

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



السَّلَامُ عَلَيْكُمْ وَرَحْمَةُ اللَّهِ وَبَرَكَاتُهُ

*PHYSIOLOGY OF
BRAIN STEM*

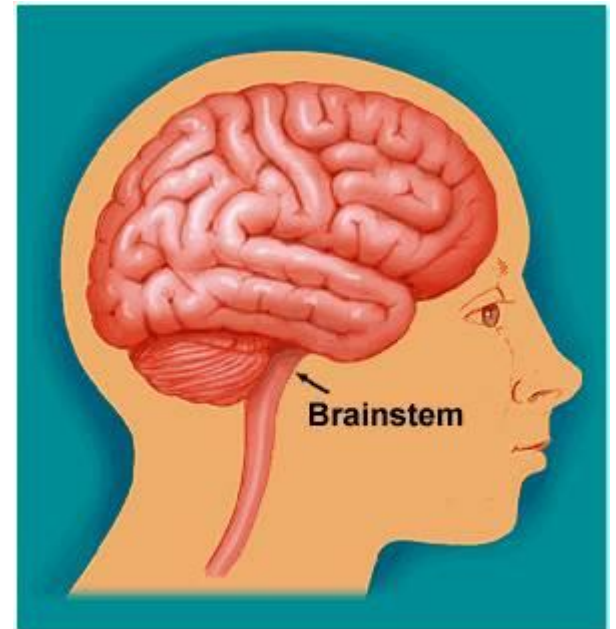
*Dr. Hayam Gad
Associate Professor of
Physiology*

Learning Objectives

- *Components of Brain stem*
- *Important structures in brain stem*
- *Functions of the Brain Stem*
- *Signs & Symptoms of brain stem lesion*
- *Brain stem function tests*

THE BRAIN STEM

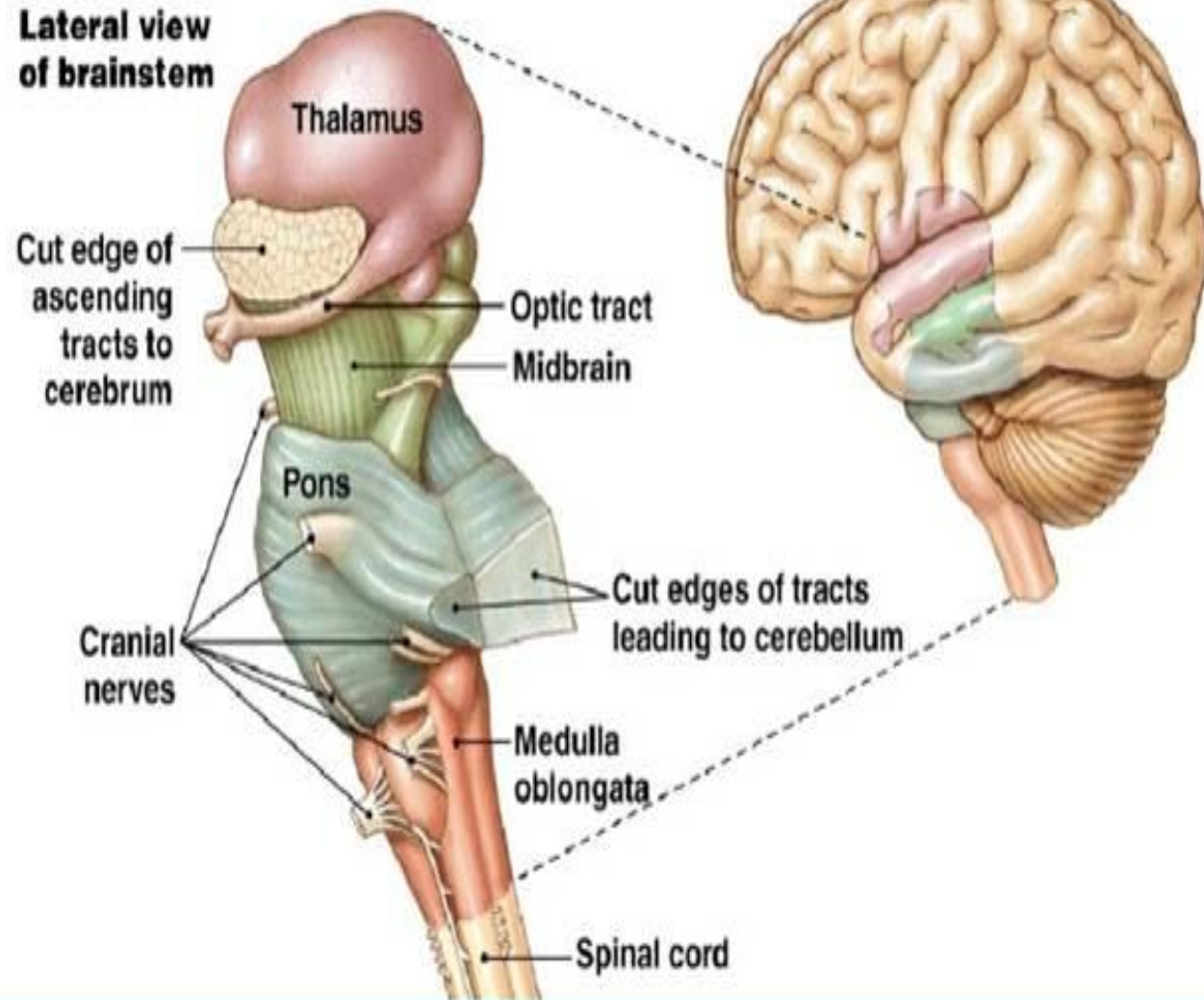
The brain stem is the lower part of the brain, adjoining and structurally continuous with the spinal cord.



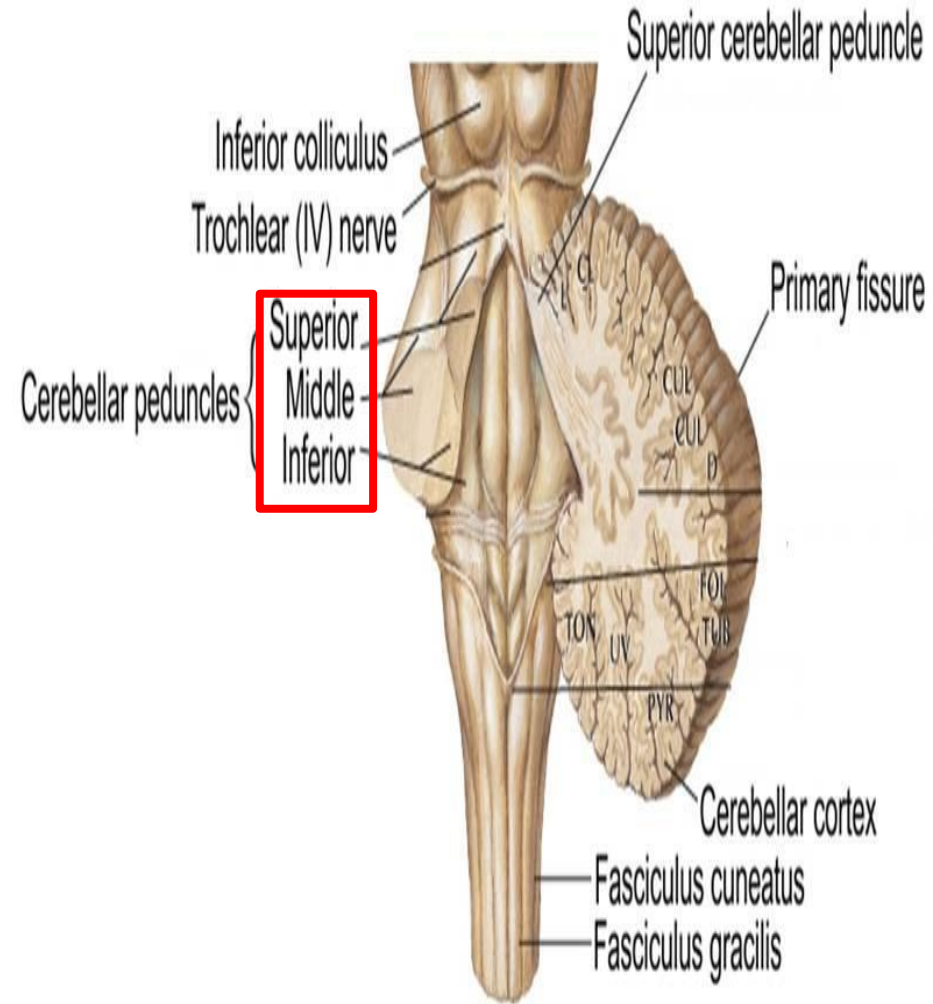
Components of Brain stem

- Mid Brain
- Pons
- Medulla Oblongata

Lateral view of brainstem



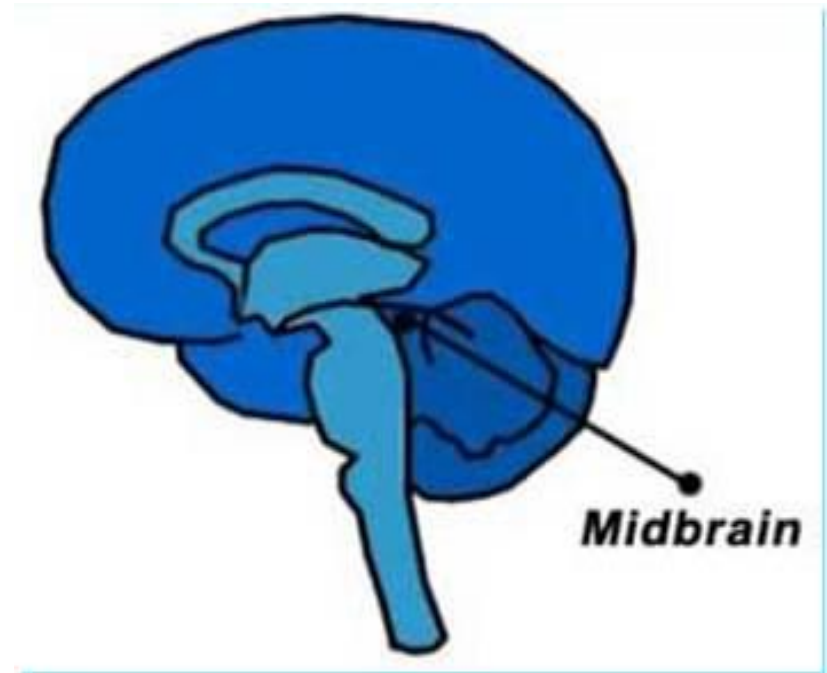
- The midbrain, pons and medulla connect to the cerebellum via the superior, middle and inferior peduncles respectively.

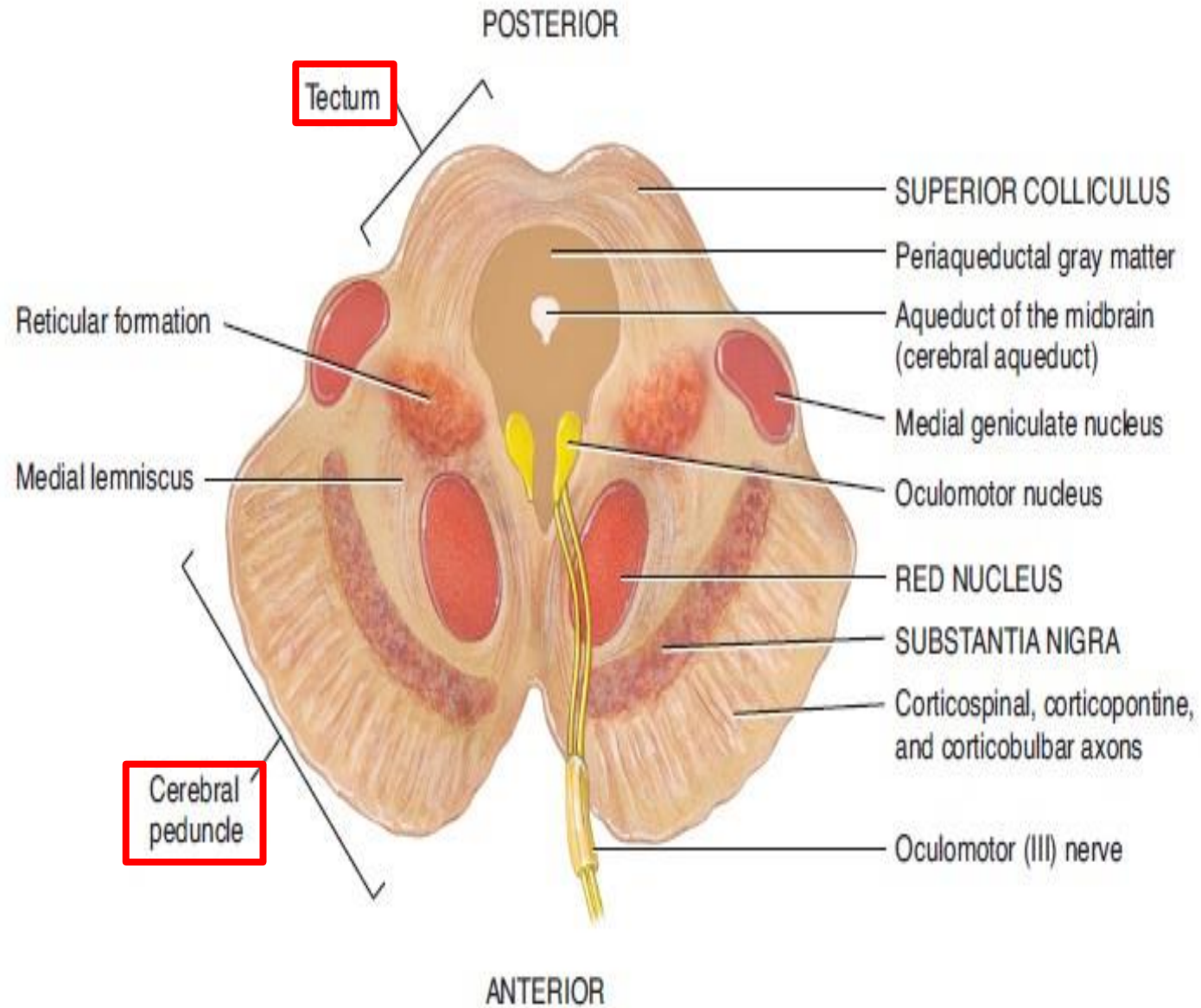
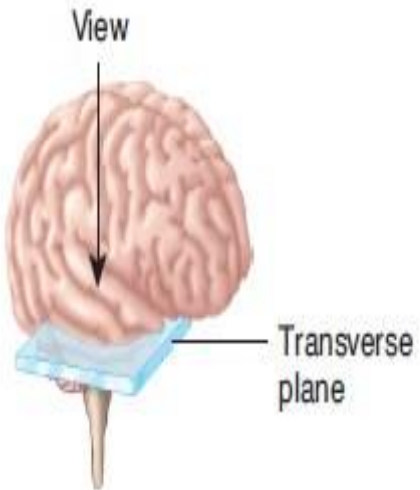


Midbrain

The midbrain is divided into three parts:

- 1- The Tectum
- 2- The Tegmentum
- 3- Cerebral Peduncles



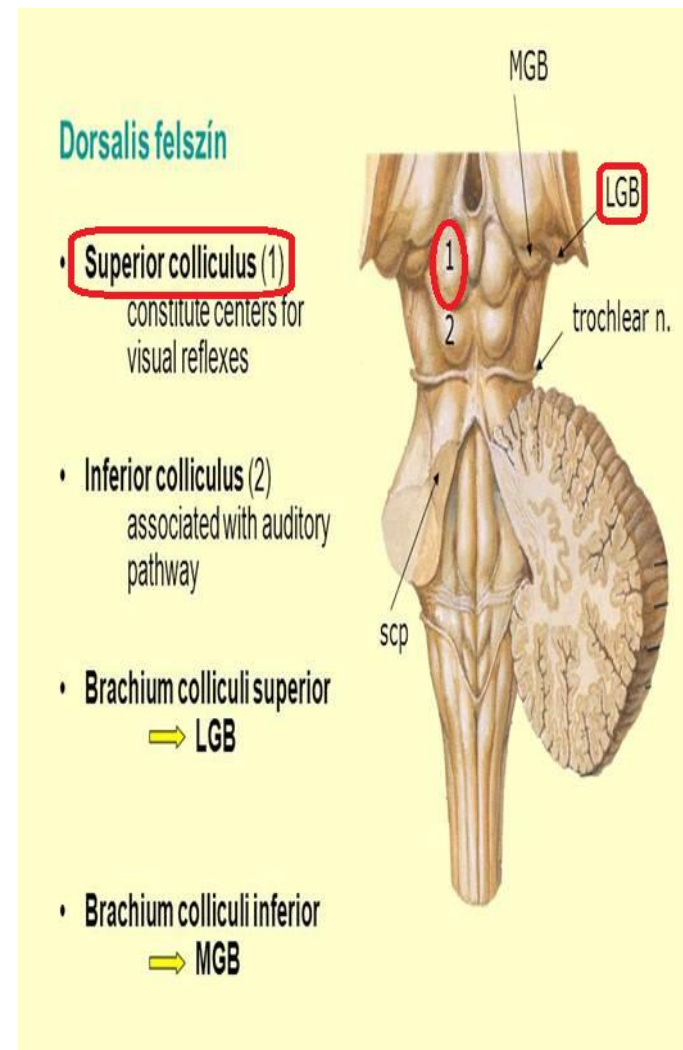


(b) Transverse section of midbrain

1- The Tectum ("roof" in latin) includes:

a) The superior colliculus

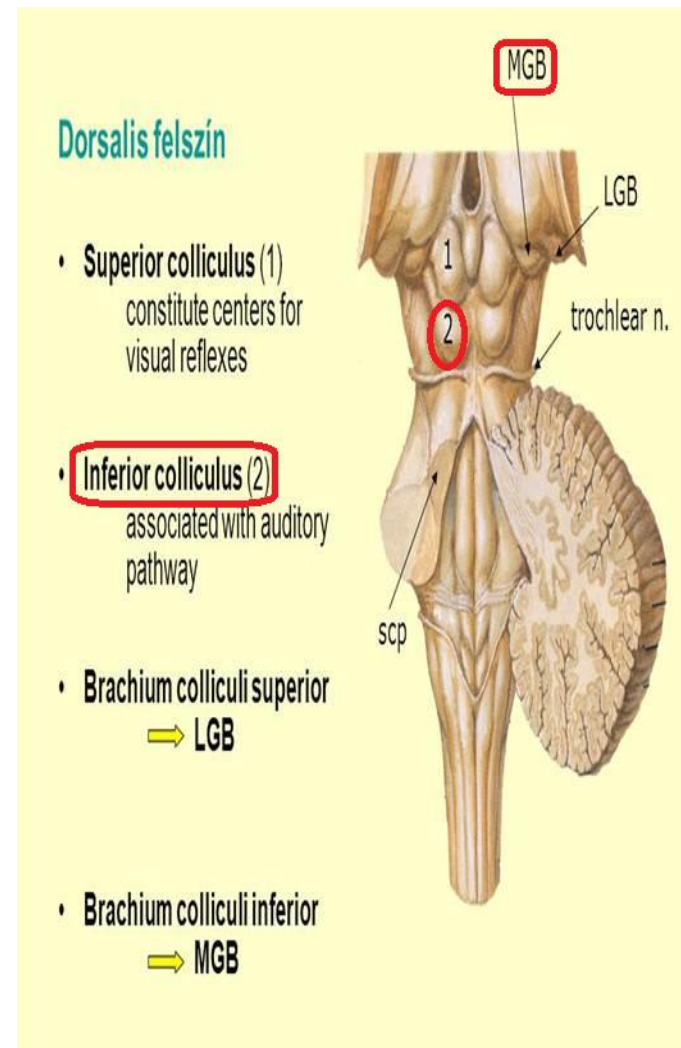
It is involved in the special sense of vision and sends its superior brachium to the lateral geniculate body of the thalamus.



b) The inferior colliculus

It is involved in the special sense of hearing & sends its inferior brachium to the **medial geniculate body** of the thalamus.

The cerebral aqueduct runs through the midbrain, beneath the colliculi.

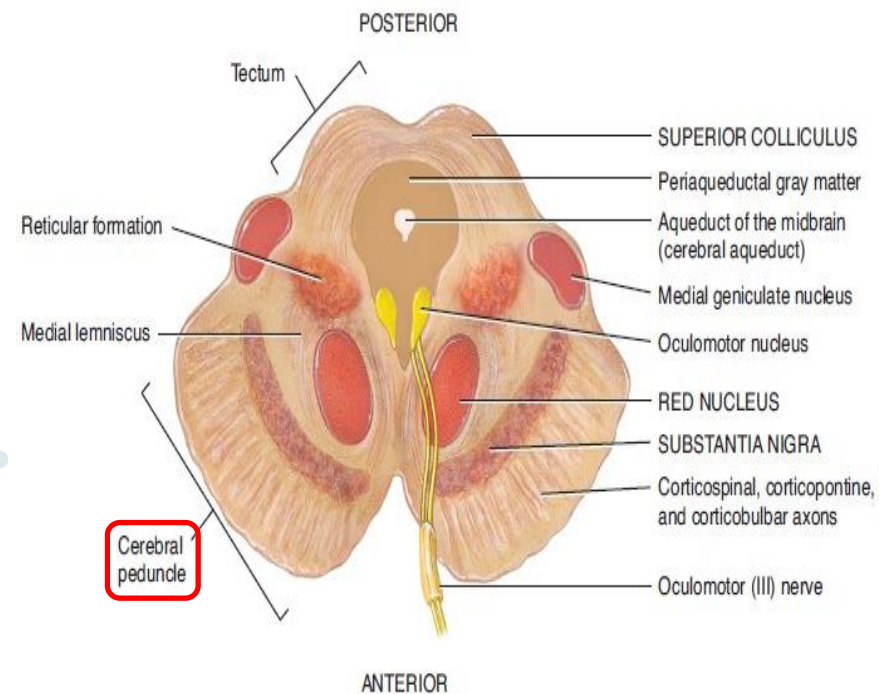


2- The Tegmentum

Ventral to the cerebral aqueduct. Several nuclei, tracts and the reticular formation is contained here.

3- The ventral side is comprised of paired Cerebral Peduncles.

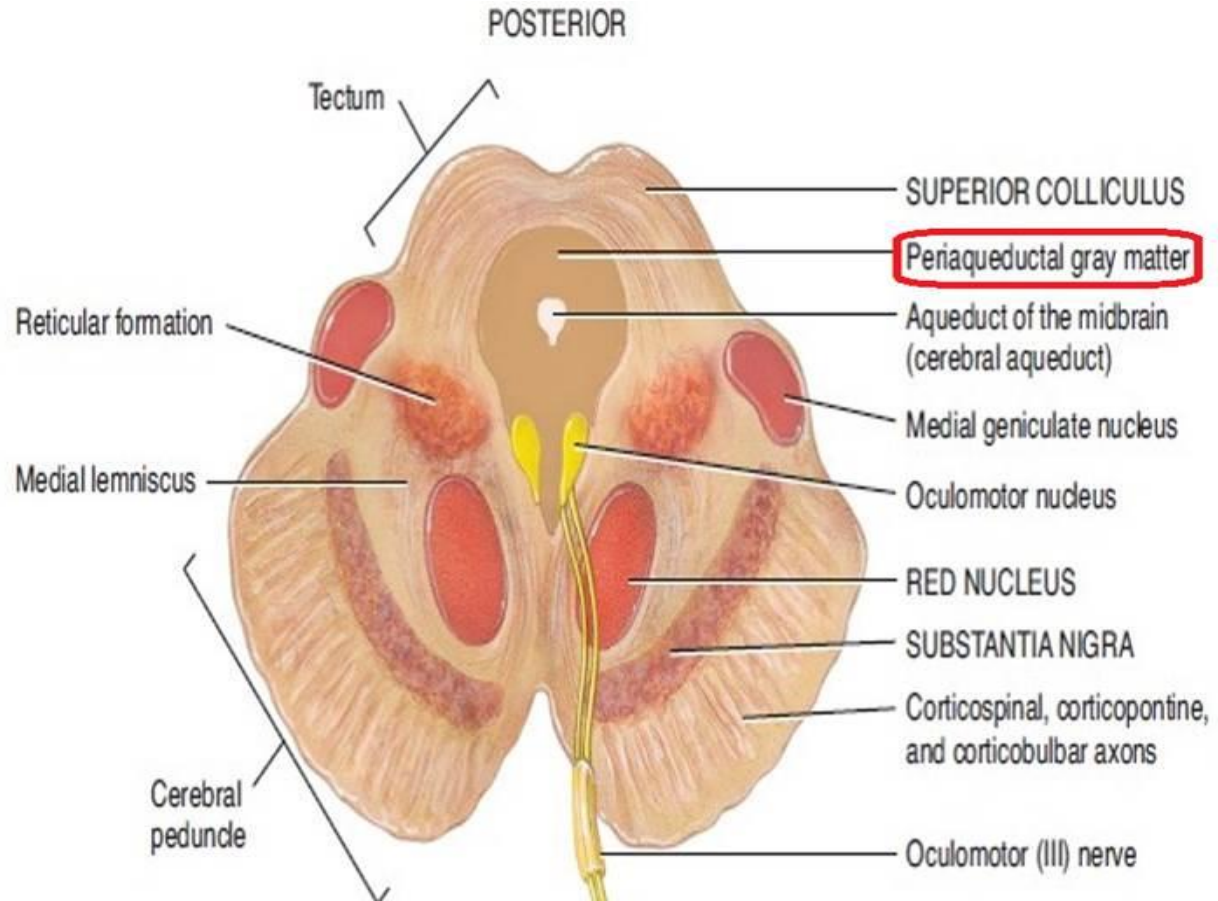
These transmit axons of UMN.

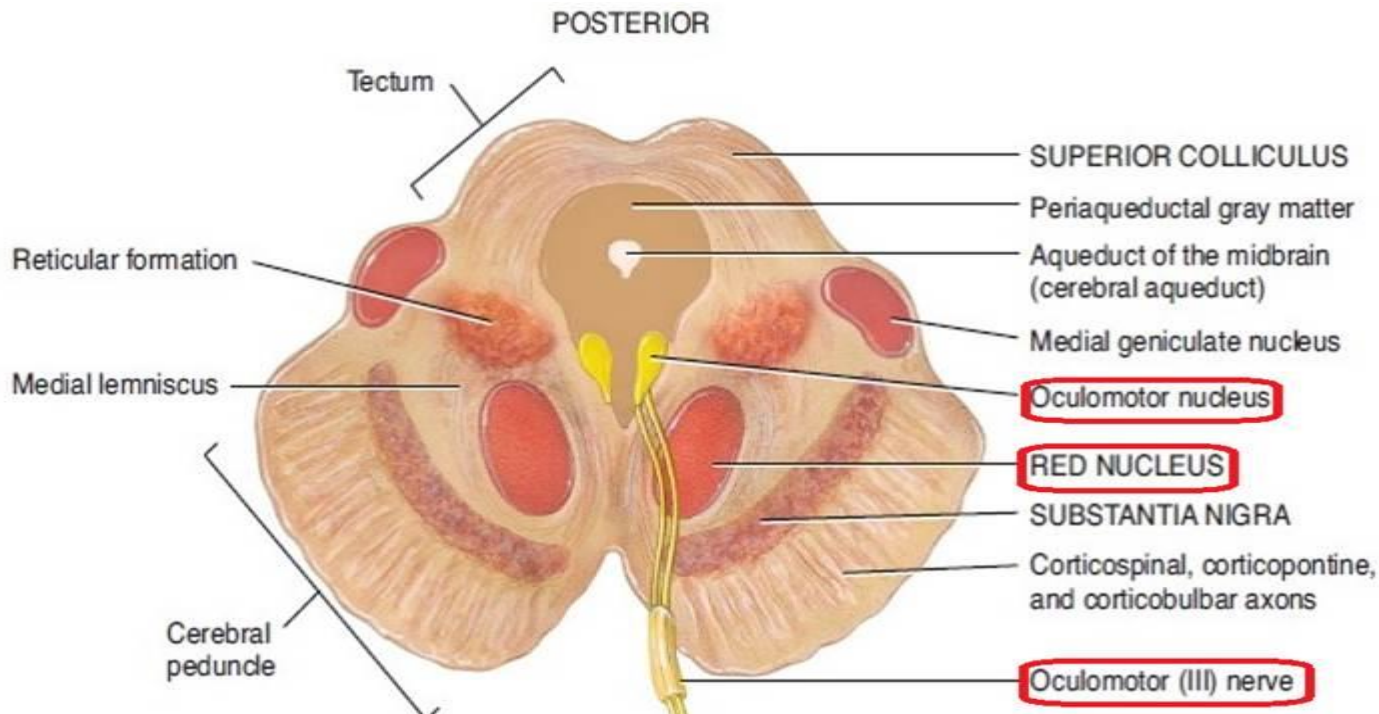


(b) Transverse section of midbrain

Midbrain internal structures

∞ **Periaqueductal Gray:** Around the cerebral aqueduct, contains neurons involved in the **pain desensitization** pathway.



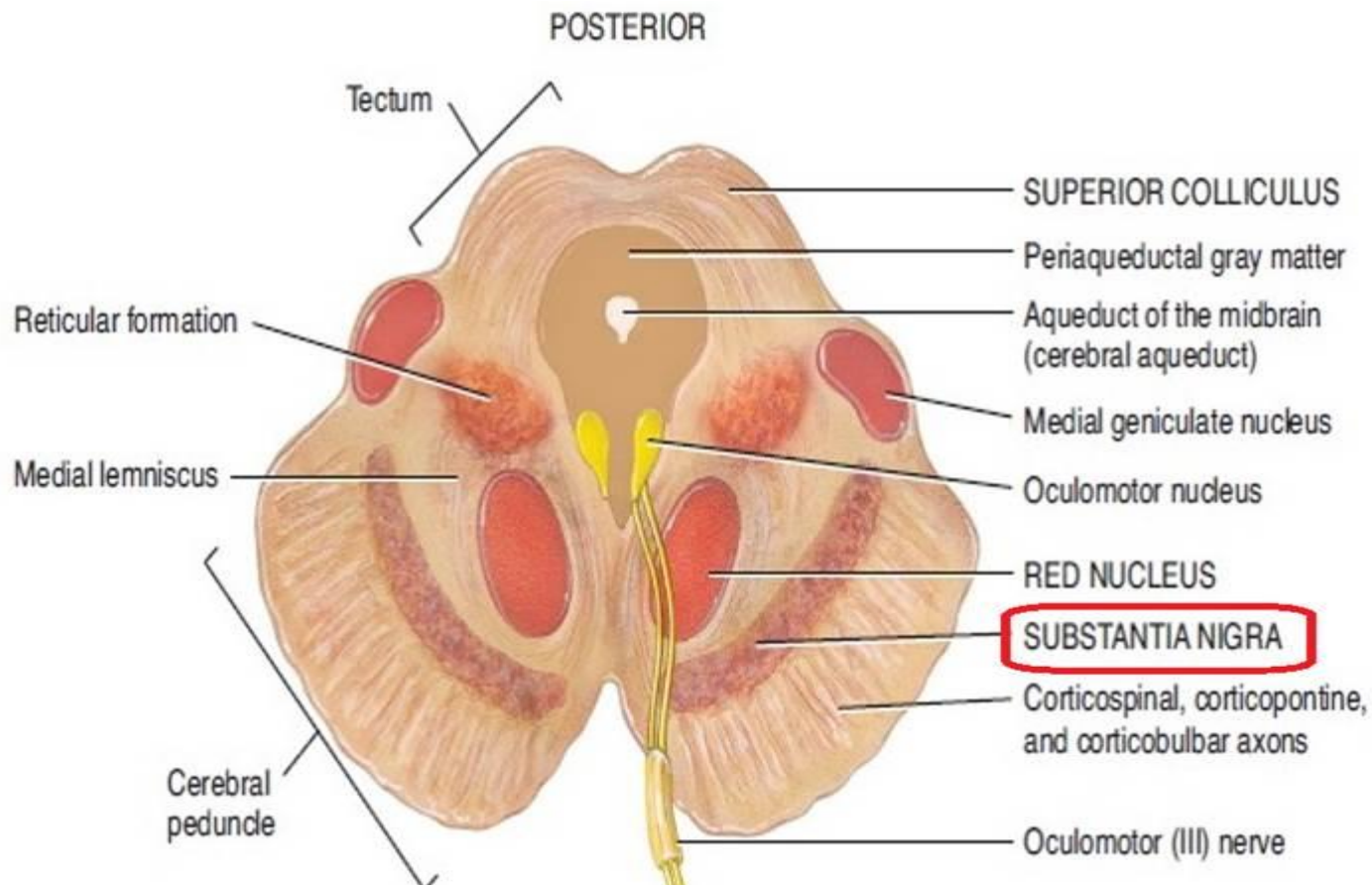


❧ **Oculomotor Nerve (CN III) nucleus.**

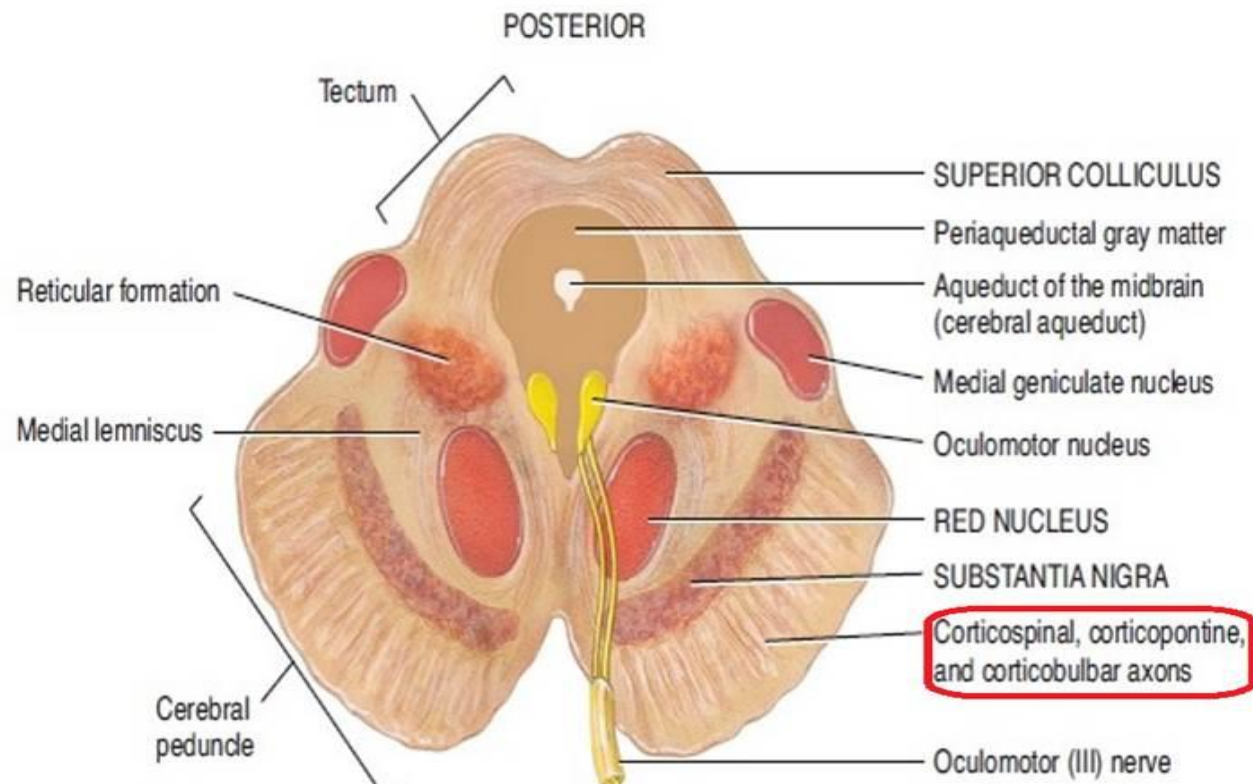
❧ **Trochlear Nerve (CN IV) nucleus.**

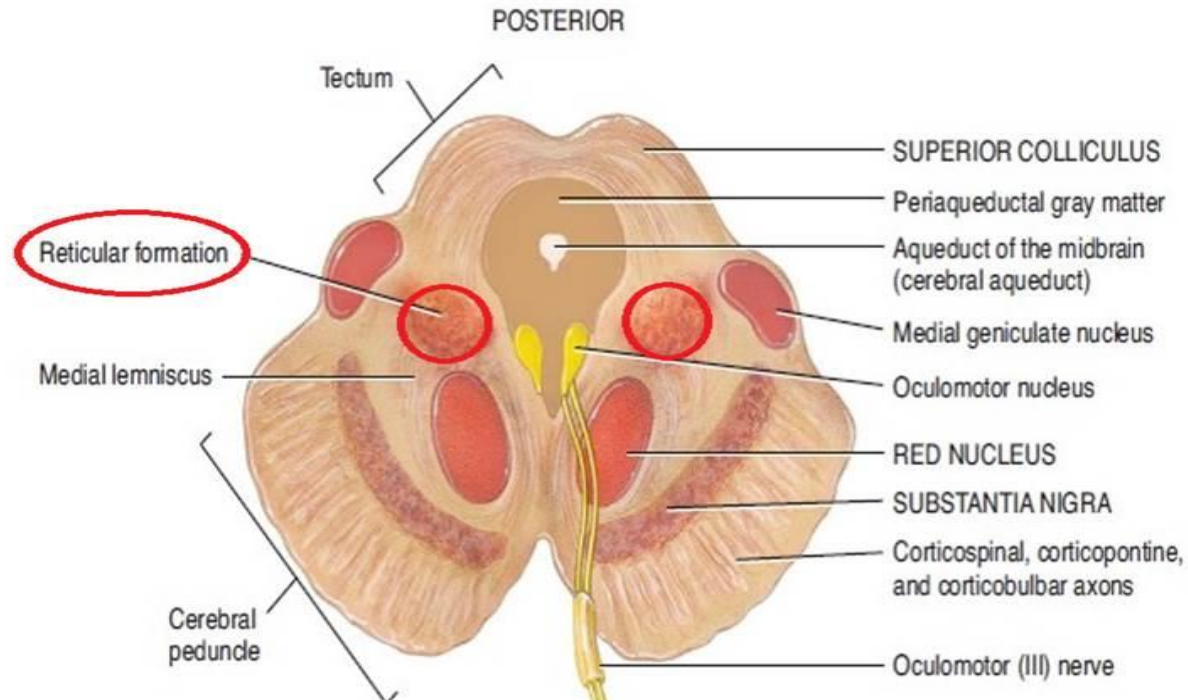
❧ **Red Nucleus:** This is a motor nucleus that sends a **descending tract** to the lower motor neurons.

➤ **Substantia Nigra:** This is a concentration of neurons in the ventral portion of the midbrain that is involved in motor function.



❧ **Central Tegmental Tract:** Directly anterior to the floor of the 4th ventricle, this is a pathway by which many tracts project up to the cortex and down to the spinal cord.



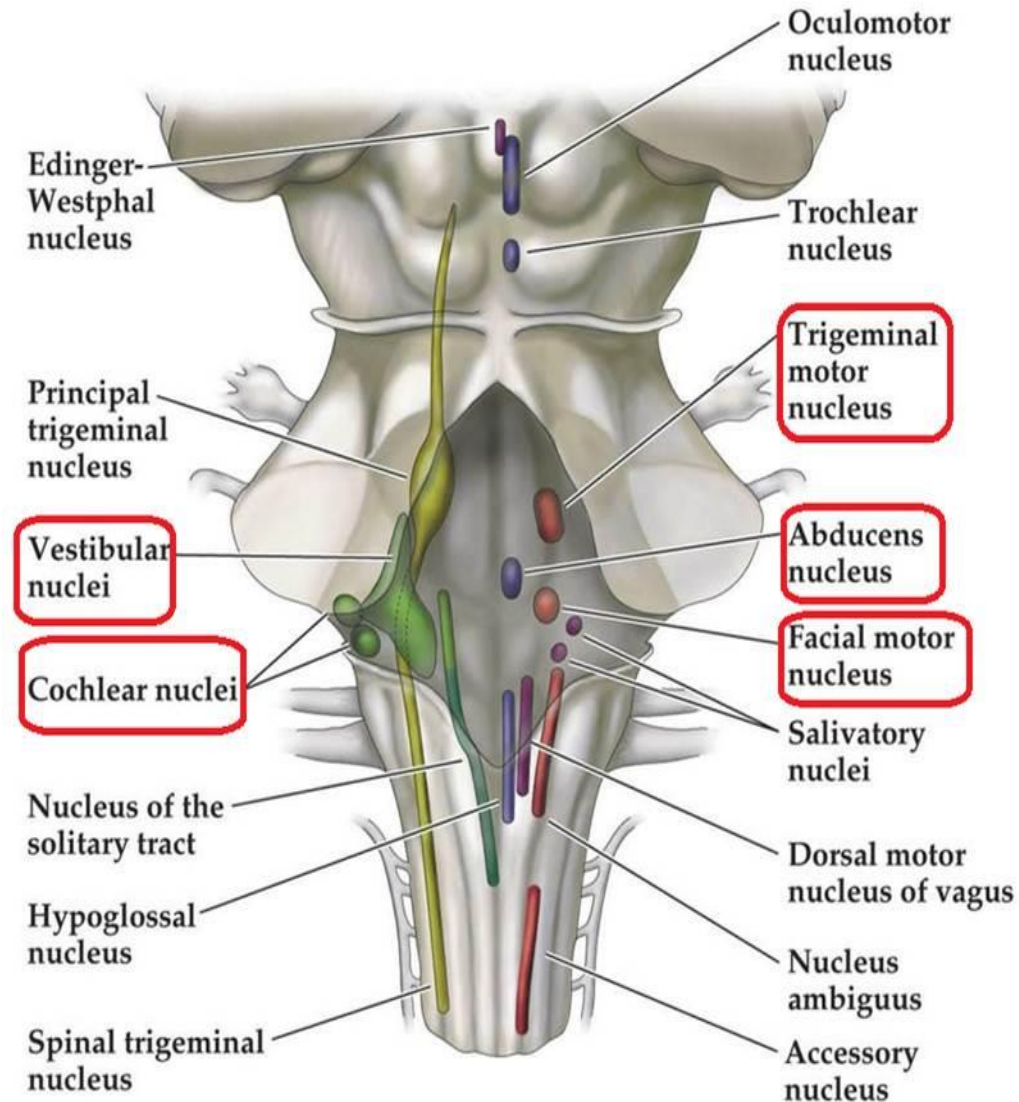


∞ **Reticular Formation:** A large area that is involved in various important functions of the midbrain:

- ☑ It contains LMN
- ☑ It is involved in the pain desensitization pathway
- ☑ It is involved in the arousal and consciousness systems
- ☑ It contains the locus ceruleus, which is involved in intensive alertness modulation and in autonomic reflexes.

Pons

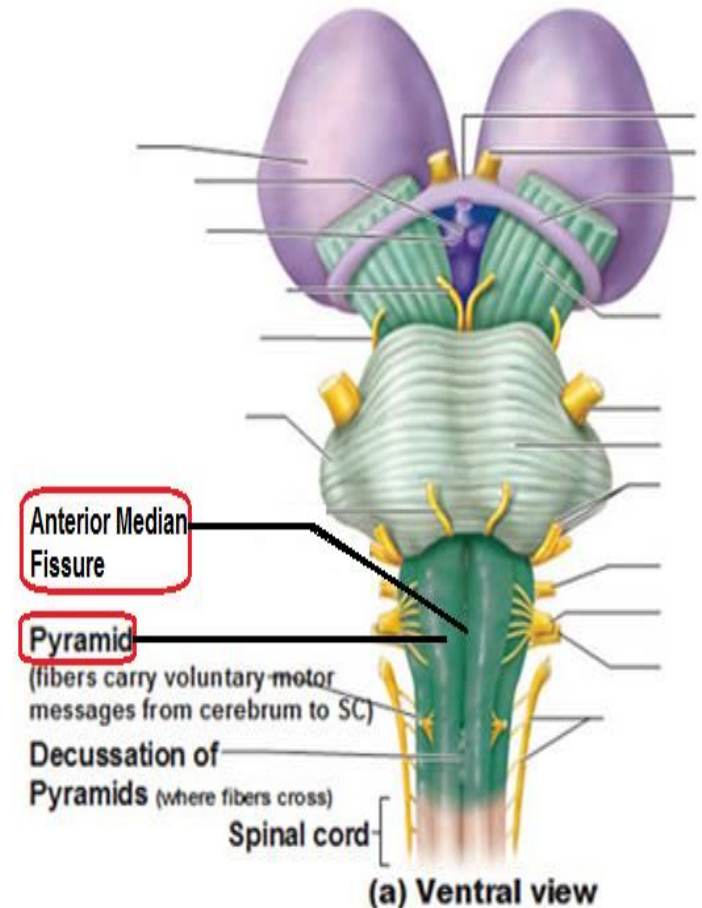
- At the level of the midpons, the large trigeminal nerve (CN V) emerges.
- Between the basal pons, cranial nerve 6 (abducens), 7 (facial) & 8 (vestibulo-cochlear) emerge (medial to lateral).



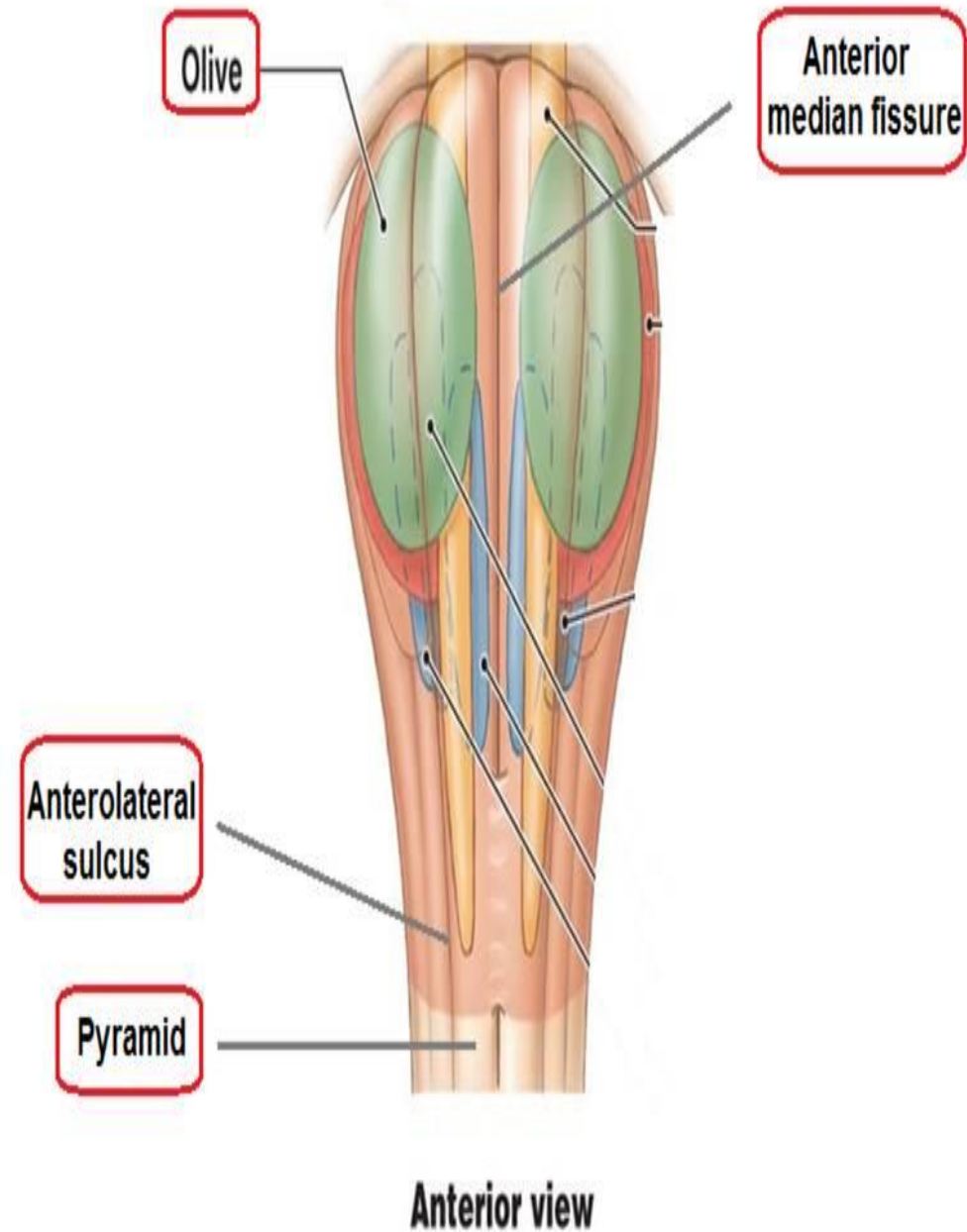
Medulla

Ventral view

- The most medial part of the medulla is the anterior median fissure.
- Moving laterally on each side are the pyramids. They contain the fibers of the **corticospinal (pyramidal) tract** as they head inferiorly to synapse on lower motor neuronal cell bodies within the ventral horn of the spinal cord.



Structure of the medulla oblongata

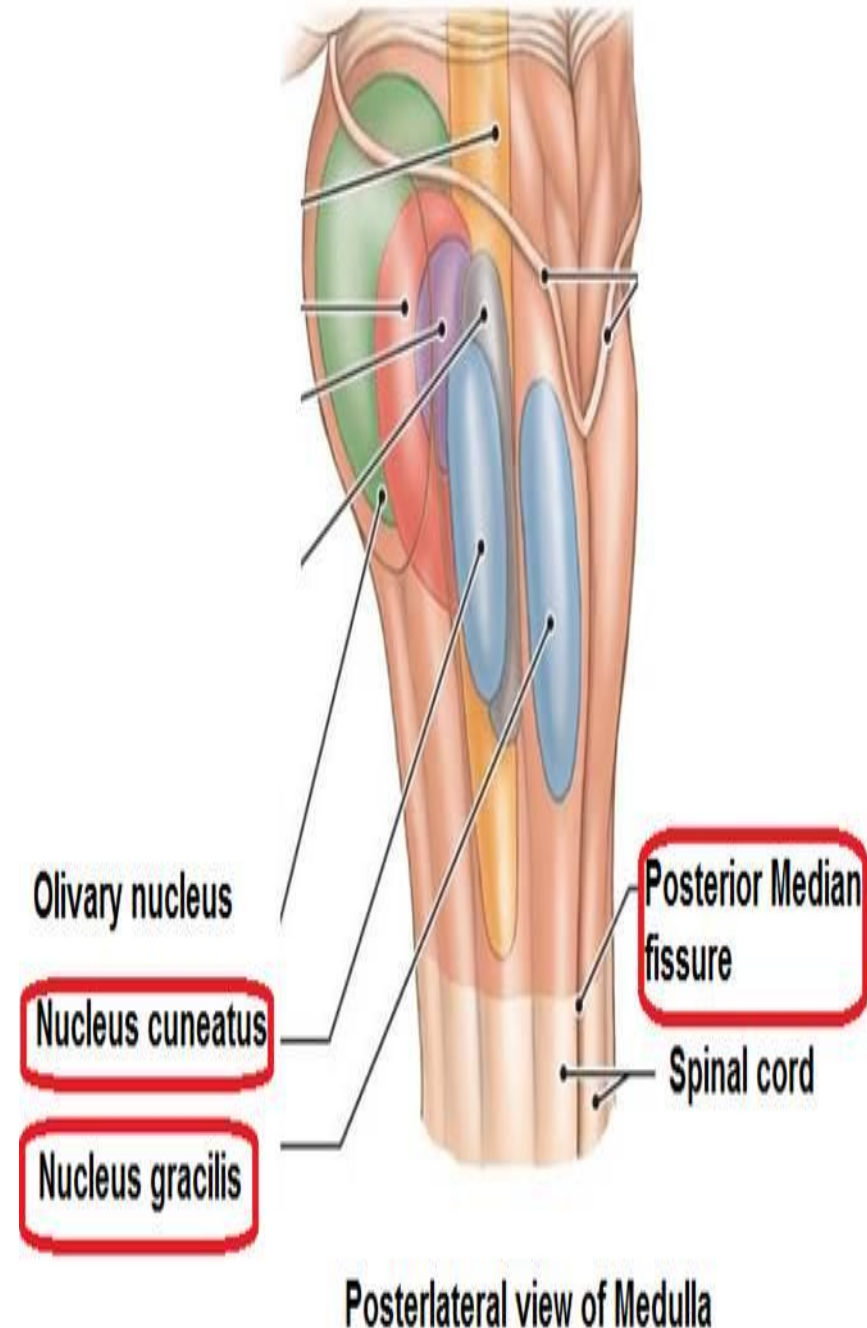


Anterior view

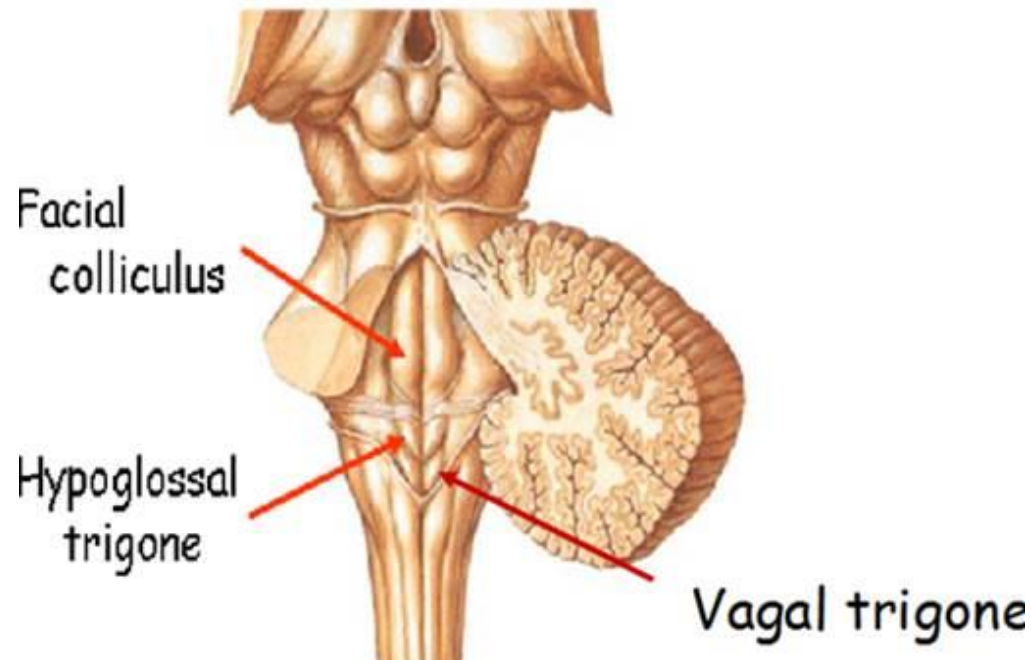
- The anterolateral sulcus is lateral to the pyramids.
- Emerging from the anterolateral sulci are the **hypoglossal nerve** (CN XII) rootlets.
- Lateral to these rootlets and the anterolateral sulci are the **olives**. They are swellings in the medulla containing underlying inferior olivary nuclei (containing various nuclei and afferent fibers).
- Lateral (and dorsal) to the olives are the rootlets for **glossopharyngeal** (IX) & **vagus** (X) cranial nerves.

Dorsal view

- ❖ The most medial part of the medulla is the **posterior median fissure**.
- ❖ Moving laterally on each side is **the fasciculus gracilis**.
- ❖ Lateral to that is **the fasciculus cuneatus**.
- ❖ Superior to each of these, are the **gracile and cuneate tubercles**, respectively. Underlying these are their respective nuclei.



- ❖ In the midline is the vagal trigone and superior to that is the hypoglossal trigone. Underlying each of these are motor nuclei for the respective cranial nerves.



Functions of the Brain Stem

Though small, brain stem is an extremely important part of the brain:

1. Conduct functions.
2. Provides the origin of the cranial nerves (CN III-XII).
3. Conjugate eye movement.
4. Integrative functions.

1. Conduct functions

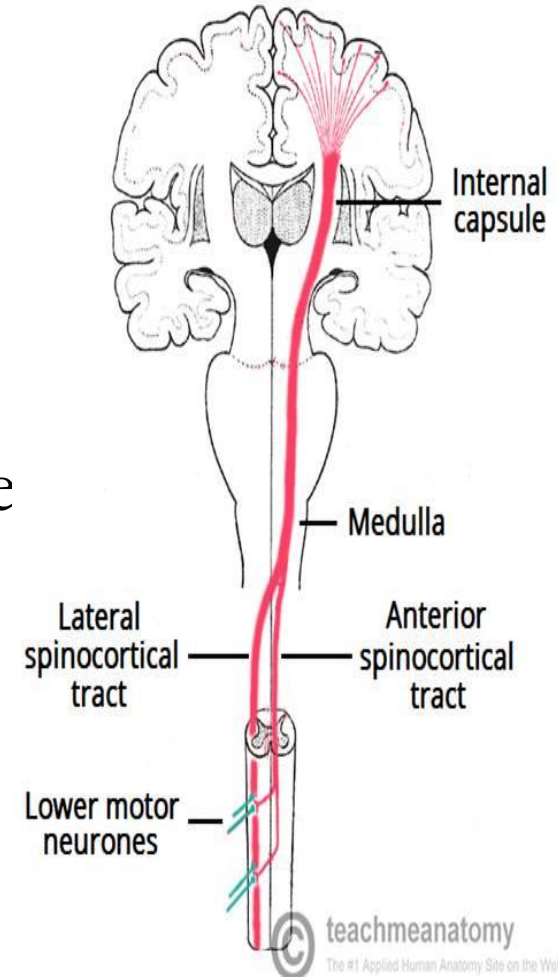
All information related from the body to the cerebrum and cerebellum and vice versa, must traverse the brain stem.

a) The ascending sensory pathways coming from the body to the brain includes:

- The spinothalamin tract for pain and temperature sensation.
- The dorsal column, fasciculus gracilis, and cuneatus for touch, proprioceptive and pressure sensation.

b) Descending tracts

- The corticospinal tract (UMN): runs through the crus cerebri, the basal part of the pons and the medullary pyramids; 70-90 % of fibers cross in the pyramidal decussation to form the lateral corticospinal tract, destined to synapse on lower motor neurons in the ventral horn of the spinal cord.



- Upper motor neurons that originate in the brain stem's vestibular, red, and reticular nuclei, which also descend and synapse in the spinal cord.

2. The brain stem provides the main motor and sensory innervation to the face and neck via the cranial nerves (CN III-XII).

The fibers of cranial nerve nuclei except for **olfactory & optic nerve** either originating from, or terminating in, the cranial nerve nuclei in brain stem.

Origin & functions of the cranial nerves

From midbrain

- CN III (oculomotor)
- CN IV (trochlear)

Both moves eyes; CN III constricts the pupils, accommodates.

From pons

- CN V (trigeminal): Chews and feels front of the head.
- CN VI (abducens): Moves eyes.
- CN VII (facial): Moves the face, tastes, salivates, cries.
- CN VIII (acoustic): Hears, regulates balance.

From medulla

- CN IX (glossopharyngeal): Tastes, salivates, swallows, monitors carotid body and sinus.
- CN X (vagus): Tastes, swallows, lifts palate, talks, communication to and from thoraco-abdominal viscera.
- CN XI (accessory): Turns head, lifts shoulder.
- CN XII (hypoglossal): Moves tongue.

- **Sensory**

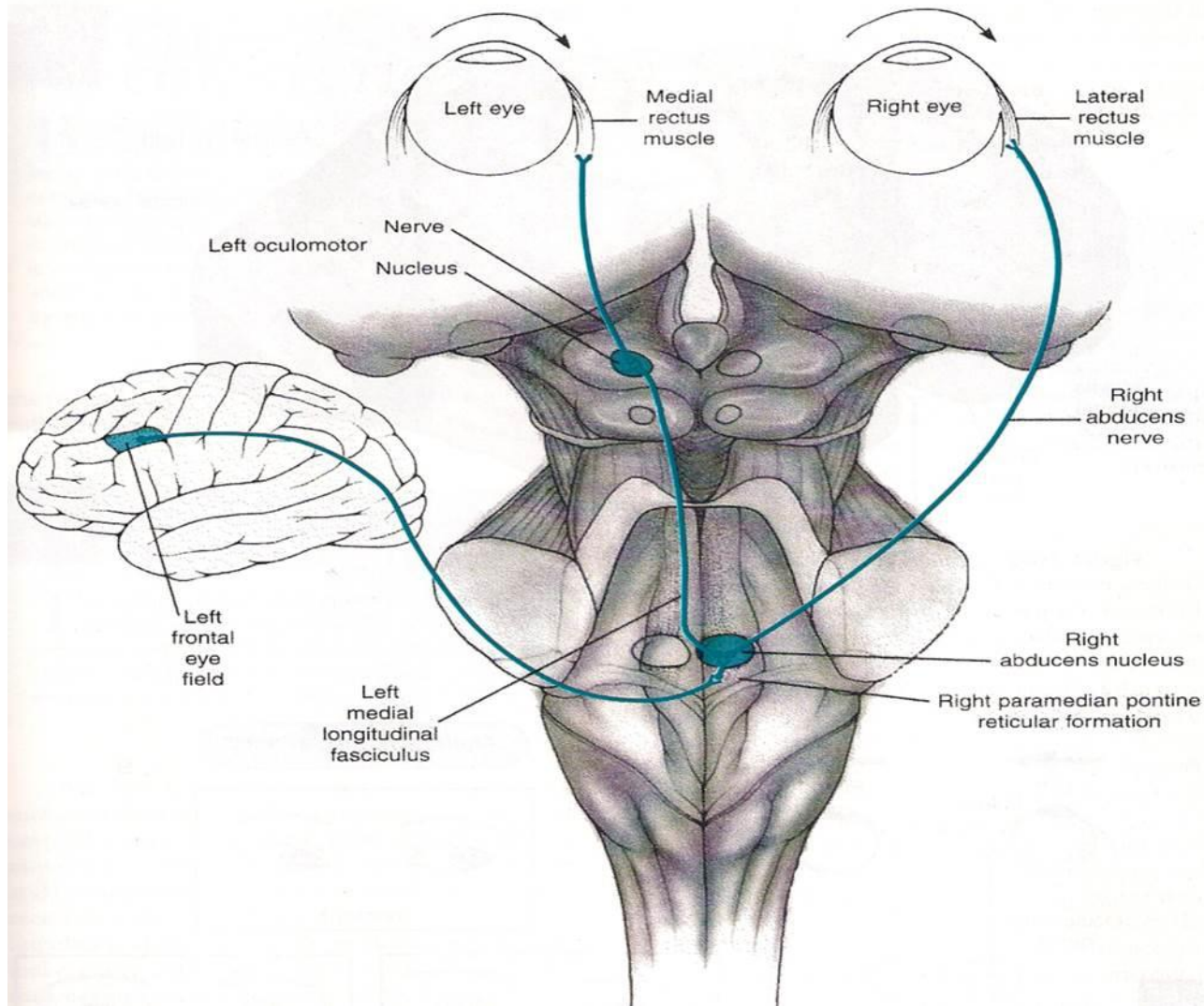
CN I, CN II, CN VIII

- **Motor**

CN III, CN IV, CN VI, CN XI, CN XII

- **Mixed**

CN V, CN VII, CN IX, CN X



The frontal eye field (FEF) projects to the opposite side at the midbrain-pontine junction, and then innervates the paramedian pontine reticular formation (PPRF).

From there, projections directly innervate the lateral rectus (**contralateral to FEF**) and the medial rectus muscle (**ipsilateral to FEF**).

The left FEF command to trigger a saccade culminates in conjugate eye movements to the right.

4. Integrative functions

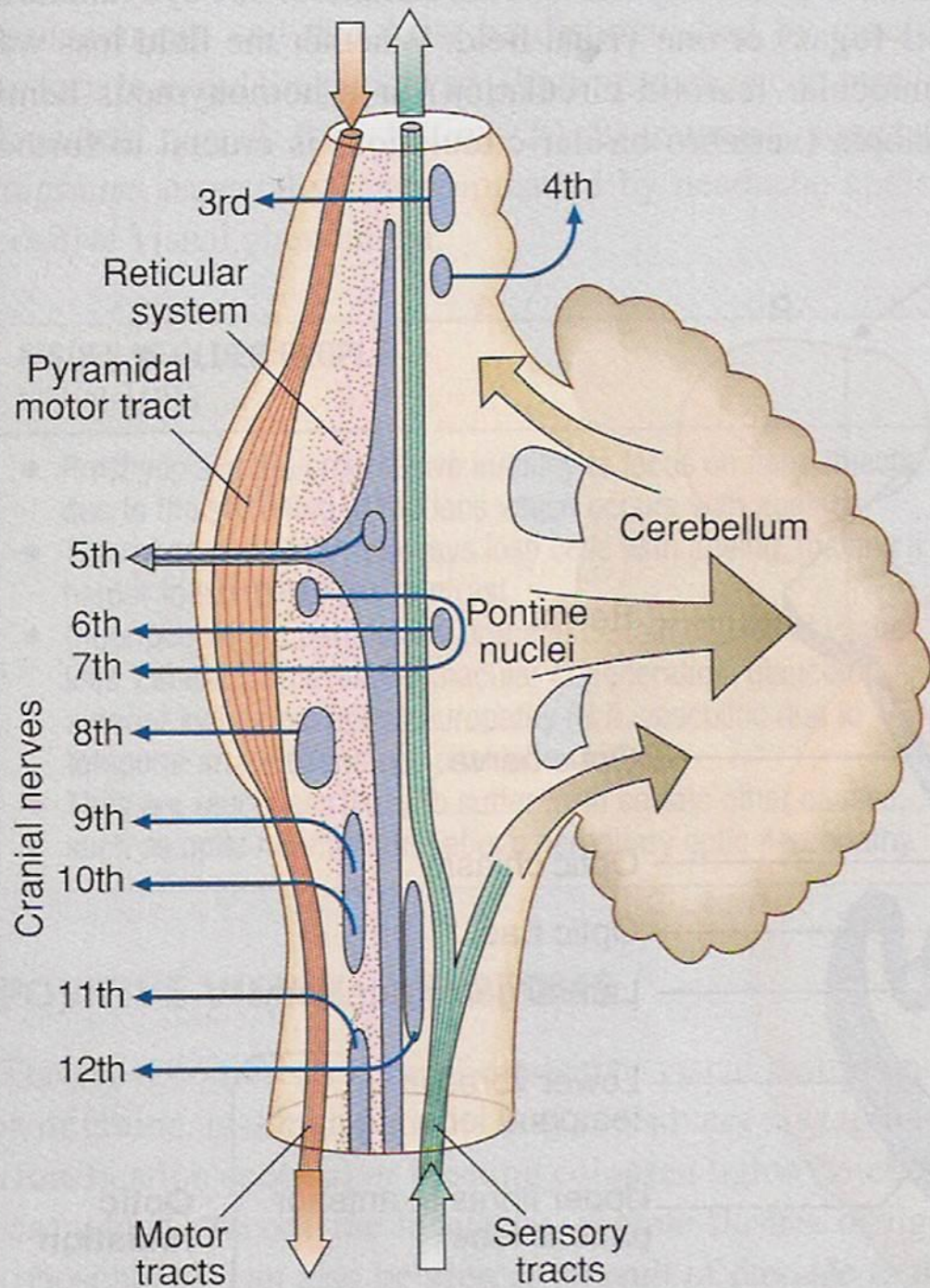
- It controls consciousness & sleep cycle (alertness and arousal) through reticular formation.
- It has got center for cardiovascular, respiratory & autonomic nervous system.
- It has centers for cough, gag, swallow, and vomit.
- Sense of body balance (Vestibular functions)

- **Substantia** which is a part of the basal ganglia is present in midbrain and is involved in control of movement.
- Midbrain also contain **red nucleus** which regulate the motor activity through cerebellum.

- Inferior and superior colliculi are situated on the dorsal surface of the midbrain and is involved in auditory & visual processing required for head movements.
- Pain sensitivity control: **Periaqueductal grey matter** of mesencephalon is an area which is rich in endogenous opioid and is important in modulation of painful stimuli.

Functional organization of the Brain Stem

- Ventral layer of brainstem is **motor** in function.
- Middle layer is **sensory** in function & contains medial lemniscus which conveys sensory information from dorsal column.



Function of Midbrain

- Nerve pathway to cerebral hemispheres.
- Auditory and Visual reflex centers.
- Cranial Nerves:
 - **CN III - Oculomotor [motor]**. (Related to eye movement).
 - **CN IV - Trochlear [motor]**. (Superior oblique muscle of the eye which rotates the eye down and out).

Signs & Symptoms of midbrain lesion

- CN (Cranial Nerve) Deficits: Ipsilateral CN III, CN IV palsy and ptosis (drooping).
- Pupils:
 - Size: Midposition to dilated.
 - Reactivity: Sluggish to fixed.
- Movement: Abnormal extensor.
- Respiratory: Hyperventilating.
- Loss of consciousness (LOC): Varies

Functions of pons

- Respiratory Center.
- Cranial Nerves:
 - **CN V - Trigeminal** [motor and sensory]. (Skin of face, tongue, teeth; muscle of mastication).
 - **CN VI - Abducens** [motor]. (Lateral rectus muscle of eye which rotates eye outward).
 - **CN VII - Facial** [motor and sensory]. (Muscles of expression).
 - **CN VIII - Acoustic** [sensory]. (Hearing)

Symptoms and signs of lesion in pons

- Pupils size: Pinpoint
- LOC: Semi-coma
- Movement: Abnormal extensor.
- Respiratory:
 - Apneustic (Abnormal respiration marked by sustained inhalation).
 - Hyperventilation.
- CN Deficits: CN V, CN VI, CN VII, CN VIII.

Functions of medulla oblongata

- Crossing of motor tracts.
- Cardiac Center.
- Respiratory Center.
- Vasomotor Center (nerves having muscular control of the blood vessel walls)
- Centers for cough, gag, swallow, and vomit.
- Cranial Nerves:

- **CN IX - Glossopharyngeal** [mixed]. (Muscles & mucous membranes of pharynx, the constricted openings from the mouth & the oral pharynx and the posterior third of tongue).
- **CN X - Vagus** [mixed]. (Pharynx, larynx, heart, lungs, stomach).
- **CN XI - Accessory** [motor]. (Rotation of the head and shoulder).
- **CN XII - Hypoglossal** [motor]. (Intrinsic muscles of the tongue).

Signs and symptoms of lesion in medulla

- Movement: Ipsilateral paralysis.
- Pupils:
 - Size: Dilated.
 - Reactivity: Fixed.
- Respiratory: Abnormal breathing patterns
- CN Palsies: Inability to control movement.
Absent cough, gag.
- LOC: Comatose.

Brain Stem Function Tests

☞ **To test reticular formation**

Alertness, Consciousness & Sleep.

☞ **Corticospinal tract**

Motor power, reflexes

☞ **Pain response**

Facial grimacing on firm pressure over the supra orbital ridge.



☞ **To test respiratory center**

look for the normal pattern of respiration

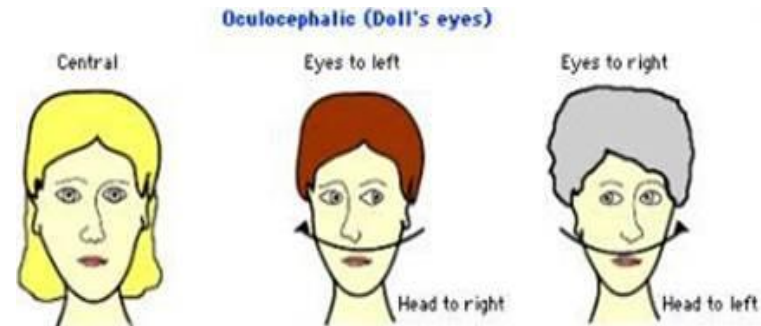
☞ To test cardiovascular center

Look for normal circulatory function

☞ To test brainstem reflexes:

- Pupillary and corneal reflexes.
- Vestibulo-ocular reflex: Injection of iced water into the ear will produce eyes movement.

- Oculo-cephalic reflex: Eyes rotate to the opposite side to the direction of head rotation.



- Gag reflex.



- Cough reflex

