# Systemic Module
# CNS

## “Anatomy”

## Brain Stem - Medulla Obolngata

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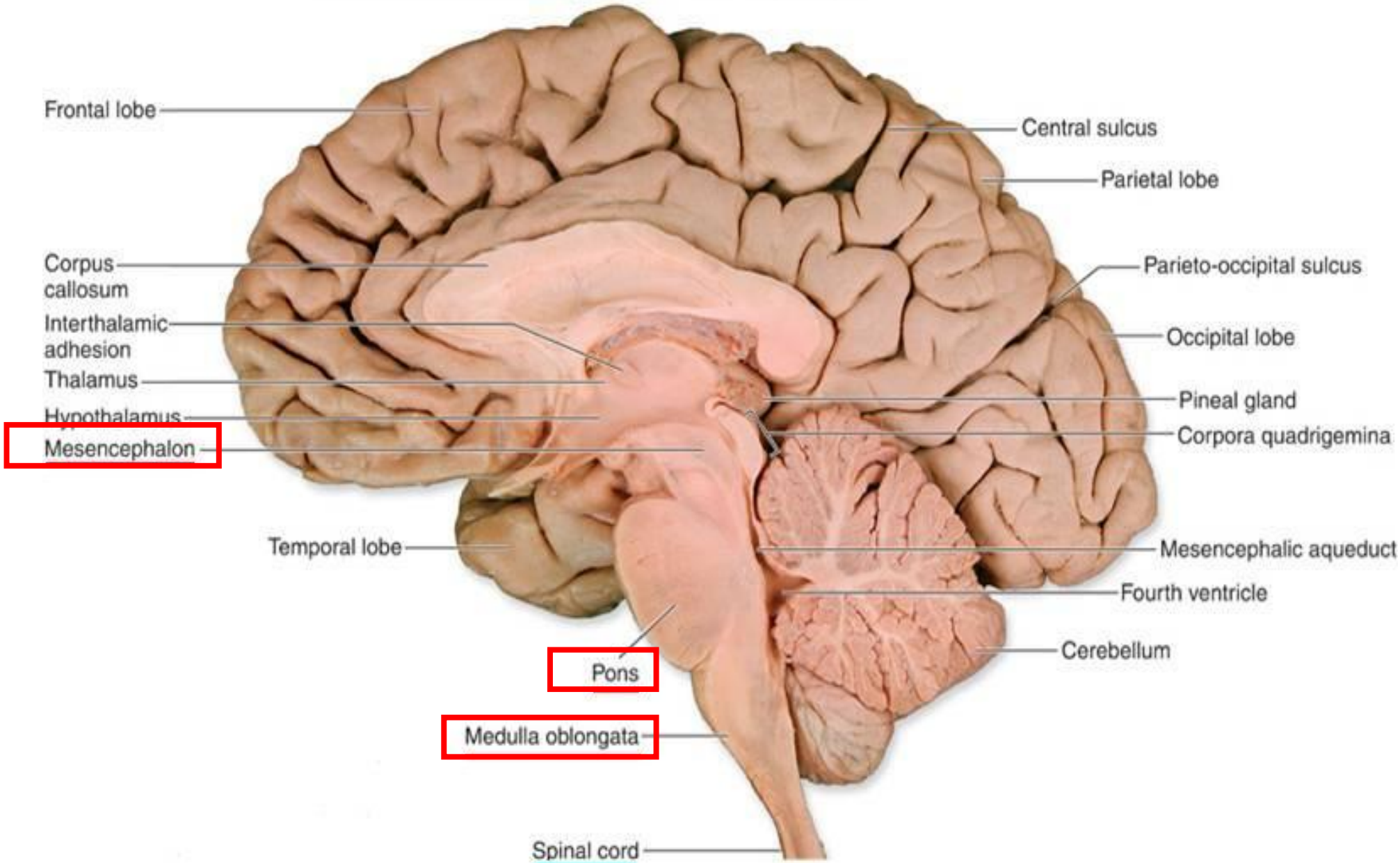
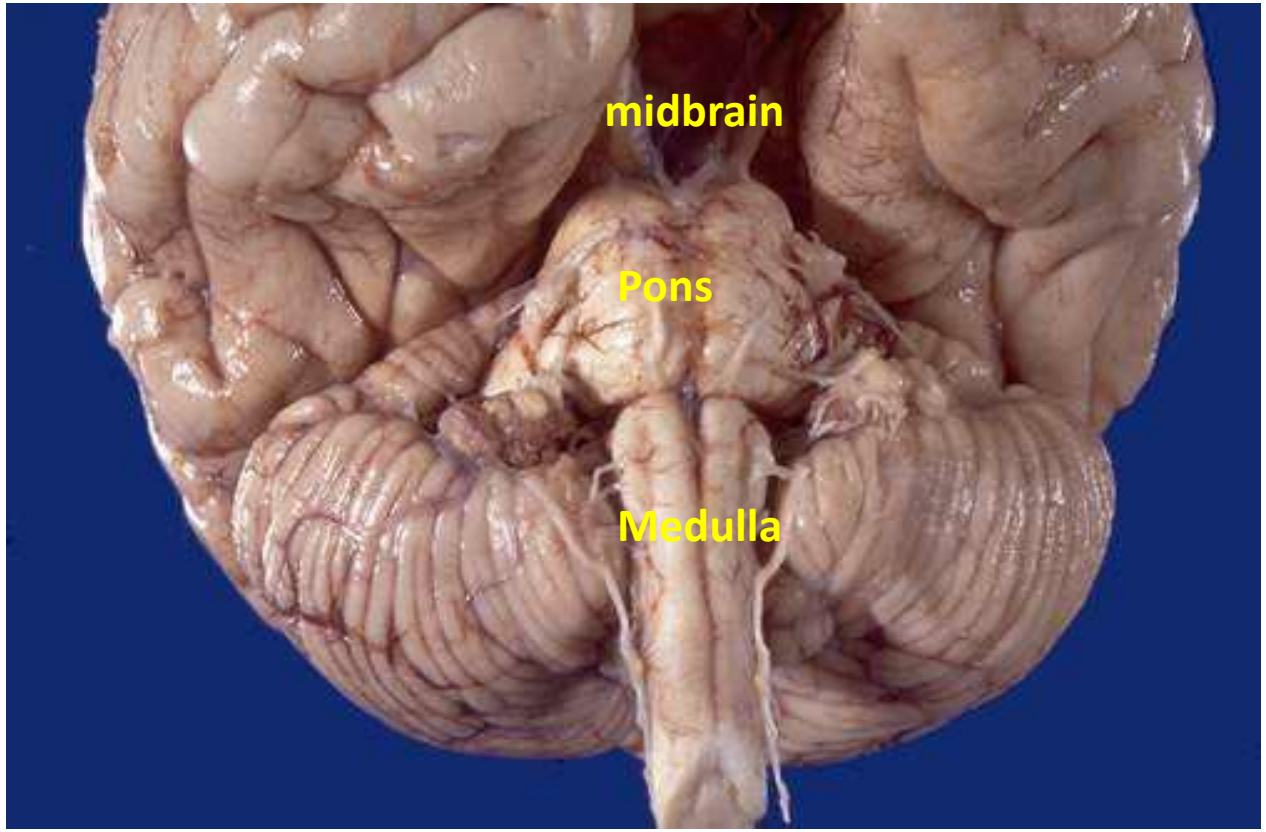
# Brain Stem

- The brain stem is the structure that connects the cerebrum and the spinal cord.
- Consists of:
  1. **Midbrain**
  2. **Pons**
  3. **Medulla oblongata**
- Present in the posterior cranial fossa.
- Each part of brain stem is connected to cerebellum by **cerebellar peduncles** (superior, middle & inferior).
- Microscopically, it consists of deep grey matter surrounded by white matter fiber tracts




**Midsagittal view**


midbrain
Pons
Medulla

# Functions of Brain Stem

1. Pathway of **ascending and descending tracts** connecting the spinal cord to the different parts of the higher centers in the forebrain.

2. Site of the **nuclei of cranial nerves*** (3 to 12).

3. Site of other nuclei such as the **olivary nuclei** in the medulla, the **pontine nuclei** in the pons and the **red nucleus** and **substantia nigra** in the midbrain.

4. Contains groups of nuclei & related fibers known as **reticular formation** responsible for: control of level of consciousness, perception of pain, regulation of cardiovascular & respiratory systems.

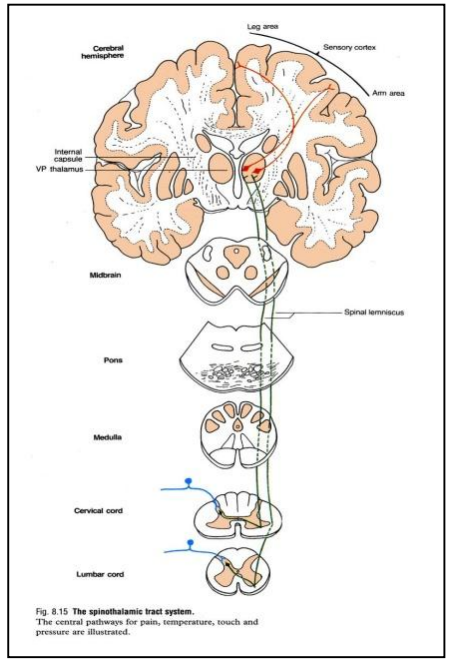
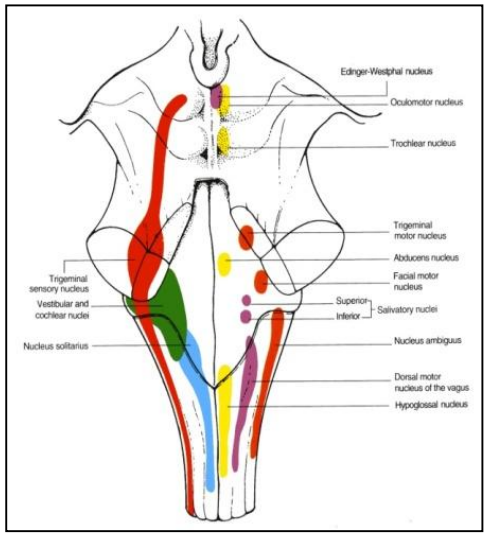
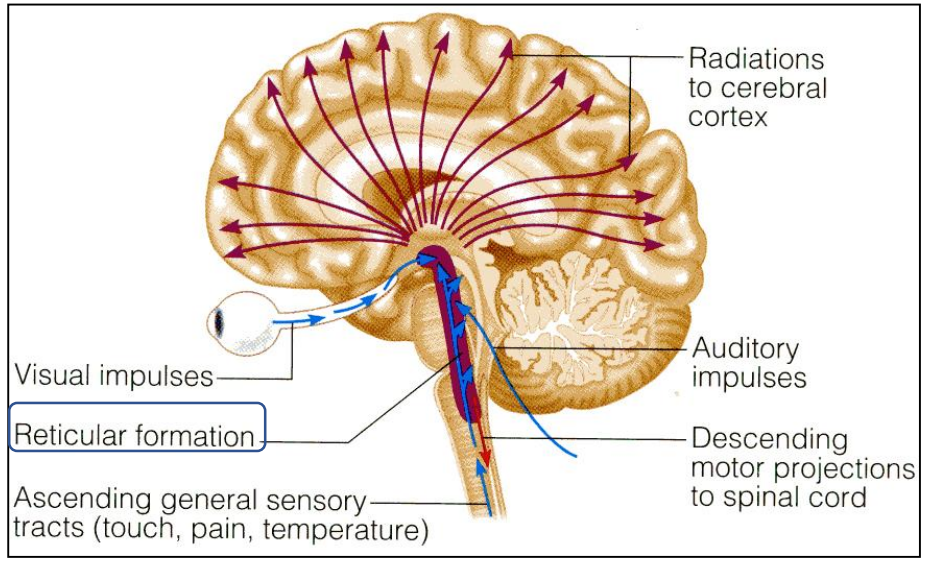


Fig. 8.15 **The spinothalamic tract system.** The central pathways for pain, temperature, touch and pressure are illustrated.



# *Nuclei of Cranial Nerves (III-XII)

- They are collection of cell bodies (gray matter) participate in formation of cranial nerve.

- They are either sensory or motor:

## 1- Sensory cranial nuclei:

- Receive the sensory fibers of the cranial nerves.

- The cell bodies of these fibers are located in sensory ganglia associated with the cranial nerves.

# *Nuclei of Cranial Nerves (III-XII)

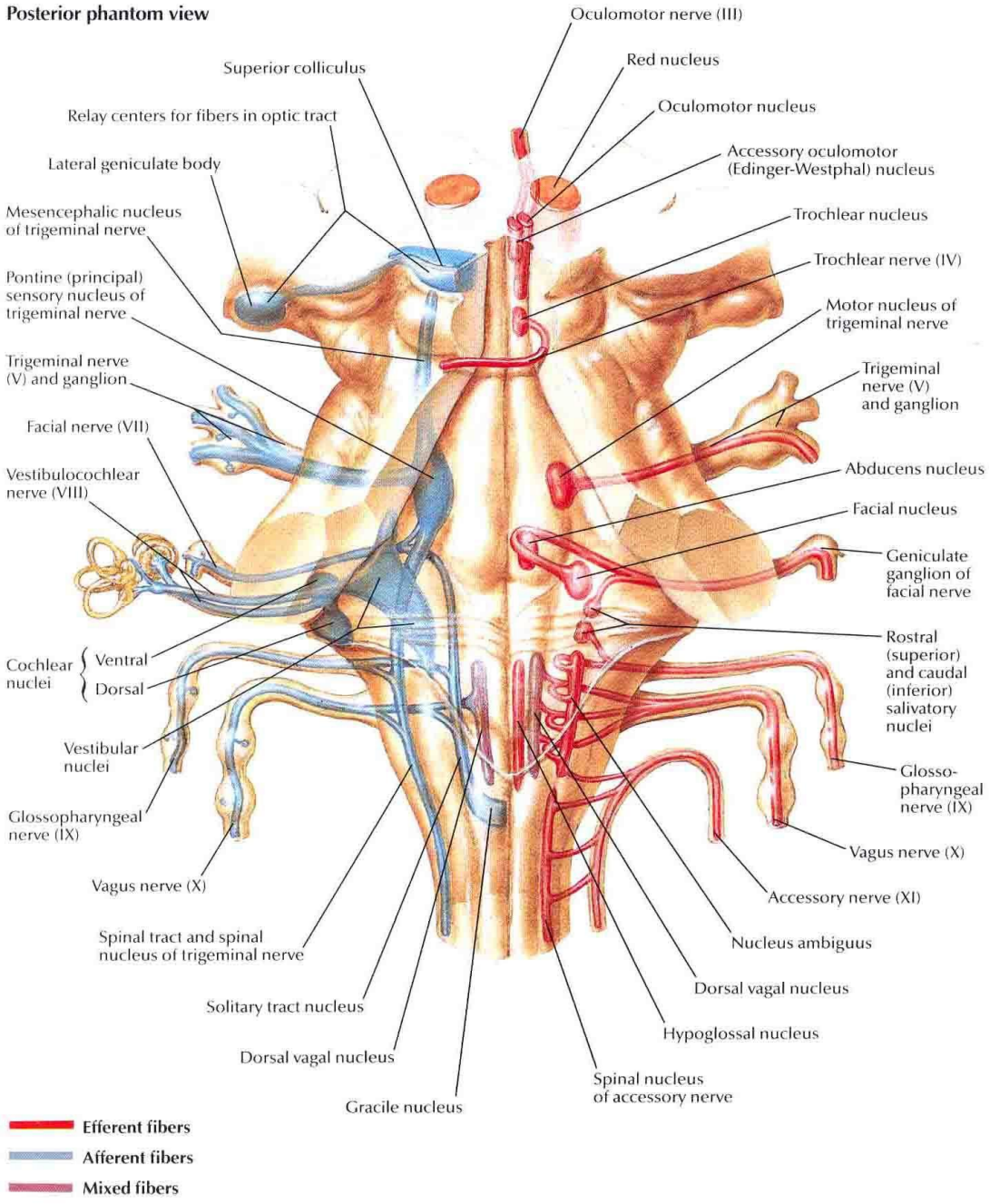
## 2- Motor cranial nuclei:

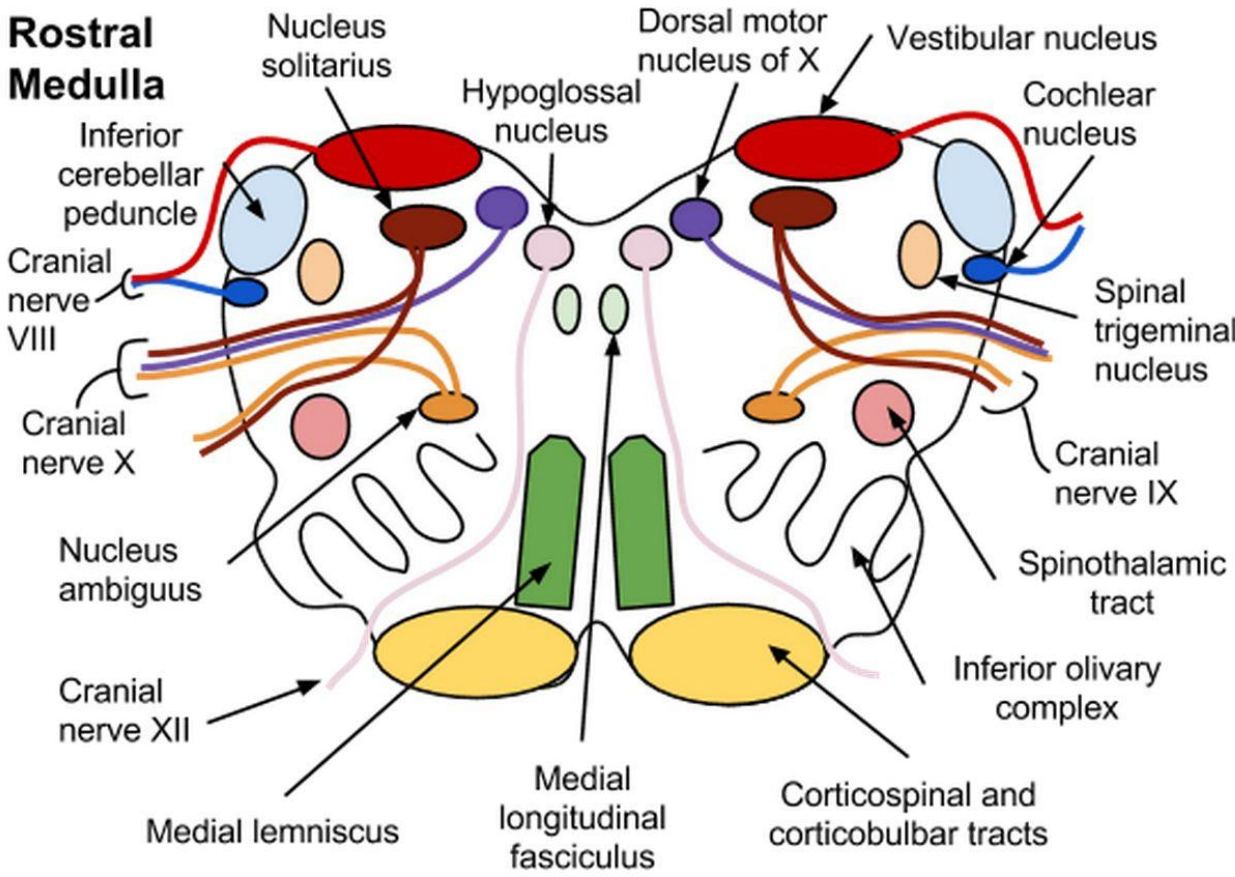
- Send motor fibers with the cranial nerves to supply structures mainly in head and neck. Except the vagus nerve has fibers supply structures in chest and abdomen.

- The motor cranial nuclei are either voluntary or involuntary.

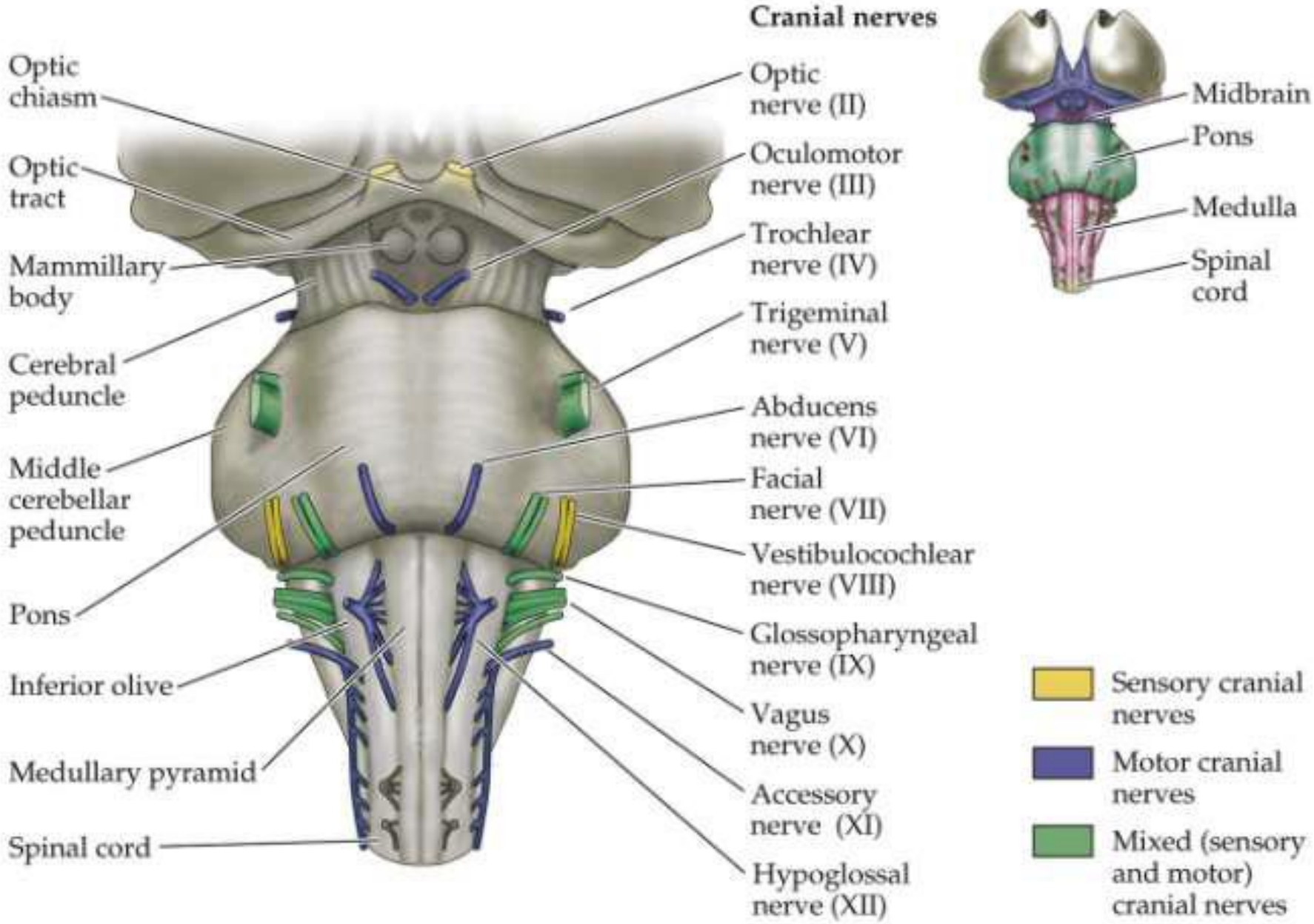
    - **The voluntary nuclei** supply the voluntary muscles and mainly controlled by the cerebral cortex (receive corticonuclear fibers).

    - **The involuntary nuclei** supply the involuntary structure (smooth muscle and glands) and mainly controlled by the hypothalamus.




**There are shared nuclei (two cranial nerves or more can share ONE nucleus .. )**

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# Medulla Oblongata

- The medulla oblongata is 3 cm in length and is the **most inferior portion** of the brainstem.
- Becomes the spinal cord at the level of the foramen magnum.
- Conical in shape; broad above ,joins with pons narrow below, continuous with spinal cord.
- The central canal in lower half continues as that of spinal cord while the upper half expands as the cavity of fourth ventricle.

# External Features

## *Anterolateral Surface:*

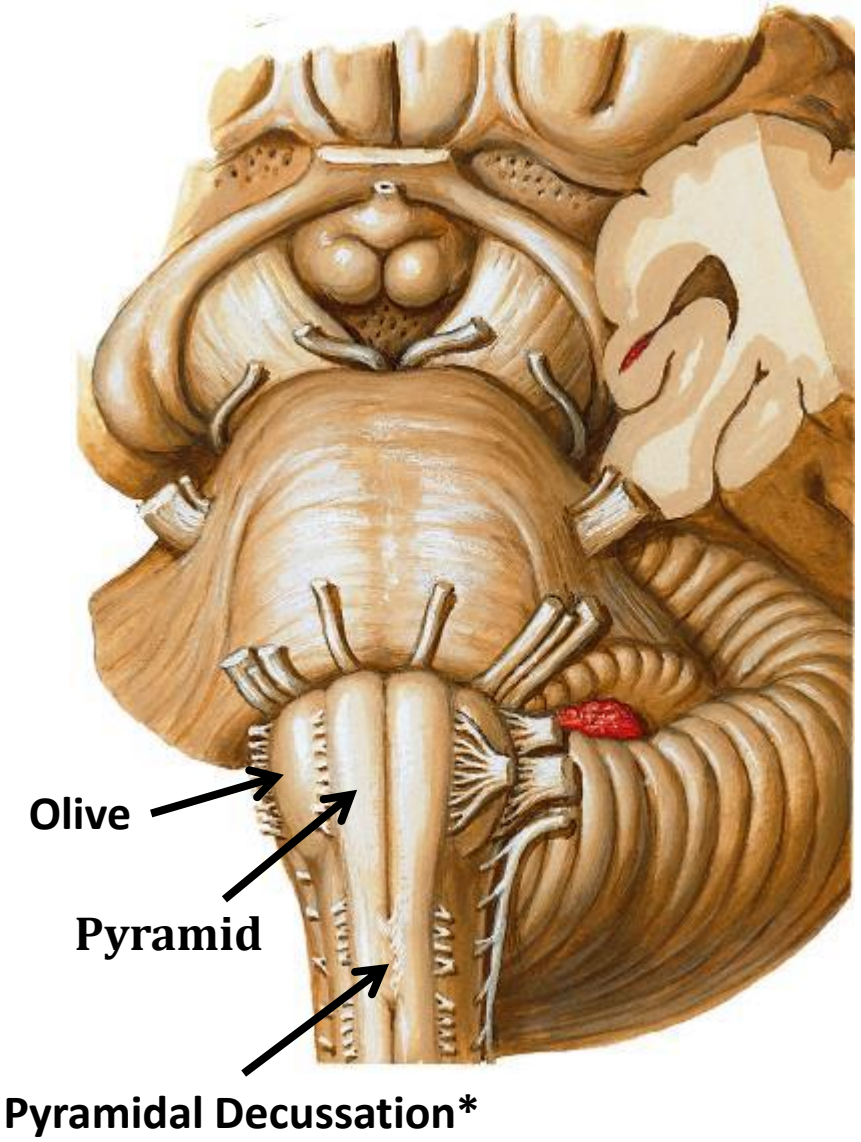
- The **anterior median fissure** in the anterior surface.

- Three elevations lie on each side of the anterior median fissure, from medial to lateral:

  - **The pyramid**: formed by the pyramidal (corticospinal) tract.

  - **The olive**: formed by the inferior olivary nucleus.

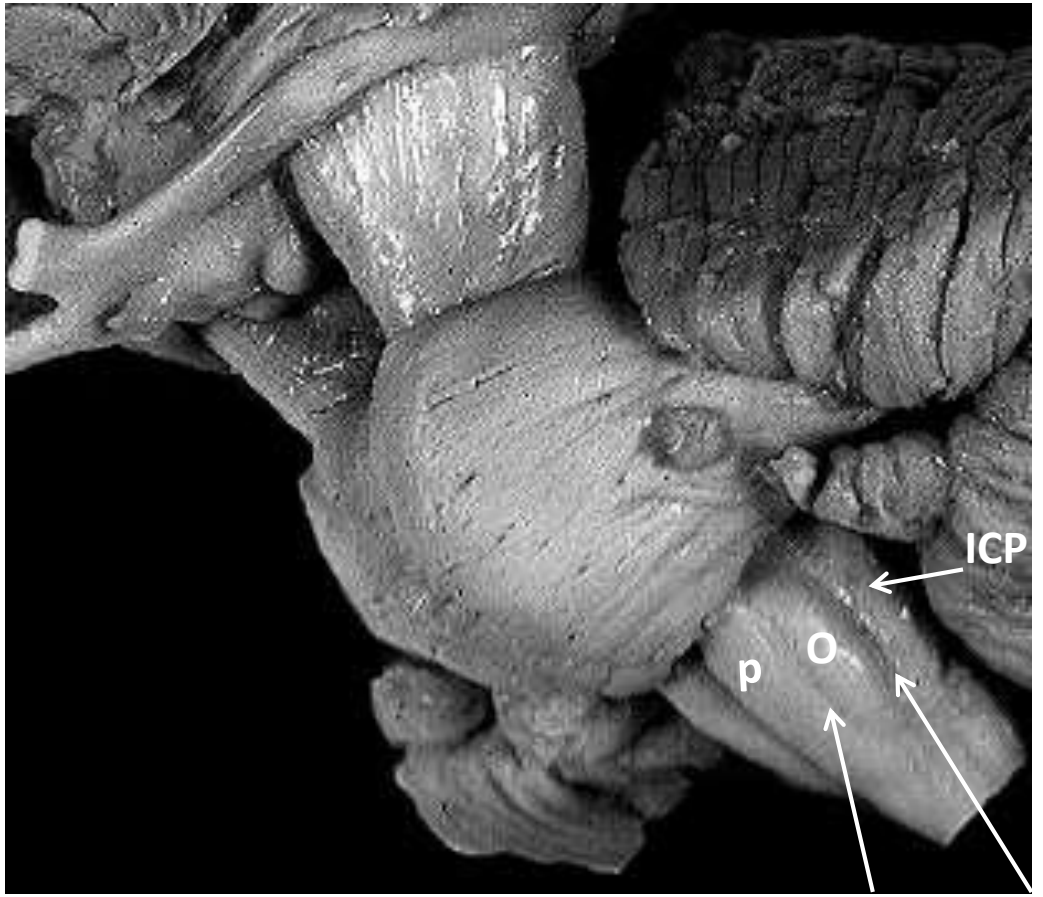
  - **The inferior cerebellar peduncle (ICP)**: formed by fibers connecting the medulla and cerebellum.

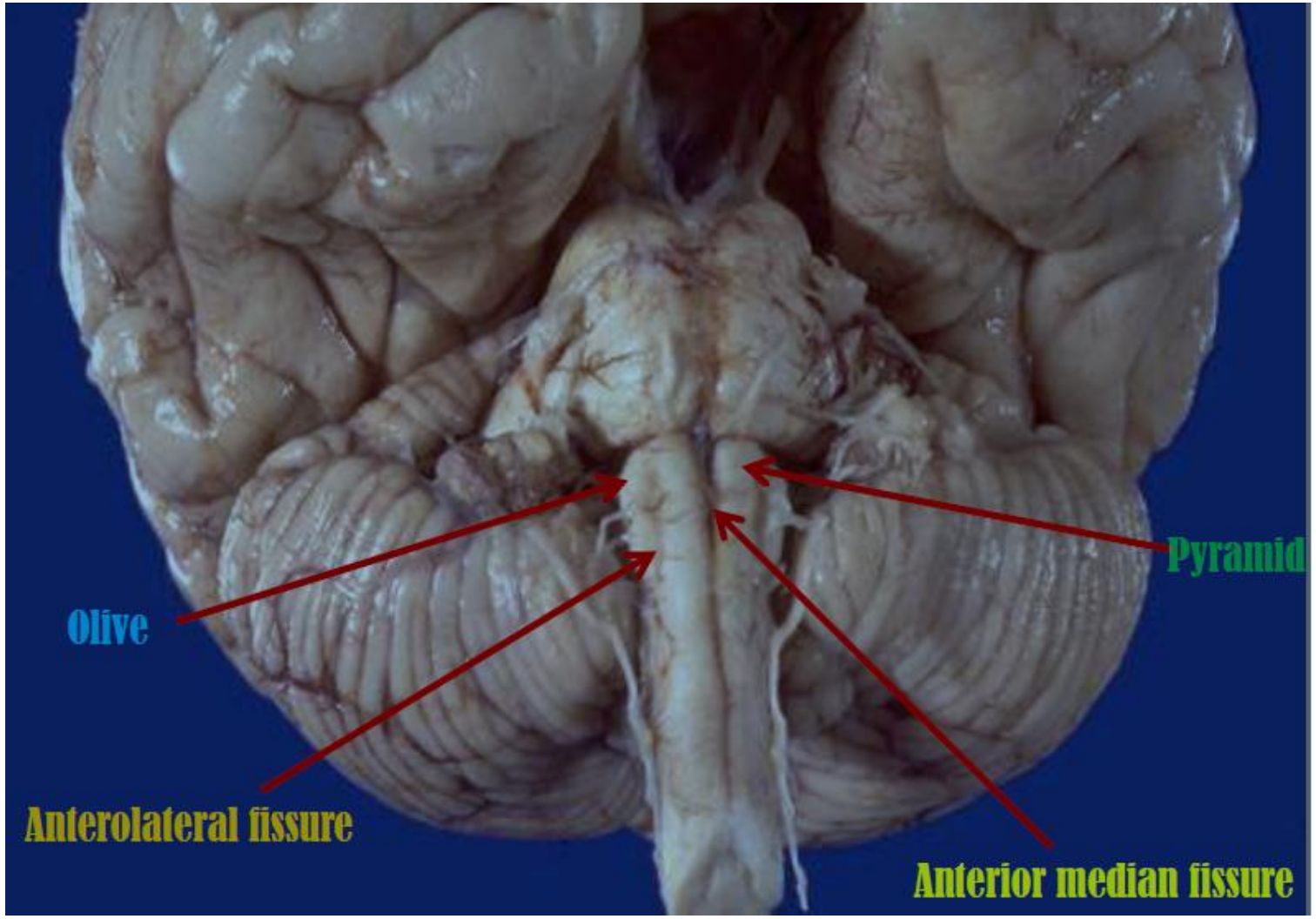


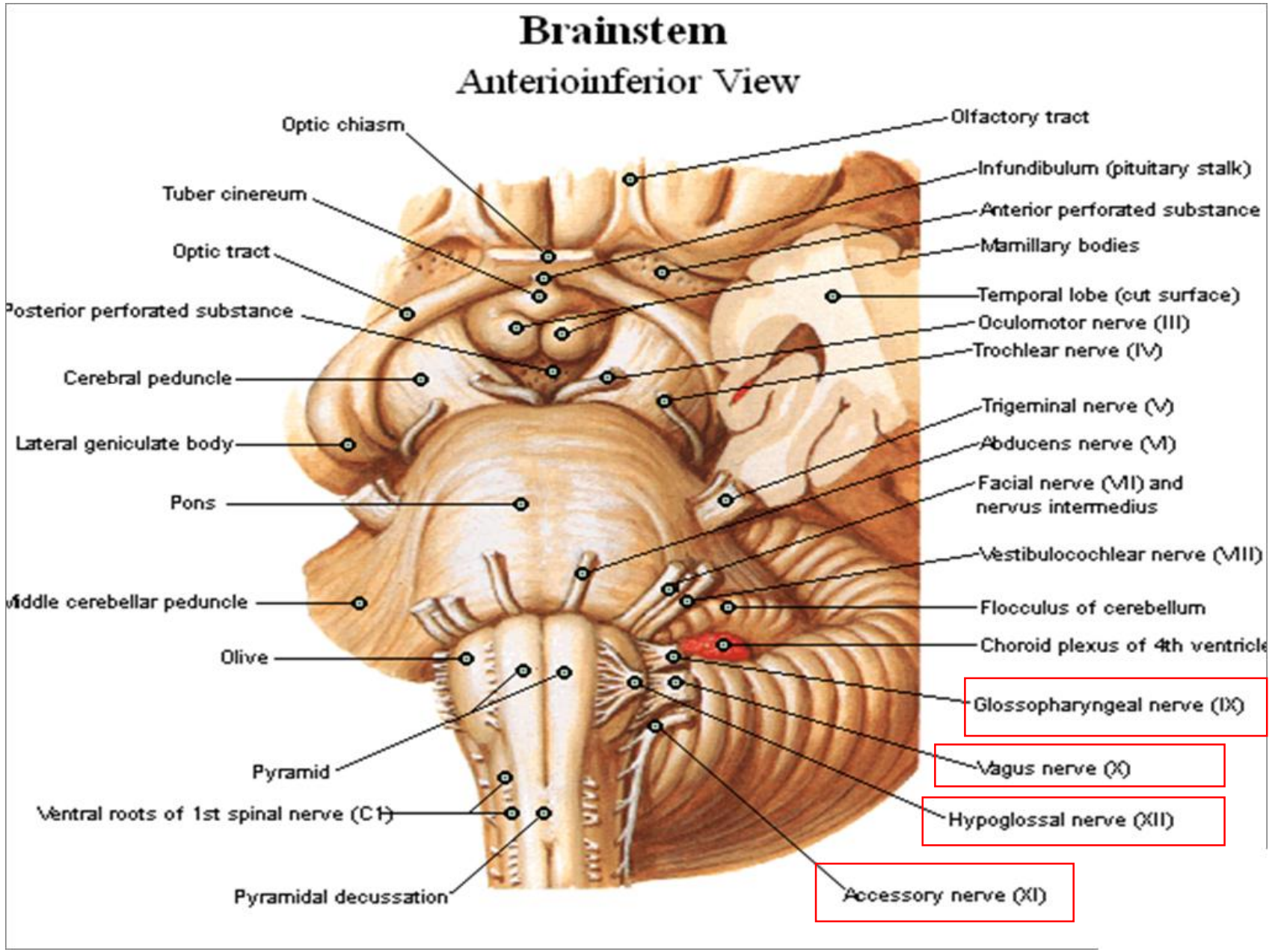
# External Features

## *Anterolateral Surface (Contd):*

- **The anterolateral** (preolivary) **sulcus:** between pyramid and olive, gives exit to the hypoglossal nerves.
- **The posterolateral** (postolivary) **sulcus:** between olive and ICP, gives exit to the glossopharyngeal, vagus and cranial accessory nerves.



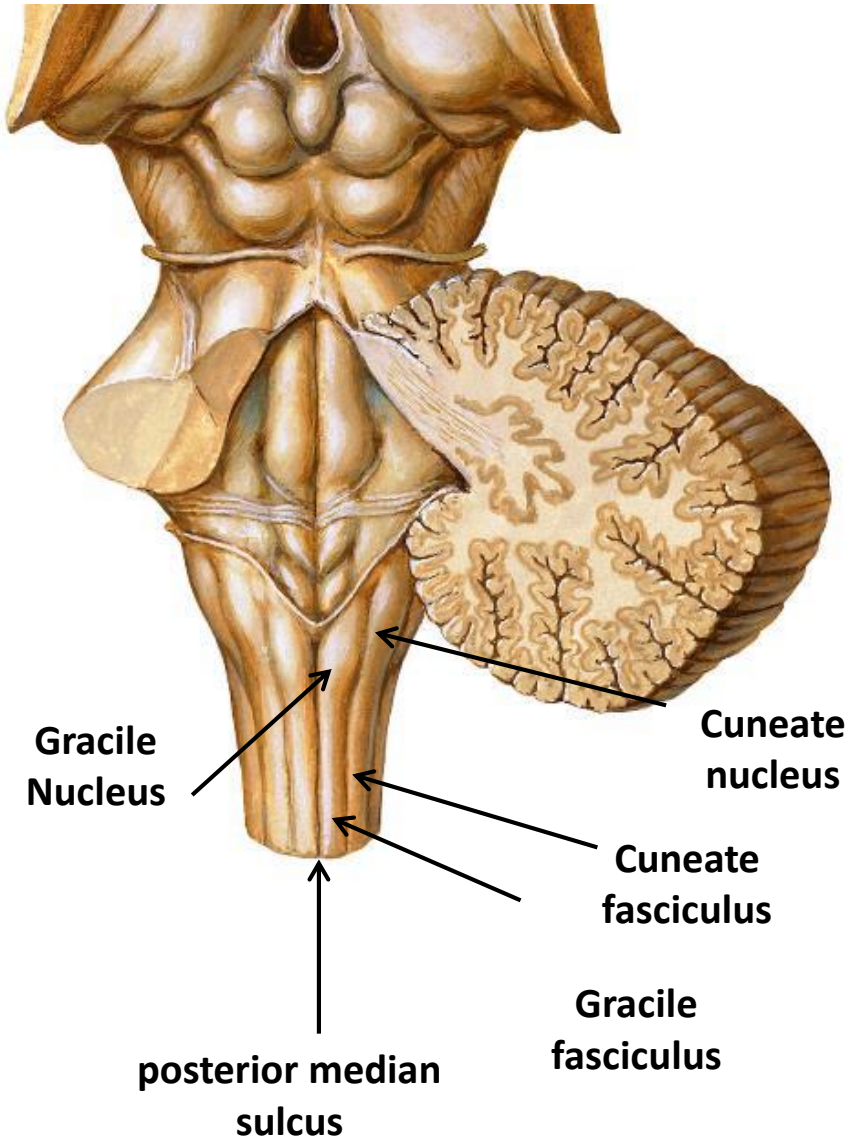

Olive
Pyramid
Anterolateral fissure
Anterior median fissure


Brainstem
Anterioinferior View
Optic chiasm
Tuber cinereum
Optic tract
Posterior perforated substance
Cerebral peduncle
Lateral geniculate body
Pons
Middle cerebellar peduncle
Olive
Pyramid
Ventral roots of 1st spinal nerve (C1)
Pyramidal decussation
Olfactory tract
Infundibulum (pituitary stalk)
Anterior perforated substance
Mamillary bodies
Temporal lobe (cut surface)
Oculomotor nerve (III)
Trochlear nerve (IV)
Trigeminal nerve (V)
Abducens nerve (VI)
Facial nerve (VII) and nervus intermedius
Vestibulocochlear nerve (VIII)
Flocculus of cerebellum
Choroid plexus of 4th ventricle
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Hypoglossal nerve (XII)
Accessory nerve (XI)

# External Features

## *Posterior Surface (Lower Half- Closed Medulla)*

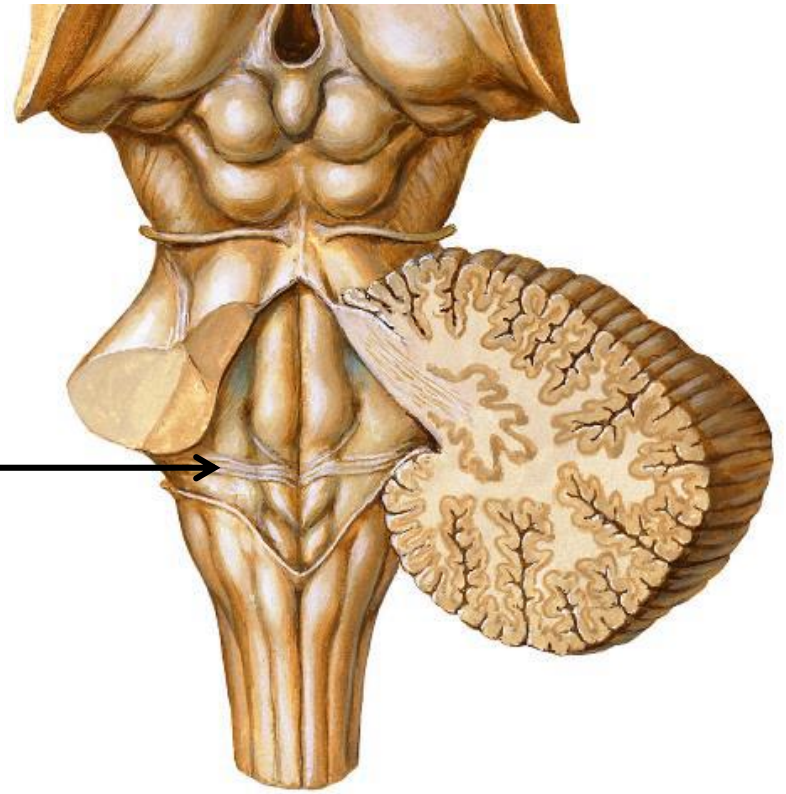
- The **posterior median sulcus**
- Tow columns lie on each side of the posterior median sulcus:
  - **Gracile fasciculus (tract)** ending in rounded **gracile tubercle** made of **gracile nucleus.**
  - **Cuneate fasciculus (tract)** ending in rounded **cuneate tubercle** made of **cuneate nucleus.**



# External Features

## *Posterior Surface (Upper Half- Open Medulla)*

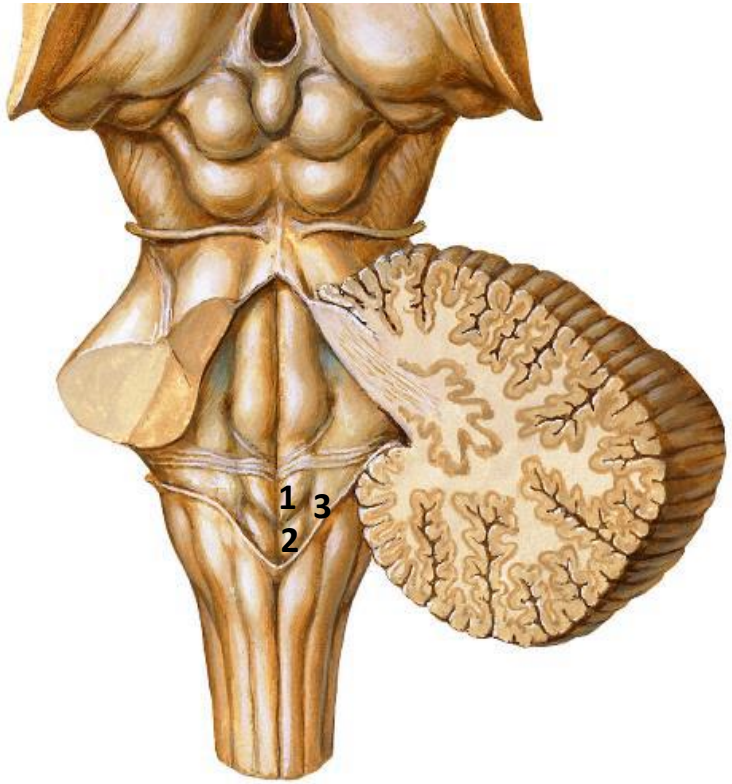
- The posterior surface of the upper half of the medulla forms the lower part of the floor of the fourth ventricle.
- It is triangular in shape; having:
  - **Base** (above) separated from pons by **stria medullaris**.
  - **Apex** (below) continuous with central canal.
  - **Floor**



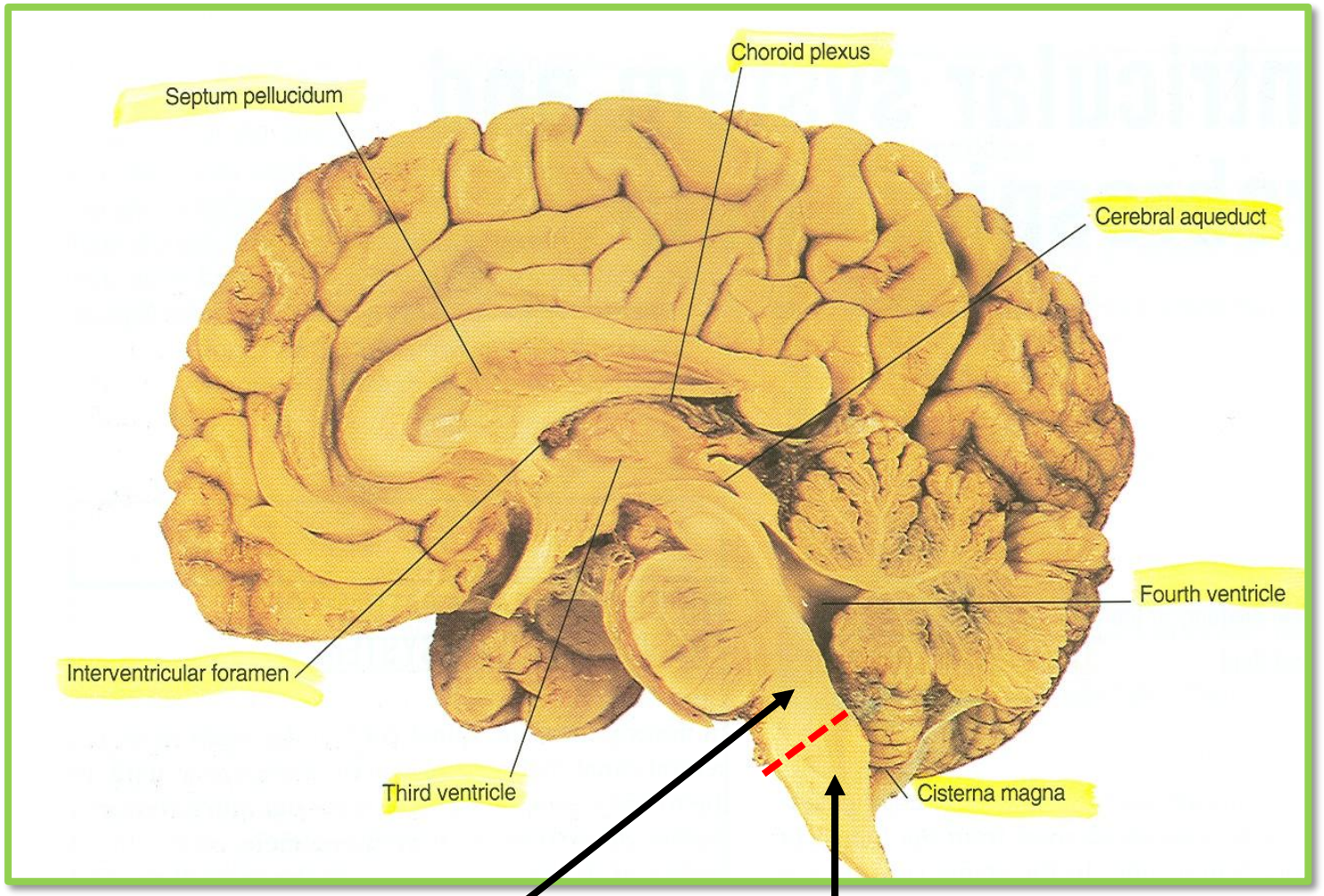
# External Features

## *Posterior Surface (Upper Half- Open Medulla)*

- In the floor each side of the median sulcus lies an inverted V-shaped sulcus, divides the area into 3 parts (from medial to lateral):

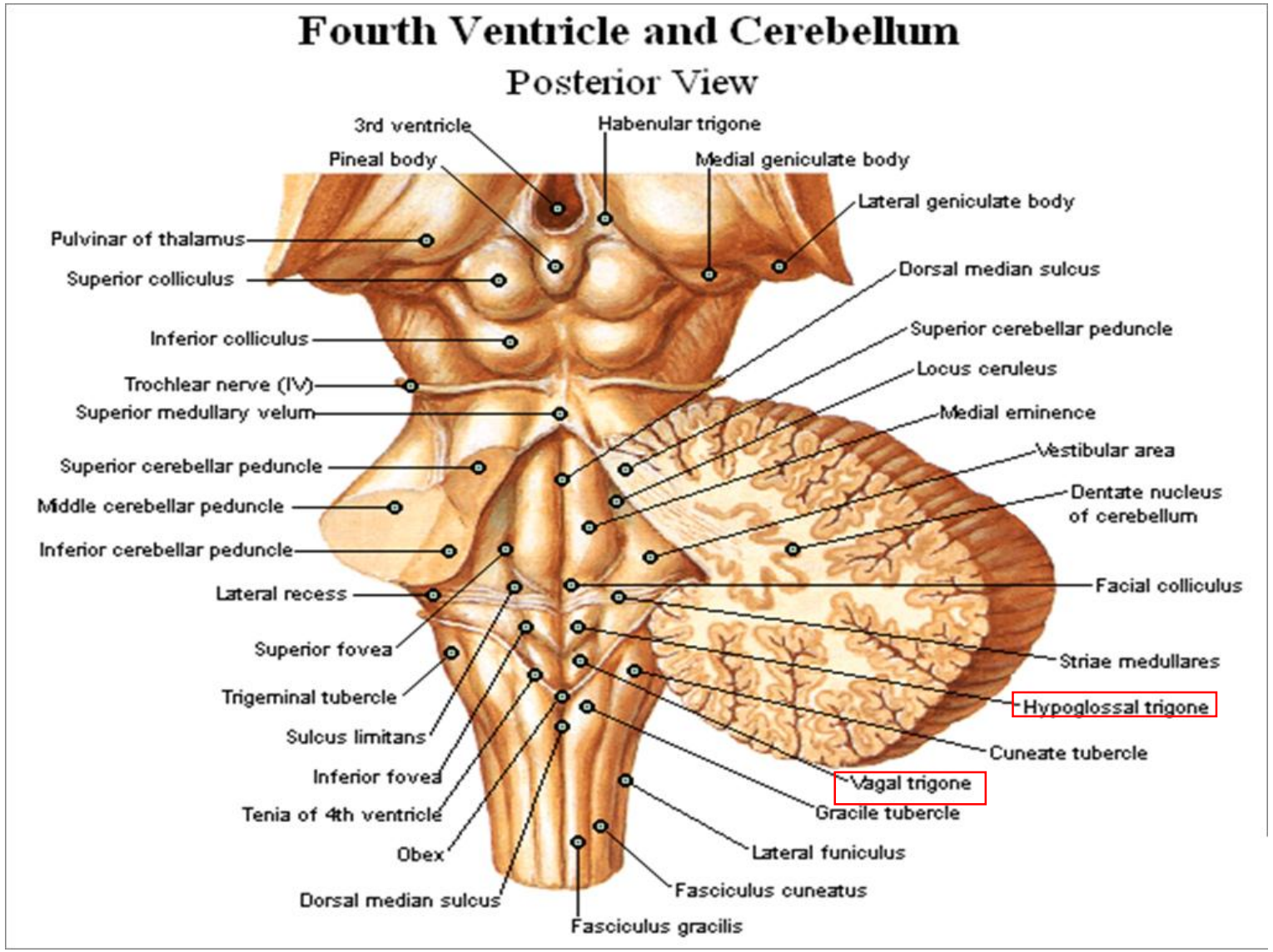



1. **Hypoglossal Trigone (1):** overlies hypoglossal nucleus.
2. **Vagal Trigone (2)**: overlies dorsal motor nucleus.
3. **Vestibular area (3)**: overlies vestibular nuclei




**Open Medulla**

**Closed Medulla**


Fourth Ventricle and Cerebellum
Posterior View
3rd ventricle
Habenular trigone
Pineal body
Medial geniculate body
Lateral geniculate body
Pulvinar of thalamus
Superior colliculus
Dorsal median sulcus
Inferior colliculus
Superior cerebellar peduncle
Trochlear nerve (IV)
Locus ceruleus
Superior medullary velum
Medial eminence
Vestibular area
Superior cerebellar peduncle
Dentate nucleus of cerebellum
Middle cerebellar peduncle
Inferior cerebellar peduncle
Facial colliculus
Lateral recess
Striae medullares
Superior fovea
Hypoglossal trigone
Trigeminal tubercle
Cuneate tubercle
Sulcus limitans
Vagal trigone
Inferior fovea
Gracile tubercle
Tenia of 4th ventricle
Lateral funiculus
Obex
Fasciculus cuneatus
Dorsal median sulcus
Fasciculus gracilis

# Internal Structures of Medulla

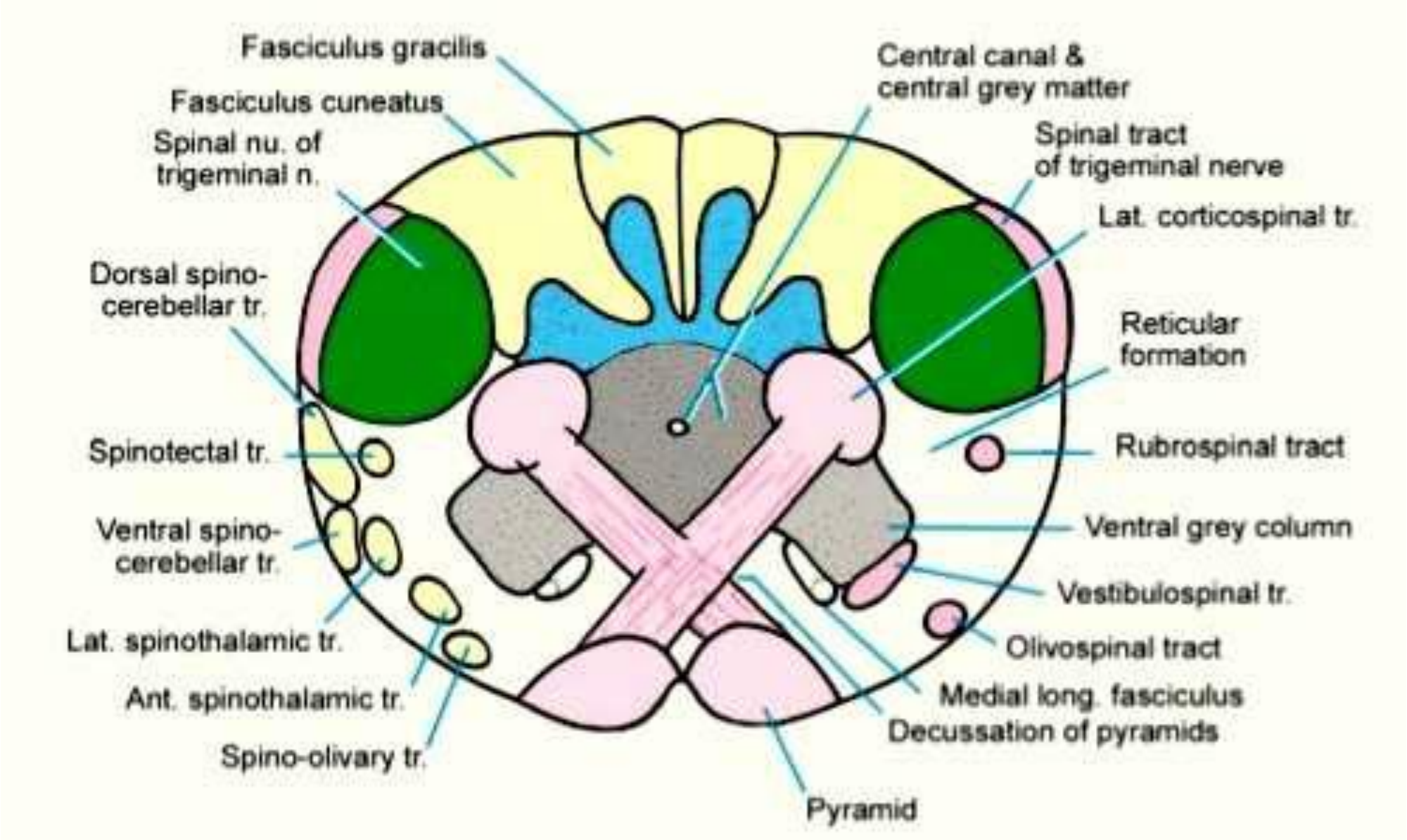
- We divided the medulla anatomically into three levels:

1. **Level of pyramidal (motor) decussation**
2. **Level of Lemniscal (sensory) decussation**
3. **Level of the olives (Rostral (open) Medulla)**

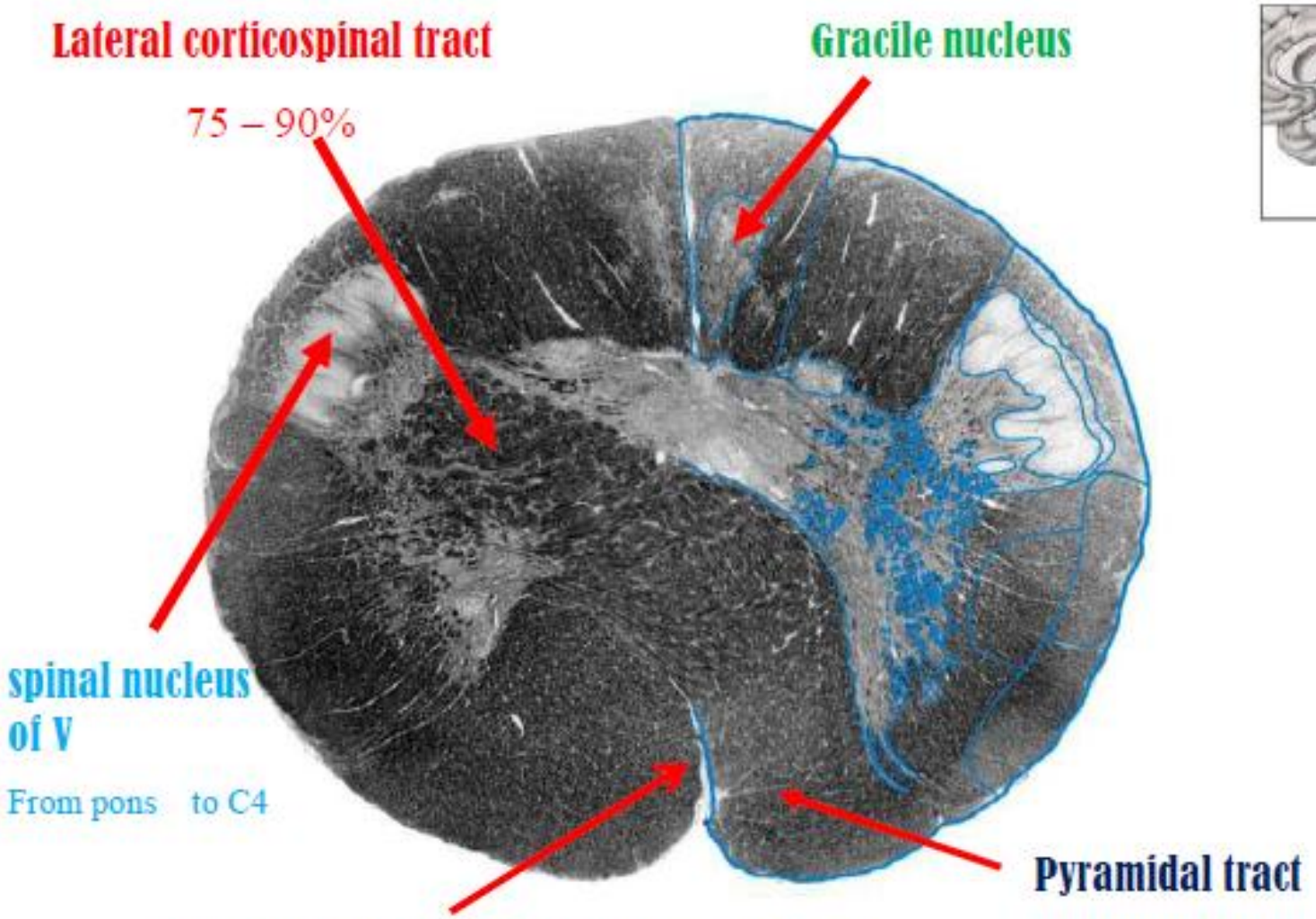
# Level of Pyramidal (motor) Decussation

- Around 80%  of corticospinal tracts fibers decussate at this level.
- The **cuneate** and **gracile nuclei** appear at this level to their respective fasciculi (tracts).
- Includes the **Spinal Nucleus of Trigeminal nerve** (Trigeminal  sensory nucleus).
- **Fibers of the anterolateral system** lie adjacent to each other in the lateral medulla.

# Level of Pyramidal Decussation



# Level of Pyramidal Decussation




# Trigeminal Sensory Nucleus and Tract

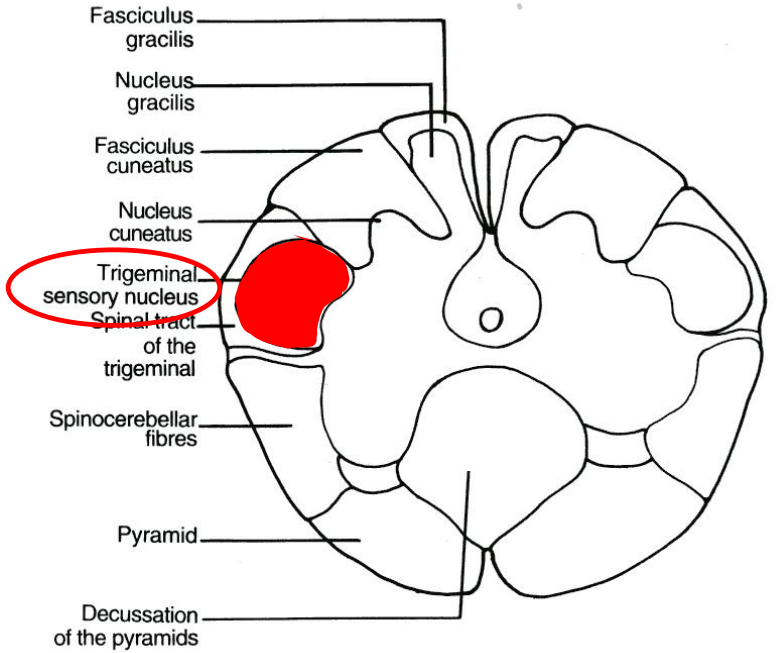
- It is a large sensory nucleus, receives pain and temperature from face and head.

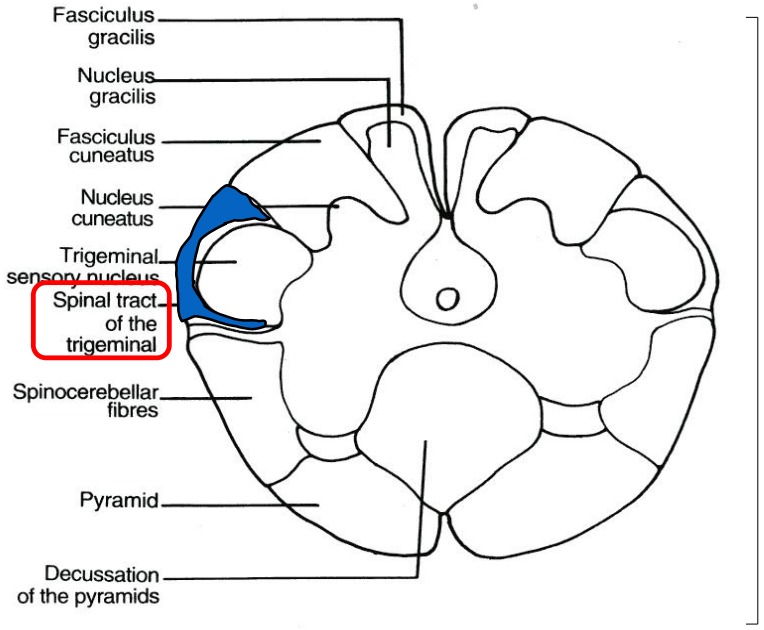
- It is the brain stem continuation of the Substantia Gelatinosa of spinal cord.

- The Nucleus extends through the whole length of the brain stem and into upper segments of spinal cord.

- It lies in all levels of M.O, medial to the spinal tract of the trigeminal.

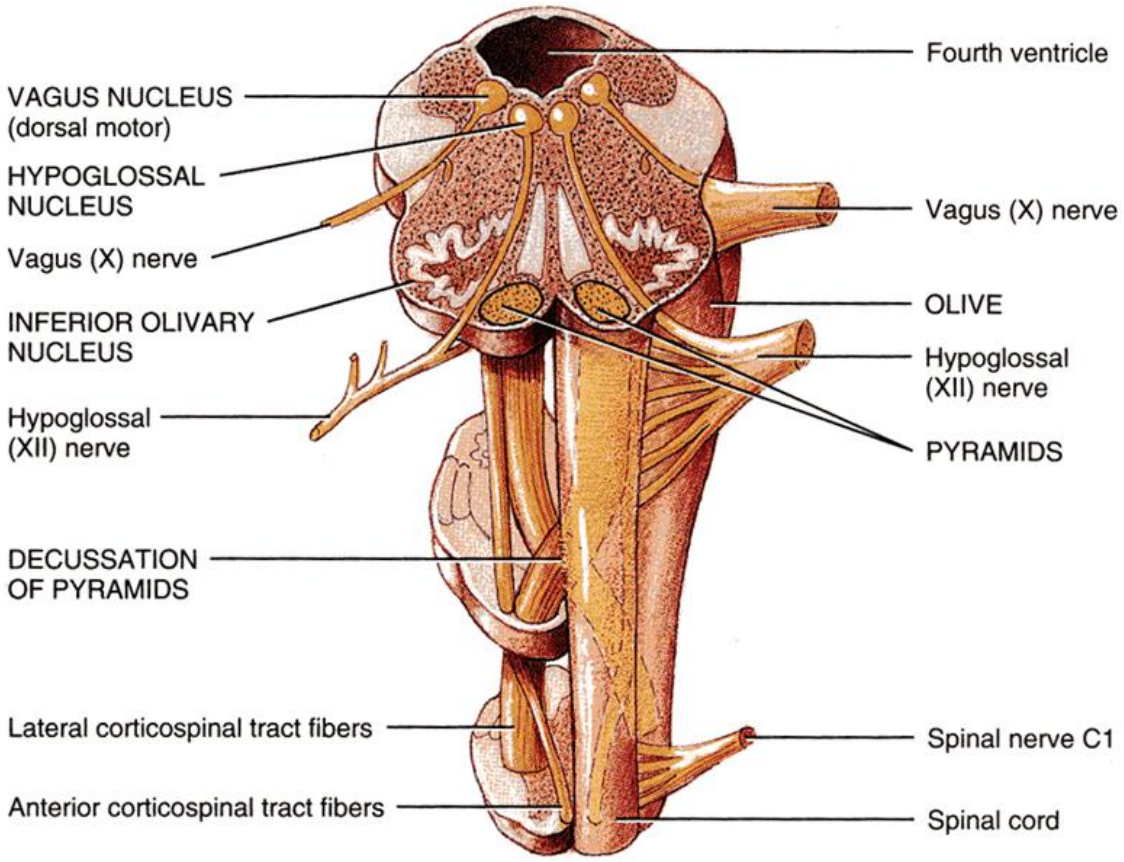
- Its tract is present in all levels of M.O. and it is formed of descending fibers that terminate in the trigeminal nucleus.



# Pyramidal Decussation

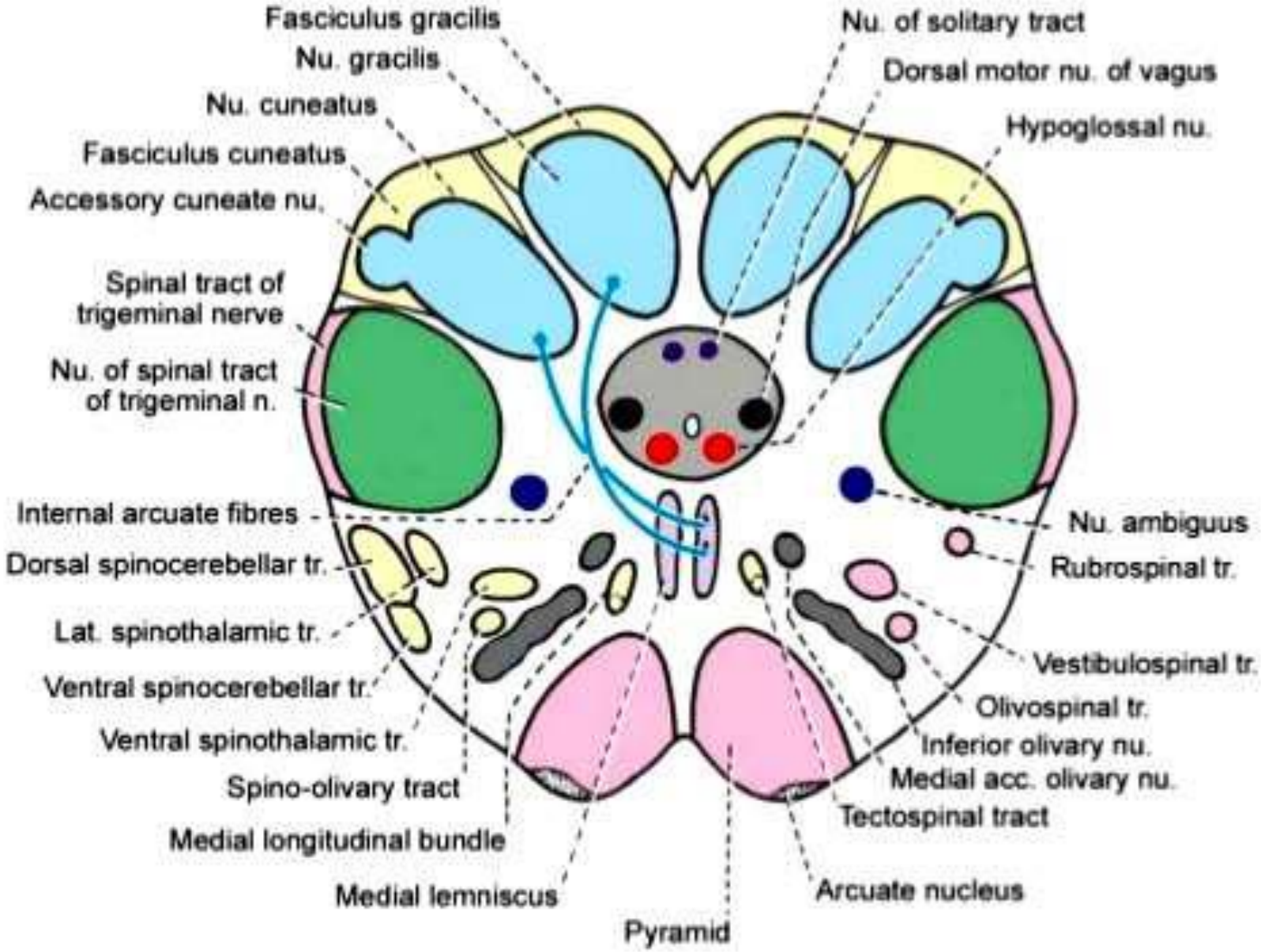
- It is the Motor Decussation.
- Formed by pyramidal fibers, (80%) cross to the opposite side .
- The uncrossed fibers descend in the lateral white column of the spinal cord as the lateral corticospinal tract.
- The uncrossed fibers form the ventral corticospinal tract.



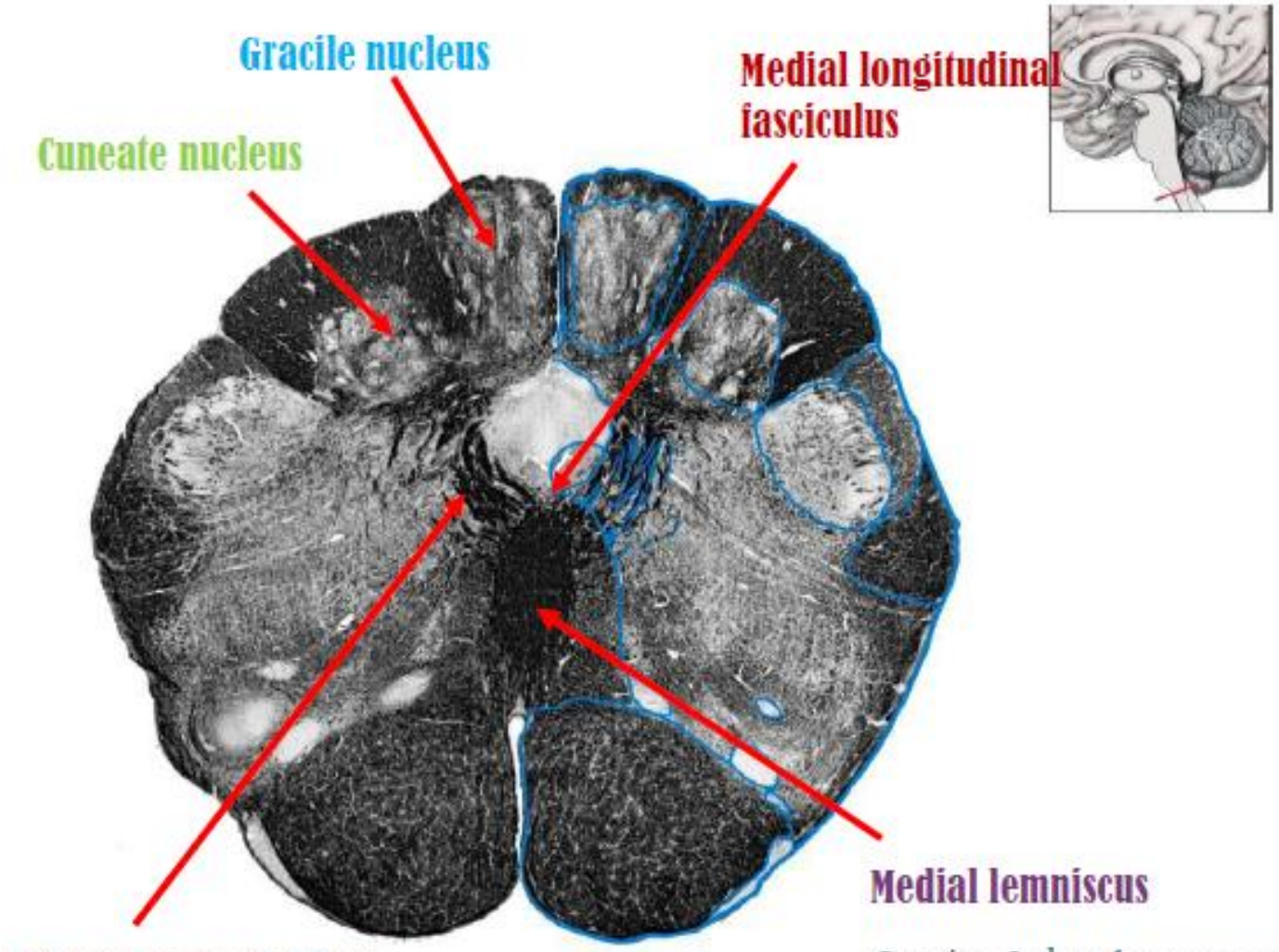
Transverse section and anterior surface of medulla oblongata

# Level of Lemniscal ( Sensory) Decussation

- Larger size **Gracile and Cuneate nuclei**, concerned with fine touch and proprioceptive sensations of the body.
- Axons of Gracile and Cuneate nuclei form the **internal arcuate fibers** (Sensory Decussation) that ascend as **Medial Lemniscus** on either side of the midline ventral to the central canal.
- The region lateral to the medial lemniscus contains scattered neurons mixed with nerve fibers. This region is the **reticular formation**.
- More laterally there is a mass of white matter containing various tracts
- **The spinal nucleus of the trigeminal nerve** lies lateral to the internal arcuate fibers**.**
- **Pyramids** are prominent ventrally.


Fasciculus gracilis
Nu. gracilis
Nu. cuneatus
Fasciculus cuneatus
Accessory cuneate nu.
Spinal tract of trigeminal nerve
Nu. of spinal tract of trigeminal n.
Internal arcuate fibres
Dorsal spinocerebellar tr.
Lat. spinothalamic tr.
Ventral spinocerebellar tr.
Ventral spinothalamic tr.
Spino-olivary tract
Medial longitudinal bundle
Medial lemniscus
Pyramid
Nu. of solitary tract
Dorsal motor nu. of vagus
Hypoglossal nu.
Nu. ambiguus
Rubrospinal tr.
Vestibulospinal tr.
Olivospinal tr.
Inferior olivary nu.
Medial acc. olivary nu.
Tectospinal tract
Arcuate nucleus

# Level of Lemniscal Decussation



# Level of Inferior Olives

## ROSTRAL (open) MEDULLA

- Section at this level passes across the inferior part of the fourth ventricle.
- Many cranial nerve nuclei appear at this level
- The most prominent nuclei are the olivary nuclear complex especially the **inferior olivary nucleus**

# Level of Inferior Olives

- The **pyramid** is clear, with **medial lemniscus** on either sides of middle line dorsal to the pyramid.
- **Olivary Nuclear Complex:** Largest = Inferior Olivary Nucleus, lie posterolateral to the pyramids. Smaller dorsal and medial accessory olivary nuclei are also present.
- The dorsal surface forms the lower part of the floor of the 4th ventricle.
- The **Inferior Cerebellar Peduncle** is dorsolateral in position, connecting M.O. with cerebellum.
- Dorsal and lateral to the Inferior cerebellar peduncle lie the **Cochlear nuclei** (dorsal and ventral).

# Level of Inferior Olives

- **Medial longitudinal fasciculus**, arises mainly from the vestibular nuclei, lies close to the midline, ventromedial to the hypoglossal nucleus.
  - *Ascending limb:*

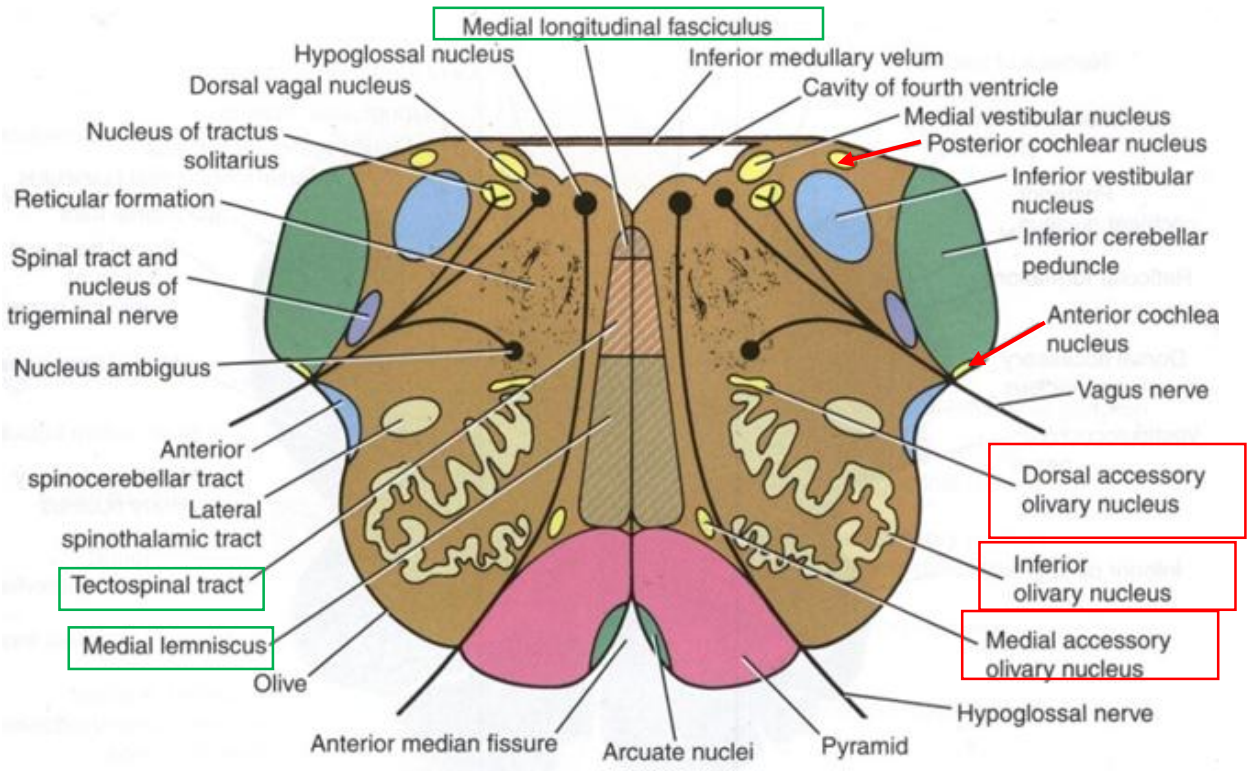
    It links the vestibular nuclei with nuclei of extraocular muscles.(3, 4 and 6) as (vestibulo-ocular tract) to help coordination of eye movements with head movements.

  - *Descending limb:*

    Descend from vestibular nuclei to anterior horn's cells of spinal cord (cervical & upper thoracic segments) in medial vestibulospinal tract---so, the neck and trunk move with head movements.

- **Tectospinal tract:** between tectum of midbrain and spinal cord (involved in head movements during visual and auditory tracking).

# Level of Inferior Olives




# Level of Inferior Olives

- **There are seven type of nuclei present:**

1. **Hypoglossal Nucleus:** (motor nucleus): lies posteriorly at the midline, gives motor fibers along hypoglossal nerve to muscles of tongue.

2. **Dorsal Nucleus of Vagus** lateral to the hypoglossal nucleus, contains preganglionic parasympathetic fibers.

3. Part of **spinal trigeminal nucleus** and some **vestibular nuclei** (associated with vestibulocochlear nerve and concerned with equilibrium).

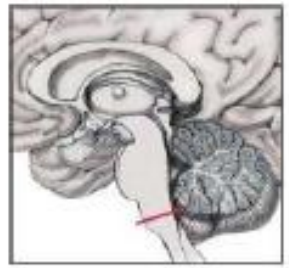
# Contd..

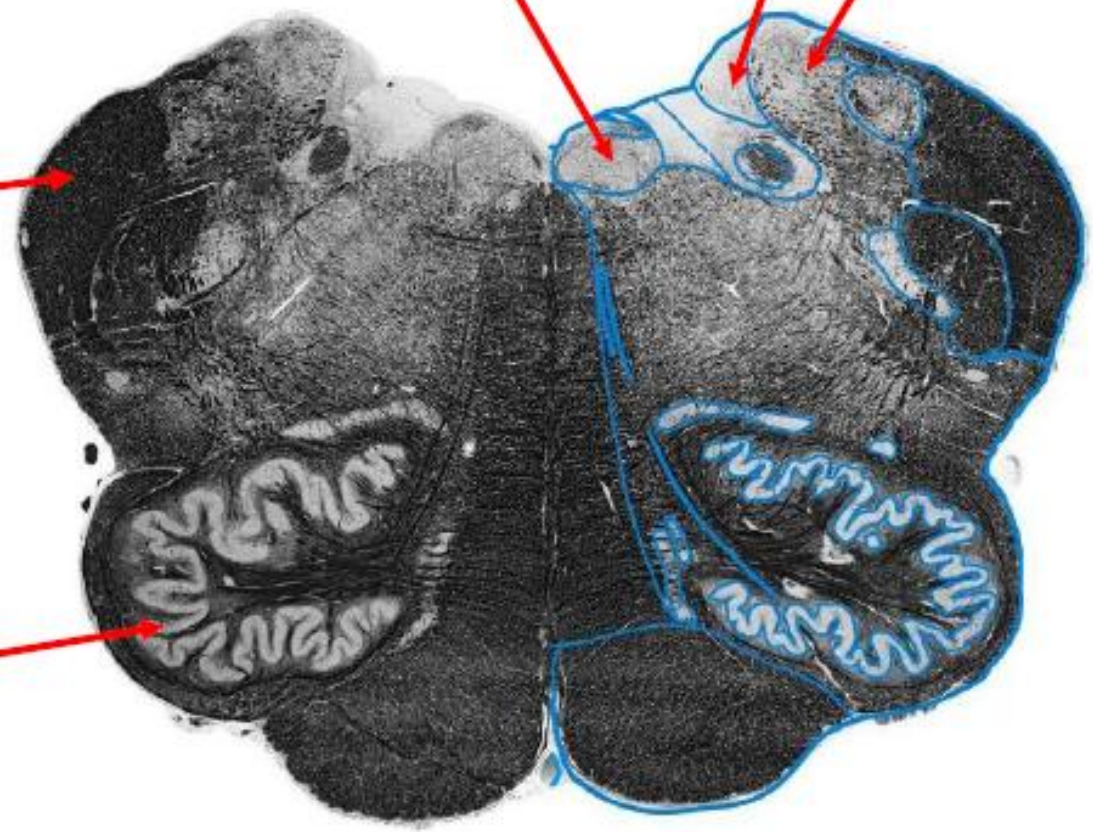
1. **Solitary nucleus** (sensory nucleus): lies ventrolateral to dorsal nucleus of vagus, receive taste sensation from the tongue along the facial (VII), glossopharyngeal (IX) and vagus (X) nerves.

2. **Inferior Olivary Nucleus:** a convoluted mass of gray matter, lies posterolateral to the pyramids It is concerned with the control of movement

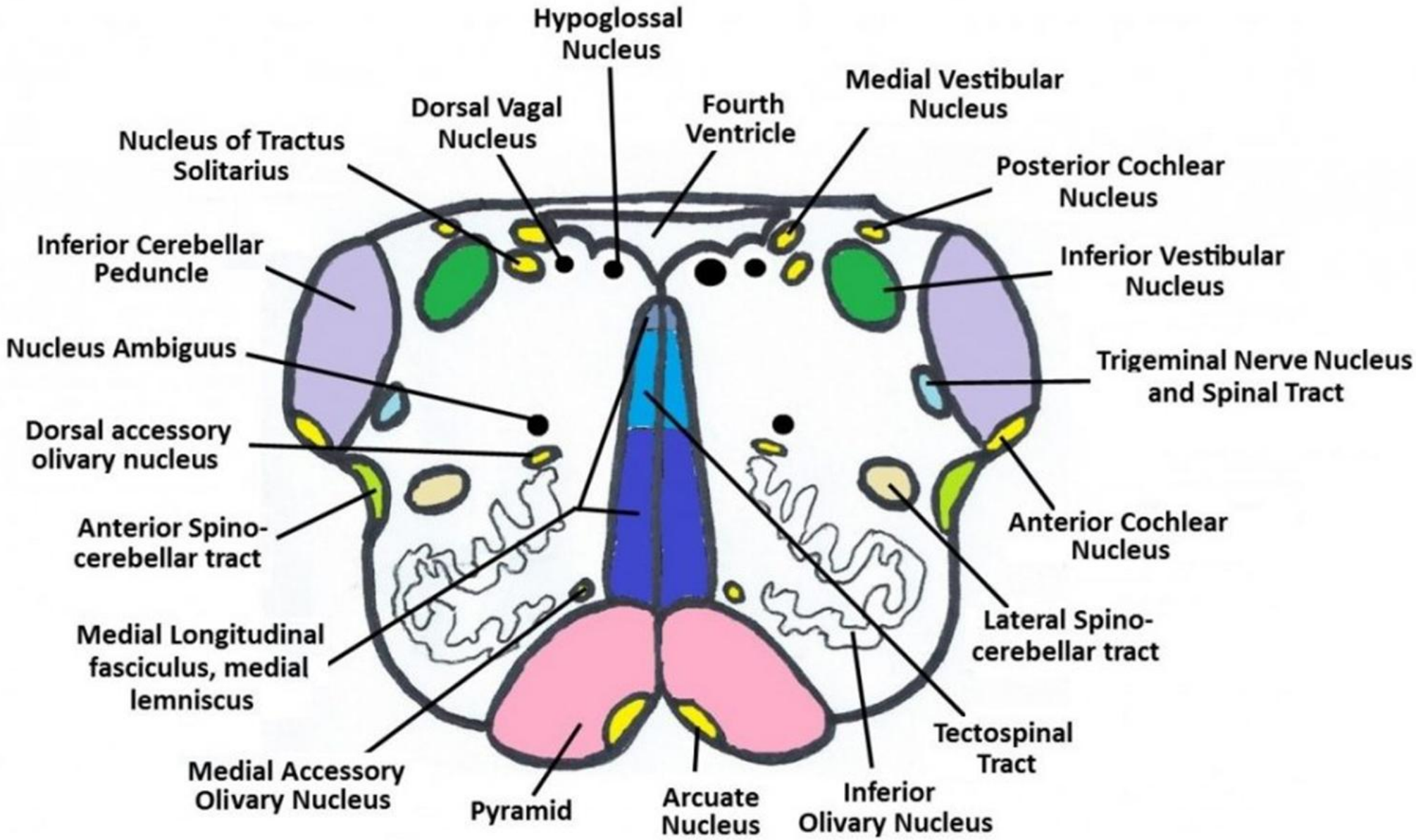
3. **Nucleus Ambiguus:** (motor nucleus): lies dorsal to olivary nucleus gives motor fibers along glossopharyngeal nerve and vagus nerve to muscles of the pharynx, larynx and palate.

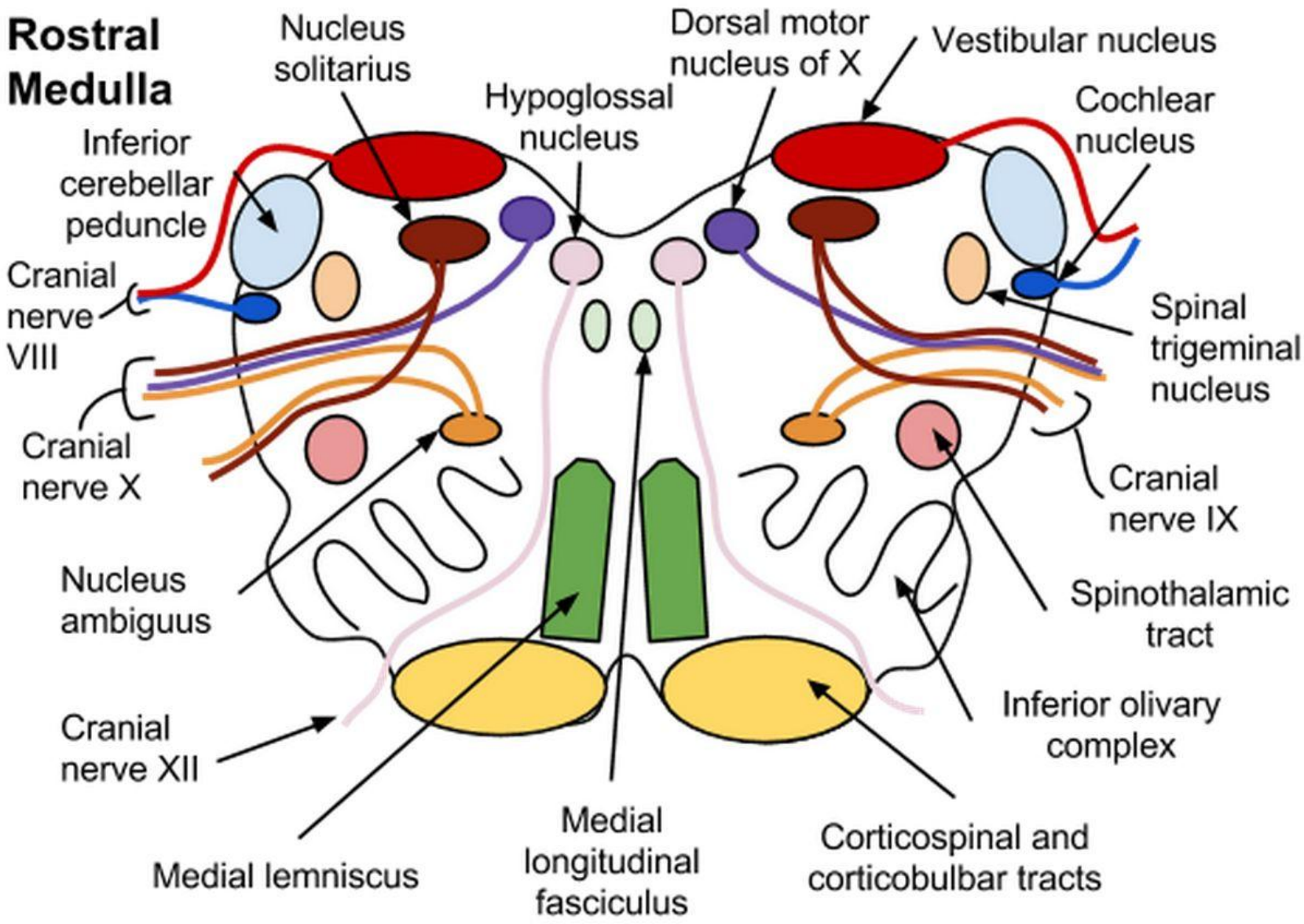
# Level of Inferior Olives






Relay between cortex, vestibular nuclei, cerebellum, basal ganglia, and dorsal column nuclei


Hypoglossal Nucleus
Medial Vestibular Nucleus
Dorsal Vagal Nucleus
Fourth Ventricle
Nucleus of Tractus Solitarius
Posterior Cochlear Nucleus
Inferior Cerebellar Peduncle
Inferior Vestibular Nucleus
Nucleus Ambiguus
Trigeminal Nerve Nucleus and Spinal Tract
Dorsal accessory olivary nucleus
Anterior Spino-cerebellar tract
Anterior Cochlear Nucleus
Lateral Spino-cerebellar tract
Medial Longitudinal fasciculus, medial lemniscus
Tectospinal Tract
Medial Accessory Olivary Nucleus
Pyramid
Arcuate Nucleus
Inferior Olivary Nucleus


Rostral Medulla
Nucleus solitarius
Dorsal motor nucleus of X
Vestibular nucleus
Hypoglossal nucleus
Cochlear nucleus
Inferior cerebellar peduncle
Cranial nerve VIII
Spinal trigeminal nucleus
Cranial nerve X
Cranial nerve IX
Nucleus ambiguus
Spinothalamic tract
Inferior olivary complex
Cranial nerve XII
Medial lemniscus
Medial longitudinal fasciculus
Corticospinal and corticobulbar tracts

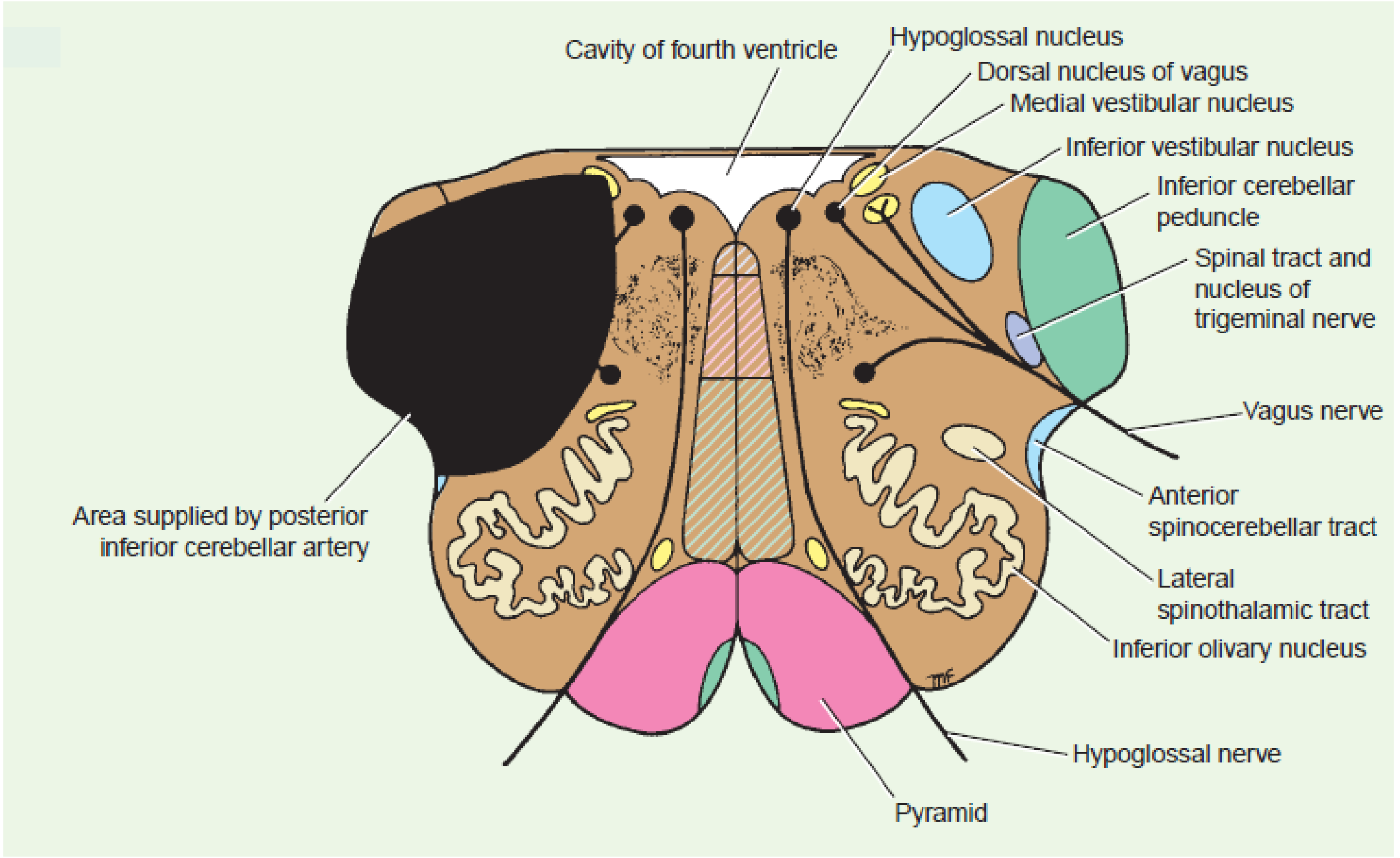
# Lesions of the Medulla Oblongata

## Lateral Medullary Syndrome

- Also known as **"Wallenberg's syndrome"**

- Results from a vascular lesion of the **vertebral** and **posterior inferior cerebellar arteries**.

- **Structures affected:**
  1. **Nucleus ambigus**
  2. **Spinal tract of trigeminal n.** ( uncrossed )
  3. **Spinal lemniscus** ( crossed ) upper continuation of anteriolateral system
  4. **Hypothalamospinal fibers of the sympathetic system**
  5. **Vestibular nuclei**
  6. **Ventral and dorsal spinocerebellar tract, inferior cerebellar peduncle and part of cerebellum**

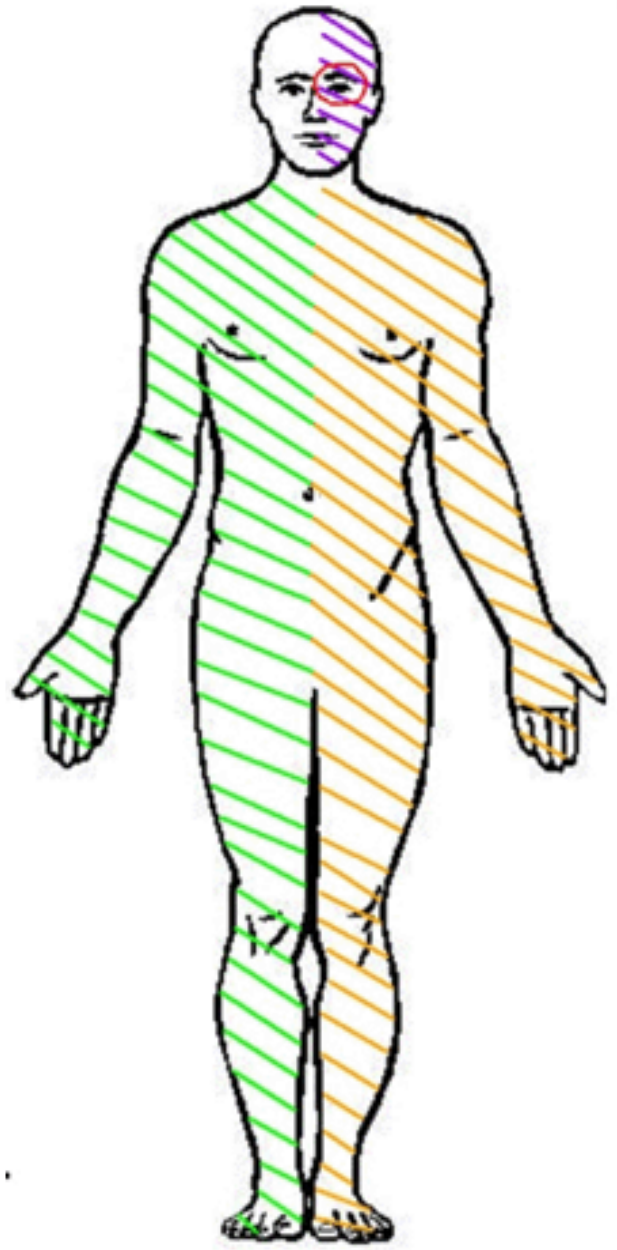

Cavity of fourth ventricle
Hypoglossal nucleus
Dorsal nucleus of vagus
Medial vestibular nucleus
Inferior vestibular nucleus
Inferior cerebellar peduncle
Spinal tract and nucleus of trigeminal nerve
Vagus nerve
Anterior spinocerebellar tract
Lateral spinothalamic tract
Inferior olivary nucleus
Area supplied by posterior inferior cerebellar artery
Hypoglossal nerve
Pyramid

# Left Lateral Medullary Syndrome

- The **green lines** indicate ***loss of pain and temperature of the contralateral limbs and trunk*** (***spinothalamic tract***).

- The ***purple lines*** on the left face ***indicate loss of pain and temperature of the ipsilateral face*** (***sensory nucleus*** **of** ***trigeminal*** **nerve**).

- The ***yellow lines*** represent ***ataxia of the ipsilateral limbs and trunk*** **(*spinocerebellar* tract)** associated with incoordination of movements and gait in affecting limbs.



# Left Lateral Medullary Syndrome

- Furthermore, patients may experience ***vertigo*** and **nystagmus (*vestibular nucleus*).**

- ***Dysphagia, hoarseness of voice and dysphonia*** **(nucleus ambiguus and glossopharyngeal nerves).**

- **Cerebellar (motor) ataxia (inferior cerebellar peduncles or spinocerebellar tract)** associated with incoordination of movements and in gait affecting limbs.

# Left Lateral Medullary Syndrome

- Also leads to **Horner's syndrome** ipsilateral (left) to the lesion by damage of **descending sympathetic fibers.** It is manifested by:

1. Ptosis (drooping of the upper eyelid).
2. Miosis (constriction of the pupil).
3. The skin of face is dry (due to loss of sweating) and warm (due to vasodilation)

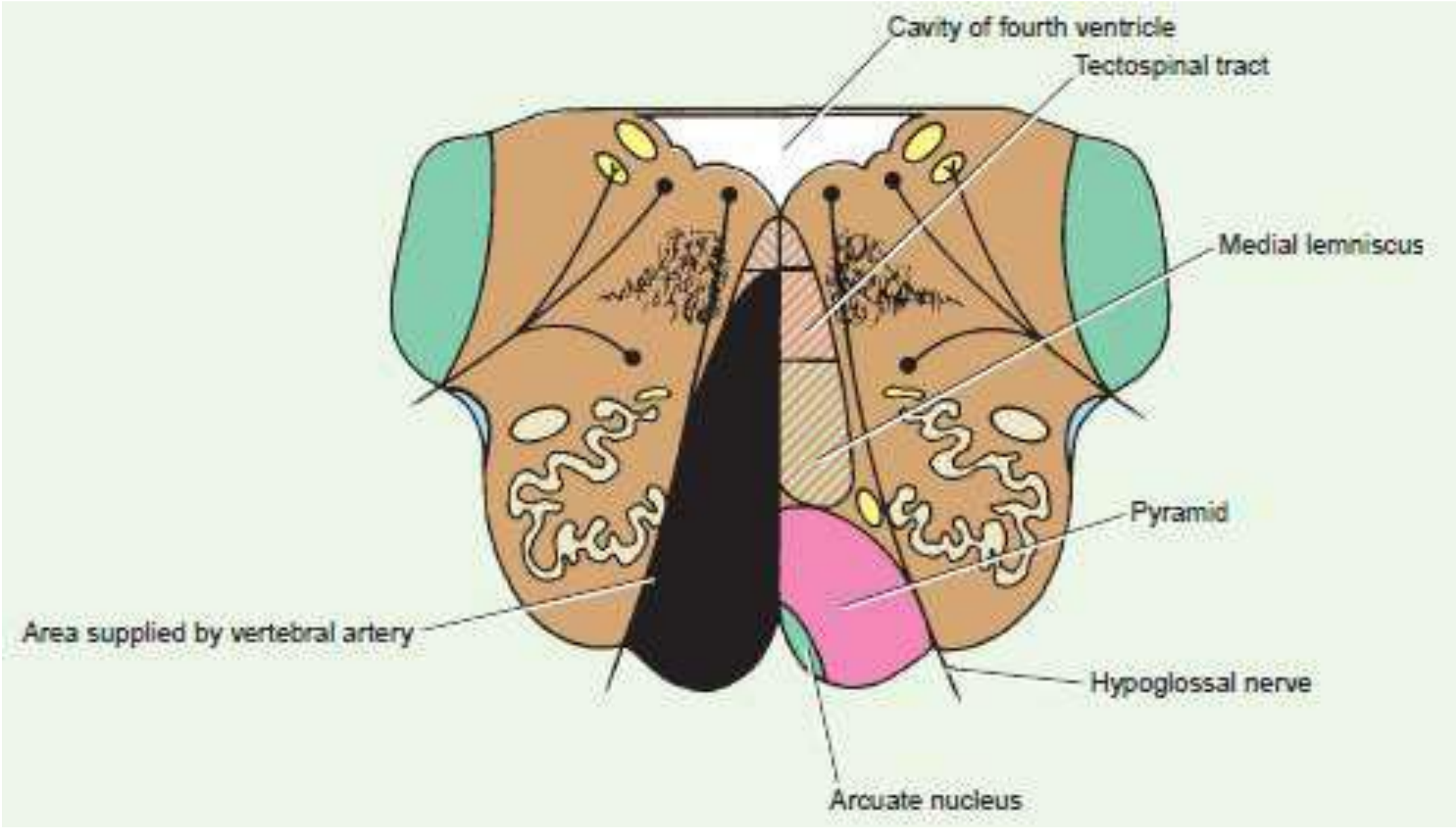
# Lesions of the Medulla Oblongata

## Medial Medullary Syndrome

- Also known as the **"Déjérine's syndrome"**

- Results from damage to the medial branches of the vertebral artery or the anterior spinal artery

- **Structures affected:**
  1. **Pyramid**
  2. **Medial lemniscus**
  3. **Hypoglossal nucleus**


Cavity of fourth ventricle
Tectospinal tract
Medial lemniscus
Pyramid
Area supplied by vertebral artery
Hypoglossal nerve
Arcuate nucleus

# Medial Medullary Syndrome

- **It will lead to:**

***IPSI LATERALLY***

- **Paralysis of the tongue on the same side ( due to damaged hypoglossal nuclei → hypoglossal nerve)**. Due to this defect, unopposed action of genioglossus of normal side will ***push*** the ***tip*** of ***tongue***, when protruded, to the ***paralyzed side***.

***CONTRALATERALY***

- **Hemiplegia** ( **crossed pyramid damage**) as it is upper motor neuron lesion, it is characterized by contralateral spastic paralysis with increased muscle tone and exaggerated tendon jerks

# Medial Medullary Syndrome

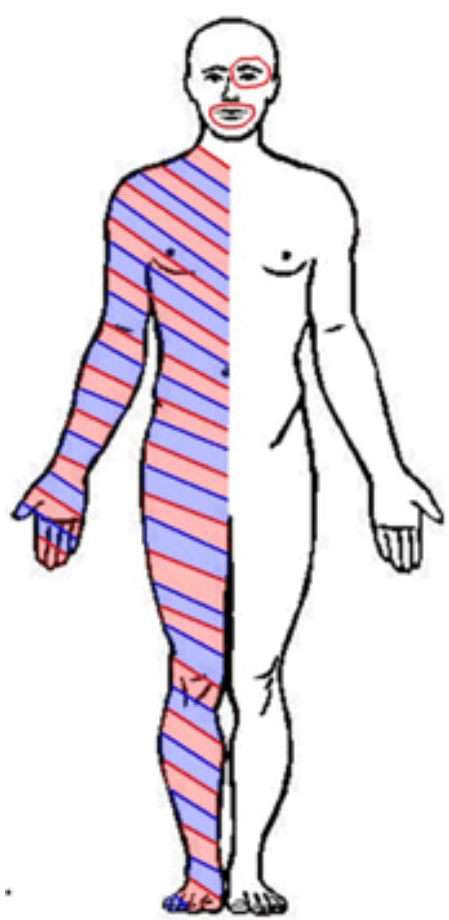
- **It will also lead to:**

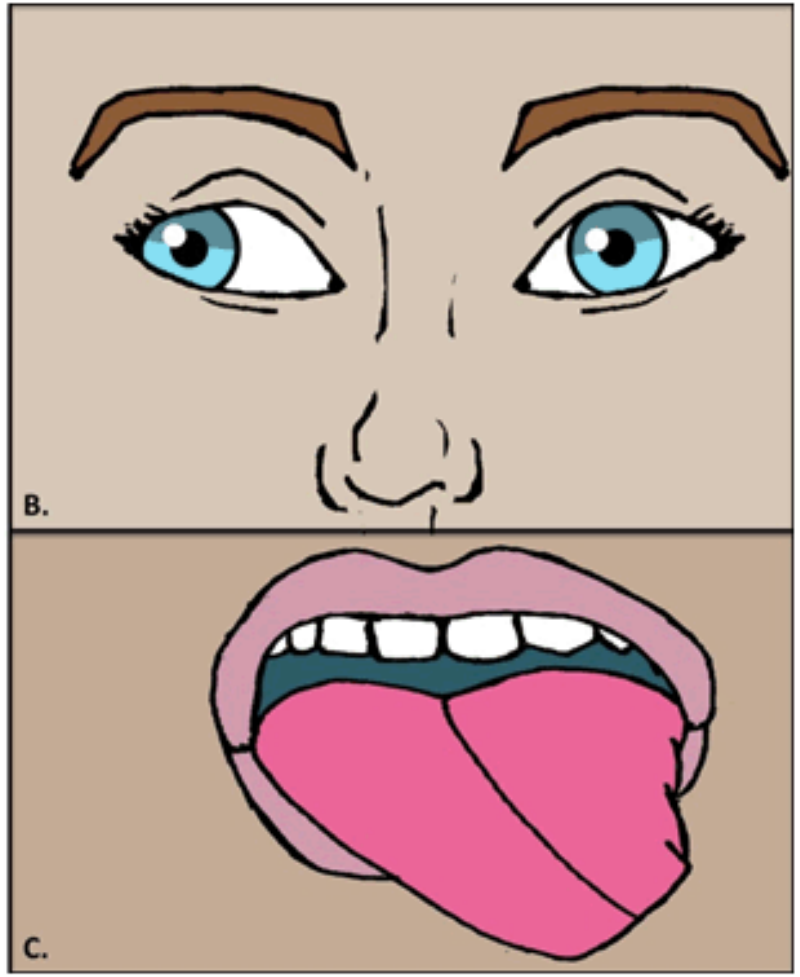
  ***Additional sensory deficit***

  - At this level of medulla (pyramidal level), medial lemniscus is situated behind pyramid. So, if the lesion is deeper, ***damage to medial lemniscus*** will cause ***loss of sense of position and movement*** (due to loss of proprioceptive sensation from muscles, tendons and joints) and **loss of *discriminative touch*** of **opposite side**.

# Left Medial Medullary Syndrome

**contralateral spastic paralysis**






**Tongue protrusion, to the paralyzed side**

# Thank you

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