

Sheet no. 9

Lecture Date: 1.3.2021

Lecture Title: Brainstem and Diencephalon I

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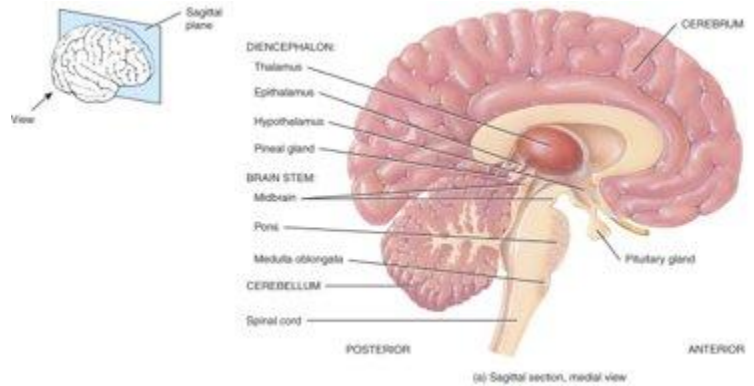
## Lecture Objectives

- Identify the gross features of the **brainstem**.
- Briefly describe the **internal structure** of the brainstem (ascending and descending pathways, sensory and motor cranial nuclei, substantia nigra, red nucleus, olivary nucleus and reticular formation).
- Describe the main connections of the sensory cranial nuclei.
- Describe the main connections of the motor cranial nuclei.
- Review the **blood supply** of the brainstem.
- Describe **lesions in the brainstem** such as medial medullary syndrome and lateral medullary syndrome.
- Describe the main connections of the substantia nigra and the red nucleus.
- Describe the main connections of **Reticular Formation** and correlate these connections with its main functions.
- Describe the anatomical features of the **diencephalon**; components, location and relations.

# The Brainstem and The Diencephalon I

Principal parts of the Brain:

- Cerebrum
- Diencephalon
  - Thalamus, hypothalamus & epithalamus
- Cerebellum
- Brainstem
  - medulla, pons & midbrain

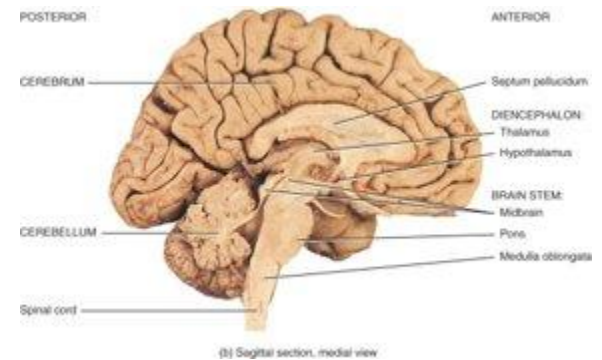


## Brainstem functions

- Part of the hierarchy of the brain , it's the connection between the brain and the spinal cord
- All the ascending and descending tracts must pass through the brainstem
- Even the fibers from the cerebellum need to pass through the brainstem
- Reflex centers
  - Cardiovascular and respiratory centers

**The brainstem is a very vital structure;**

- ☐ It has both the cardiovascular and respiratory centers so injury to the brainstem is life threatening
  - ☐ If you cut above the brainstem (cut off the diencephalon and the cortex) the person wouldn't die
  - Coughing, sneezing, swallowing
- 
- Nuclei of the cranial nerves (both motor and sensory) from CN III up to CN XII are scattered across the brainstem
  - Consciousness, arousal, coordination and modulation of a lot of functions in the CNS occur in the brainstem (specifically **the reticular formation**)



# External Anatomy of Brainstem:Ventrally

Some relations of the brainstem :

- The cerebral aqueduct passes through the midbrain
- The 4th ventricle is located between the brainstem and the cerebellum.
- The cerebellum is physically connected to the 3 parts of the brainstem

## Midbrain

The **optic tracts** surround the midbrain and mark its superior border. (they're NOT part of the midbrain)

- Cerebral peduncles (basis pedunculi)

Descending tracts (projection fibers) pass through this part of the midbrain

- Interpeduncular fossa

Contains(anteriorly):

1. The infundibulum
2. Mammillary bodies
3. Interpeduncular Cistern
4. Oculomotor nerve

## Pons

- Basilar pons (the bulgy part)
- Basilar sulcus

Contains the basilar artery (it begins with the beginning of the pons inferiorly and ends with the ending of the pons superiorly)

The trigeminal nerve(CN V) comes out from the lateral aspect of the pons

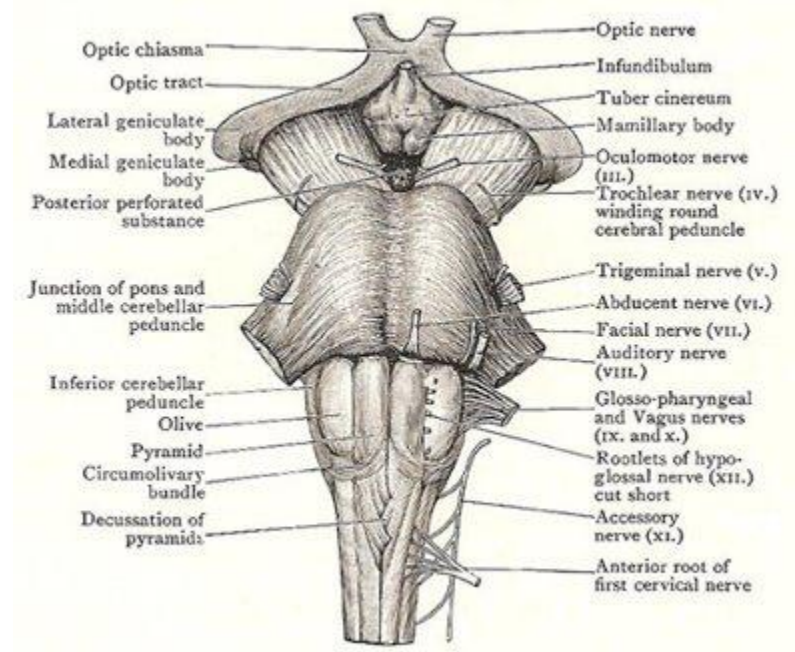
➤ Bulbopontine sulcus

Between the pons and the medulla

Nerves that exit from this sulcus (medial to lateral):

CN VI,VII and half of CNVIII

(Abducens,Facial,Vestibulocochlear)



## Medulla oblongata

- Ventral median fissure
- Pyramids

These are the (medial) columns on each side of the ventral median fissure

projection fibers pass through the pyramids, the fibers that reach this area are the ones that form the corticospinal tracts

- Decussation of pyramids

Around 90% of the fibers crossover in this area.

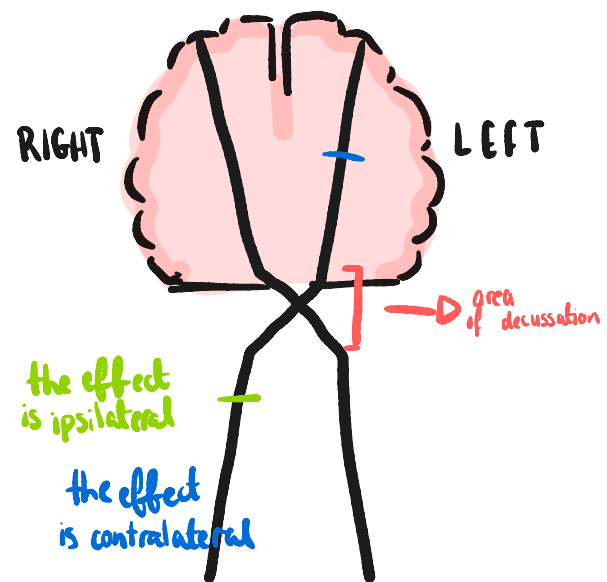
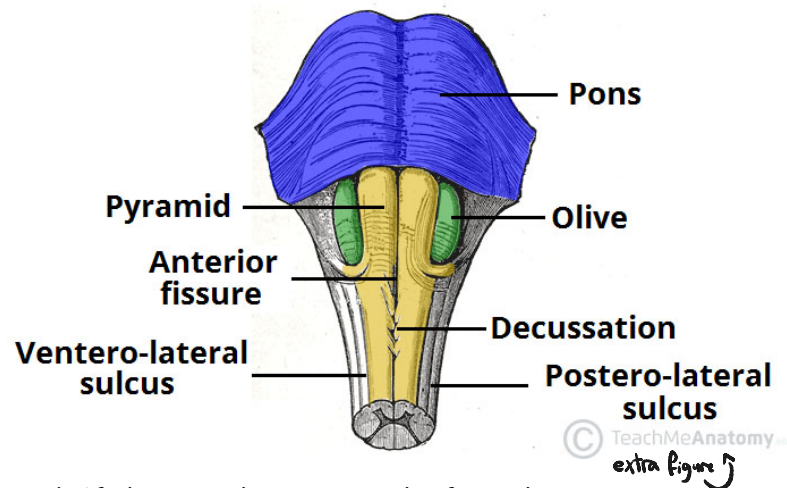
If there was a cut in the fibers before the decussation the effect of the injury would be contralateral (to the injury), if the cut happened after the decussation the effect would be ipsilateral (to the injury)

- Olives

The columns lateral to the pyramids

Contains the inferior olivary nucleus which causes it to bulge anteriorly

- Preolivary & postolivary sulci.  
CNXII exits from the preolivary sulcus  
The rest of CN VIII and CN IX, CN X, CN XI
- Inferior cerebellar peduncles



in both cases  
the affected side  
is the right side  
of the body

## External Anatomy of Brainstem: Dorsally

- **Corpora quadrigemina (midbrain)**

- Superior & inferior colliculi

- make up the posterior part of the midbrain called the **Tectum**

- Part of the motor system ,coordinates with some specific stimuli

Superior colliculus : associated with head movements in response to visual stimuli (reflexes)

- inferior colliculus : associated with head movements in response to auditory stimuli

Notice the trochlear nerve which is the only nerve that exits posteriorly (then goes anteriorly), its nucleus is located within the midbrain

- **Cerebellar peduncles**

- Lateral walls of 4th ventricle

- **Gracile & cuneate tubercles (closed surface of medulla)**

- they are like a

“station” for the ascending tracts, containing the endings of these tracts.

- These tubercles are a reflection of these tracts , and nuclei of the same names which form the second order neurons

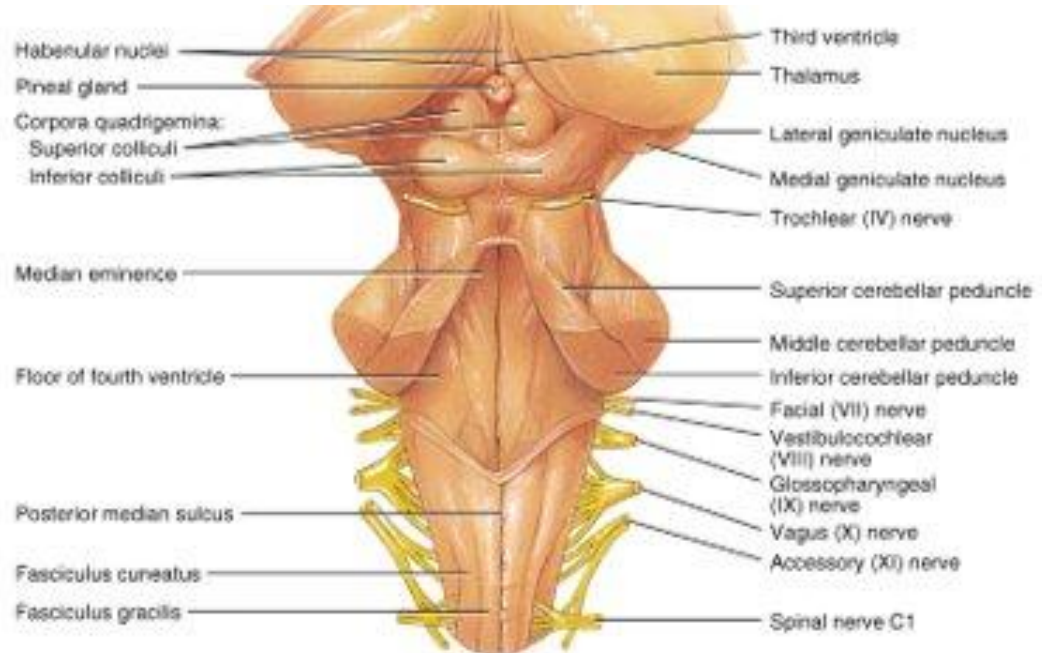
- Inferior to 4th ventricle

- **Rhomboid fossa**

- Floor of the 4th ventricle (posterior portion of pons and the open part of the medulla oblongata)

- Pontine part

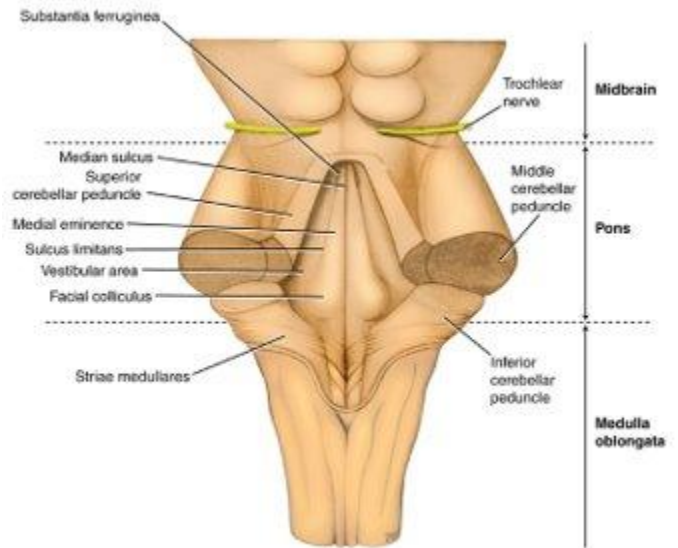
- Medullary part (open medulla)



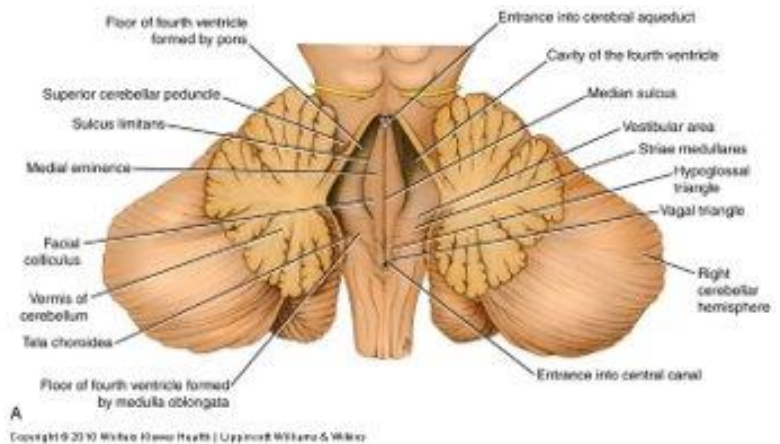


# Rhomboid Fossa

- Posterior median sulcus
  - On each side of the median sulcus
  - An embryological structure
- Medial eminence (pons)
  - On each side of the median sulcus
  - An embryological structure
- Facial colliculus
  - Caudal part of the eminence
  - Reflection of its internal structures (Fibers of the facial nerves and the nucleus of the abducens nerve)
- Sulcus limitans
  - Lateral to the medial eminence
  - An embryological structure
- Striae medullares
  - No known function, its fibers either connect the two vestibular nuclei or go towards the cerebellum.
  - Mark the border between the pons and the medulla
- Trigones
  - Vagal trigone (more lateral-inferior) Contains the vagal nuclei
  - Hypoglossal trigone (more medial-superior) Contains the hypoglossal nuclei
- Vestibular areas
  - Lateral points of the fossa
  - Contain vestibular and cochlear nuclei
- Isthmus
  - superior constriction
- Obex
  - inferior narrowing



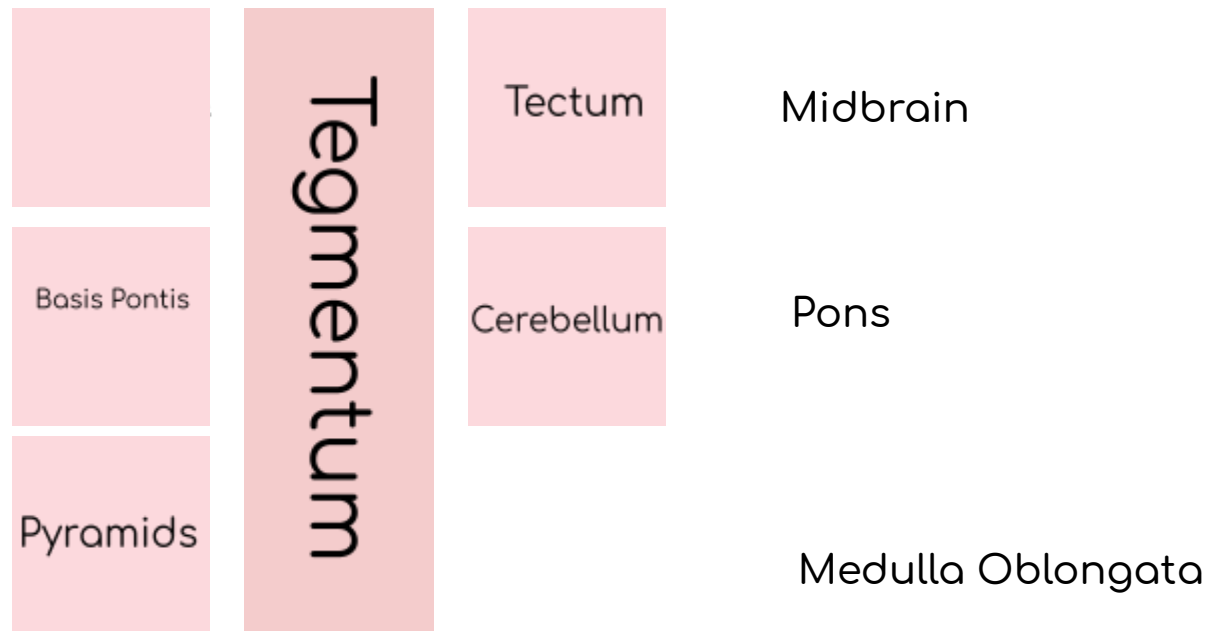
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# Brainstem Structure

Ventral      Middle      Dorsal



## Midline

- GSE(General Somatic Efferent) – III, IV, VI, XII
- SVE(Special Visceral Efferent) – V, VII, IX, X, XI (Related to the pharyngeal apparatus, the origin of the muscles in the pharyngeal apparatus is the neural crest ectoderm)
- GVE(General Visceral Efferent) – III, VII, IX, X

Preganglionic Parasympathetic

## Sulcus limitans

- GVA(General Visceral Afferent) – n. of tractus solitarius

Parasympathetic afferents

- SVA(Special Visceral Afferent) – n. of tractus solitarius

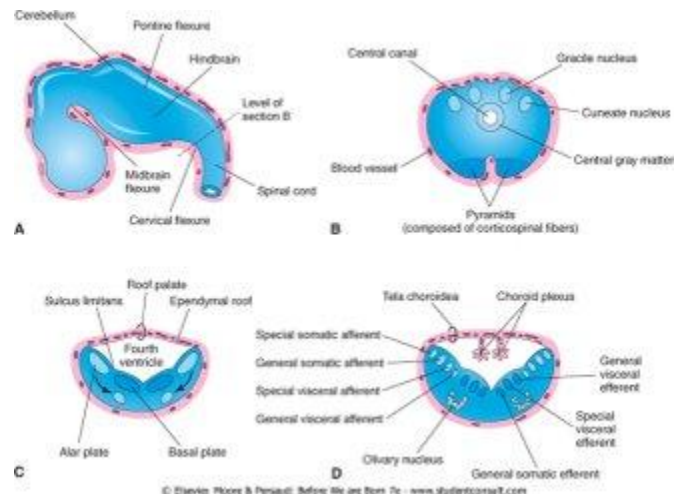
Taste and smell

- GSA(General Somatic Afferent) – V sensory nuclei

Skin

- SSA(Special Somatic Afferent) – vestibular & cochlear

Hearing and balance



These all have specific nuclei which we will further discuss in embryology

Overview: the nuclei of GSE, SVE and GVE have a specific organization (roughly):  
GSE is the nearest to the midline  
 as we saw earlier, the trigone of CN XII is medially located  
SVE are located lateral to GSE nuclei

V: Mastication muscles

VII: Facial muscles

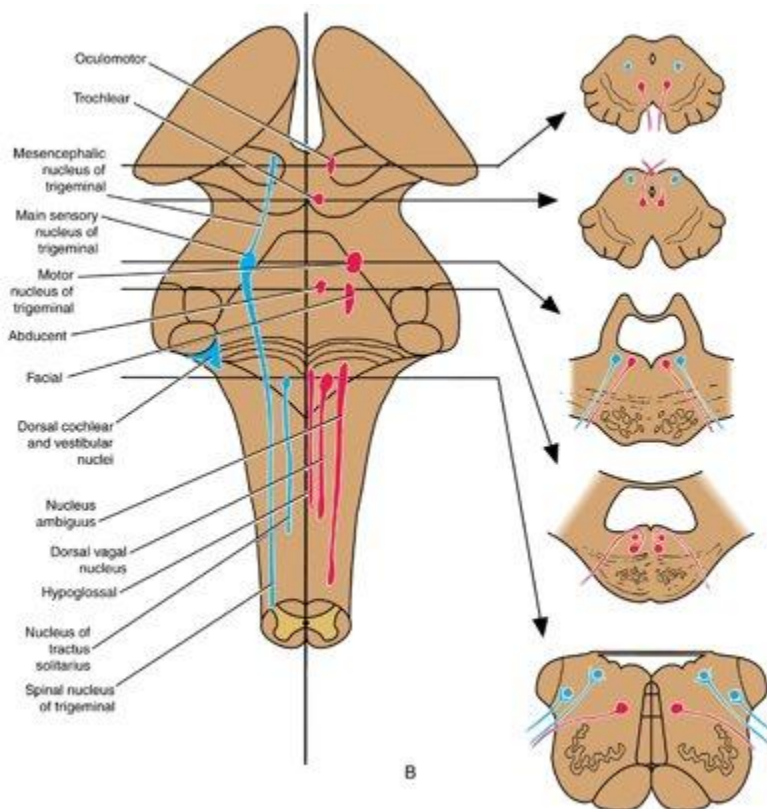
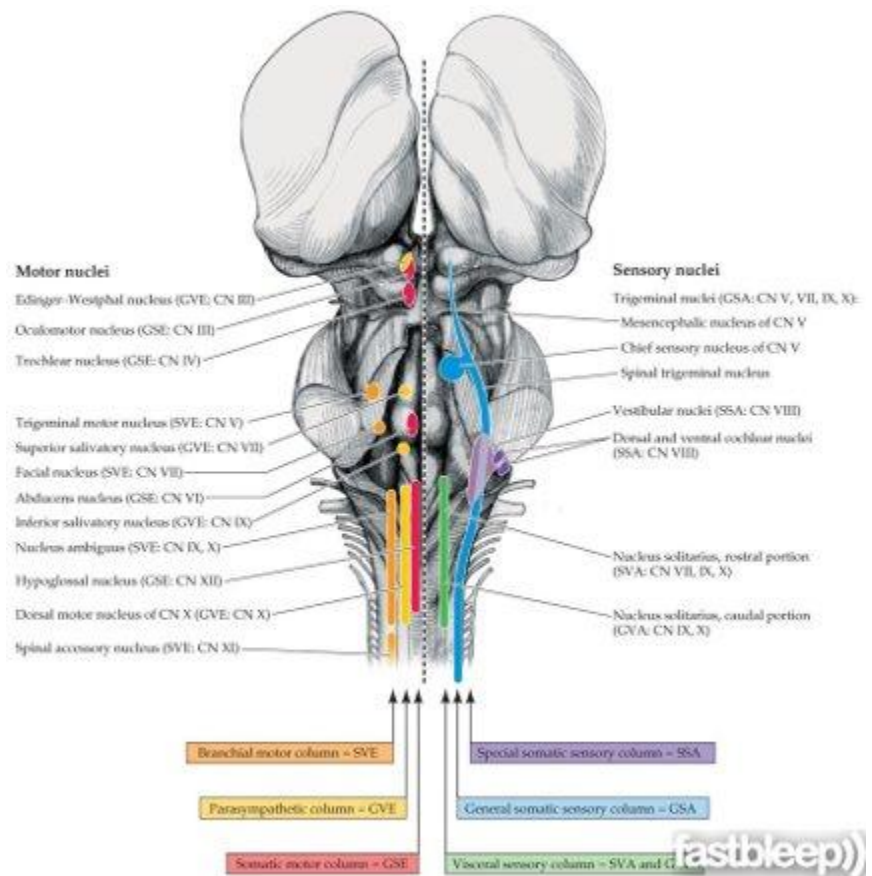
IX: Glossopharyngeus

X: Pharyngeal and laryngeal muscles

XI: Shoulder-lifting muscles

GVE nuclei located lateral to SVE nuclei (debatable)

Some nuclei are longitudinal and some are more localized at specific points





# Internal Structures of the Medulla

## Level of pyramidal decussation

(closed part)

Notice the central canal in the closed(lower) part of the medulla

- Cranial nerve nuclei
  - Spinal tract & nucleus of trigeminal nerve

The nucleus of the trigeminal nerve traverses the length of the brainstem, starting with a large **spinal nucleus** (because it starts in the spine, upper part of the cervical segments) and continues up to the middle of the pons where there is another nucleus called the

**main sensory nucleus**, and then it continues as the **mesencephalic nucleus**.

These represent General Somatic Afferent fibers -Skin from the head and neck

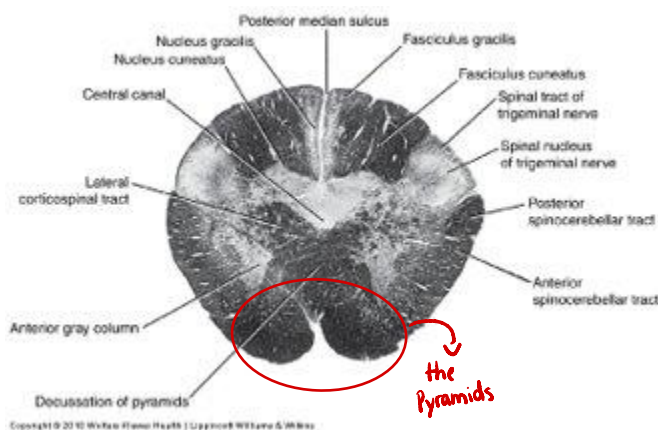
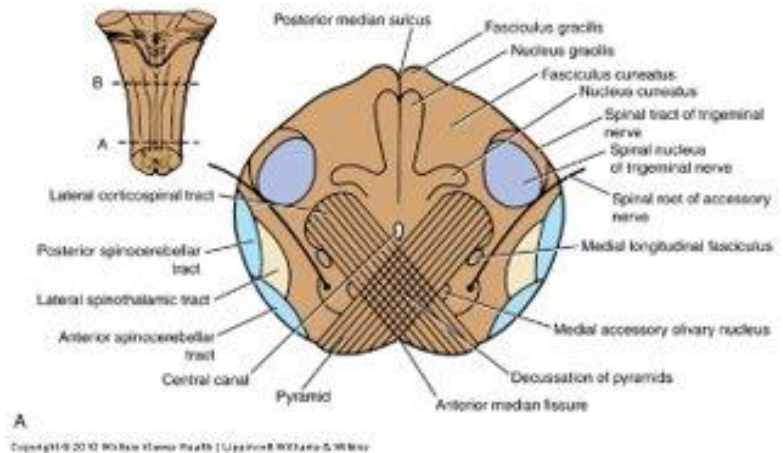
- Motor pathways

- Pyramids
  - Decussation of pyramids

The decussating fibers go posteriorly to form the descending tracts (lateral corticospinal tract-lateral white column in the spinal cord)

- Somatosensory pathways

- Nucleus gracilis & cuneatus
- Fasciculus gracilis & cuneatus



This is a real stained section  
The staining causes the white matter(myelin sheath) to stain black

And the gray matter stains white

As we go up the brainstem we'll start seeing more nuclei and less tracts

## Level of internal arcuate fibers (closed part)

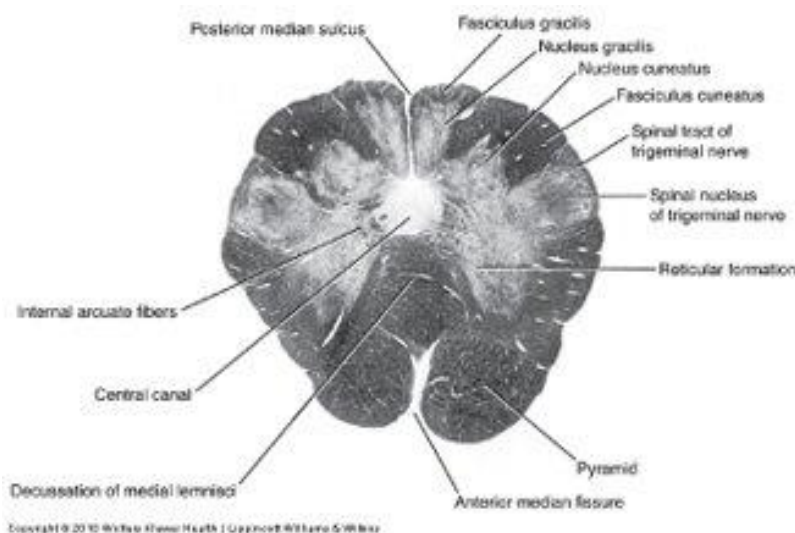
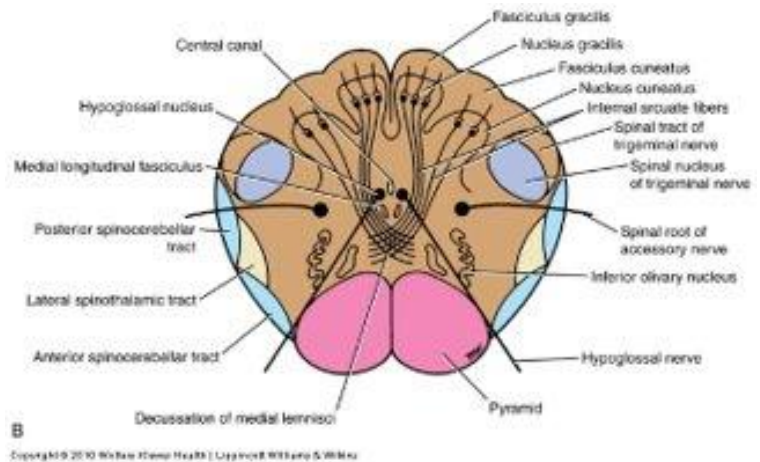
Notice how the central canal is wider in this section; because it's closer to the 4th ventricle

- Cranial nerve nuclei
  - Spinal tract & nucleus of trigeminal nerve
- Motor pathways
  - Pyramids
- Somatosensory pathways
  - Fasciculus gracilis & cuneatus
  - Nucleus gracilis & cuneatus (contain cell bodies of second order neurons) (more nuclei and less fibers)
  - Internal arcuate fibers

These are axons from the second order neurons cell bodies located in the gracilis and cuneate nuclei.

These fibers will decussate (in the same area as the pyramidal decussation in the level below) and form the medial lemniscus

(ascending tracts, located in the posterior column of the spinal cord that's why they are located posteriorly in the medulla oblongata)



## Level of olivary nucleus (open part)

### - Cranial nerve nuclei

- Hypoglossal nucleus

Reflected externally as the hypoglossal trigone

- Dorsal vagal nucleus

Reflected externally as the vagal trigone

The vagus is the only cranial nerve that leaves the head and neck area, it is parasympathetic.

- Vestibular nuclei (and maybe the cochlear nuclei)

Most laterally located

- Nucleus of tractus solitarius

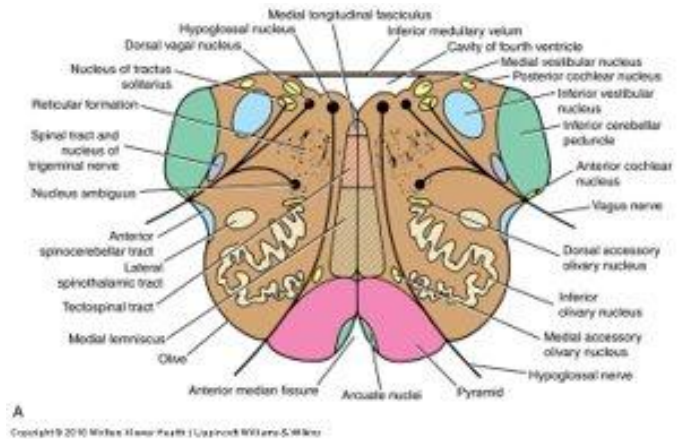
- Spinal tract & nucleus of trigeminal nerve

Still occupying the same area as in the previous sections, but they're smaller now

- Nucleus ambiguus

Fibers of the Glossopharyngeal, Vagus and Accessory nerves come out from this nucleus.

This nucleus migrated to the center of tegmentum(?) and became harder to pinpoint after mixing with the reticular formation, the latter being even more ambiguous, can only be told apart by tracing.



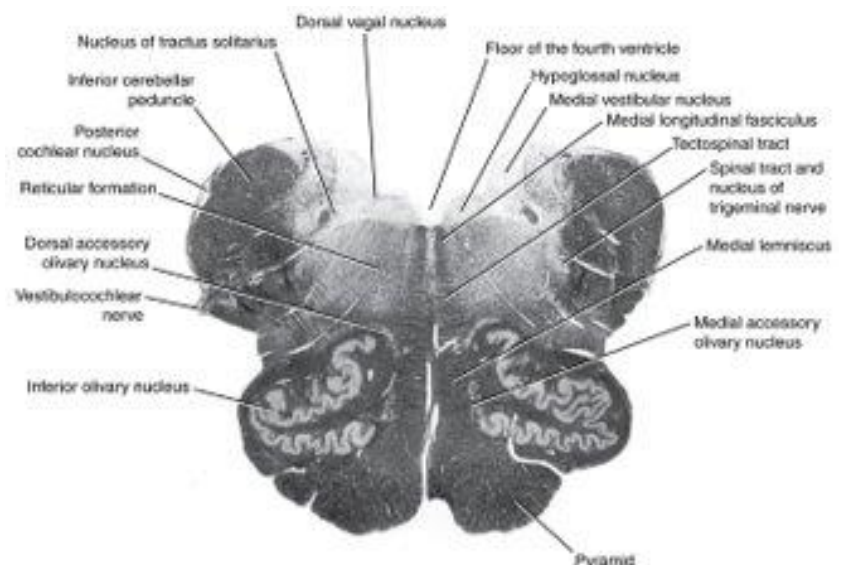
### - Motor pathways

- Pyramid
- Olivary nucleus
- Inferior cerebellar peduncle

### - Somatosensory pathways

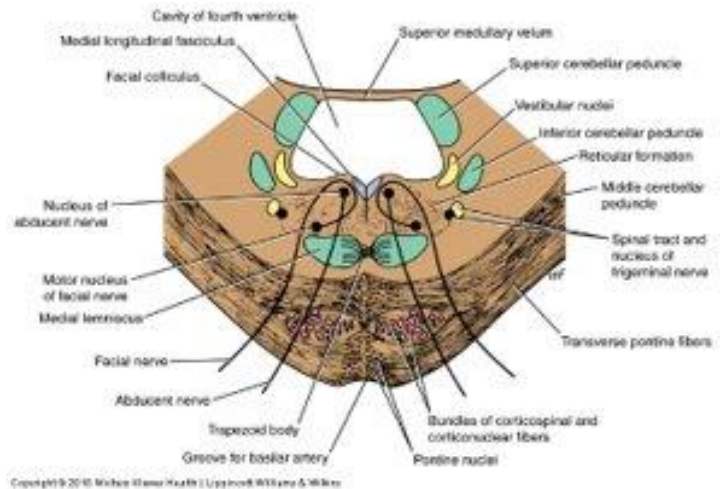
- Medial lemniscus

Notice the locations of the different nuclei mentioned



# Internal Structures of the Pons

The pons are easy to locate ,  
1-they're a bulgy structure anteriorly,  
2-there is the basilar sulcus,3- there  
is the area where the descending  
tracts mix with other tracts and  
connect the two sides of the  
cerebellum(pontine-cerebellar fibers)  
and finally 4- there are the pontine  
nuclei



## Caudal part

- Cranial nerve nuclei
  - Nucleus of abducens nerve
  - Motor nucleus of facial nerve

Externally reflected as **the Facial Colliculus** (called facial colliculus because the most externally there are the fibers of the facial nerve , although the nucleus that makes up most of the bulge is the abducens nucleus)

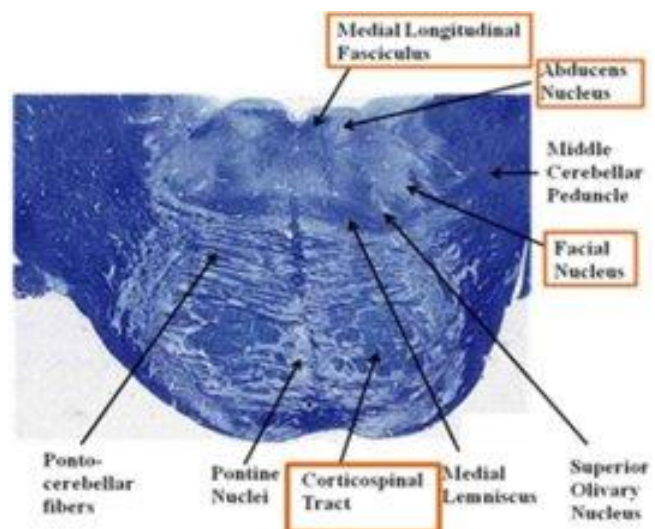
Abducens is GSE , so it's more medially located , while the vagus is SVE (more lateral)

- Motor pathways
  - Corticospinal tracts
  - Somatosensory pathways
    - Medial lemniscus

**RECALL** Fibers from gracilis and cuneate form the internal arcuate which decussates and forms the medial lemniscus

- ❑ There are medial lemniscus, spinal lemniscus and trigeminal lemniscus all of which go to the thalamus.

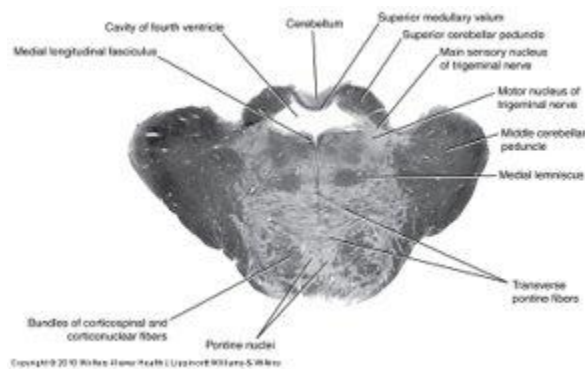
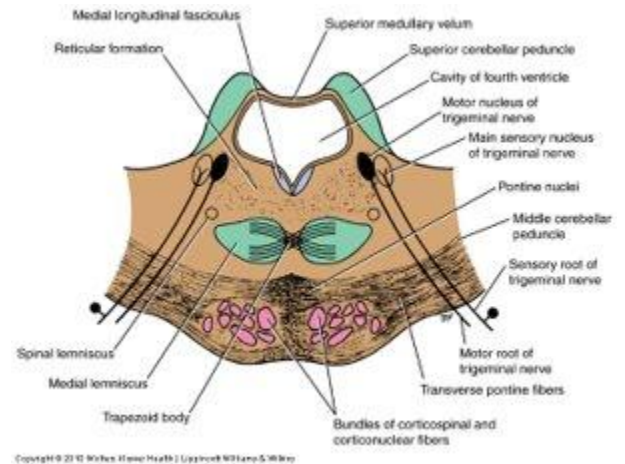
Notice the corticospinal tracts which become the pyramids in the medulla





## Cranial part

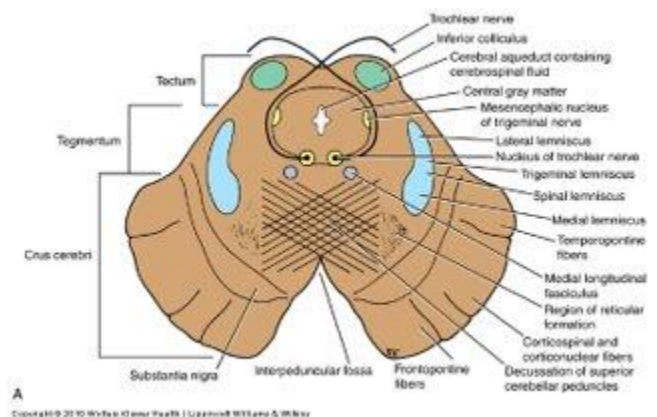
- Cranial nerve nuclei
    - Motor nucleus of trigeminal nerve
    - Main sensory nucleus of trigeminal
  - Motor pathways
    - Middle & superior cerebellar peduncles
    - Pontine nuclei
    - Corticospinal fibers
  - Somatosensory pathways
    - Medial lemniscus
- Become more lateral



## Level of inferior colliculi

We know it's on the level of the inf. Colliculi because we can see the decussation of the superior cerebral peduncles

- Cranial nerve nuclei
  - Nucleus of trochlear nerve-near the midline because it's GSE.
  - Mesencephalic nucleus of trigeminal nerve
- Motor pathways
  - Inferior colliculi
  - Decussation of superior cerebellar peduncles (each hemisphere of the cerebellum controls the ipsilateral side of the body, and due to the decussation each hemisphere of the cerebellum communicates with the contralateral side of the cerebrum)





- Substantia nigra

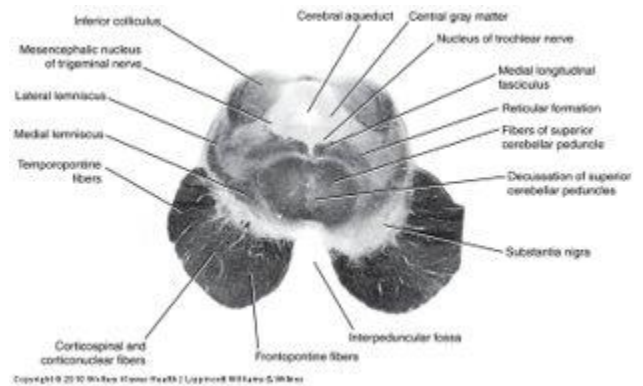
Gray matter in the tegmentum of the midbrain, very large nucleus, traverses the entire length of the midbrain till it nears the basal nuclei and the subthalamic nucleus

- Crus cerebri(Cerebral peduncles)

- Interpeduncular fossa

- Somatosensory pathways

- Medial lemniscus



## Level of superior colliculi

Notice the red nuclei, that's how we know it's on the level of the superior colliculi

- Cranial nerve nuclei

- Nucleus of oculomotor nerve

- Motor pathways

- Superior colliculi

- Red nucleus

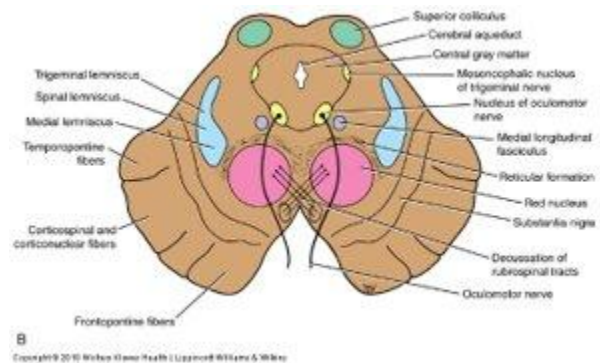
- Substantia nigra

- Crus cerebri

- Somatosensory pathways

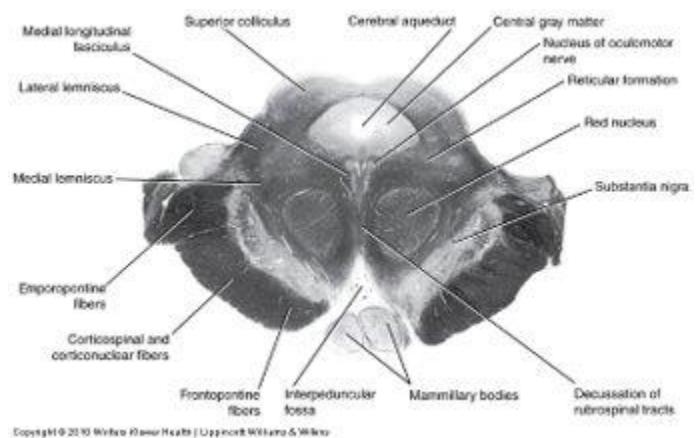
- Medial lemniscus

Continues to become more lateral



Notice:

- the mammillary bodies in the interpeduncular fossa
- The cerebral aqueduct



Spinal cord & Brainstem Labeled Sections: External Link

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