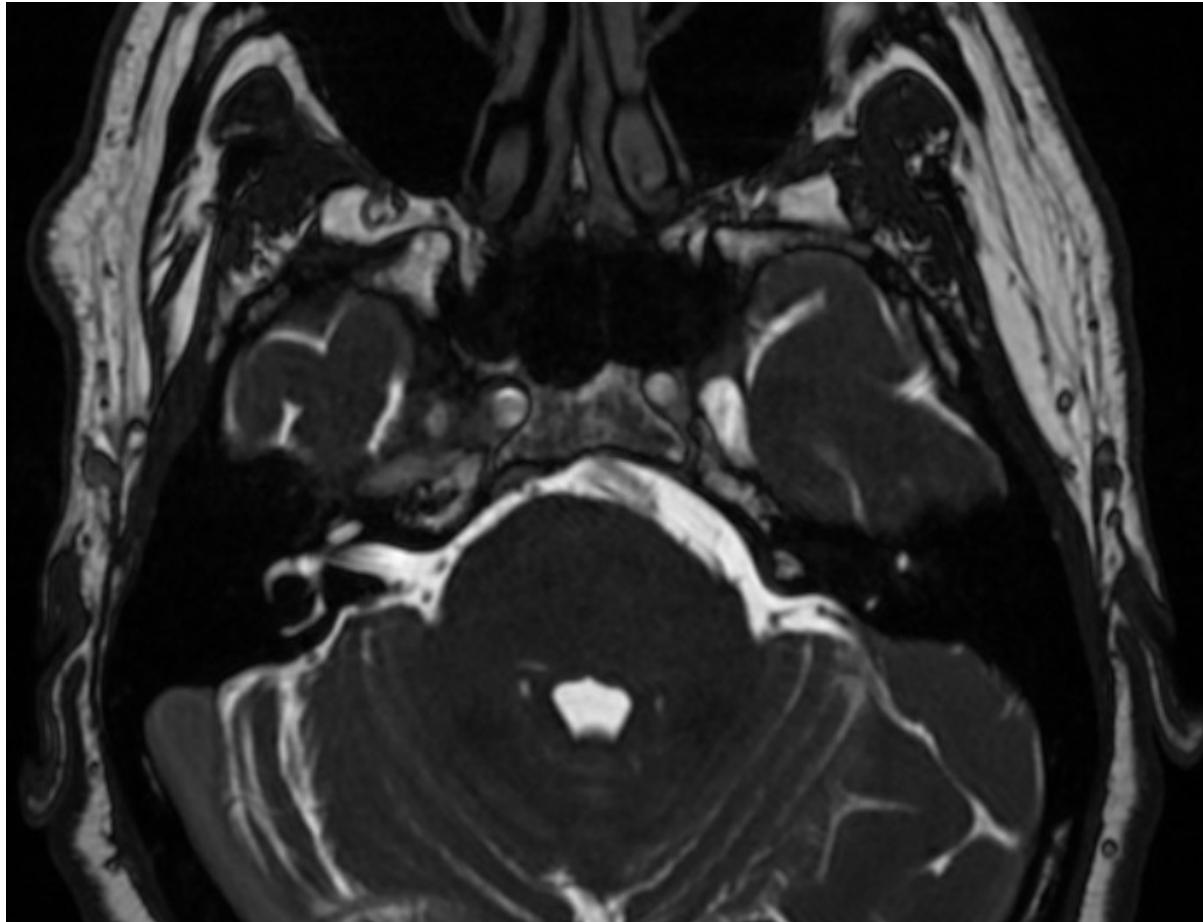
Hydrocephalus

\*Rare syndrome associated w/ pineal region  
tumors (i.e. pinealoma/ germinoma)

Note- if cerebral aqueduct obstructed by a mass  
lesion, risk of hydrocephalus



# PONS



**CN/ nuclei:** CN 5, 6, 7, 8\*; medial longitudinal fasciculus (MLF), paramedian pontine reticular formation (PPRF), spinal trigeminal tract/ nucleus, abducens nucleus, facial nucleus, vestibular nuclei

**Sensory:** Medial lemniscus, spinothalamic tract

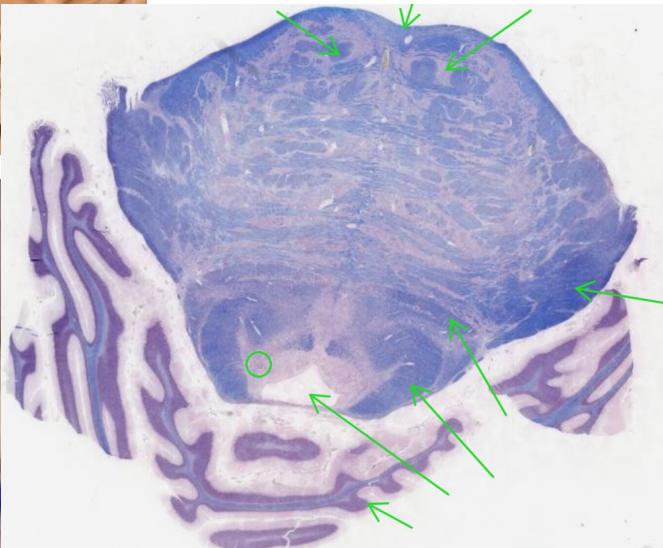
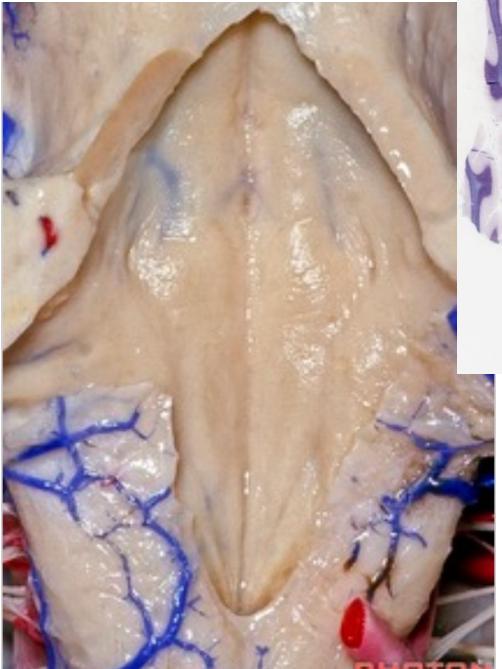
**Motor:** corticospinal tract, middle cerebellar peduncle

**CSF:** 4th ventricle

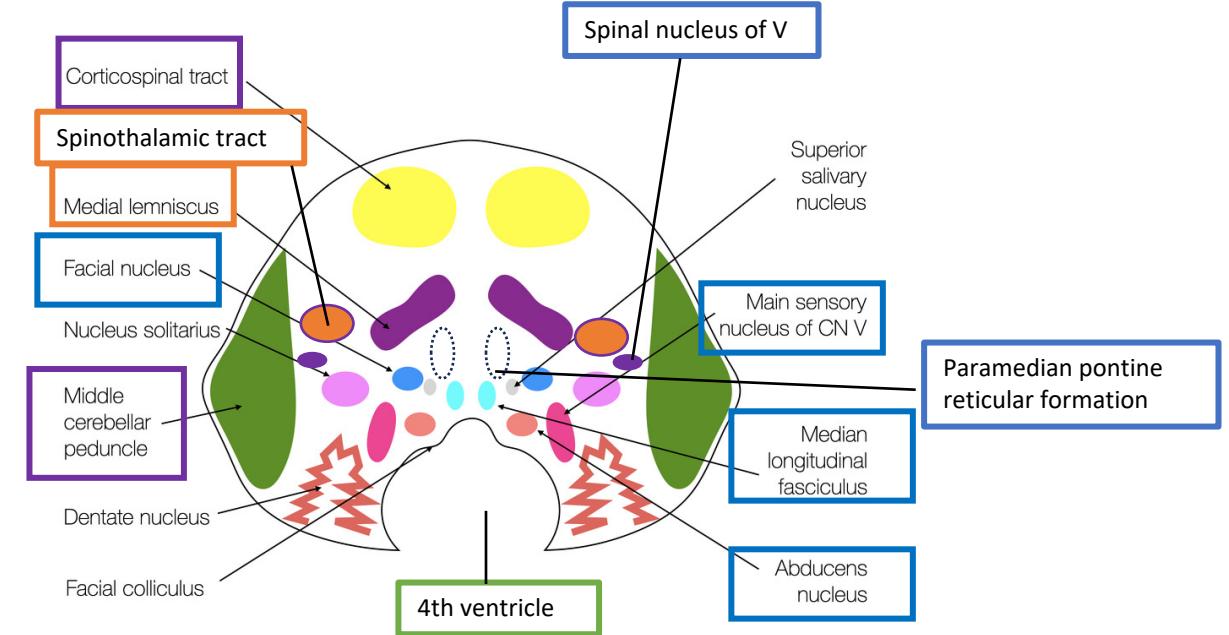
**Vascular:** basilar artery, anterior inferior cerebellar artery

\*CN 8 at pontomedullary junction

# PONS



Axial section at the level of the lower pons



Craig Hacking  
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# MEDIAL PONTINE SYNDROME

## AREAS AFFECTED

Corticospinal tract

CN 6, MLF/ PPRF

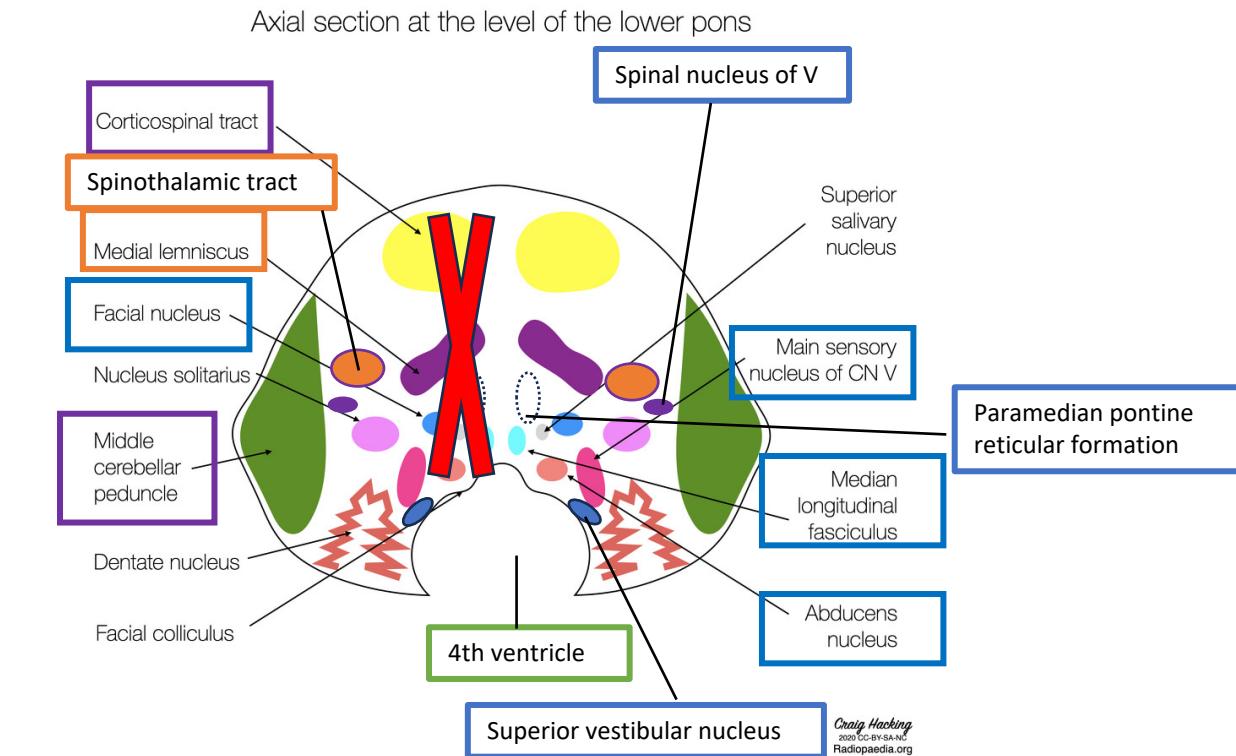
CN7

## SYMPTOMS

Contralateral hemiparesis

Lateral gaze palsy  
(can't look to affected side)

Facial palsy



## Basilar artery

\*Horner syndrome: myosis, ptosis, anhydrosis

# LATERAL PONTINE SYNDROME

## AREAS AFFECTED

Spinothalamic tract

Spinal V nucleus

Facial nucleus

Vestibular/  
cochlear nuclei

Sympathetic tract

## SYMPTOMS

Loss contralateral body  
pain/ temp

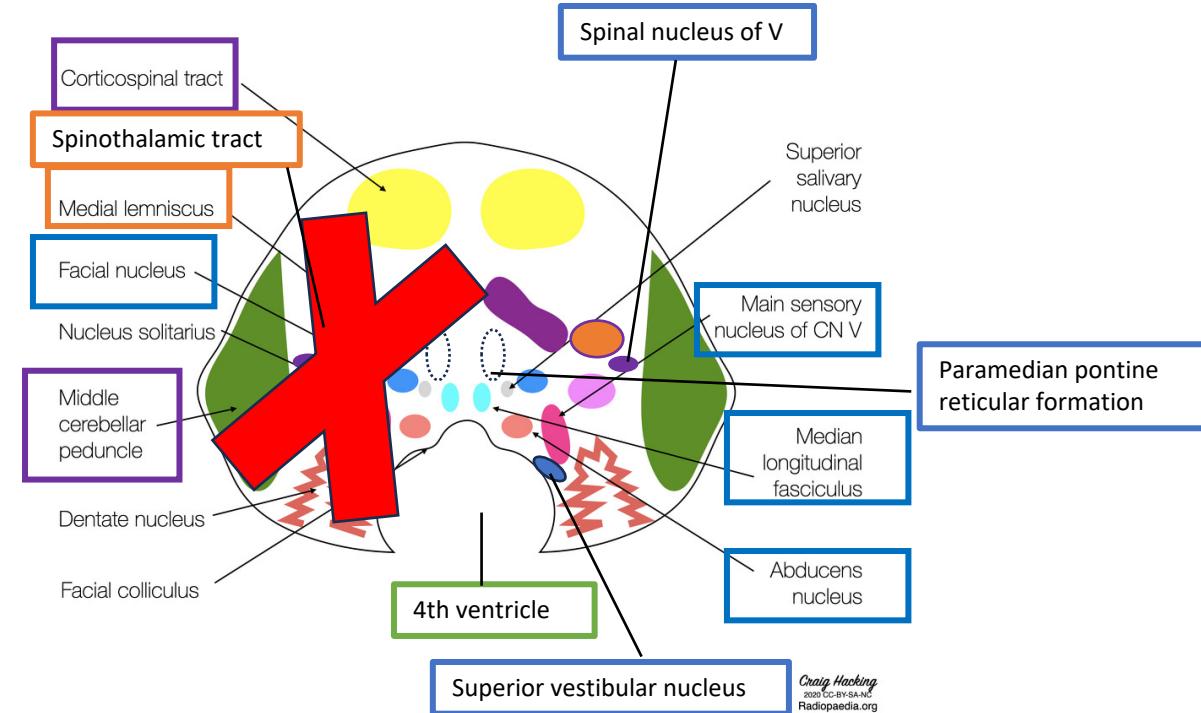
Loss ipsilateral face  
pain/ temp

Facial palsy

Hearing loss, nystagmus,  
Vertigo, n/v

\*Horner's syndrome

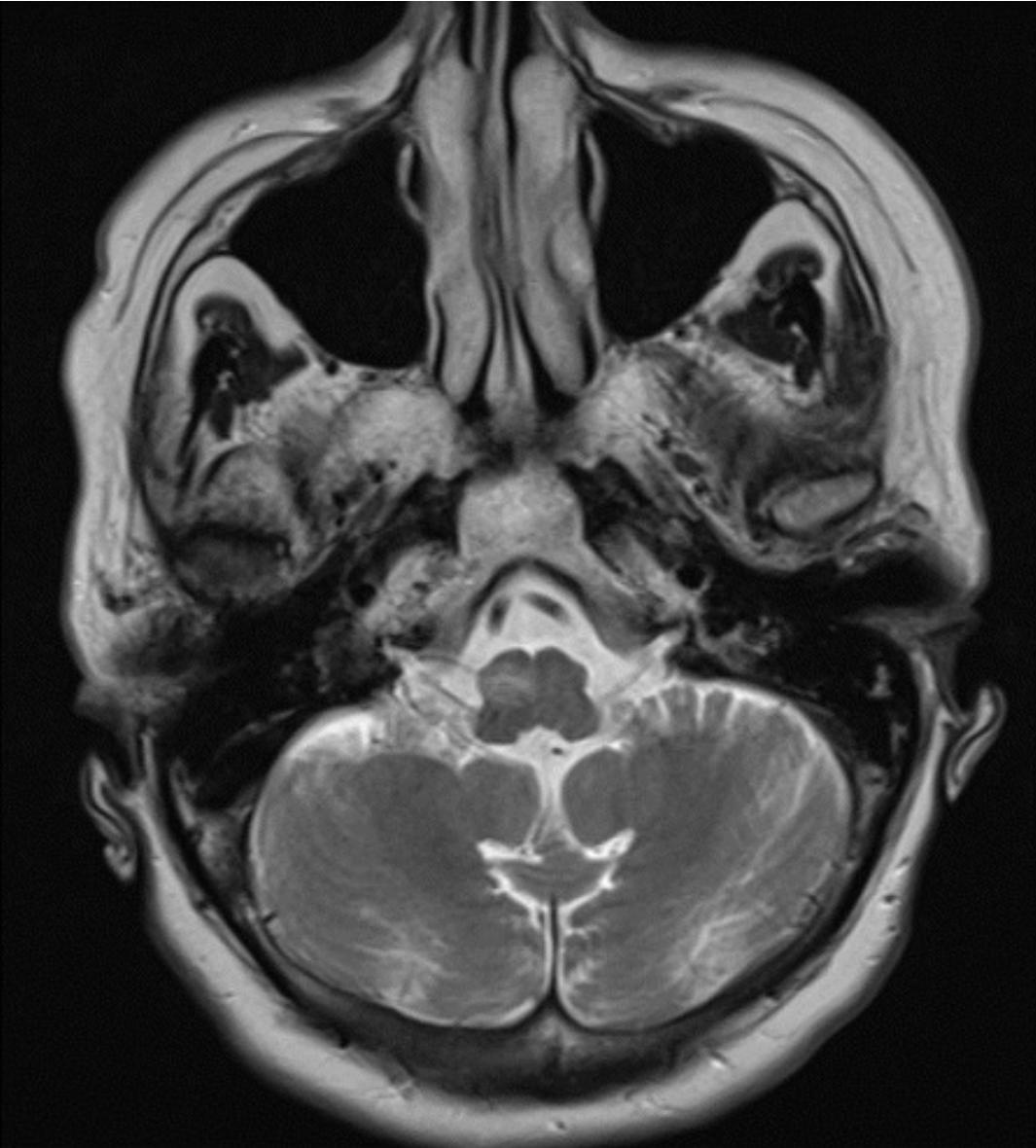
Axial section at the level of the lower pons



## Anterior inferior cerebellar artery

\*Horner syndrome: myosis, ptosis, anhydrosis

# MEDULLA



**CN/ nuclei:** CN 9, 10, 11, 12; medial longitudinal fasciculus (MLF), spinal trigeminal tract/ nucleus, vestibular nuclei, nucleus ambiguus, solitary tract, dorsal nucleus of vagus, hypoglossal nucleus

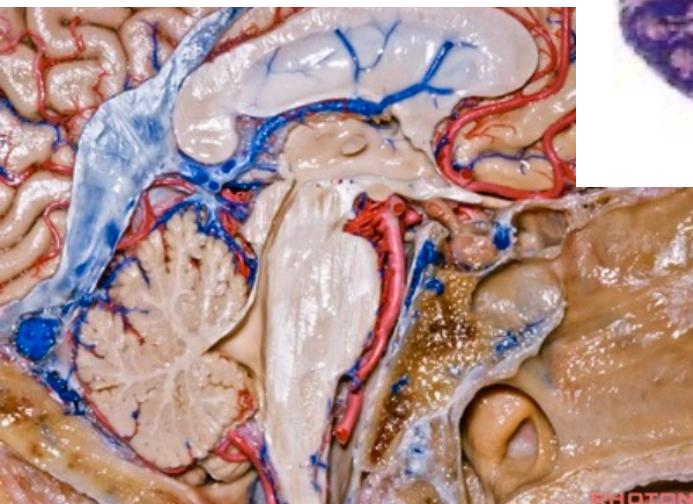
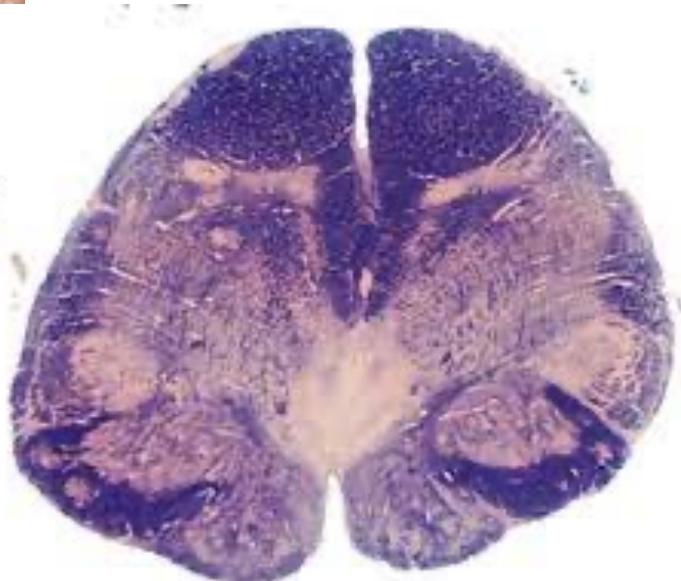
**Sensory:** Medial lemniscus, spinothalamic tract

**Motor:** pyramid, inferior olivary nucleus

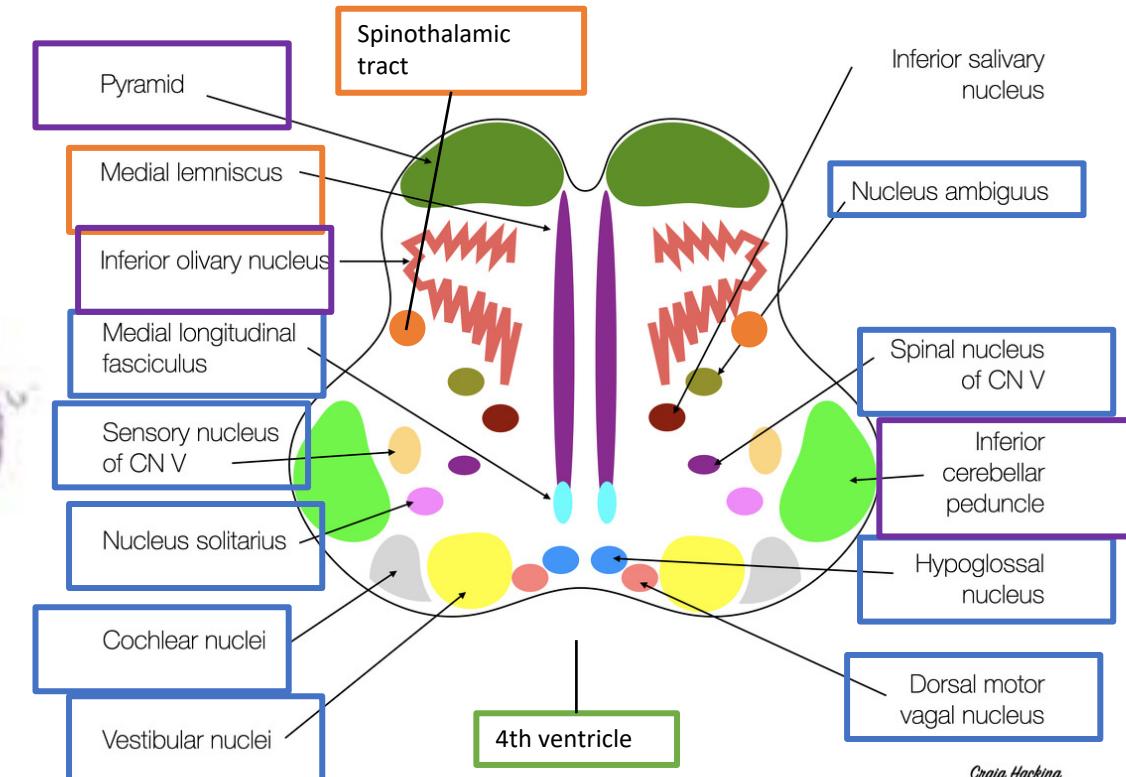
**CSF:** 4th ventricle

**Vascular:** vertebral arteries, posterior inferior cerebellar arteries

# MEDULLA



Axial section at the level of the upper medulla



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# MEDIAL MEDULLARY SYNDROME

## AREAS AFFECTED

Corticospinal tract

Medial lemniscus

CNXII

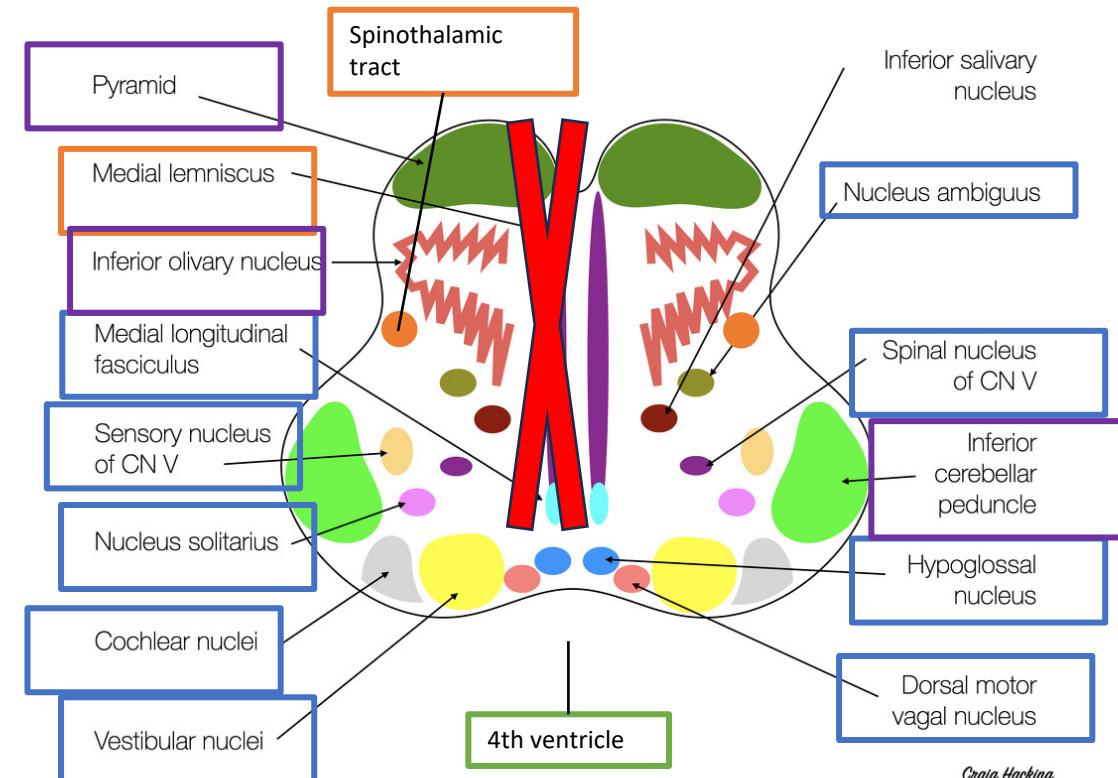
## SYMPTOMS

Contralateral hemiparesis

Contralateral loss of  
Proprioception/ vibration

Flaccid tongue paresis  
(deviates to side of lesion)

Axial section at the level of the upper medulla



Anterior spinal artery

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# LATERAL MEDULLARY SYNDROME

## AREAS AFFECTED

Spinothalamic tract

Spinal nucleus of V

Vestibular nuclei  
(VIII)

Nucleus ambiguus  
(IX, X)

Sympathetic tract

## SYMPTOMS

Contralateral loss body  
pain/ temp

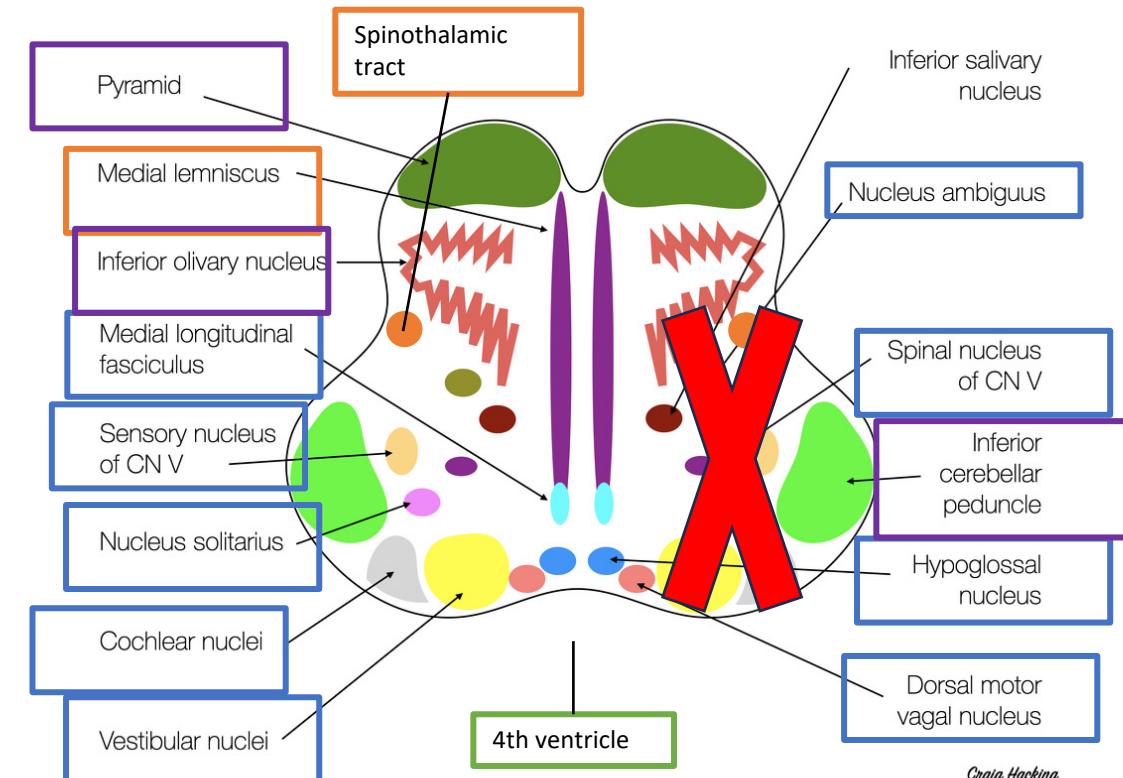
Ipsilateral loss face  
pain/temp

Nystagmus, vertigo, n/v

Dysphagia, hoarseness

Horner's syndrome

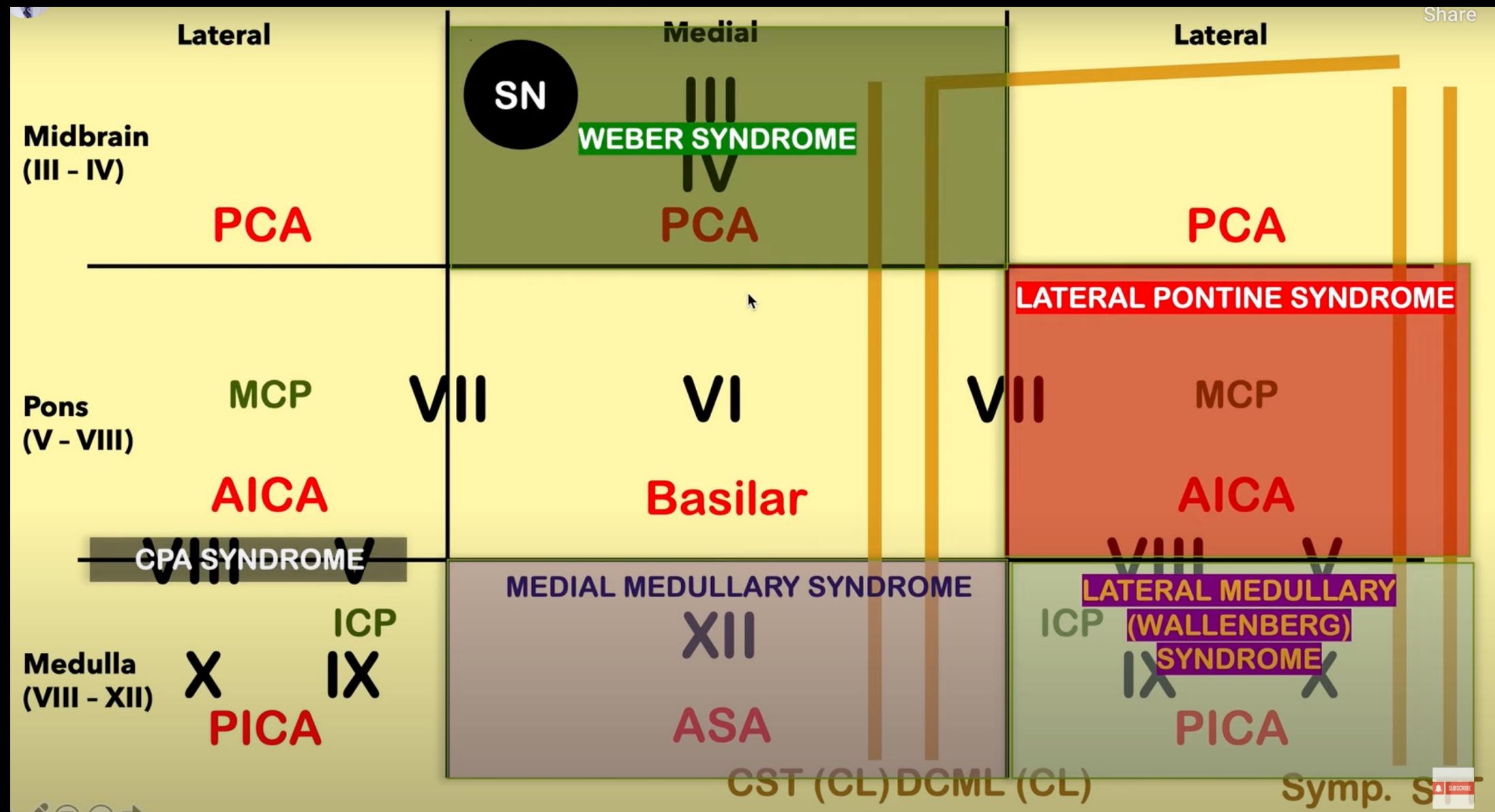
Axial section at the level of the upper medulla



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"Wallenberg's Syndrome"

Posterior inferior cerebellar artery





HOW DO WE DEFINE DEATH?

CLINICAL PRACTICE

Caren G. Solomon, M.D., M.P.H., *Editor*

## Determination of Brain Death

David M. Greer, M.D.

*This Journal feature begins with a case vignette highlighting a common clinical problem. Evidence supporting various strategies is then presented, followed by a review of formal guidelines, when they exist. The article ends with the author's clinical recommendations.*

## Bioethics for clinicians: 24. Brain death

Neil M. Lazar,<sup>\*</sup> Sam Shemie,<sup>†</sup> George C. Webster,<sup>‡</sup>  
Bernard M. Dickens<sup>§</sup>

# THANK YOU

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