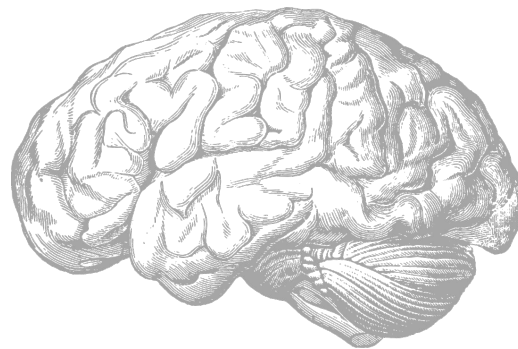




# Internal Structures of the Brainstem

CNS Block



## Color Index

- ◆ Main Text
- ◆ Female Slides
- ◆ Male Slides
- ◆ Drs' Notes
- ◆ Important
- ◆ Extra info

[The Editing File](#)





# Objectives



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 (caudal), mid and open medulla (rostral)}.
2. **Pons** (caudal, mid “**Trigeminal level**” and rostral).
3. **Midbrain** (superior and inferior colliculi).



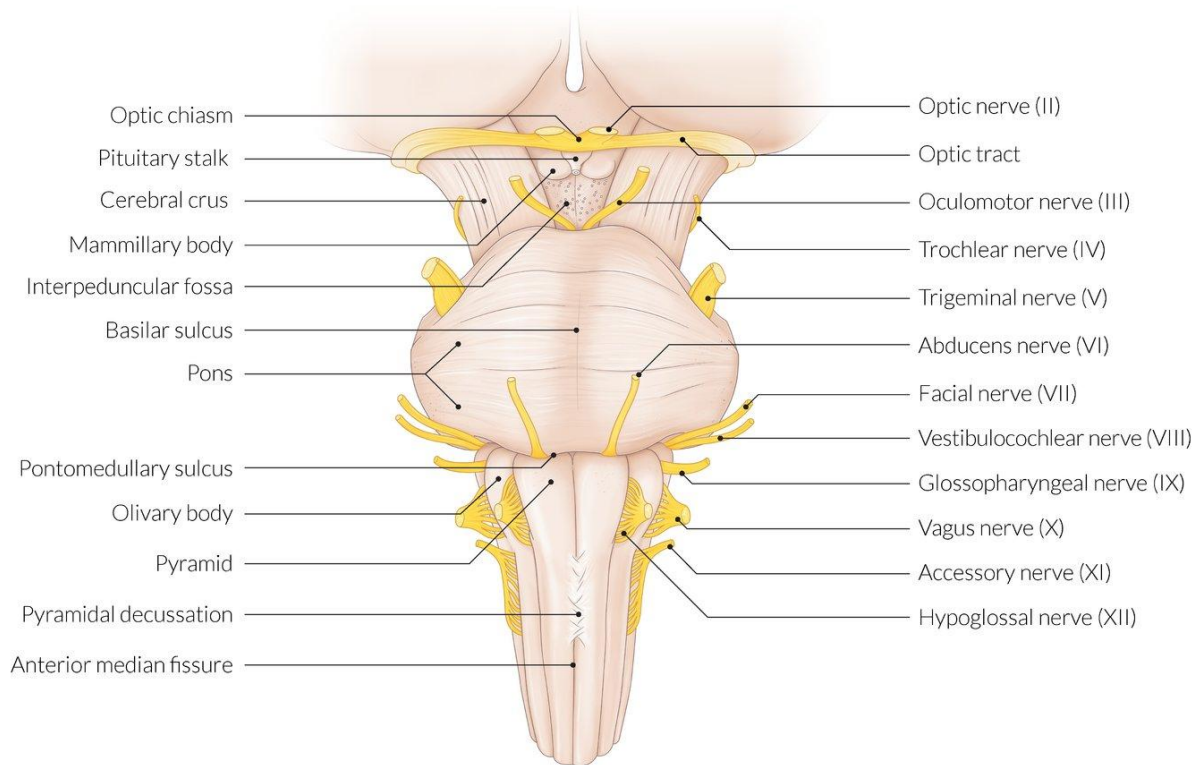
Describe in Brief the **Reticular formation** (structure, function and pathway).



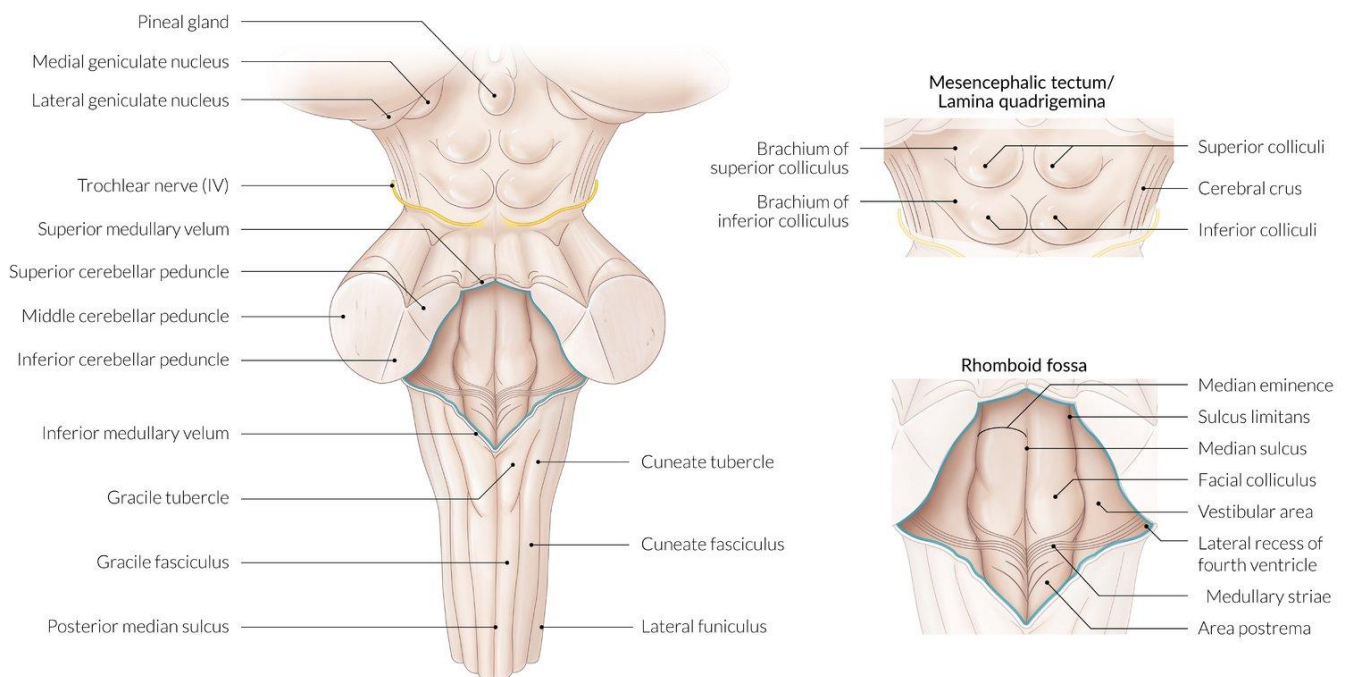
You can find Atlas by [Clicking HERE!](#)

# Brain stem - external features

## Ventral surface

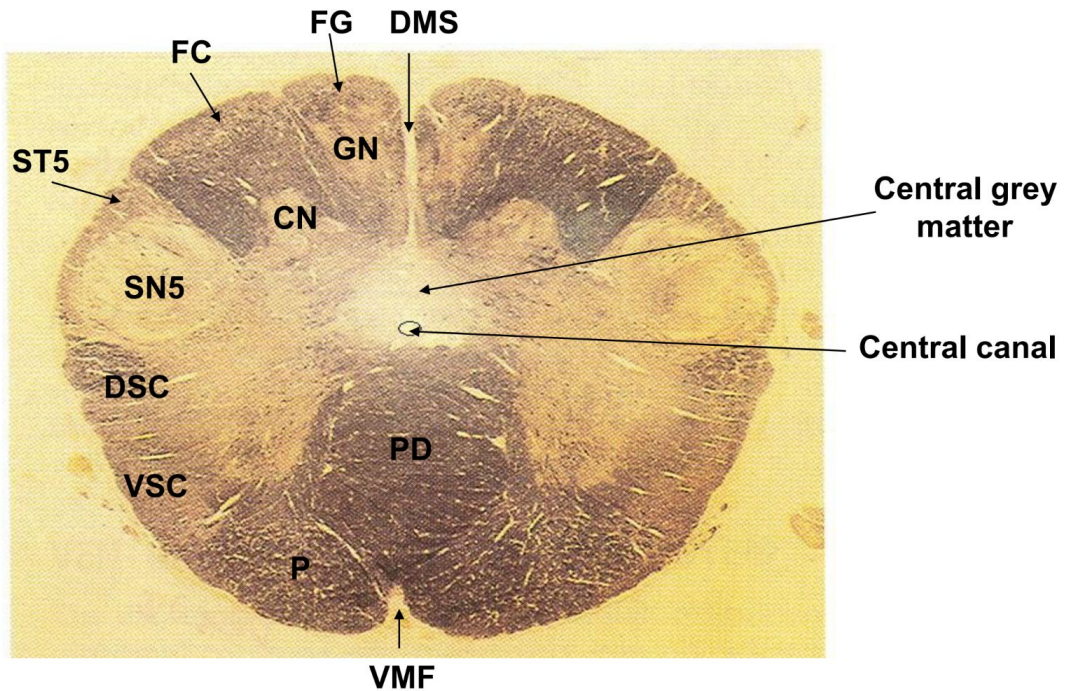


## Dorsal surface



# CAUDAL (closed) MEDULLA

It's the level of pyramidal (Motor) decussation



- DMS: Dorsal median sulcus
- FG: fasciculus gracilis
- GN: Gracile nucleus
- FC: Fasciculus cuneatus
- CN: Cuneate nucleus
- SN5: Spinal nucleus of trigeminal nerve
- ST5: Spinal tract of trigeminal nerve
- P: Pyramid
- PD: Pyramidal decussation
- DSC: Dorsal spinocerebellar tract
- VSC: Ventral spinocerebellar tract
- VMF: Ventral median fissure

## 1 Grey matter

- ❖ **Sensory nuclei:** Gracile, cuneate, spinal nucleus of trigeminal nerve.

## 2 White matter

- ❖ **Ascending tracts:** Gracile, cuneate, spinal tract of trigeminal nerve, dorsal & ventral spinocerebellar, spinal lemniscus (appears at this level).
- ❖ **Descending tracts:** Pyramidal & extrapyramidal tracts.

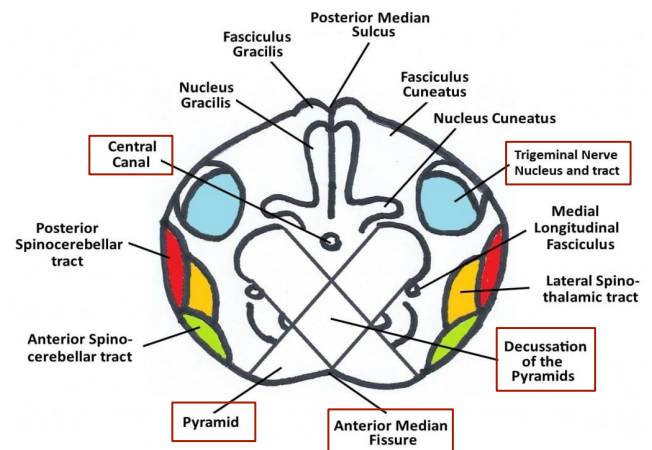


# CAUDAL (closed) MEDULLA

Just to give you an idea about the rhythm of the lecture, we will only be mentioning the most important structures that are prominent in each level of the brain stem.

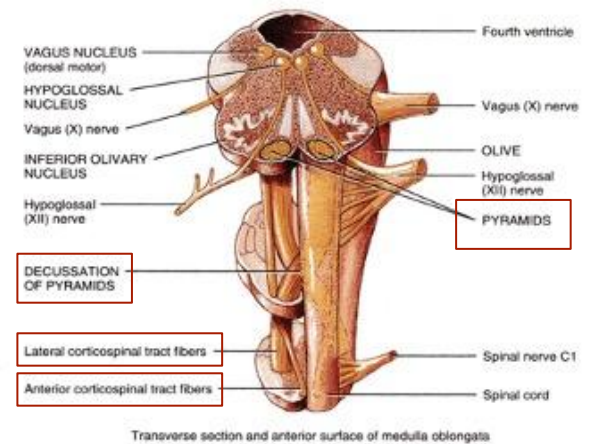
## 1 Traversed by the Central Canal

- ❖ The cerebrospinal fluid-filled space that runs through the spinal cord.



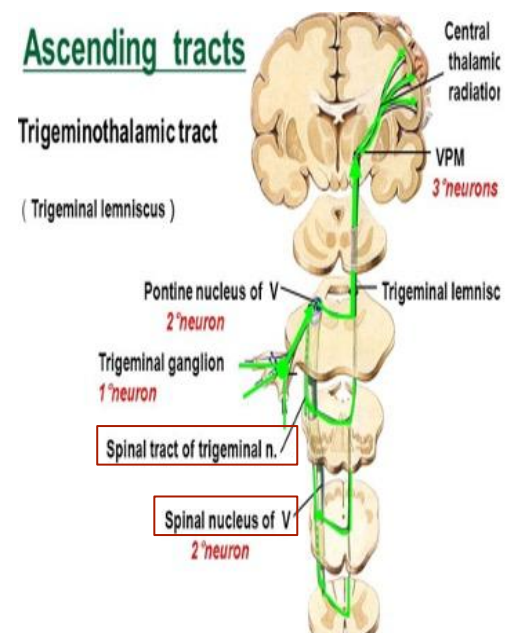
## 2 Motor/ pyramidal decussation:

- ❖ Formed by pyramidal fibers, most of the fibers (75-90%) **decussate/cross** to the opposite side then **pass laterally and dorsally** to form the lateral corticospinal tract that descends in the lateral white column of spinal cord & **terminates in ventral horn cells of opposite side**.
- ❖ The **uncrossed fibers** form the **ventral corticospinal tract**.



## 3 Spinal Nucleus of Trigeminal nerve (Trigeminal sensory nucleus):

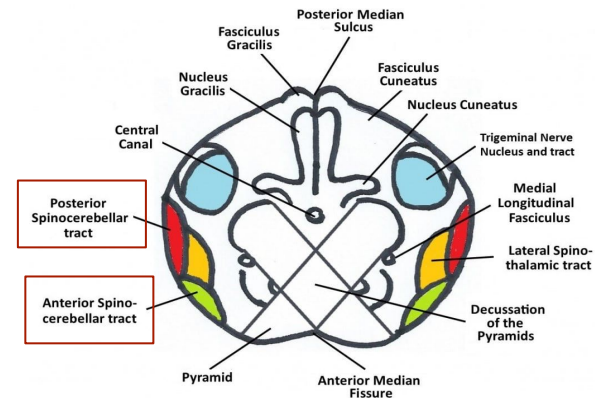
- ❖ It is a larger sensory nucleus that is considered to be the brain stem continuation of the Substantia Gelatinosa of spinal cord.
- ❖ Extends through **the lower part of pons** and the whole length of the **medulla/brain stem**, and **upper segments (2<sup>nd</sup> cervical segment)** of spinal cord.
- ❖ It lies in all levels of M.O medial to the trigeminal spinal tract. Formed of descending fibers that terminate in the trigeminal nucleus.
- ❖ It receives **pain and temperature** from **face and forehead** along the trigeminal nerve.



# CAUDAL (closed) MEDULLA

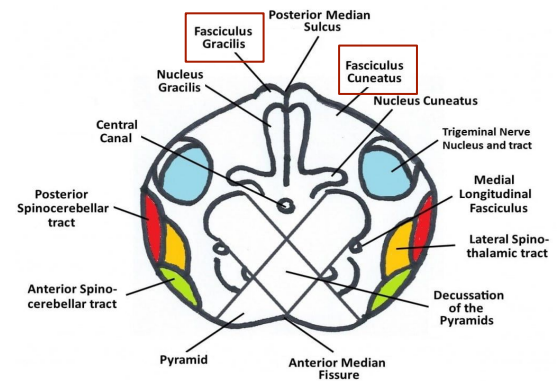
## 1 Dorsal & ventral spinocerebellar tracts

- ❖ They carry **proprioceptive fibers** to the **cerebellum** through **inferior cerebellar peduncle** (dorsal) & **superior cerebellar peduncle** (ventral).



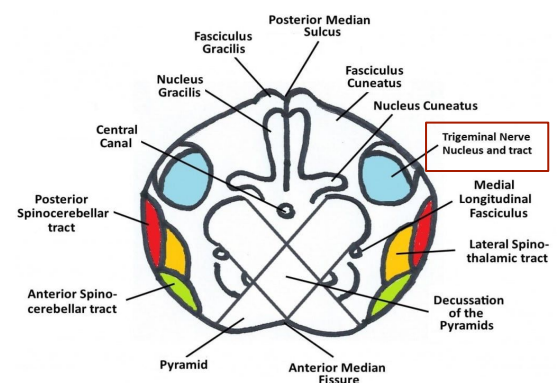
## 2 Gracile & Cuneate tracts

- ❖ They carry proprioceptive & fine touch sensations.
- ❖ They end in **gracile and cuneate nuclei** (2<sup>nd</sup> order neurons in dorsal column tract).



## 3 Spinal lemniscus

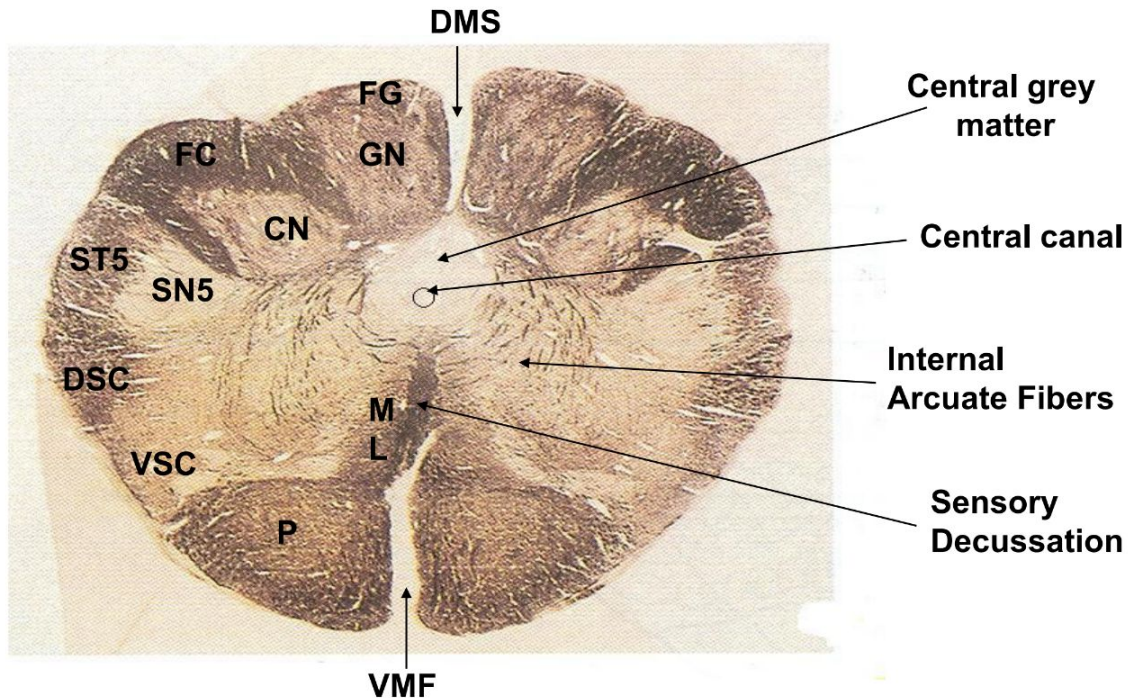
- ❖ It carries **pain, temperature & touch** sensations from the **opposite side** of the body to ventral posterolateral nucleus of thalamus.



Q. What is the function of the dorsal & ventral spinocerebellar tracts :

A1: They carry proprioceptive sensations to the cerebellum.

## It's the level of Sensory decussation



- ▶ **DMS**: Dorsal median sulcus
- ▶ **FG**: fasciculus gracilis
- ▶ **GN**: Gracile nucleus
- ▶ **FC**: Fasciculus cuneatus
- ▶ **CN**: Cuneate nucleus
- ▶ **SN5**: Spinal nucleus of trigeminal nerve
- ▶ **ST5**: Spinal tract of trigeminal nerve
- ▶ **P**: Pyramid
- ▶ **ML**: Medial lemniscus
- ▶ **DSC**: Dorsal spinocerebellar tract
- ▶ **VSC**: Ventral spinocerebellar tract
- ▶ **VMF**: Ventral median fissure

### 1 Grey matter

- ❖ **Sensory nuclei**: Gracile, cuneate, spinal nucleus of trigeminal nerve.

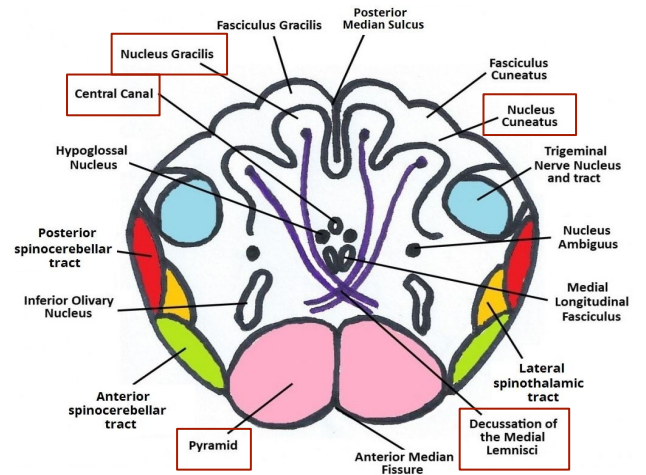
### 2 White matter

- ❖ **Ascending tracts**: Gracile, cuneate, spinal tract of trigeminal nerve, dorsal & ventral spinocerebellar, spinal lemniscus, **medial lemniscus** (appears at this level).
- ❖ **Descending tracts**: Pyramidal & extrapyramidal tracts.

# Mid MEDULLA

1 Traversed by the Central Canal.

2 Pyramids are prominent ventrally.

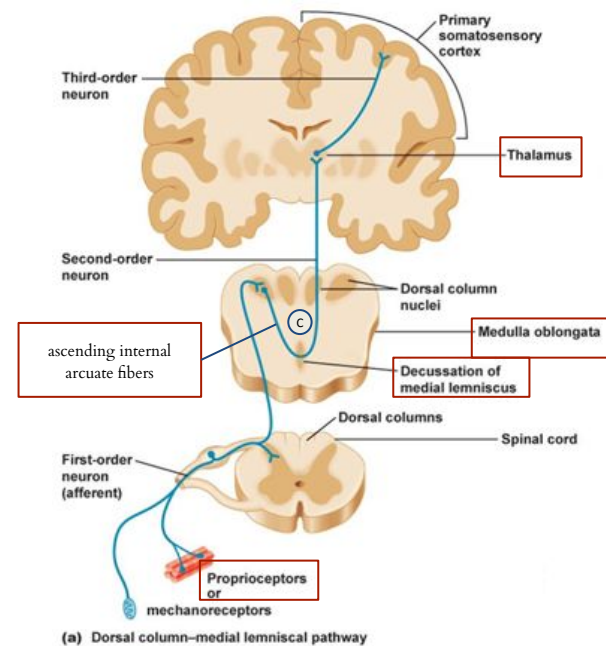


3 Larger size Gracile & Cuneate nuclei, concerned with proprioceptive deep sensations of the body.

Female Slides

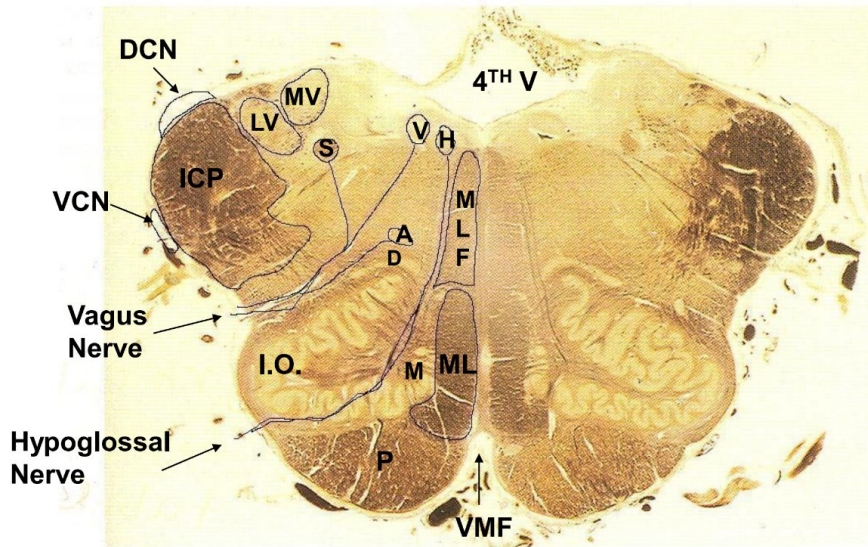
4 Medial Lemniscus:

- ❖ Lies adjacent to the middle line, ventral to the central canal.
- ❖ Gracile and cuneate nuclei are more prominent. Axons of cells of gracile & cuneate nuclei curve around the central canal as **internal arcuate fibers** then decussate forming the **sensory decussation** & ascend in the brain stem as **medial lemniscus** that ends in the ventral posterolateral nucleus of **thalamus**.
- ❖ Concerned with proprioceptive deep sensation.





# Rostral MEDULLA



- ▶ **H:** Hypoglossal nucleus
- ▶ **V:** Dorsal vagal nucleus
- ▶ **S:** Nucleus solitarius
- ▶ **A:** Nucleus ambiguus
- ▶ **MV:** Medial vestibular nucleus
- ▶ **LV:** Lateral vestibular nucleus
- ▶ **DCN:** Dorsal cochlear nucleus
- ▶ **VCN:** Ventral cochlear nucleus
- ▶ **ICP:** Inferior cerebellar peduncle
- ▶ **I.O.:** Inferior olive
- ▶ **D:** Dorsal accessory olive
- ▶ **M:** Medial accessory olive
- ▶ **MLF:** Medial longitudinal fasciculus
- ▶ **ML:** Medial lemniscus
- ▶ **P:** Pyramid
- ▶ **VMF:** Ventral median fissure

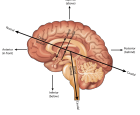
## 1 Grey matter

- ❖ **Sensory nuclei:** Nucleus solitarius, medial & lateral vestibular nuclei, dorsal & ventral cochlear nuclei, spinal nucleus of trigeminal nerve.
- ❖ **Motor nuclei:** Hypoglossal, dorsal vagal, nucleus ambiguus.
- ❖ **Extrapyramidal nuclei:** Inferior olive, medial & dorsal accessory olive.

## 2 White matter

- ❖ **Ascending tracts:** Medial lemniscus, spinal lemniscus, spinal tract of trigeminal nerve, ventral spinocerebellar tract.
- ❖ **Descending tracts:** Pyramidal & extrapyramidal tracts.
- ❖ **Both ascending & descending tract:** Medial longitudinal fasciculus.
- ❖ **Inferior cerebellar peduncle.**

# Rostral (open) MEDULLA



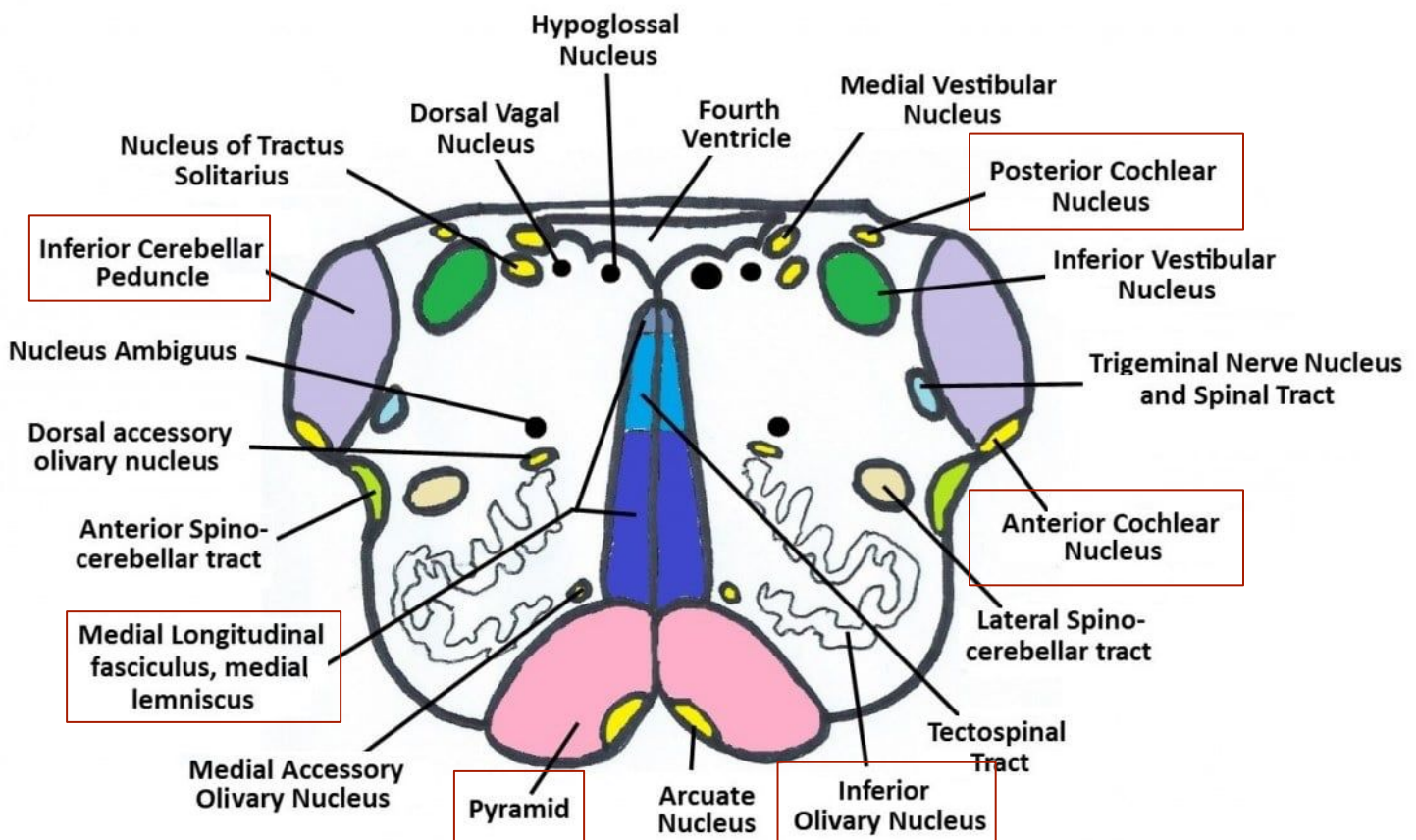
Rostral = superior/toward nasal or oral region

## 1 Ventral aspect

- ❖ The pyramid is clear.
- ❖ 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. **Concerned with the control of movements.**

## 2 Dorsal aspect

- ❖ Forms the Lower part of the floor of the 4<sup>th</sup> ventricle.
- ❖ The Inferior Cerebellar Peduncle is connecting the medulla with cerebellum.
- ❖ **Cochlear nuclei** (dorsal and ventral); **concerning with hearing.**



# Rostral (open) MEDULLA

MCQ

## Beneath the floor of 4<sup>th</sup> ventricle lie:

1

**Hypoglossal Nucleus :** It lies in the medial part of floor of 4th ventricle. It contains motor neurons innervating muscles of tongue (except palatoglossus) through hypoglossal nerve.

2

**Dorsal Vagal Nucleus:** It lies in the floor of 4th ventricle, lateral to hypoglossal nucleus. It contains preganglionic parasympathetic neurons running in the vagus nerve.

3

**Solitary Nucleus (sensory nucleus):** It lies ventrolateral to dorsal vagal nucleus. Receives taste sensation from the tongue along the facial (VII), glossopharyngeal (IX) and vagus (X)

4

**Medial & lateral vestibular nuclei complex:** they lie the floor of 4th ventricle, lateral to dorsal vagal nucleus. they receive afferent fibers from vestibular nerve. concerned with equilibrium.

5

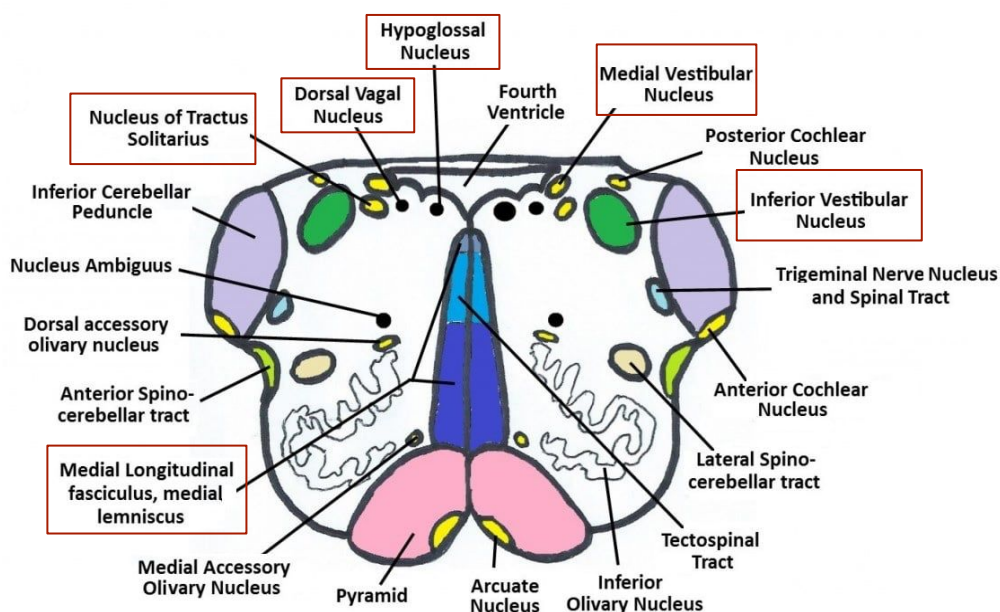
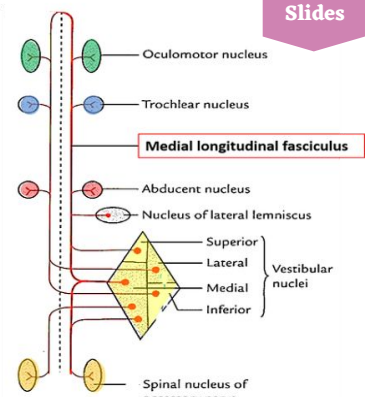
**Medial Longitudinal Fasciculus:** it is an important association tract.

**Upwards:**

It links the vestibular nuclei with nuclei of extraocular muscles (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) to help coordination of neck & trunk movements with the head movements.



# Rostral (open) MEDULLA

MCQ

Beneath the floor of 4<sup>th</sup> ventricle lie:

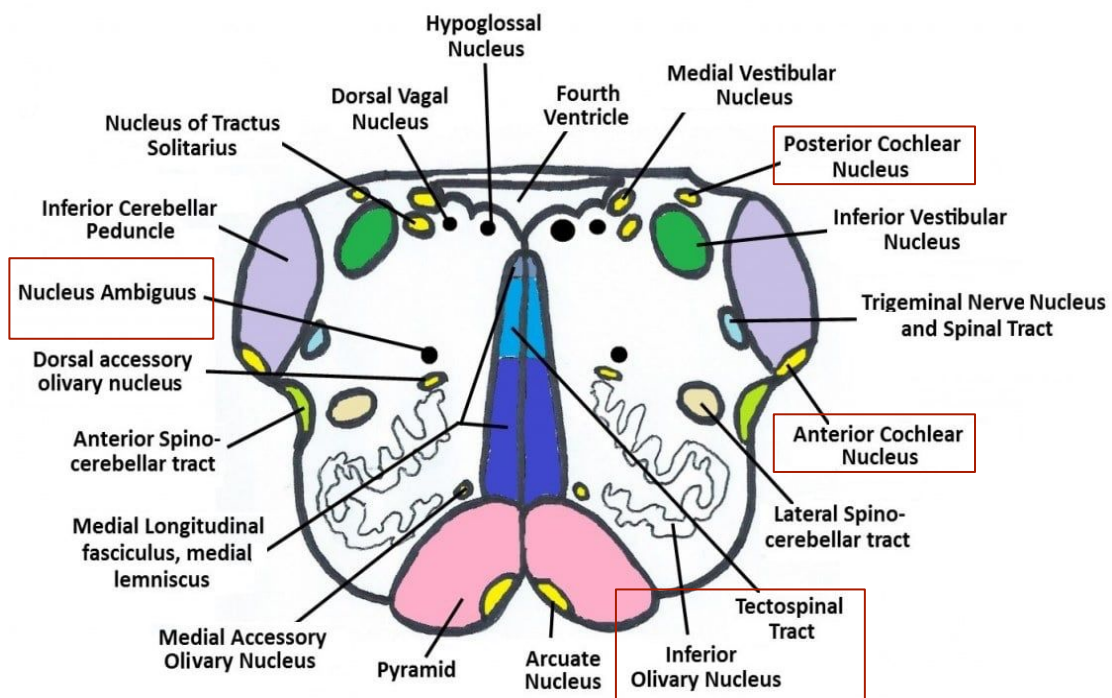
**Olivary nuclear complex:** It is formed of a large nucleus (inferior olive) & 2 smaller nuclei (medial & dorsal accessory olive).

1. **Afferents:** From cerebral cortex & spinal cord.
2. **Efferents:** To cerebellum through ICP.
3. **Function:** They are concerned with control of movement and assistance of cerebellar motor function.

**Nucleus Ambiguus (motor nucleus):** It lies dorsal to inferior olivary nucleus. It gives motor fibers along glossopharyngeal N. & vagus N. and cranial part of accessory nerve to muscles of the pharynx, larynx & palate.

**Dorsal & ventral cochlear nuclei:** They lie dorsal (dorsal nucleus) & lateral (ventral nucleus) to ICP. They receive afferent fibers from cochlear nerve.

**Tectospinal Tract:** lies between tectum of midbrain and spinal cord. Involved in head movements in response to visual and auditory stimuli.





# The pons

More pictures in the next slide

MCQ

It is divided into an anterior part (**Basis Pontis (Same at all levels)**) & a posterior part (**Tegmentum**) by the Trapezoid Body (consists of crossed acoustic fibres from cochlear nuclei to ascend **into midbrain** as lateral lemniscus **and terminate in inferior colliculus**). Trapezoid nuclei are segregated cells within trapezoid body and, together with superior olivary nucleus, are efferent parts of a reflex modulating auditory stimuli.

The ventral portion (**In all Levels of Pons**): marked by numerous transversely oriented fascicles of **pontocerebellar fibres** that originate from scattered cell groups (the pontine nuclei), and that pass to the contralateral side of the cerebellum through the middle cerebellar peduncle.

## Caudal Pons

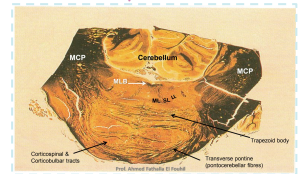
(Level of Facial Colliculus)

### Pontine Nuclei:

- ❖ Small masses of nerve cells, receive cortico pontine fibers.
- ❖ Their axons form the **transverse pontocerebellar fibers** which pass to the **contralateral** side of the cerebellum through **Middle Cerebellar peduncles**.

### Descending bundles of corticospinal & corticonuclear /Corticobulbar fibres (Pyramidal fibres):

- ❖ Axons of cells located in motor areas of cerebral cortex (particularly area 4).
- ❖ They end in anterior horn cells of spinal cord (for corticospinal fibers) or motor nuclei in pons & medulla (for corticobulbar fibers).



### Grey Matter:

1. **Motor nuclei:** Abducent nucleus, motor nucleus of facial nerve (axons turn around abducent nucleus forming facial colliculus).
2. **Sensory nuclei:** Nucleus solitarius, Vestibular nuclei, ventral & dorsal cochlear nuclei, spinal nucleus of trigeminal nerve.

### White Matter:

1. **Ascending tracts:** Medial lemniscus they rotate 90 degrees and lies almost horizontally, spinal lemniscus, lateral lemniscus (appears at this level), spinal tract of trigeminal nerve, ventral spinocerebellar tract.
2. **Descending tracts:** Tectospinal tract, rubrospinal tract.
3. **Both ascending & descending tract:** Medial longitudinal bundle (fasciculus).
4. **Inferior & middle cerebellar peduncles.**

## Mid Pons

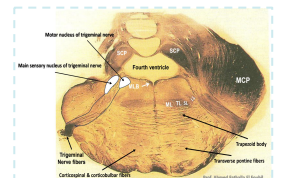
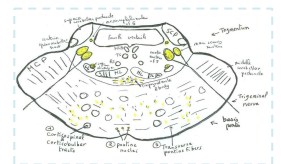
(Level of the Trigeminal N.)

### Grey Matter:

1. **Motor nucleus of the trigeminal N.:** Lies in the lateral part of the floor of the 4<sup>th</sup> ventricle.
2. **Main sensory nucleus and mesencephalic nucleus of the trigeminal nerve:** It lies lateral to the motor nucleus.

### White Matter:

1. **Superior and middle cerebellar peduncles:** form the lateral boundary of the 4<sup>th</sup> ventricle.
2. **Ascending tracts:** Medial lemniscus, spinal lemniscus, **trigeminal lemniscus** (appears at this level), lateral lemniscus, ventral spinocerebellar tract.
3. **Descending tracts:** Tectospinal tract, rubrospinal tract.
4. **Both ascending & descending tract:** Medial longitudinal bundle (fasciculus).



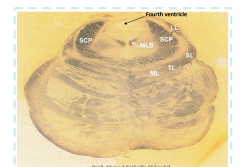
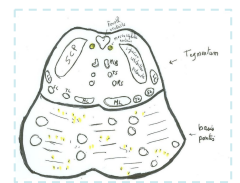
**Superior Medullary Velum:** Passes between the two peduncles & forms the roof of the 4<sup>th</sup> ventricle.

### Grey Matter:

- **Sensory nucleus:** Mesencephalic nucleus of trigeminal nerve.

### White Matter:

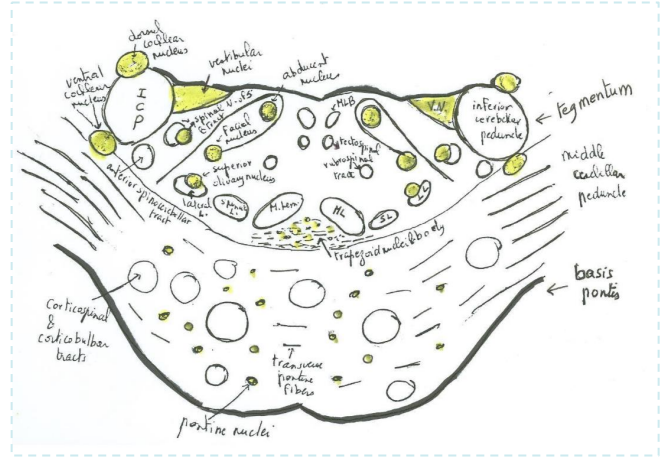
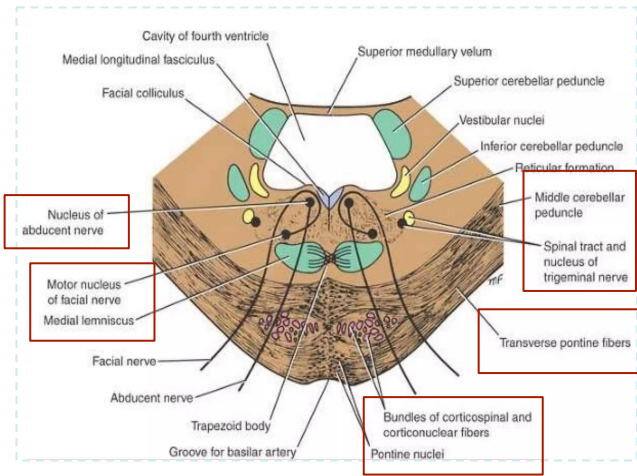
1. **Superior cerebellar peduncles**
2. **Medial longitudinal fasciculus (Both ascending & descending):** Lies close to the midline beneath the floor of the 4<sup>th</sup> ventricle.
3. **Ascending tracts:** Medial lemniscus, spinal lemniscus, trigeminal lemniscus, lateral lemniscus, ventral spinocerebellar tract.
4. **Descending tracts:** Tectospinal tract, rubrospinal tract.



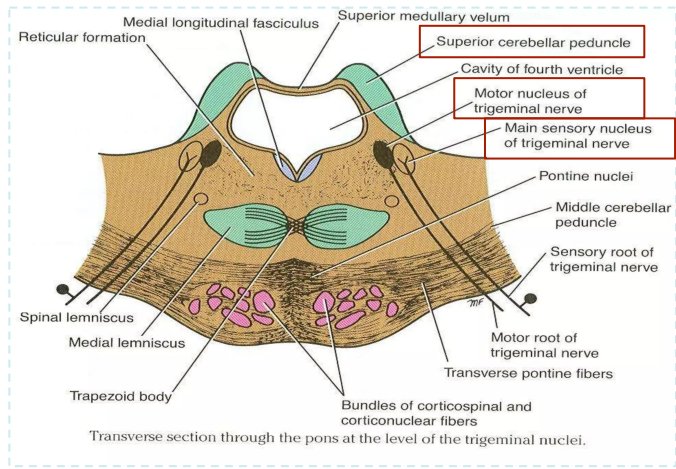
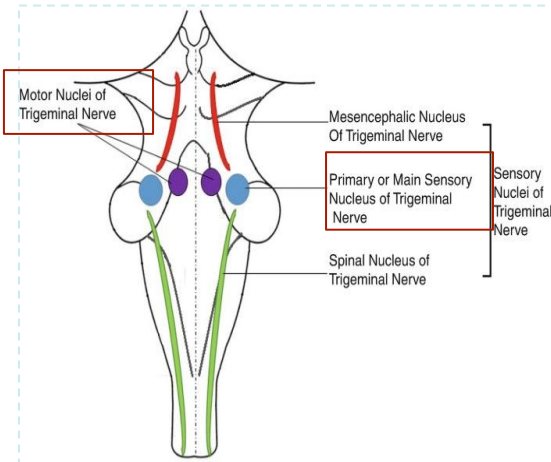
## Rostral Pons

# The pons

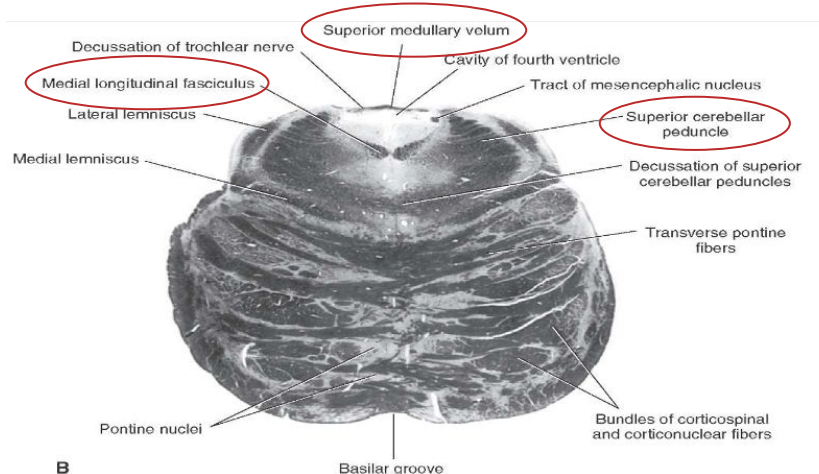
## Caudal pons



## Mid pons



## Rostral pons





# Midbrain

Pictures are in the next slide

MCQ

1

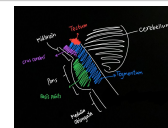
Midbrain is divided into a dorsal part (Tectum) of 4 colliculi and a ventral part (Tegmentum) at the level of the cerebral aqueduct. The cerebral aqueduct is surrounded by a pear shaped periaqueductal (central) gray matter.

Female Slides

2

Ventral part: **TWO CRURA CEREBRI** (same at both levels) separated by interpeduncular fossa. Each crus is **formed of descending tracts** and divided into 3 parts.

Dorsal part: **TEGMENTUM** (the part of tegmentum that lies dorsal to cerebral aqueduct is formed of 4 colliculi and called the tectum).



Thanks to Remaz Almahmoud for the picture

Male Slides

3

**Crus Cerebri** is the most ventral part of the tegmentum separated by interpeduncular fossa, it's a massive fibrous mass ventral to the substantia nigra, present in both levels of colliculi.

- ❖ It consists entirely of descending cortical efferent fibers/tracts to the motor nuclei in anterior horn cells of spinal cord, and divided into 3 parts: The medial 1/5 is formed by Frontopontine fibers, The middle 3/5 is formed by Corticospinal & Corticobulbar fibers. The lateral 1/5 is formed by Temporopontine, Parietopontine and Occipitopontine Fibres.
- ❖ Involved in the coordination of movement.

## Structures at the level of Inferior Colliculus

### Substantia nigra:

- ❖ It is a mass/layer of deeply pigmented melanin neurons that occupies the most ventral part of the tegmentum.
- ❖ It projects to the basal ganglia (responsible for voluntary movements).
- ❖ Separates crus cerebri from tegmentum.
- ❖ Its degeneration is associated with Parkinson's disease.



### Grey Matter:

1. **Inferior colliculus:** is a large nucleus of gray matter, Its efferent fibers pass to the thalamus and receives fibers from the lateral lemniscus. It is a part of the auditory pathway.
2. **Trochlear nucleus (Motor nucleus):**
  - ❖ lies in the central gray matter close to the median plane.
  - ❖ The fibers of the trochlear nerve decussate in the superior medullary velum and emerges from posterior surface of midbrain.
3. **Sensory nuclei:** Mesencephalic nucleus of trigeminal nerve

### White matter:

1. **Decussation of the superior cerebellar peduncles** lies in the midline.
2. **Ascending Lemnisci** composed of: Medial lemniscus, Spinal (Lateral & anterior spinothalamic tracts), Trigeminal (Lateral & medial), Lateral lemniscus (ends at this level).
3. Crus cerebri
4. **Descending tracts:** Tectospinal tract, rubrospinal tract.
5. **Both ascending & descending tract:** Medial longitudinal bundle (fasciculus).

## Structures at the level of Superior Colliculus

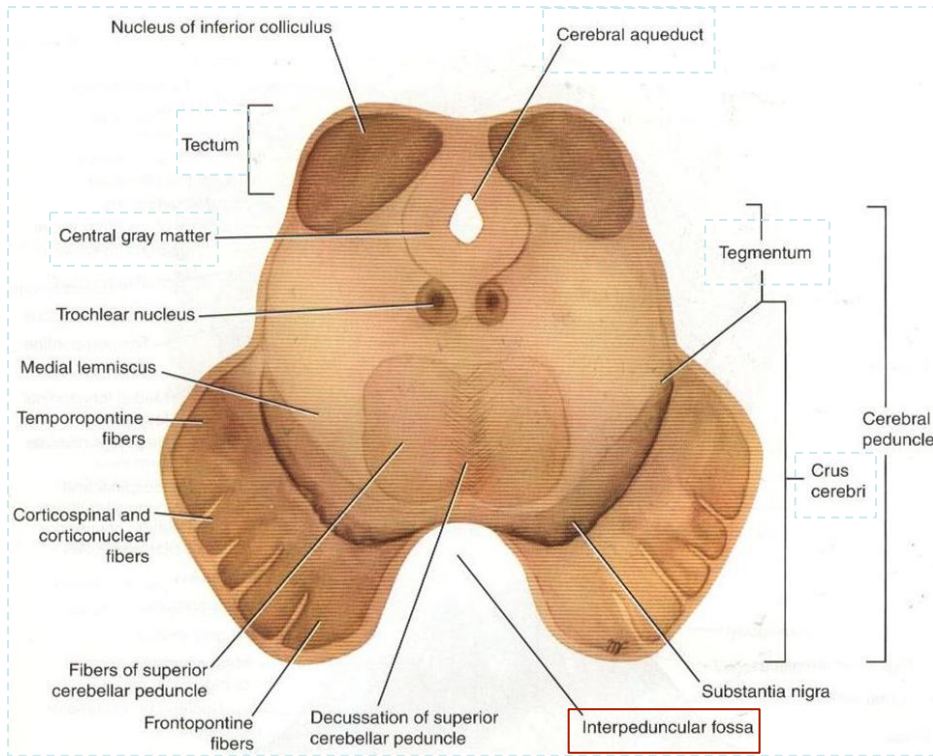
### Grey Matter:

1. **Superior colliculus:** is a large nucleus of gray matter, Its efferent fibers go to the anterior horn cells & to cranial nuclei (3, 4, 6, 7 & 11).
  - ❖ It forms part of the visual reflexes. Their axons form the tectospinal tract.
  - ❖ It is responsible for the reflex movements of the eyes, head and neck in response to visual stimuli.
2. **Oculomotor nucleus (Motor nucleus):** Situated in the central gray matter. The fibers of the oculomotor nerve passes anteriorly through the red nucleus to emerge on the medial side of the crus cerebri (In interpeduncular fossa).
3. **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.
  - ❖ It is involved in motor control/regulation.
  - ❖ Their axons form the rubrospinal tract.
4. **Sensory nucleus:** Mesencephalic nucleus of trigeminal nerve.
5. **Pretectal nucleus:** They are concerned with pupillary light reflex.

### White matter:

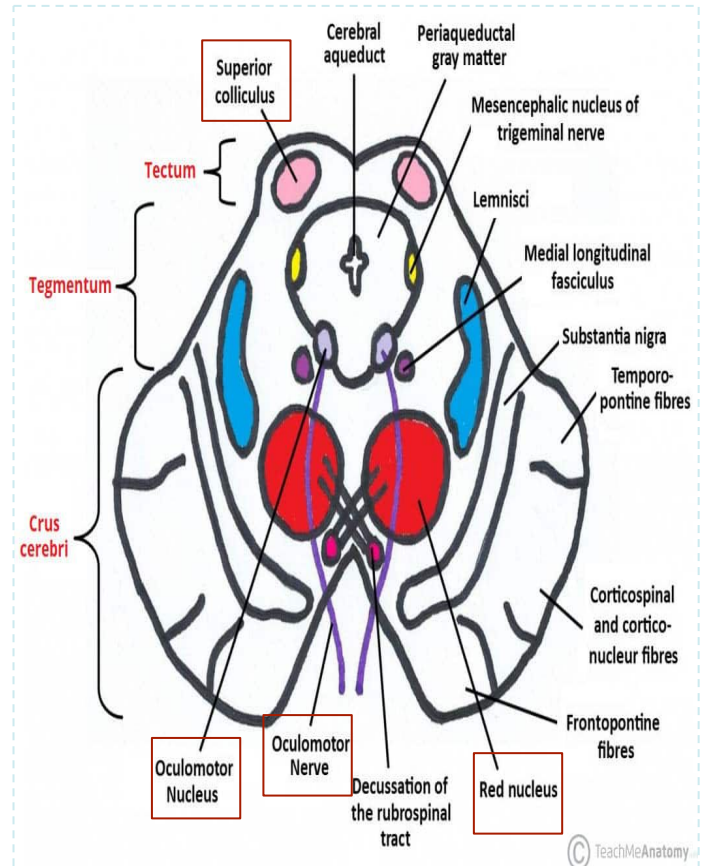
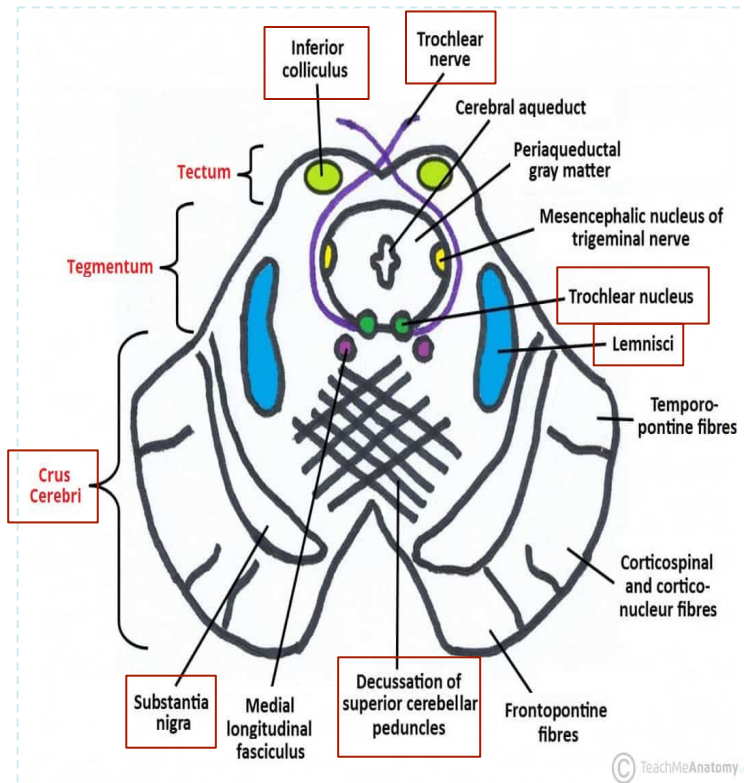
1. **Ascending tracts:** Medial lemniscus, spinal lemniscus, trigeminal lemniscus.
2. **Descending tracts:** Tectospinal tract, their decussation is called "dorsal tegmental decussation", rubrospinal tract, their decussation is called "ventral tegmental decussation".
3. **Both ascending & descending tract:** Medial longitudinal bundle (fasciculus).

# Midbrain



## Inferior colliculus

## Superior colliculus



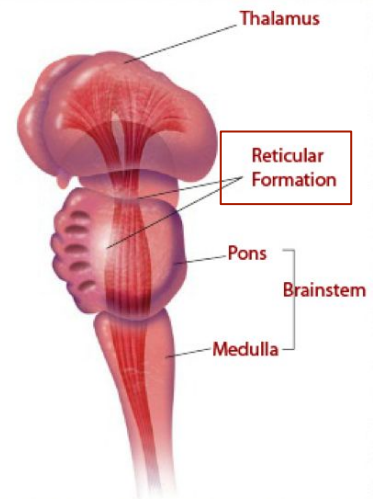


# Reticular formation & tracts

## Reticular formation

It is a complex matrix of nerve fibers & groups of nerve cells that extends throughout the brain stem.

It has a number of important functions i.e. **Respiratory and Cardio-vascular control.**

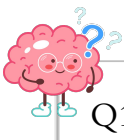
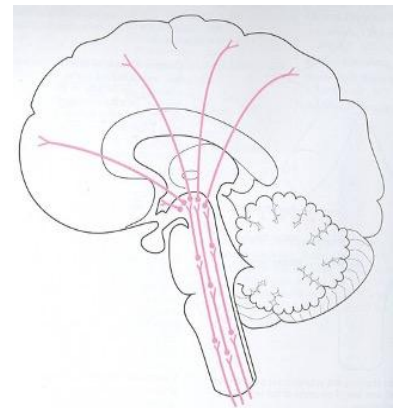


## Reticular tracts

**Reticulospinal tracts:** Descending fibres influence muscle tone & posture.

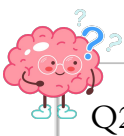
**Reticular Activating system:** Ascending fibers through the thalamus; then to the cerebral cortex for:

1. **Regulation of arousal and activation of awake.**
2. **Involved in perception of sensory stimuli as dull aching (slow pain).**



Q1. Explain how decussation of pyramidal fibers occurs:

A1: The motor fibers coming from the motor cortex descend into the medulla to form the ventral pyramidal fibers (ventral corticospinal tract) and then 80% to 90% of these fibers will cross over to form the lateral corticospinal tracts found in the spinal cord. The rest of the fibers will continue as the ventral corticospinal tracts and cross over later on.



Q2. What is the function and location of the medial longitudinal fasciculus ?

A2: It is a tract that is found just under the floor of the 4th ventricle. (1) It connects the vestibular nuclei with the ocular nuclei upwards to coordinate the movement of the eyes and head. (2) It connects the vestibular nuclei with the anterior horn of the spinal cord downwards to coordinate the movement of the trunk and head.

# MCQs

Q1. Which of the following receives pain and temperature sensation from the face and forehead ?

- |                    |                   |                         |                   |
|--------------------|-------------------|-------------------------|-------------------|
| A. Olivary nucleus | B. Gracile nuclei | C. Trigeminal S. nuclei | D. Cuneate nuclei |
|--------------------|-------------------|-------------------------|-------------------|

Q2. Which of the following is concerned with proprioceptive deep sensations of the body ?

- |                    |                    |                      |                     |
|--------------------|--------------------|----------------------|---------------------|
| A. Cochlear nuclei | B. Olivary nucleus | C. Vestibular nuclei | D. Medial lemniscus |
|--------------------|--------------------|----------------------|---------------------|

Q3. The sensory decussation occurs in which part of the medulla ?

- |                   |                |                            |                           |
|-------------------|----------------|----------------------------|---------------------------|
| A. Caudal medulla | B. Mid medulla | C. Ventral rostral medulla | D. Dorsal rostral medulla |
|-------------------|----------------|----------------------------|---------------------------|

Q4. What's the nucleus that receives taste fibers from glossopharyngeal nerve?

- |                     |                              |                       |                         |
|---------------------|------------------------------|-----------------------|-------------------------|
| A. Nucleus ambiguus | B. Nucleus of solitary tract | C. Salivatory nucleus | D. Vagus dorsal nucleus |
|---------------------|------------------------------|-----------------------|-------------------------|

Q5. Which of the following nuclei lies in the midbrain at the level of inferior colliculus ?

- |                      |                |                   |                             |
|----------------------|----------------|-------------------|-----------------------------|
| A. Trochlear nucleus | B. Red nucleus | C. Facial nucleus | D. Inferior olivary nucleus |
|----------------------|----------------|-------------------|-----------------------------|

Q6. In which of the following structures the corticopontine fibers are included?

- |                    |                 |                 |            |
|--------------------|-----------------|-----------------|------------|
| A. Medial eminence | B. Crus cerebri | C. Basis pontis | D. Pyramid |
|--------------------|-----------------|-----------------|------------|

A1. C A2. D A3. B A4. B A5. A A6. B

**FOR ANKI FLASHCARDS**





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