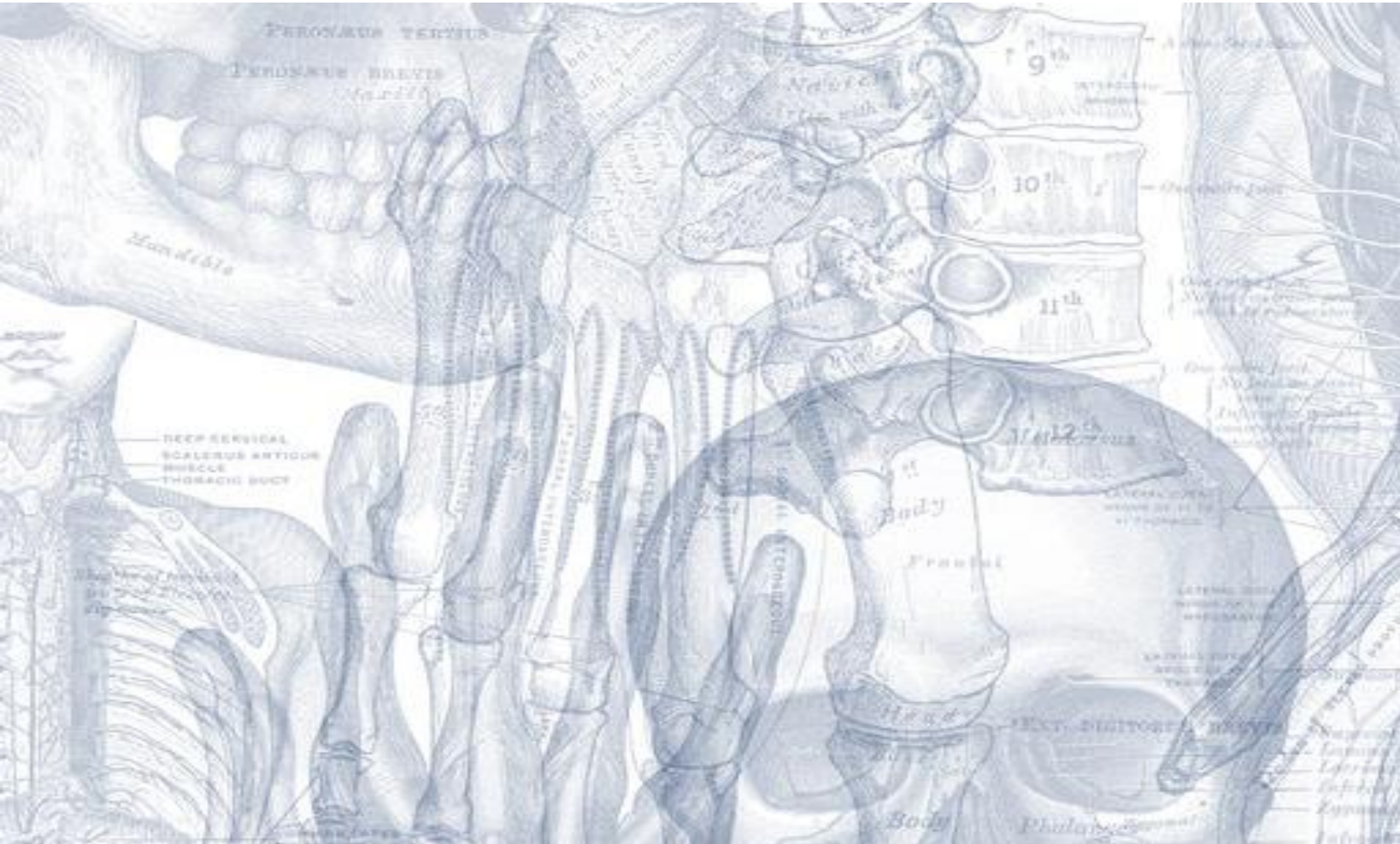


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Internal Structures of the Brain Stem

Please view our [Editing File](#) before studying this lecture to check for any changes.

Color Code

- Important
- Doctors Notes
- Notes/Extra explanation

Objectives

By the end of the lecture, students will be able to :

- ✓ Distinguish the internal structure of the components of the brain stem in different levels and the specific criteria of each level.
 - 1. Medulla oblongata (closed, mid and open medulla)
 - 2. Pons (caudal, mid “Trigeminal level” and rostral).
 - 3. Mid brain (superior and inferior colliculi).
- ✓ Describe the Reticular formation (structure, function and pathway) being an important content of the brain stem.

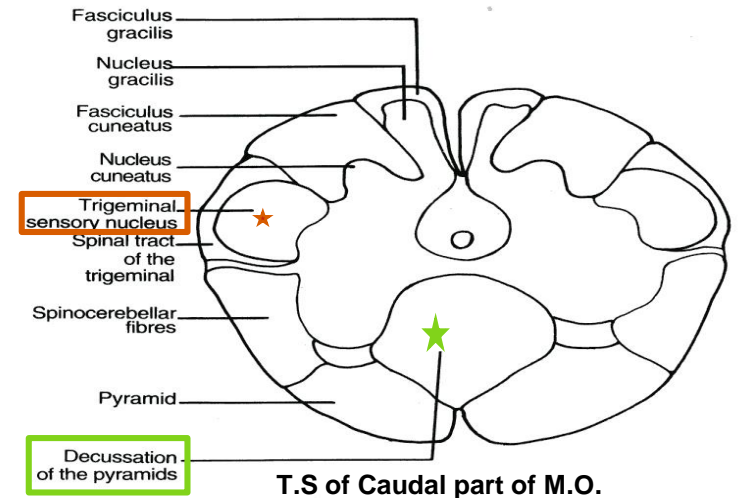
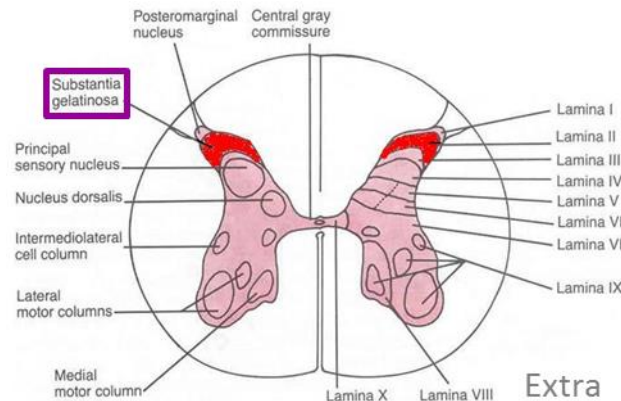
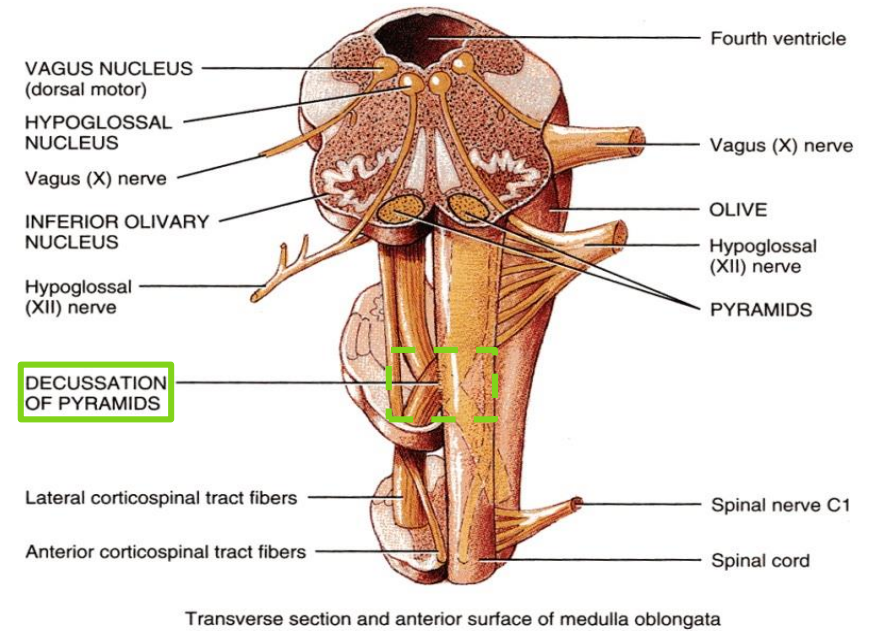
1. Medulla Oblongata

Caudal (closed) Medulla

- Traversed* by the Central Canal.
- Motor Decussation**.
- Spinal Nucleus of Trigeminal nerve (Trigeminal sensory nucleus):
 - It is a larger sensory nucleus.
 - It is the brain stem continuation of the Substantia Gelatinosa of spinal cord.

* *Traversed* = travel across or through
 ** *Decuss-* = crossing

Doctor's note: the major thing we see in the closed Medulla is The Motor Decussation.

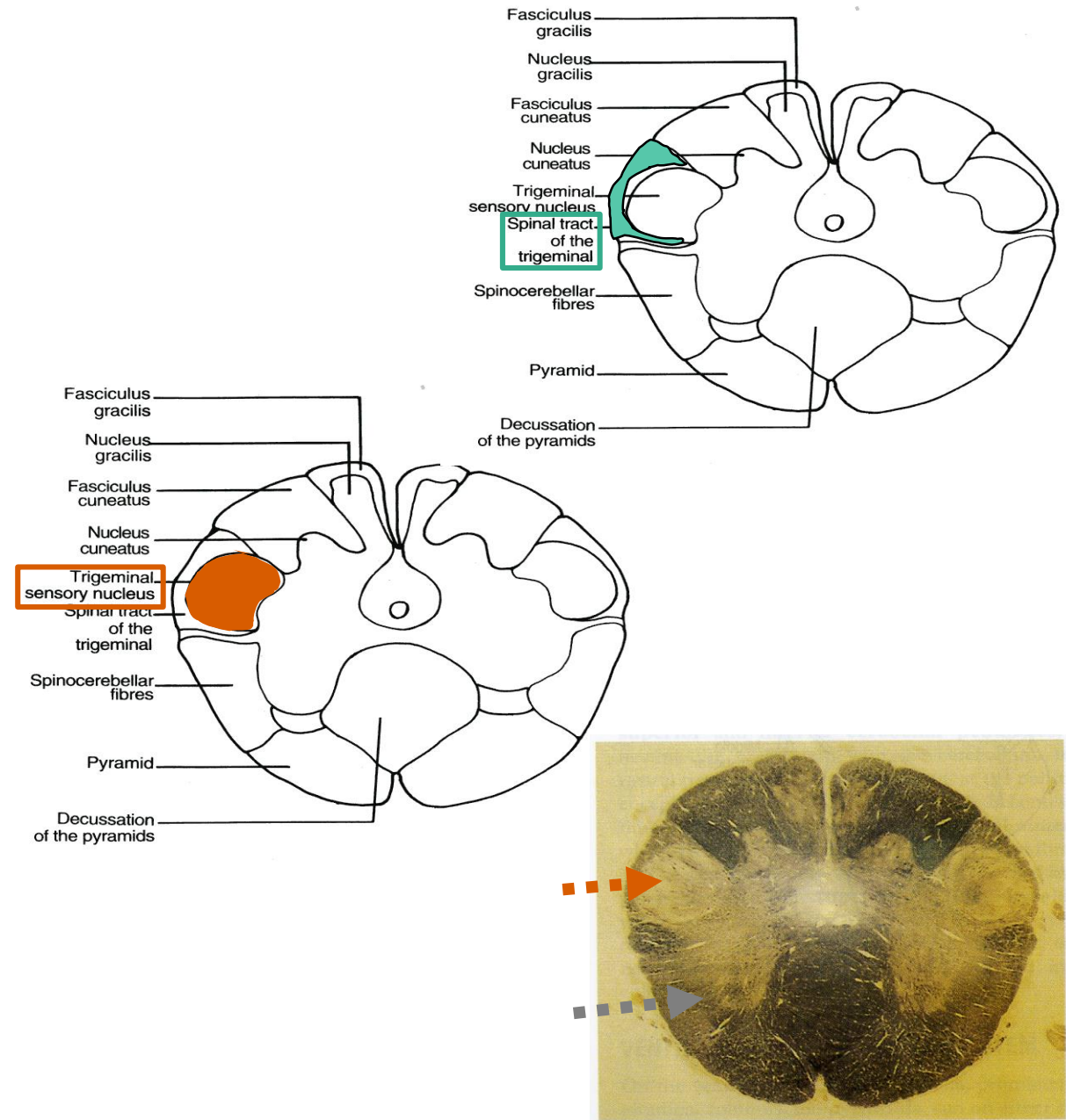


1. Medulla Oblongata

Caudal (closed) Medulla

Trigeminal Sensory Nucleus & Tract

- The Nucleus Extends :
 - *Through the whole length of the brain stem and into upper segments of spinal cord.*
- It lies in all levels of medulla oblongata, **medial** to the spinal tract of the trigeminal.
- It receives **pain** and **temperature** from face and forehead (recall this was the function of substantia gelatinosa).
- Its tract present in all levels of M.O. is *formed of descending fibers* that terminate in the trigeminal nucleus.



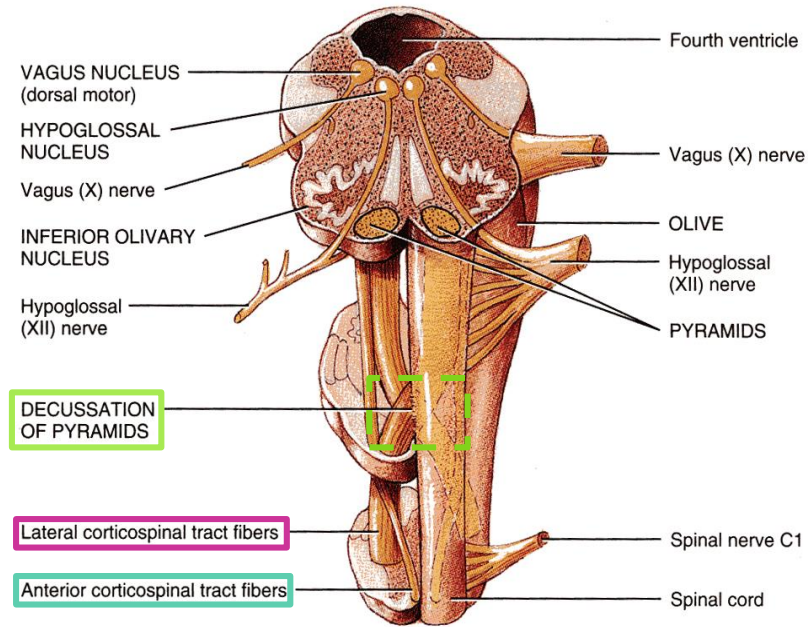
1. Medulla Oblongata

Caudal (closed) Medulla

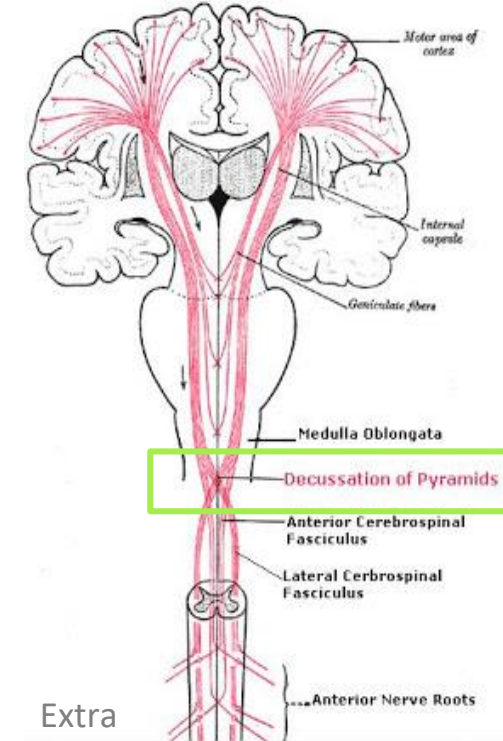
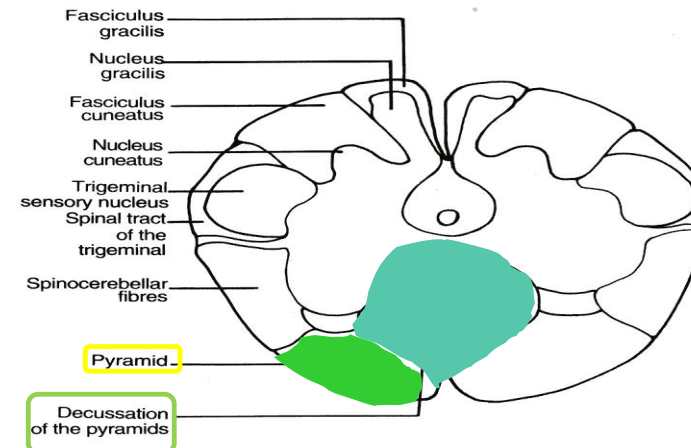
Pyramidal Decussation

- Pyramidal decussation is Motor Decussation*.
- Formed by pyramidal fibers, (75-90%) cross to the opposite side
- They descend in the lateral white column of the spinal cord as the lateral corticospinal tract.
- The uncrossed fibers (the remaining 10-25%) form the ventral corticospinal tract.

**Decuss*- = crossing



Transverse section and anterior surface of medulla oblongata



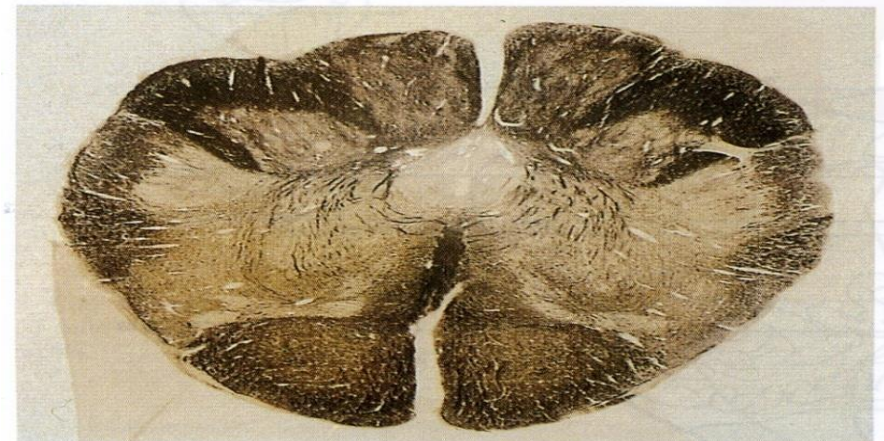
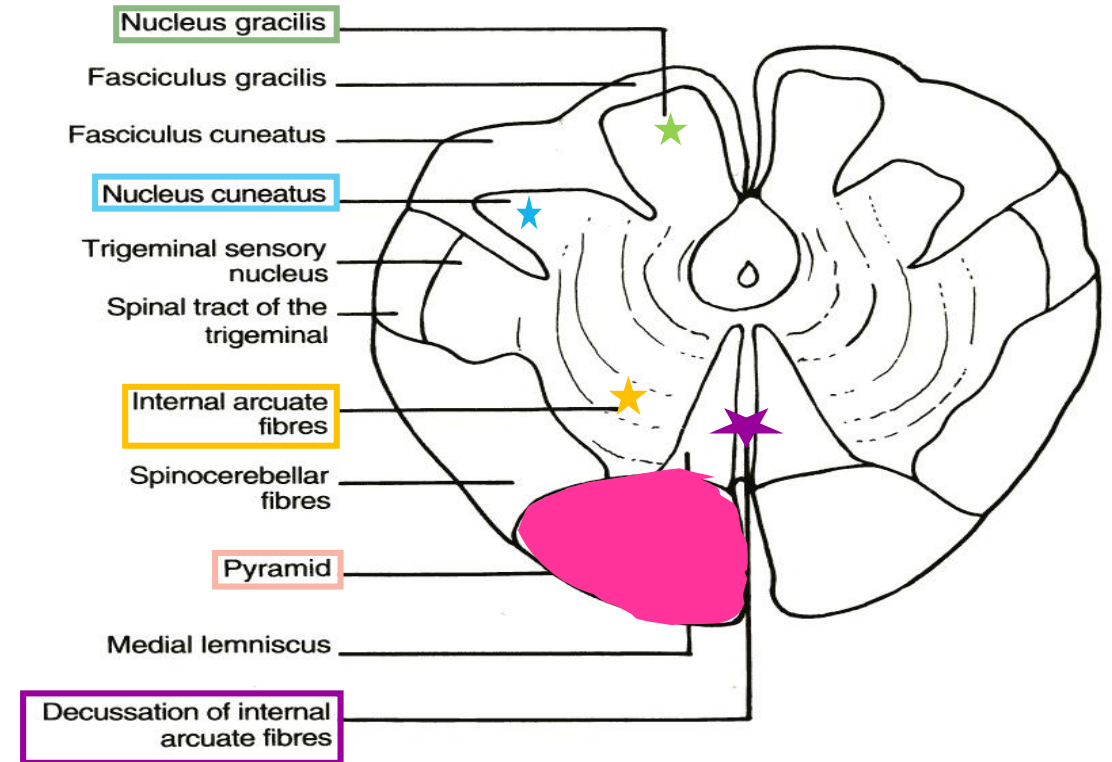
Extra

1. Medulla Oblongata

Mid Medulla

- Traversed by **Central Canal**.
- Larger size **Gracile & Cuneate nuclei**, concerned with *proprioceptive (knowing the normal body position) deep sensations of the body*.
- Axons of Gracile & Cuneate nuclei form the **internal arcuate fibers**; (they form arch like structure) **Sensory Decussation**.*
- **Pyramids** are prominent *ventrally*.

Motor decussation (pyramids): Closed/Caudal Medulla
Sensory decussation (internal arcuate fibers): Mid Medulla



1. Medulla Oblongata

Mid Medulla

Sensory Decussation

- Formed by the crossed internal arcuate fibers.
- Medial Lemniscus*:
 - Composed of the ascending *internal arcuate fibers* after their crossing.
 - Lies adjacent to the middle line ventral to the central canal
 - Terminates in thalamus.
 - Concerned with proprioceptive deep sensation.

**lemniscus* = ribbon

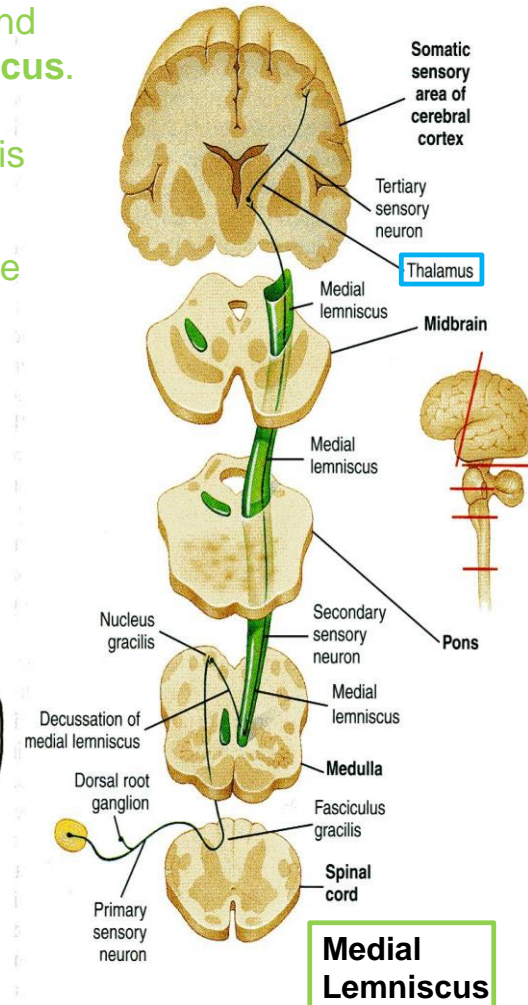
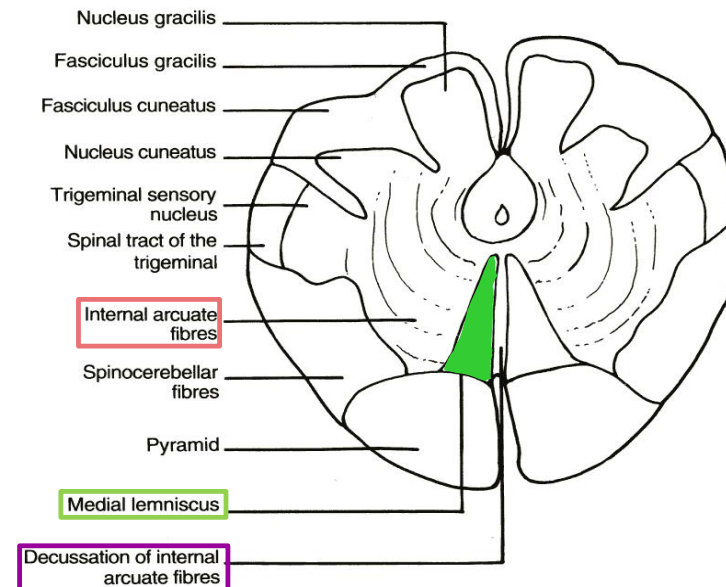
Doctor's note: don't be confused about Tracts , Fasciculus , Lemniscus . They are all tracts with different locations and shapes.



After crossing and they ascend and form the **medial lemniscus**.

At the level of the crossing it is called **sensory decussation**

Before they cross they are the **internal arcuate fibers** from gracile and cuneate nuclei



1. Medulla Oblongata

Rostral (open) Medulla

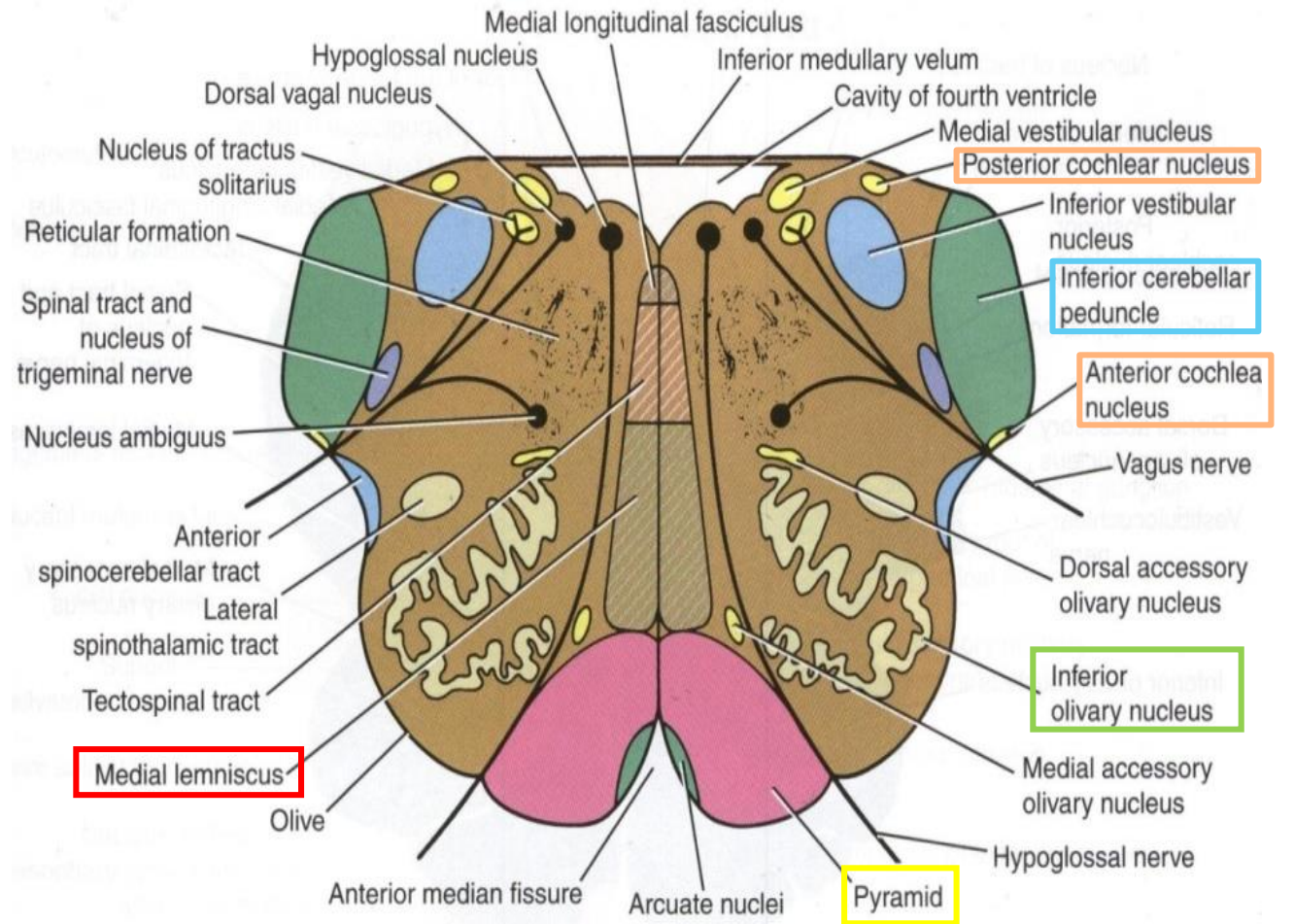
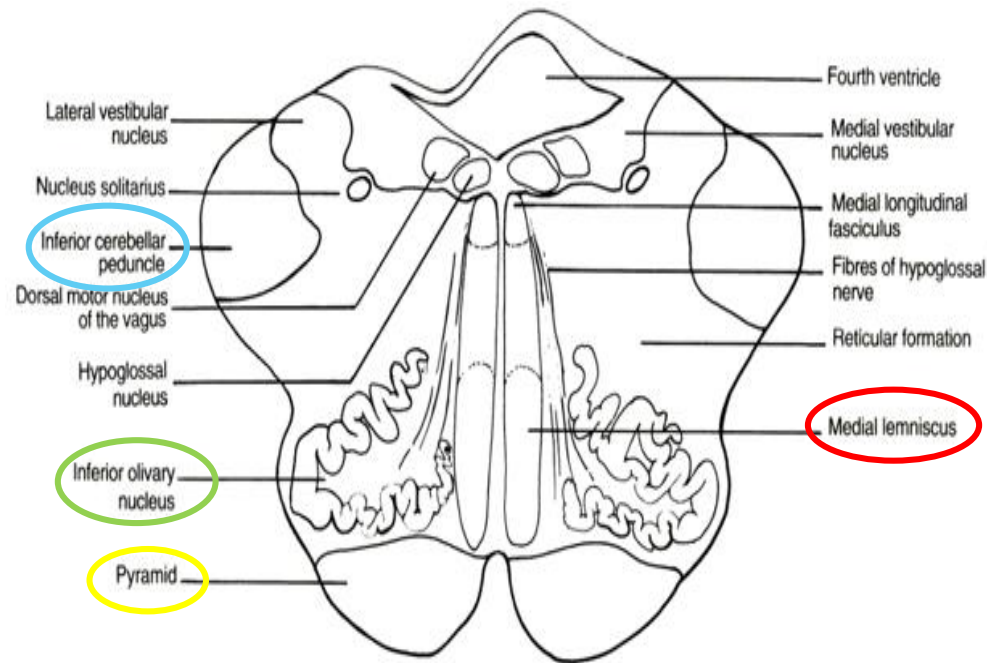
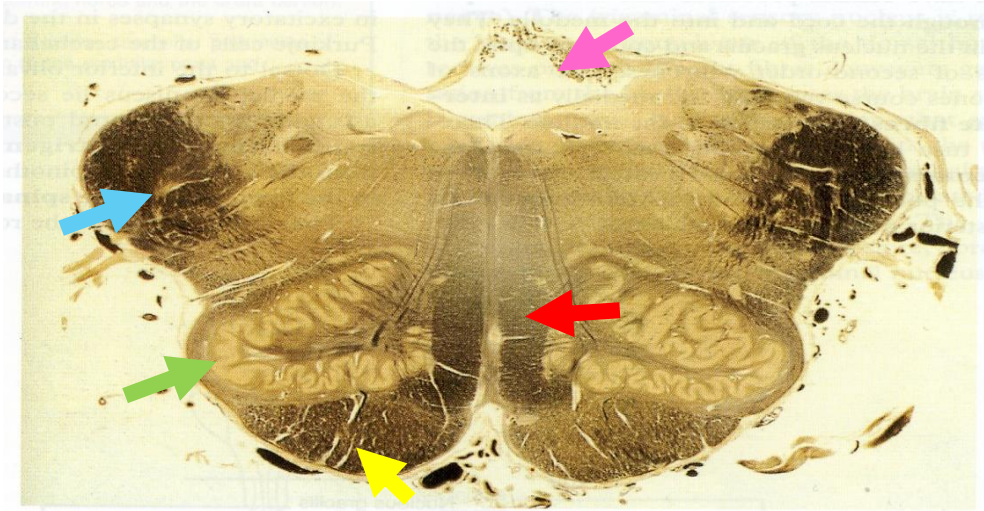
On the ventral aspect :

- The pyramid is clear, with medial lemniscus on either sides of middle line dorsal to the pyramid
- Inferior Olivary Nucleus:
 - A convoluted mass of gray matter, lies posterolateral to the pyramids & lateral to the medial lemniscus.
 - It is concerned with the *control of movement*. *The fibers in here will come from the cerebellum.*

Doctor's Note: we call it open medulla because the central canal will open at this level into the 4th ventricle.

Its dorsal surface forms:

- Lower part of the floor of the 4th ventricle.
- The Inferior Cerebellar Peduncle is, *connecting Medulla Oblongata with cerebellum*.
- Dorsal and lateral to the Inferior cerebellar peduncle lie the Cochlear nuclei (*dorsal and ventral*).



1. Medulla Oblongata

Rostral (open) Medulla

Beneath the floor of *4th ventricle* lie :

1. Hypoglossal Nucleus.

2. Dorsal Nucleus of Vagus

lateral to the hypoglossal nucleus, contains preganglionic parasympathetic fibers.

3. Medial longitudinal fasciculus.

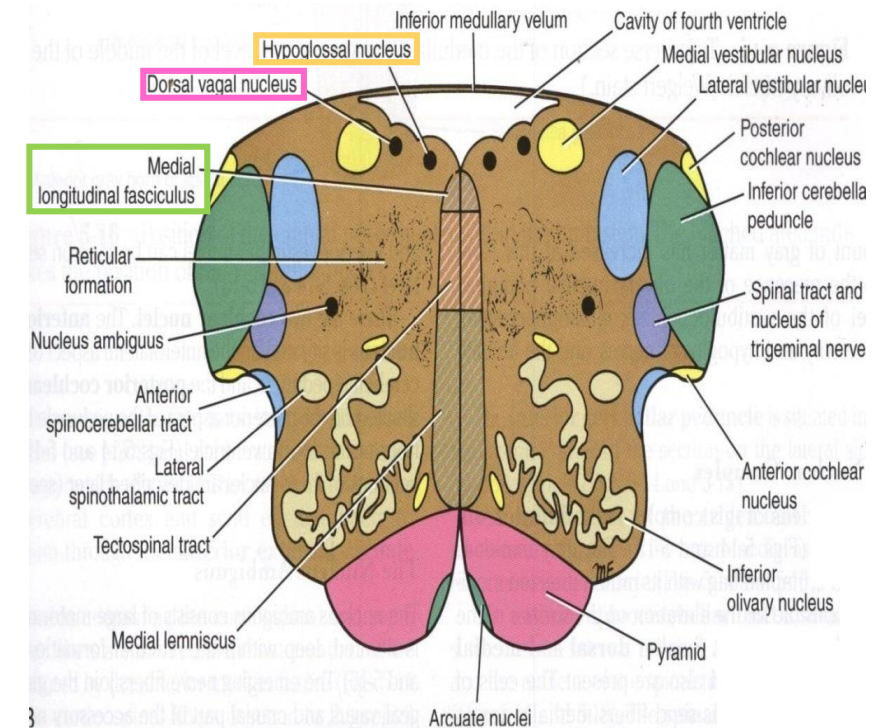
it is **important association tract**, lies close to the midline, ventromedial to the hypoglossal nucleus. *Function:*

- *Upwards :*

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

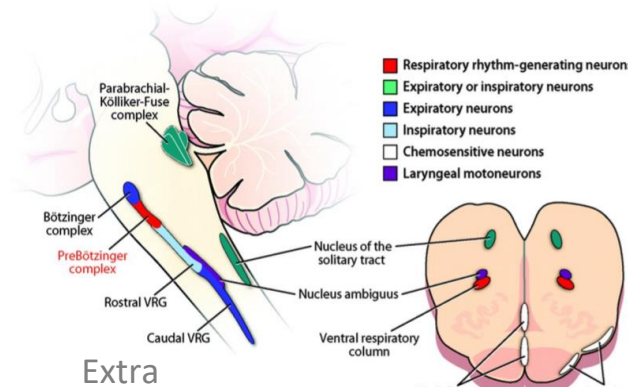
- *Downwards :*

It links vestibular nuclei with **anterior horn cells of spinal cord (cervical & upper thoracic segments)** as (vestibulo-spinal tract)---so, the neck & trunk move with head movements.



1. Medulla Oblongata

Rostral (open) Medulla

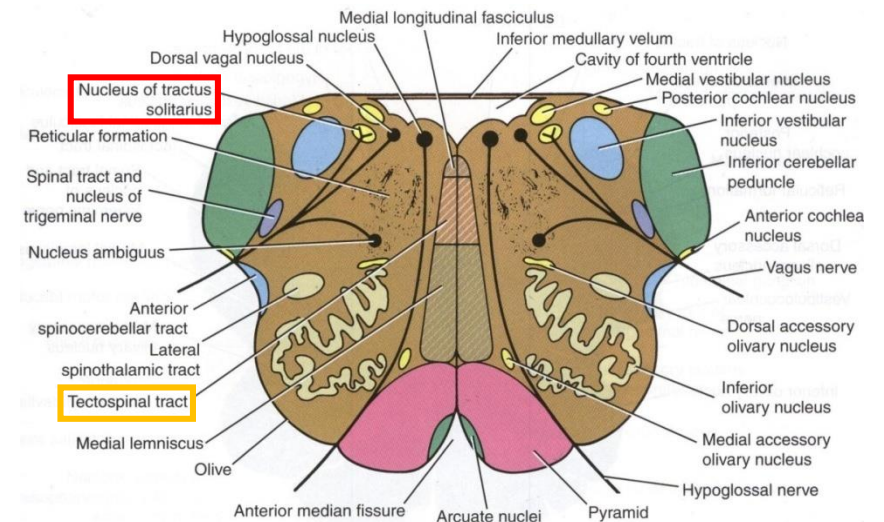
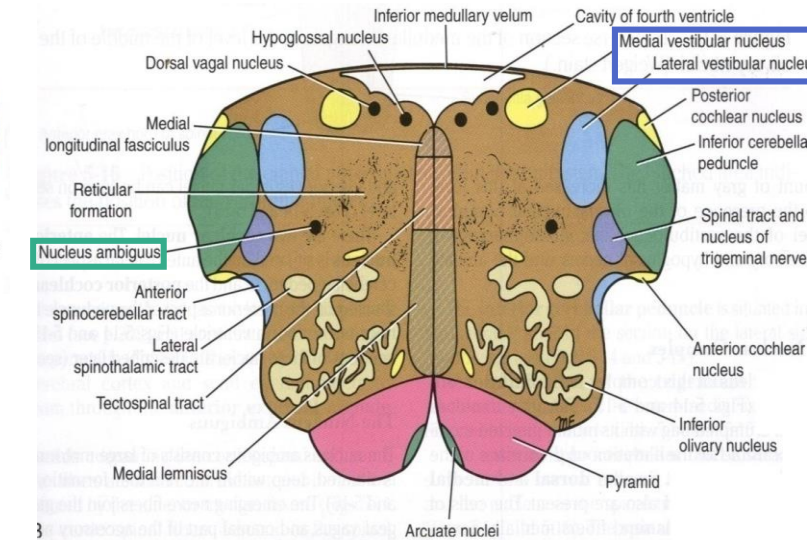


4. Vestibular nuclei complex : concerned with *equilibrium*.

5. Nucleus Ambiguus: (motor nucleus) : lies dorsal to olivary nucleus gives motor fibers along *glossopharyngeal N.* & *vagus N.* to motor supply of the constrictors of the pharynx, intrinsic muscles of the larynx & palate.

6. 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)*.

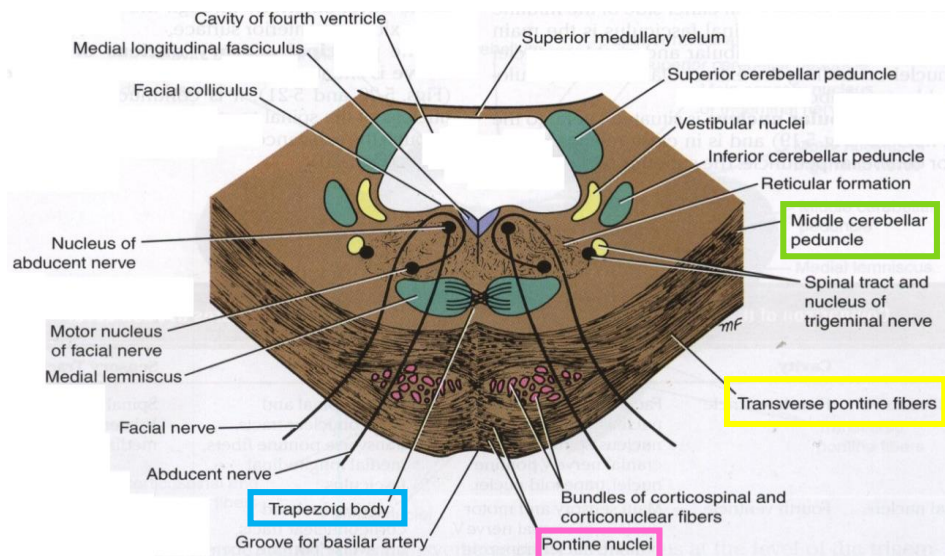
7. Tectospinal tract : between tectum of midbrain and spinal cord (involved in head movements during visual and auditory tracking).



2. Pons

Caudal Part of Pons

- Divided into an anterior part (**Basis Pontis**) & a posterior part (**Tegmentum**) by the Trapezoid Body.
- The trapezoid body consists of acoustic fibres (**hearing fibers**) from **cochlear nuclei** to ascend into midbrain as *lateral lemniscus* and terminate in *inferior colliculus*.
- The ventral(anterior) portion is marked by numerous *transversely* oriented fascicles of pontocerebellar fibres that originate from scattered cell groups, the pontine nuclei (black dots) and that pass to the *contralateral side* of the cerebellum through the massive middle cerebellar peduncle.



Compare:

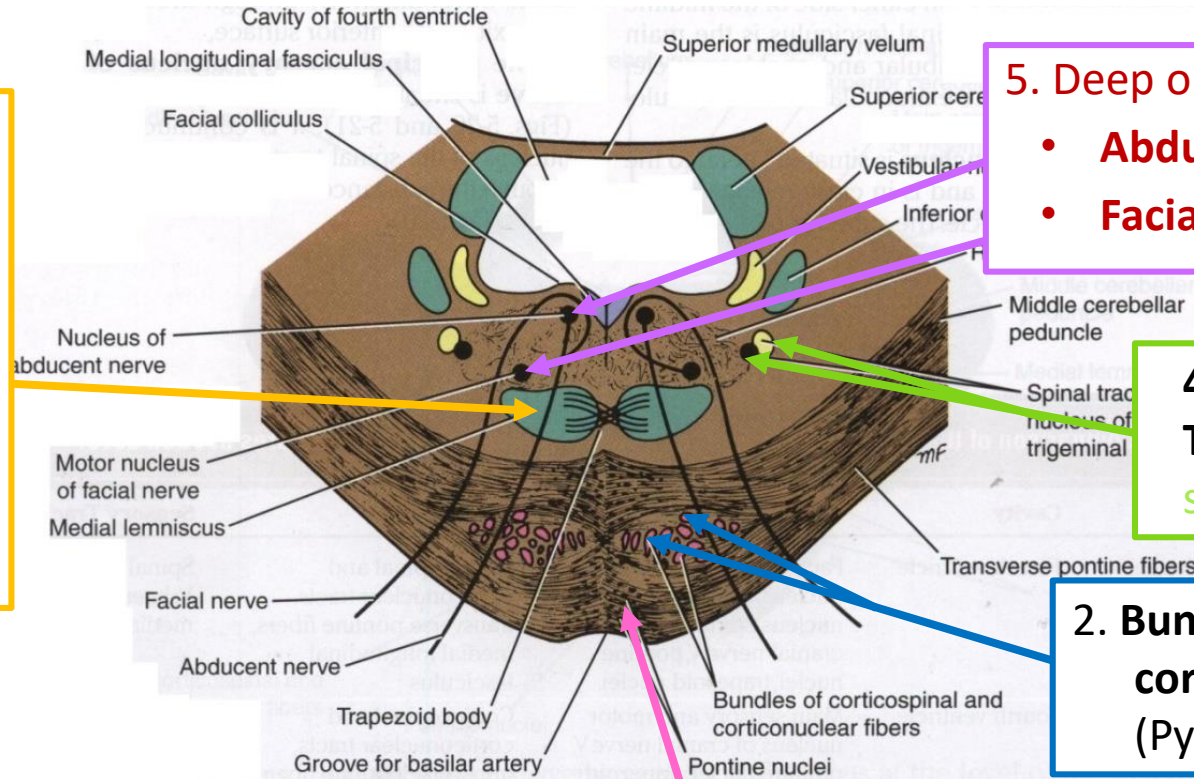
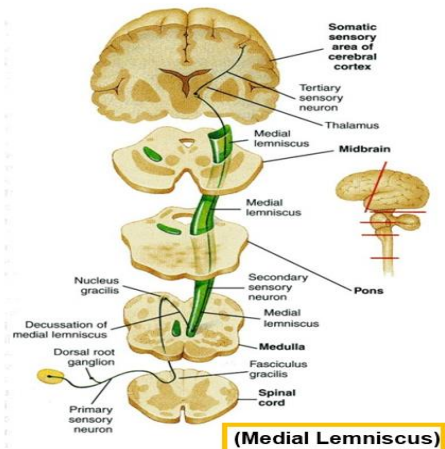
Medial lemniscus	Lateral lemniscus
<i>Ascending internal arcuate fibers</i>	<i>Acoustic fibres from cochlear nuclei</i>
Terminates in <u>thalamus</u>	Terminate in <u>inferior colliculus</u>

2. Pons

Caudal Part of Pons

3. The *ascending fibres* of the **medial lemniscus**

- become separated from the pyramid and displaced *dorsally*.
- The Medial Lemniscus rotates 90 degrees and lies almost horizontally.



5. Deep origin of cranial nerve nuclei :

- **Abducent nucleus**
- **Facial motor nucleus**

4. Spinal tract & nucleus of **Trigeminal**. (they become smaller)

2. **Bundles of corticospinal & corticonuclear fibres** (Pyramidal fibres)

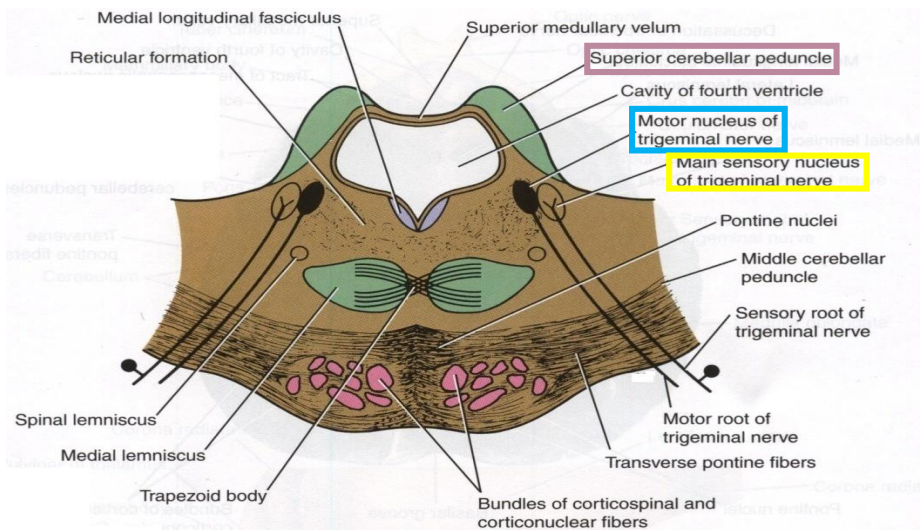
1. **Pontine Nuclei:**

- Are small masses of nerve cells, receive corticopontine fibers (involved in motor activity).
- Their axons form the **transverse pontocerebellar fibers** which pass to the contralateral side of the cerebellum through **Middle Cerebellar peduncles**.

2. Pons

Level of Trigeminal Nerve (Mid Pons)

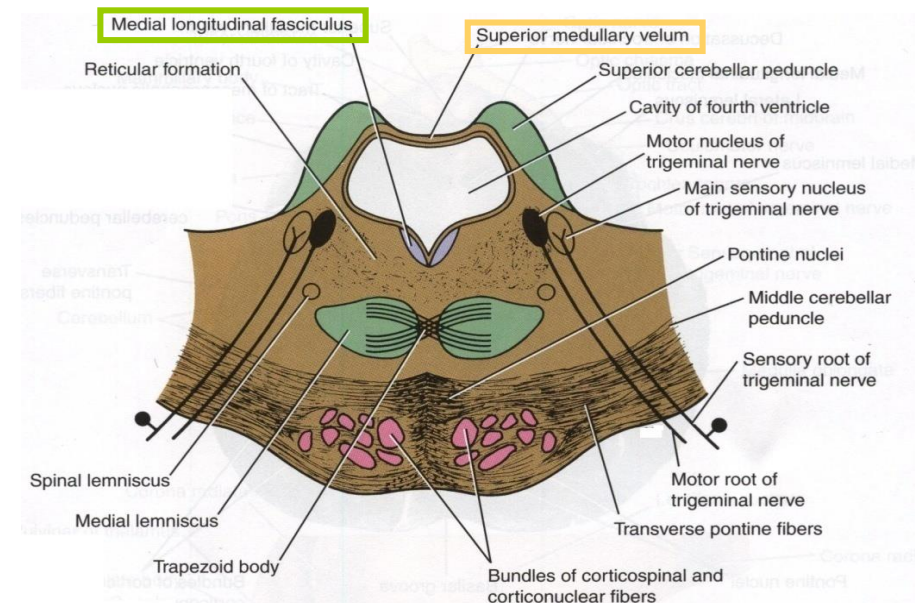
- **Motor nucleus** of the trigeminal nerve: Lies in the lateral part of the floor of the *4th ventricle*.
- **Main sensory nucleus** of the trigeminal nerve: Reaches its maximum extent in the pons and it lies lateral to the *motor nucleus*.
- **Superior cerebellar peduncles** form the lateral boundary of the *4th ventricle*.



Transverse section through the pons at the level of the trigeminal

Rostral Pons

- **Superior Medullary Velum:**
 - Passes *between* the two peduncles & forms the *roof of the 4th ventricle*.
- **Medial longitudinal fasciculus:**
 - Lies close to the midline *beneath* the floor of the *4th ventricle*.

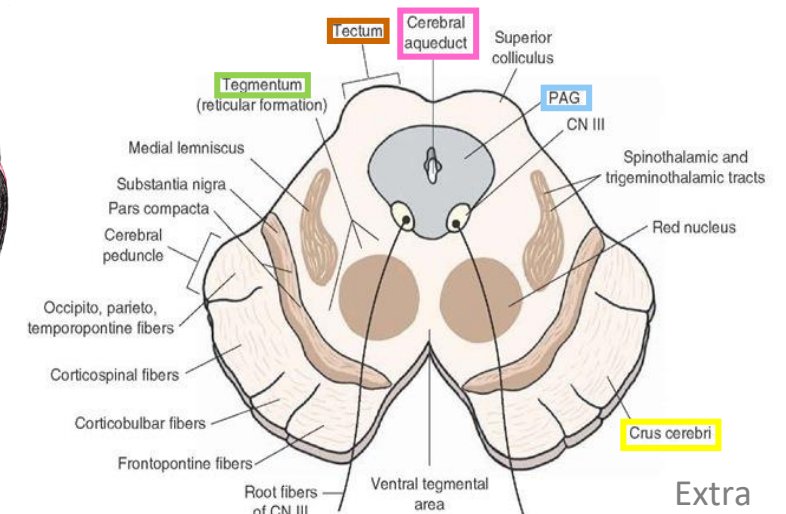
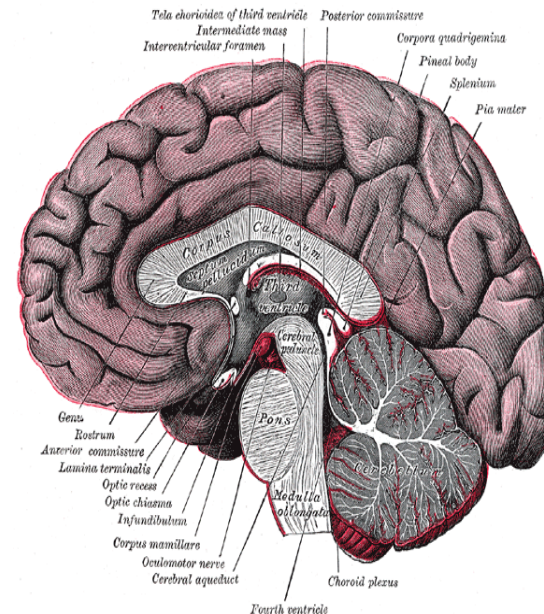
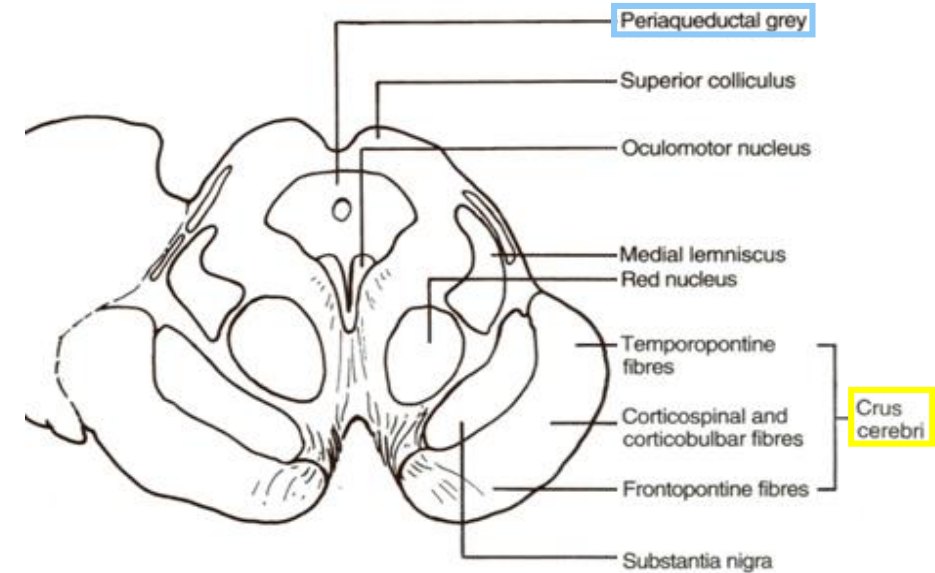


3. Midbrain

- It is divided at the *level of the cerebral aqueduct* into :
 - a dorsal part (**Tectum**) and
 - a ventral part (**Tegmentum**)

In pons it will be the opposite.

- The cerebral aqueduct is surrounded by a pear shaped periaqueductal (central) gray matter.
- The *most ventral part* of the tegmentum is the massive fibrous mass (**Crus Cerebri**).



3. Midbrain

Inferior Colliculus Level

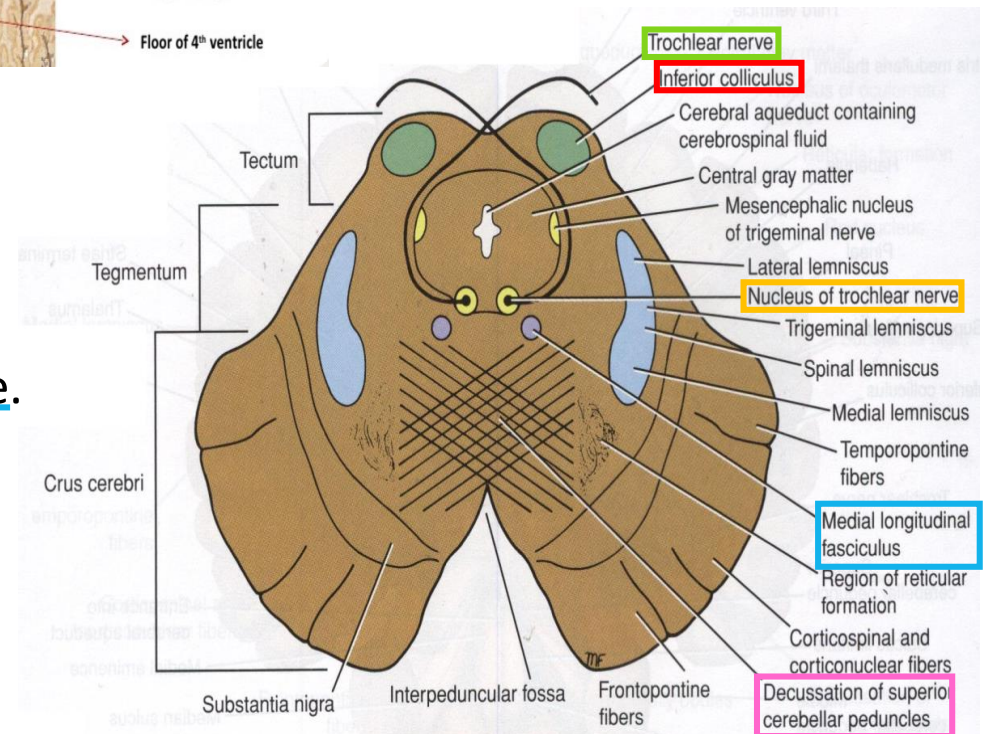
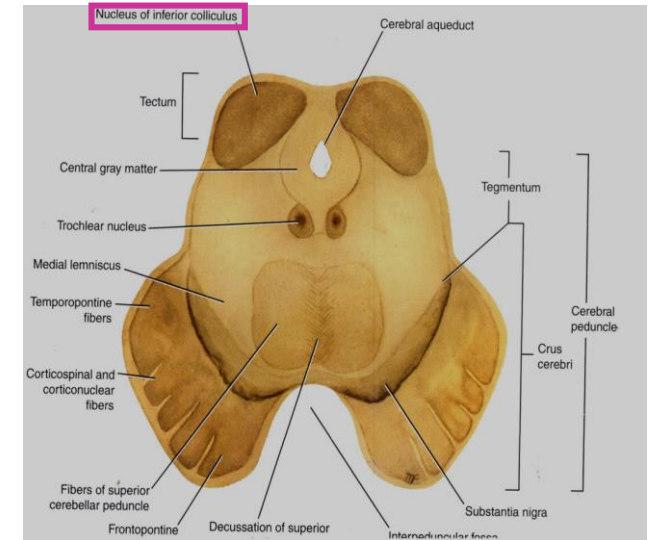
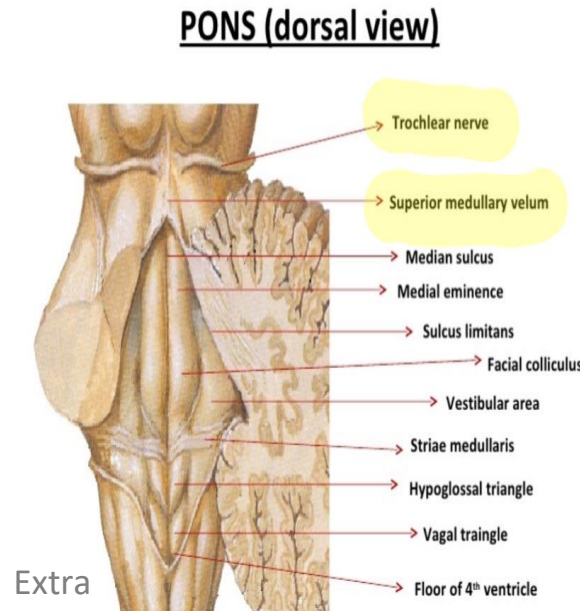
- **Inferior colliculus** is a large nucleus of gray matter that lies beneath a corresponding surface elevation.
- It is part of the *auditory* pathway.
- It receives fibers from the *lateral lemniscus*.
- Its efferent fibers pass to the *thalamus*.

Structures:

1. **Trochlear nucleus:**

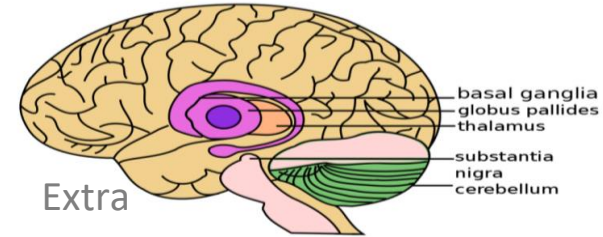
- lies in the central gray matter close to the median plane just posterior to the **medial longitudinal bundle**.
- The fibers of the **trochlear nerve** decussate in the **superior medullary velum**.

2. **Decussation of the superior cerebellar peduncles** in the mid line.



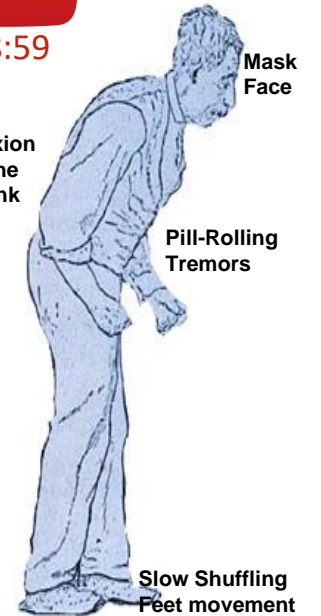
3. Midbrain Inferior Colliculus Level

Basal Ganglia and Related Structures of the Brain



08:59

Flexion of the Trunk



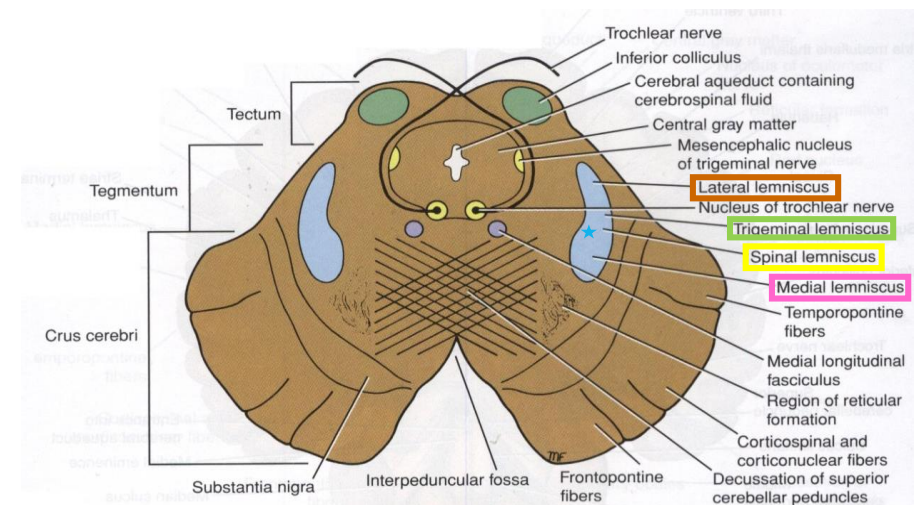
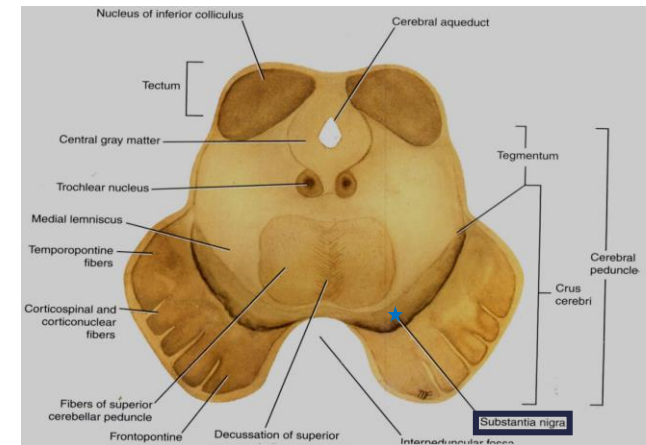
3. Substantia nigra :

- Occupies the most ventral part of the tegmentum.
- It consists of pigmented, melanin containing neurones.
- It projects to the basal ganglia. Its degeneration is associated with *Parkinson's disease**.

Tone of the muscle will be lost.

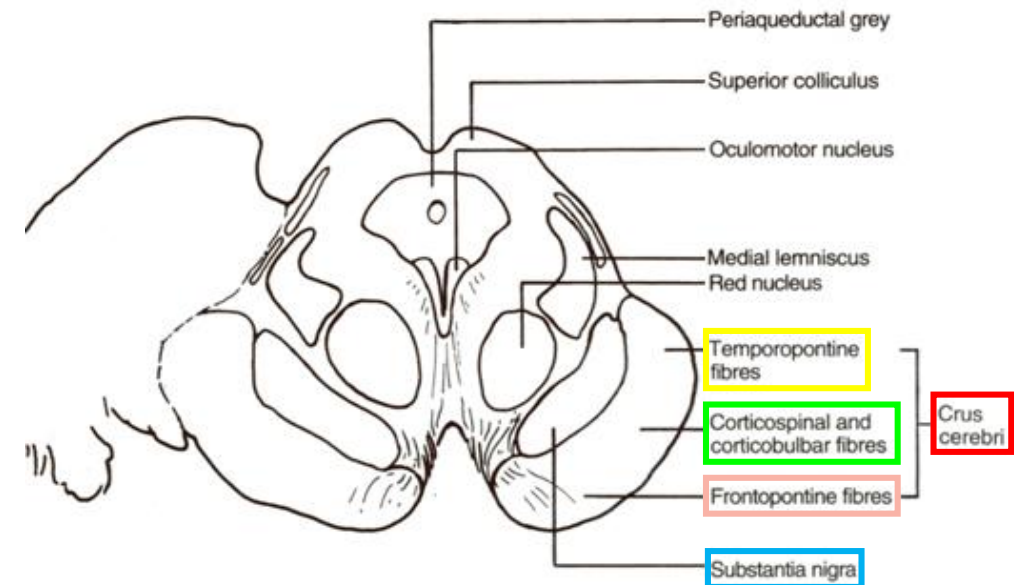
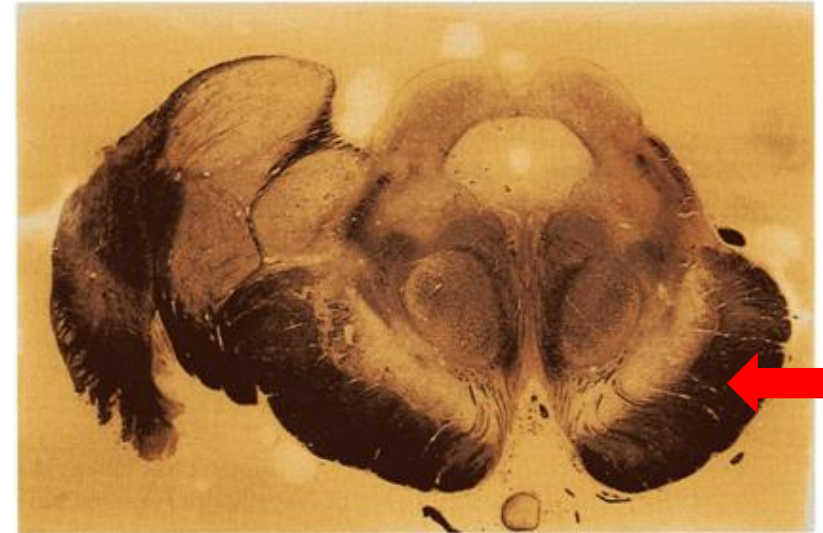
4. Ascending Lemnisci:

- Composed Of:
 - Medial lemniscus.
 - Spinal (Lateral & anterior spinothalamic tracts)
 - Trigeminal (Lateral & medial).
 - Lateral lemniscus.



3. Midbrain Crus Cerebri

- It is a massive mass ventral to the substantia nigra.
- It consists entirely of **descending cortical efferent fibers** (Frontopontine, Corticospinal & corticobulbar and Temporopontine Fibres) to the *motor cranial nerve nuclei* and to *anterior horn cells*.
- Involved in the **coordination of movement**.
- Present in both levels of colliculi (inferior and superior).



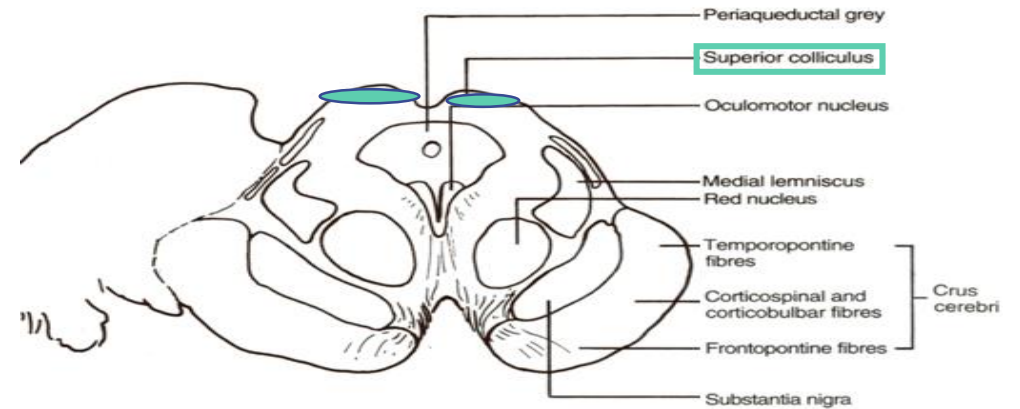
3. Midbrain

Superior Colliculus Level

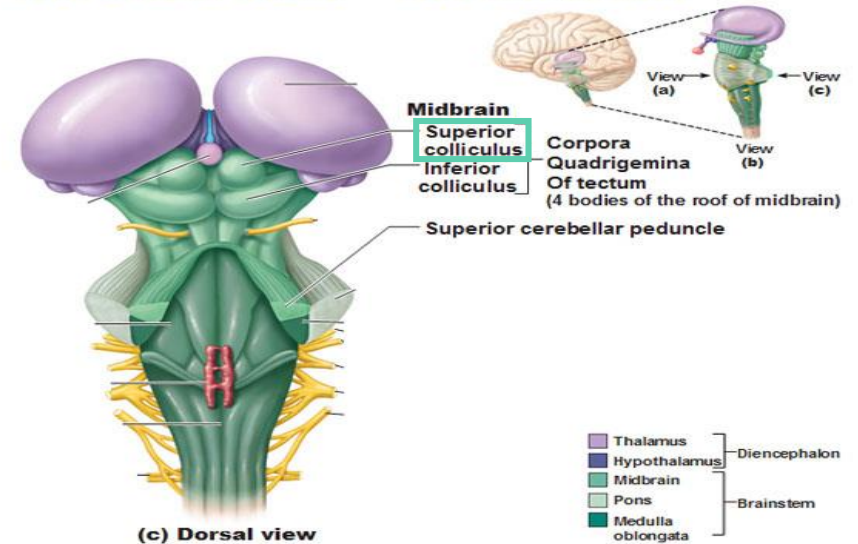
- A large *nucleus of gray matter* that lies beneath corresponding elevation.
- It forms part of the *visual reflexes**.
- Its *efferent fibers* go to the **anterior horn cells & to cranial nuclei 3, 4, 6, 7 & 11.**
- It is responsible for the reflex movements of the eyes, head and neck in response to visual stimuli, as in following a moving object or altering the direction of the gaze.

*to remember:

The eyes are on top so the superior colliculus → visual



The Brain Stem—The Midbrain



3. Midbrain

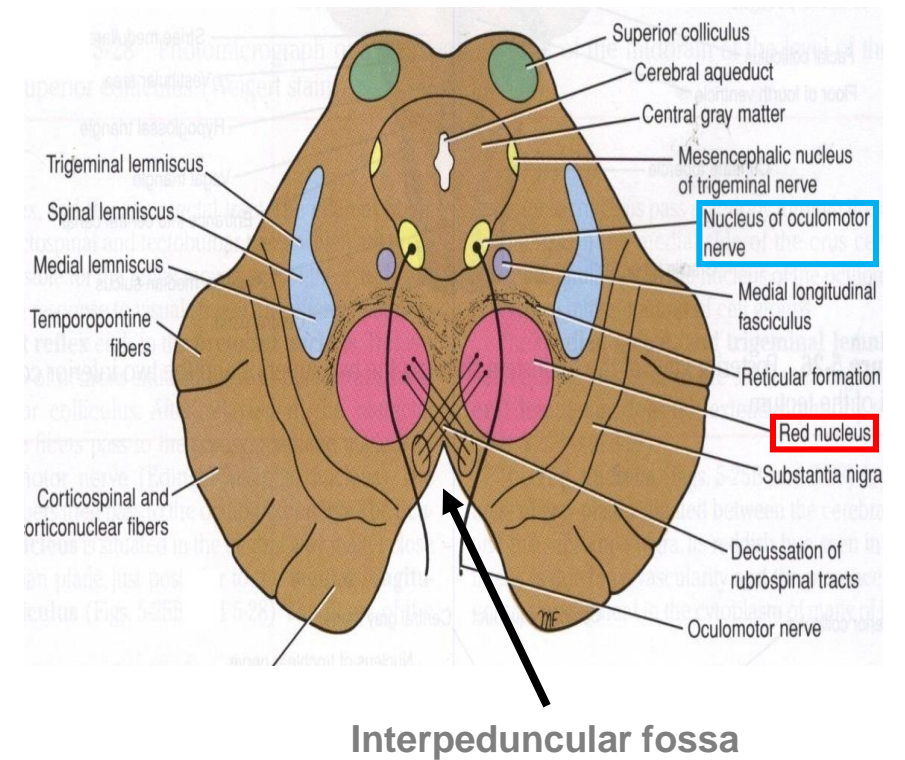
Superior Colliculus Level

1. Oculomotor nucleus:

- Situated in the *central gray matter* close to the median plane.
- The fibers of the oculomotor nerve passes *anteriorly* through the red nucleus to emerge on the **medial side of the crus cerebri**.

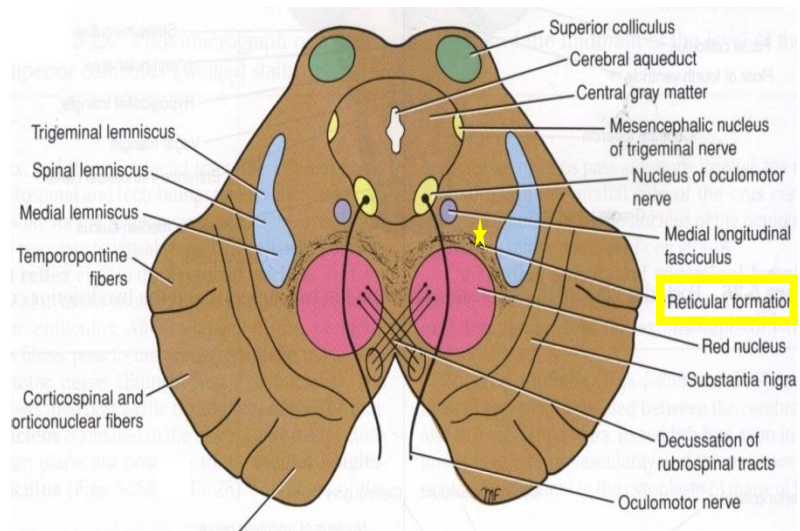
2. Red nucleus :

- A rounded mass of gray matter that lies in the *central portion of the tegmentum*.
- Its **red coloration** is due to its vascularity and the presence of an iron containing pigment in the cytoplasm of its neurons. (Important)
- It is involved in **motor control**.

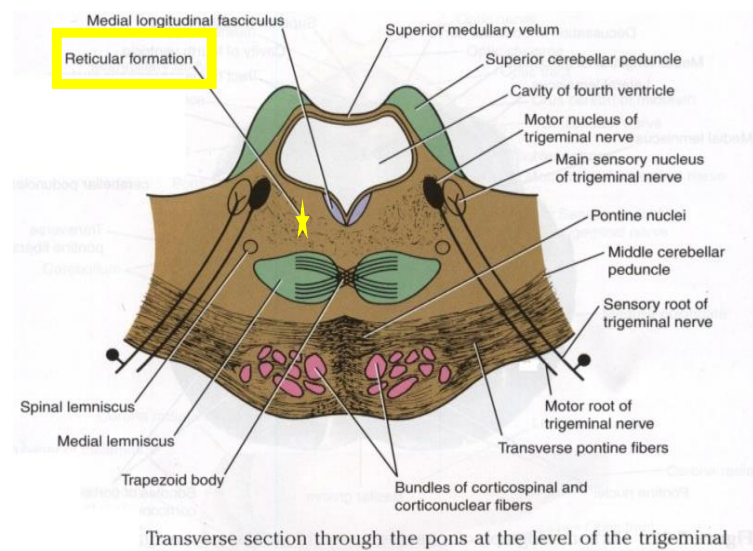


Reticular Formation (these are important fibers and mostly unnamed)

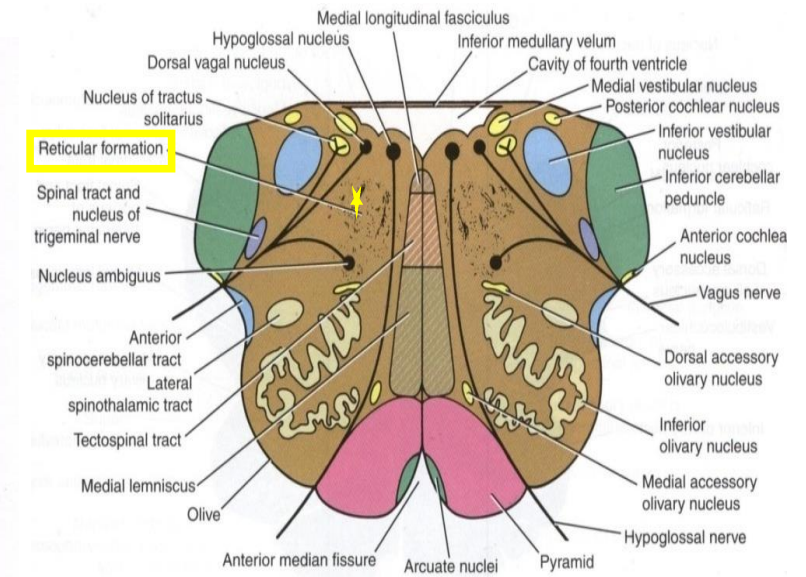
- It is a complex matrix of nerve fibers & small groups of nerve cells that extends *throughout the brain stem.*
- It has a number of important functions i.e. **Respiratory** and **Cardio-vascular centers** are located in the *medullary* and *caudal pontine* reticular formation.



MIDBRAIN



PONS

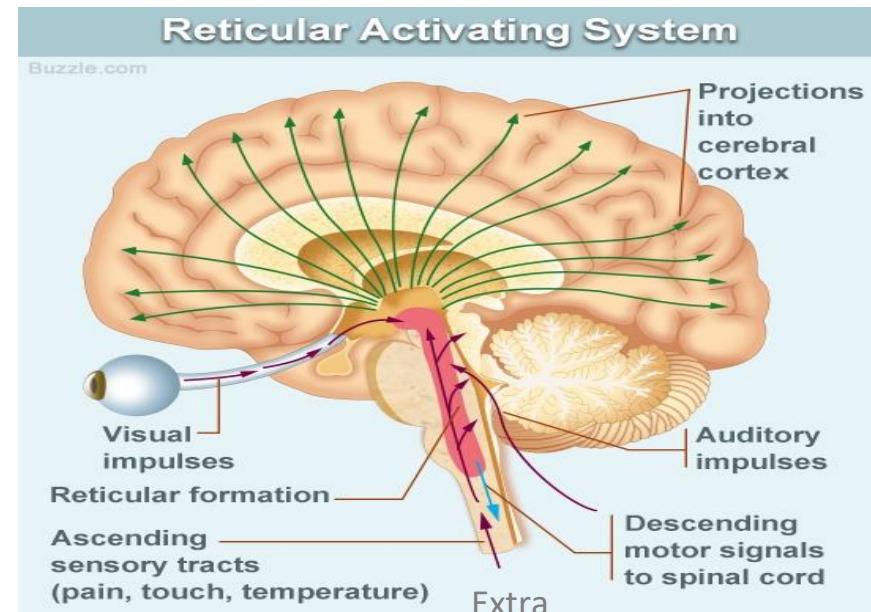
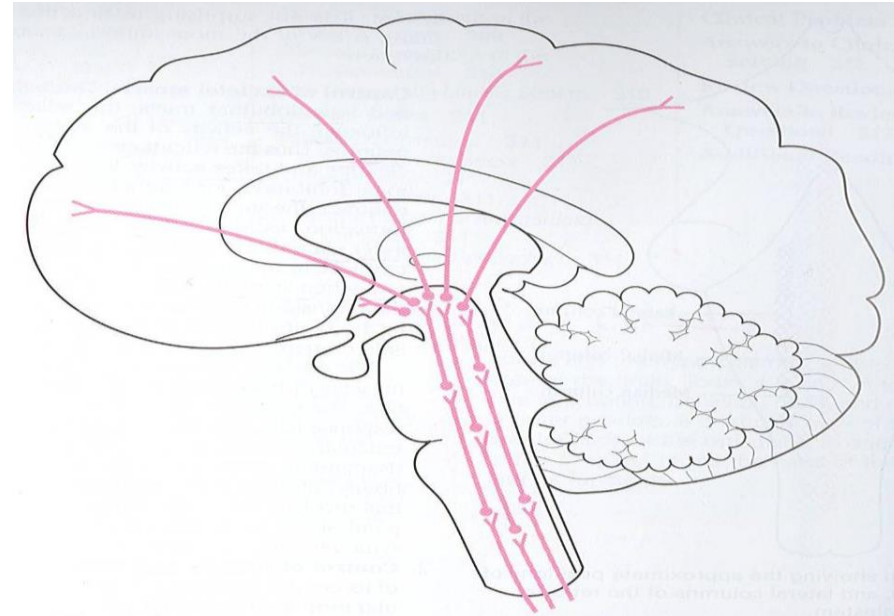


MEDULLA

Reticular Formation

Reticular Tract

- **Reticulo spinal tracts:**
 - Influence a muscle tone & posture
- **Reticular Activating system:**
 - Formed of some of the ascending fibers of the reticular formation.
 - They activate the cerebral cortex through the thalamus.

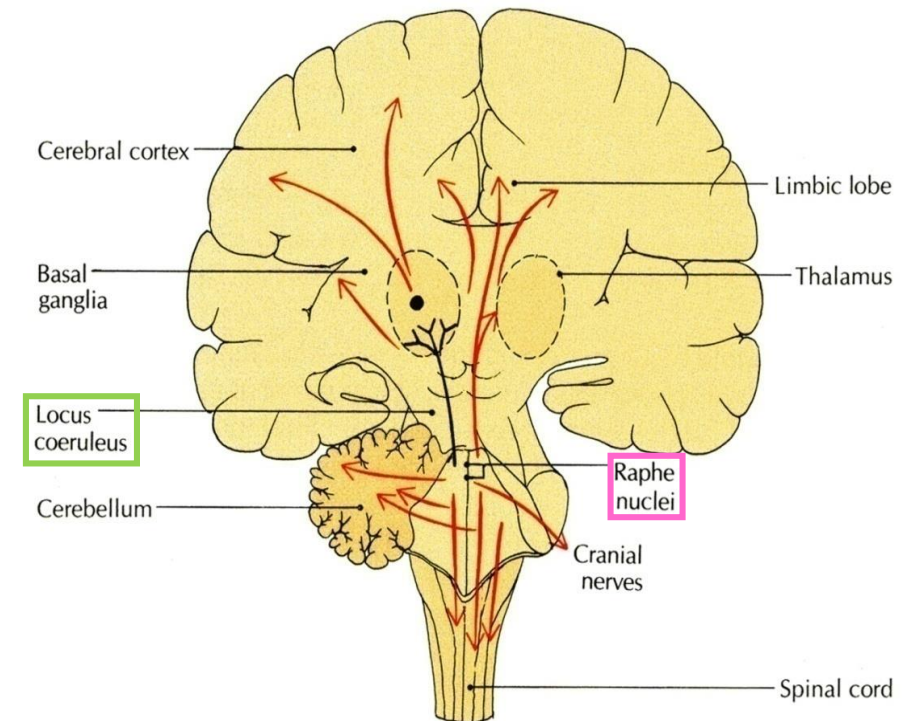
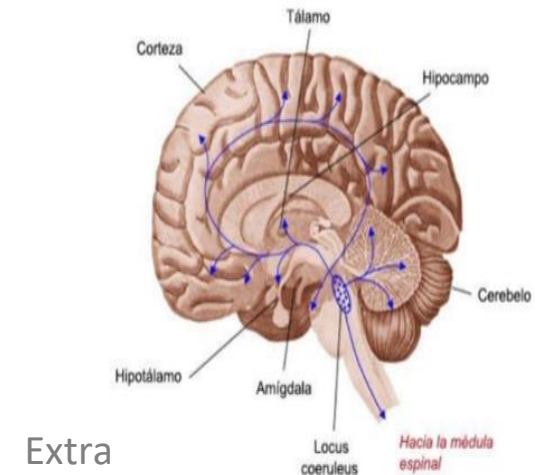
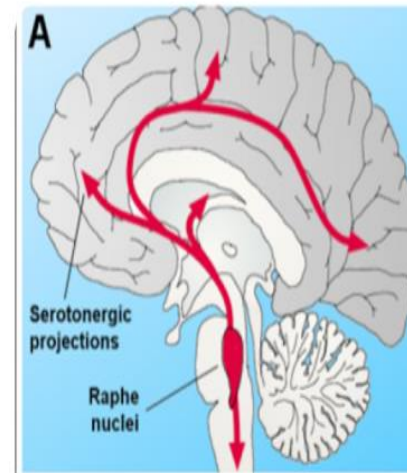


Reticular Formation

Reticular Neurones

- **Raphe Nuclei:**
 - Midline reticular nuclei.
 - They are serotonergic* (serotonin producing)
 - Its ascending fibers to the cerebral cortex are involved in the mechanisms of **sleep**.
 - Its descending fibers to the spinal cord are involved in the modulation of **Pain**.
- **Locus Ceruleus:**
 - Pigmented neurons that lie in the tegmentum of the caudal midbrain & rostral pons
 - It is the main noradrenergic cell group of the brain.
 - Helps in **arousal** and **sleep-wake cycles**.

*A serotonergic or serotonergic agent is any chemical that modifies the effects of serotonin in the body



Summary of levels and structures:

Medulla	Caudal / Closed	<ol style="list-style-type: none"> 1. Traversed by central canal 2. Motor decussation 3. Trigeminal sensory nucleus
	Mid	<ol style="list-style-type: none"> 1. Traversed by central canal 2. Gracile and cuneate nuclei 3. Internal arcuate fibers 4. Sensory decussation 5. Medial lemniscus
	Rostral / Open	<ol style="list-style-type: none"> 1. Dorsal surface forms lower part of floor of 4th ventricle 2. Cochlear nuclei (dorsal and ventral) 3. Hypoglossal nucleus 4. Dorsal nucleus of vagus 5. Medial longitudinal fasciculus 6. Vestibular nuclei complex 7. Nucleus ambiguus 8. Solitary nucleus 9. Tectospinal tract

Pons	Caudal	<ol style="list-style-type: none"> 1. Trapezoid body (divides it into basis pontis and tegmentum) 2. Transverse pontocerebellar fibers 3. Pontine nuclei 4. Bundles of corticospinal & corticonuclear fibers. 5. Medial lemniscus 6. Spinal tract & nucleus of trigeminal 7. Deep origin of CN 6 & 7
	Mid (level of trigeminal)	<ol style="list-style-type: none"> 1. Motor nucleus of trigeminal 2. Main sensory nucleus of the trigeminal 3. Superior cerebellar peduncle (forms lateral boundary of 4th ventricle)
	Rostral	<ol style="list-style-type: none"> 1. Superior medullary velum 2. Medial longitudinal fasciculus

Midbrain	Inferior colliculi (auditory)	<ol style="list-style-type: none"> 1. Trochlear nucleus 2. Decussation of cerebellar peduncle in the midline 3. Substantia nigra (parkinsons) 4. Ascending lemnisci
	Crus cerebri	<ol style="list-style-type: none"> 1. Descending cortical efferent fibers (present in superior and inferior colliculi)
	Superior colliculi (visual)	<ol style="list-style-type: none"> 1. Oculomotor nucleus 2. Red nucleus

MCQs

1. Most axons of cochlear nuclei cross the midline of pons forming:

- A- the medial lemniscus
- B- the red nucleus
- C- trapezoid body
- D- the medial longitudinal fasciculus

Answer: C

2. The axons of the cochlear nuclei are represented in:

- A- trapezoid body
- B- medial longitudinal bundle
- C- tectospinal tract
- D- spinal lemniscus

Answer: A

3. Which of the following lies in the tegmentum of the midbrain:

- A- oculomotor nuclei
- B- trochlear nucleus
- C- red nucleus
- D- fascial nucleus

Answer: C

4. Parkinsons disease results from degeneration of:

- A- red nucleus
- B- substantia nigra
- C- inferior olivary nucleus

Answer: B

5. Solitary nucleus is responsible for which of the following?

- A- hearing
- B- taste sensation
- C- vision
- D- fine touch

Answer: B

6. The caudal pons give have deep nuclei of which nerve?

- A- vagus
- B- facial
- C- trigeminal

Answer: B

7. The reticular formation is found in:

- A- midbrain
- B- pons
- C- medulla oblongata
- D- all of the above

Answer: D

8. Which nerve fibers emerge on the medial side of the crus cerebri:

- A- oculomotor
- B- ophthalmic
- C- vestibulocochlear

Answer: A



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