CNS
Brain stem

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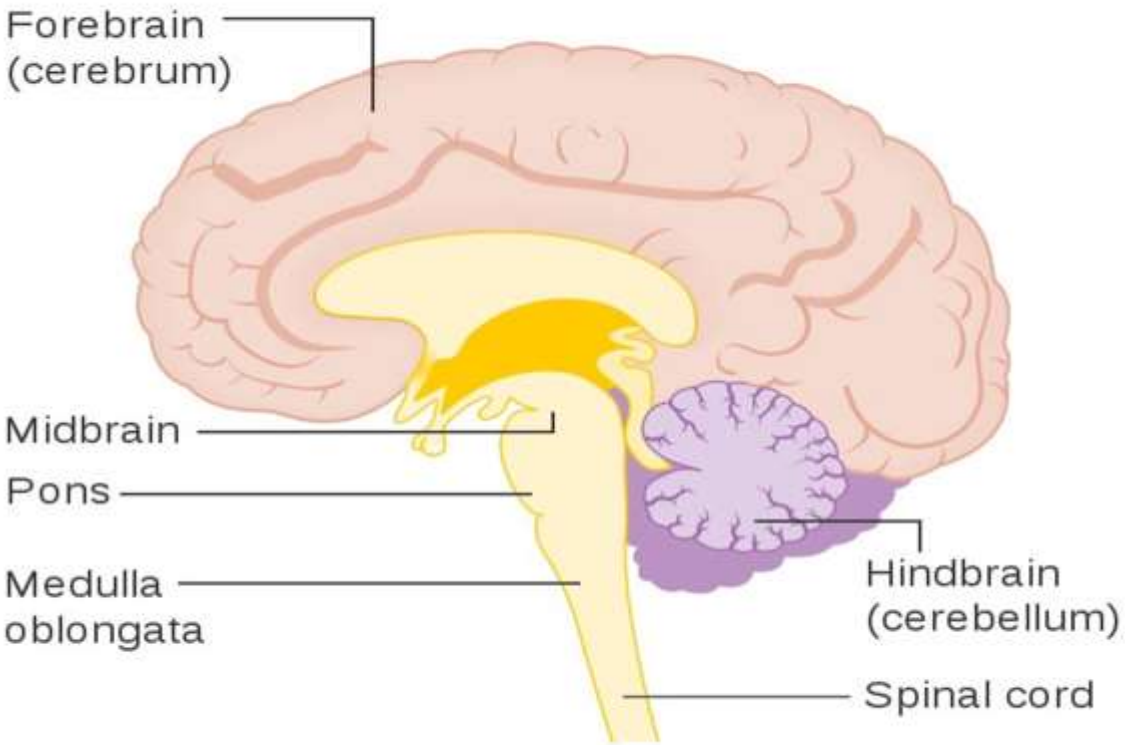
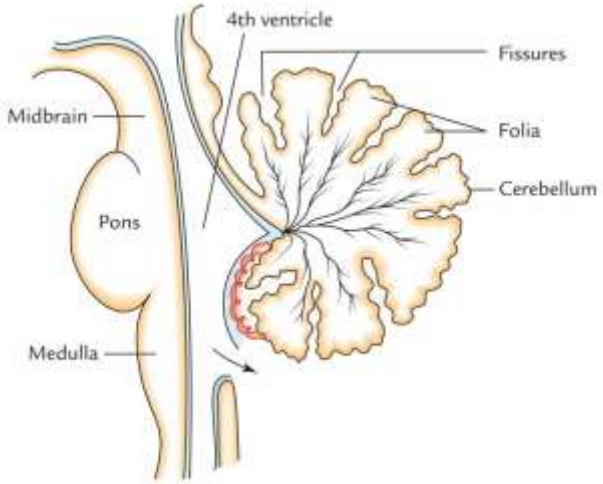
BRAIN STEM

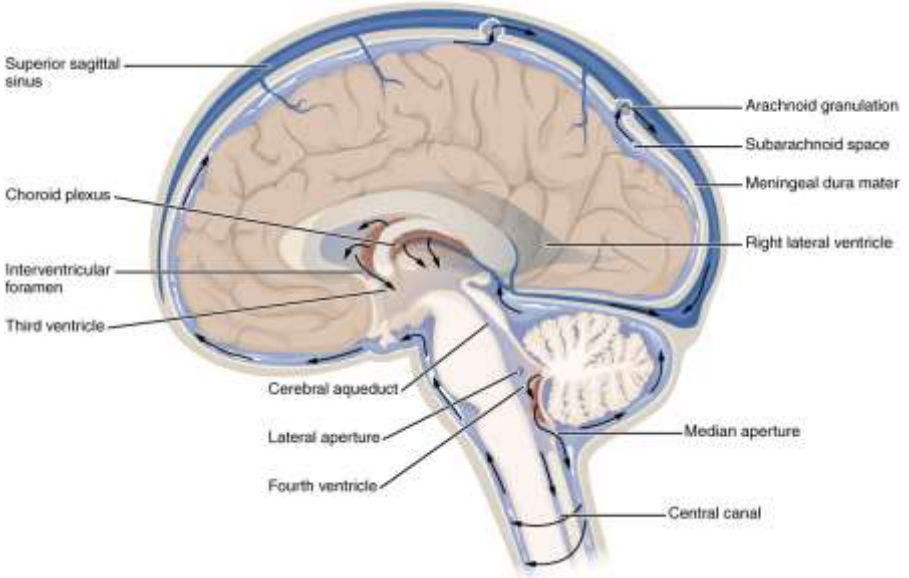
- It is irregular in structure externally and internally.
- It is formed from below upward from: 1- Medulla oblongata (5 cm). 2- Pons (2.5 cm). 3- Midbrain (2 cm).
- In each part, it must know their levels, the main structures and the cranial nerves nuclei present in in each level.



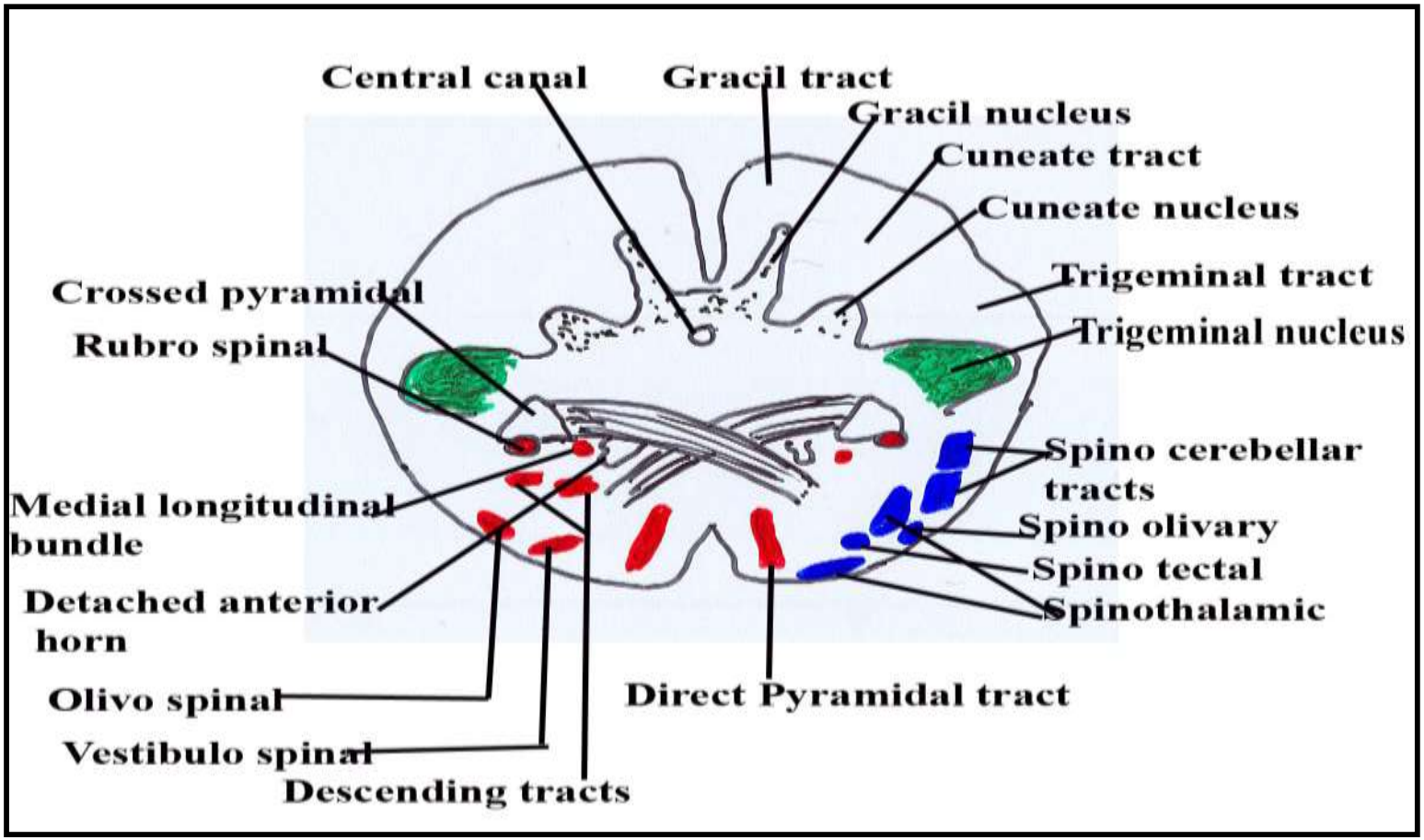
Medulla oblongata

- It is the lower part of brain stem.
- It connects the pons superiorly with the spinal cord inferiorly.
- The lower level contains central a canal and is known as closed medulla.
- The upper level opens in the 4th ventricle and is known as open medulla.
- The medulla oblongata has three levels from lower to upper (two closed & one open):





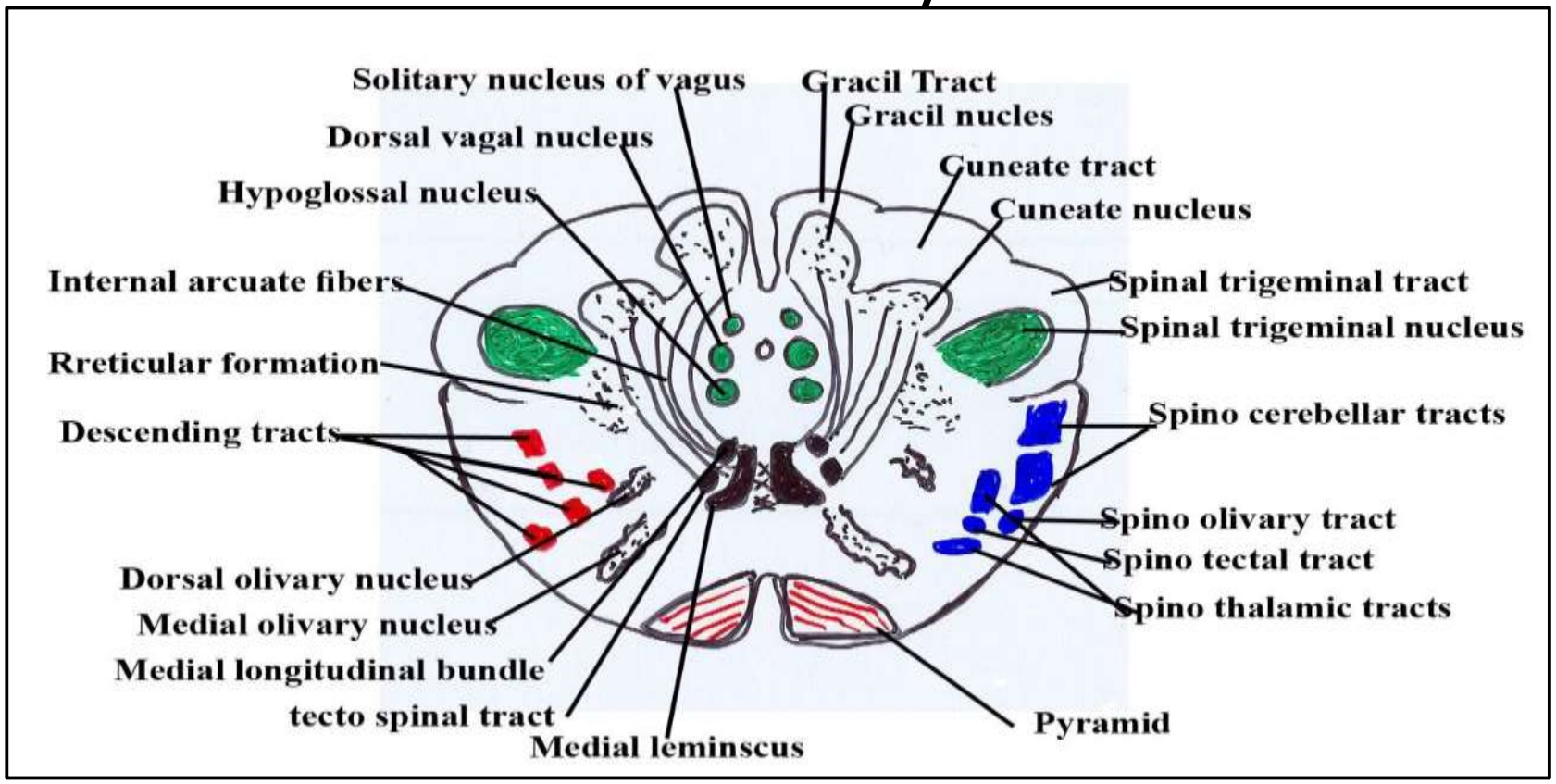
1- Closed medulla (motor decussation):



Closed medulla oblongata (motor decussation)

- It contains central canal which is posterior.
- Gracile and cuneate nuclei start to appear and they are small while their tracts are large.
- Spinal trigeminal nucleus and tract replace the substantia gelatinosa of Rolandi and Lissauer`s tract.
- 80-90 % of pyramidal fibers cross to opposite side forming motor decussation
- and 10-20 % descend as direct pyramidal tract.

Closed medulla oblongata (sensory decussation):



2-Closed medulla oblongata (sensory decussation)

- It contains central canal which becomes more posterior.
- Gracile and cuneate nuclei are large while their tracts become small.
- Axons from gracile and cuneate nuclei form the internal arcuate fibers which cross to opposite side forming sensory decussation. The crossed sensory fibers ascend in the opposite side as medial lemniscus.
- The ventral (anterior) vestibulo spinal tract and sulcomarginal tract join each other and form medial longitudinal bundle (fasciculus).

- Cortico-spinal fibers (pyramidal tract) are present on both sides of anterior median fissure and form two masses on the anterior surface of the medulla (pyramids).

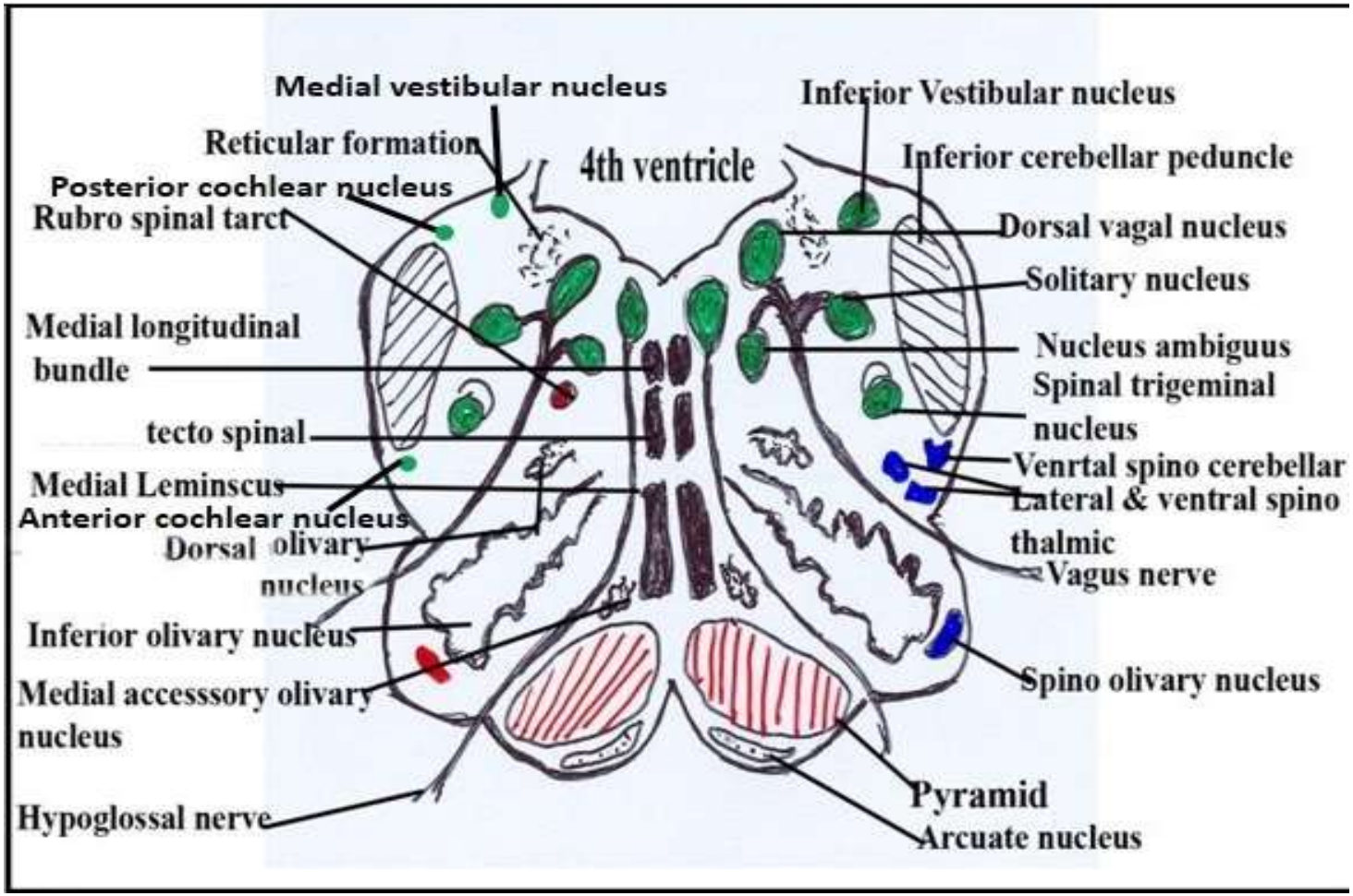
- Lower parts of some cranial nerve nuclei start to appear in the grey matter around the central canal which are:

a) Hypoglossal nucleus.

b) Dorsal vagal nucleus (motor).

c) lower part solitary nucleus of vagal

3-Open medulla oblongata



Open medulla oblongata

- **No central canal** (the central canal opens posteriorly into 4th ventricle).
- **The pyramids** are present in the anterior part.
- In the **midline** there are:

- Medial longitudinal bundle (posterior)
- Tecto spinal tract (at the middle)
- Medial lemniscus (anterior)

- The grey matter has increased due to the presence of **Olivary complex** which include:

- **Inferior** olivary nucleus (the largest one).
- **Dorsal** and **medial** accessory olivary nuclei which are smaller.

- **The arcuate nuclei:** they lie anterior to the pyramids. They are descending pontine nuclei that give the motor external arcuate fibers in the corticocerebellar pathway.
- **Presence of cranial nerve nuclei** of the lower 4 cranial nerves (9, 10, 11 &12): 9th glossopharyngeal (IX), 10th vagus (X), 11th accessory (XI) and 12th hypoglossal (XII).
- **The sensory nuclei of cranial nerves (IX & X) form solitary nucleus while the motor nuclei of cranial nerves (IX, X and XI) form nucleus ambiguus and dorsal nucleus of vagus.**
- **5th** (trigeminal) spinal nucleus and tract. **Reticular formation**
- **8th** (vestibular; medial, lateral & inferior) and cochlear nuclei start to appear.
- **Inferior cerebellar peduncles** (I.C.P) are laterally located.

VESTIBULAR NUCLEI

- Four cranial nuclei of the vestibular nerve
- They are located at the pons and medulla oblongata, at the floor of the 4th ventricle
- These nuclei are:

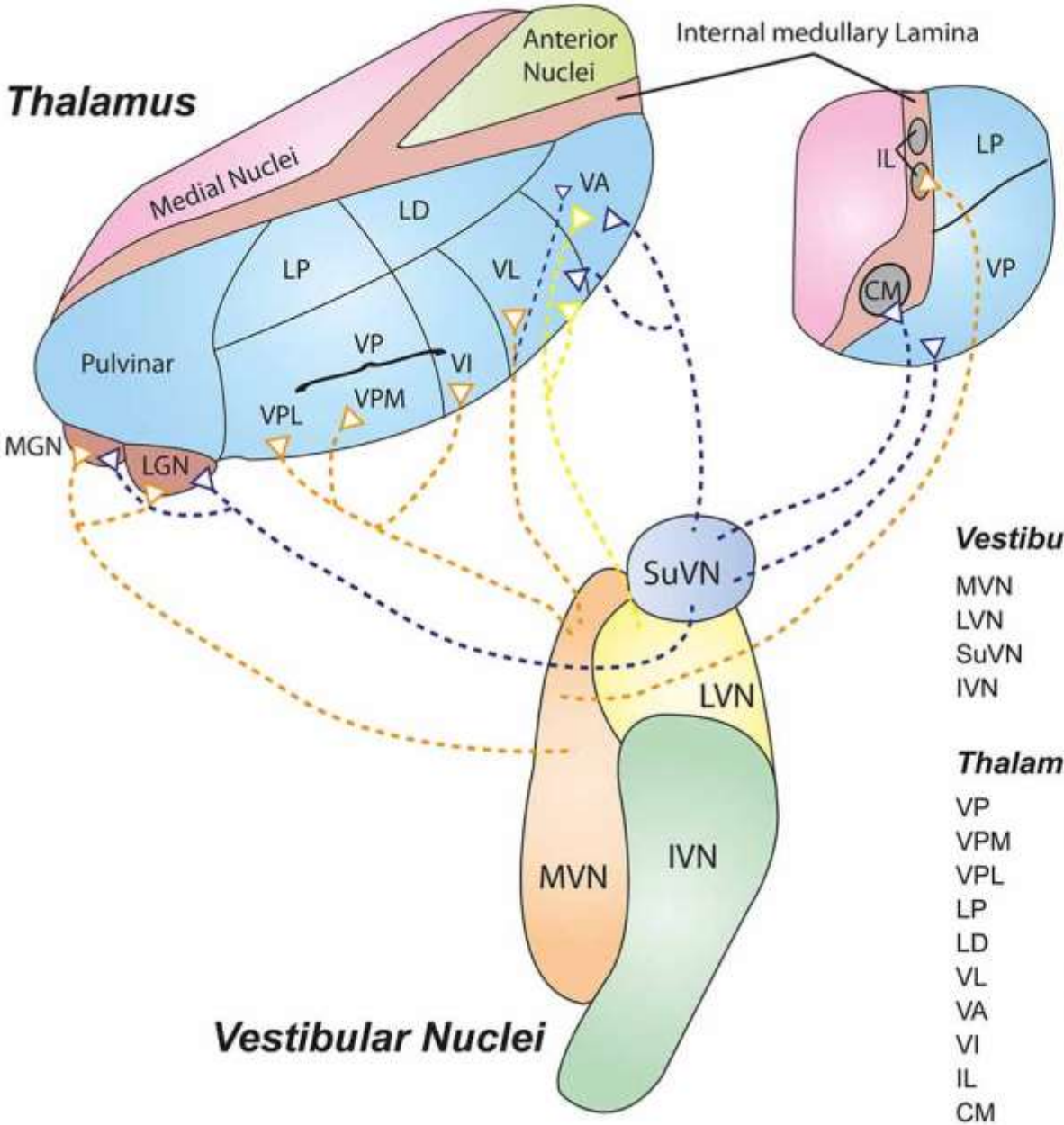
a-The medial vestibular nucleus: it is the largest nucleus (dorsal or chief vestibular nucleus)

b- The lateral vestibular nucleus: called nucleus of Deiters, as it contains an extremely large nerve cells called the giant cells of Deiters in addition to smaller neurons.

c- The inferior vestibular nuclei

These three vestibular nuclei are present in the medulla oblongata

d- The superior vestibular nucleus is present in the pons



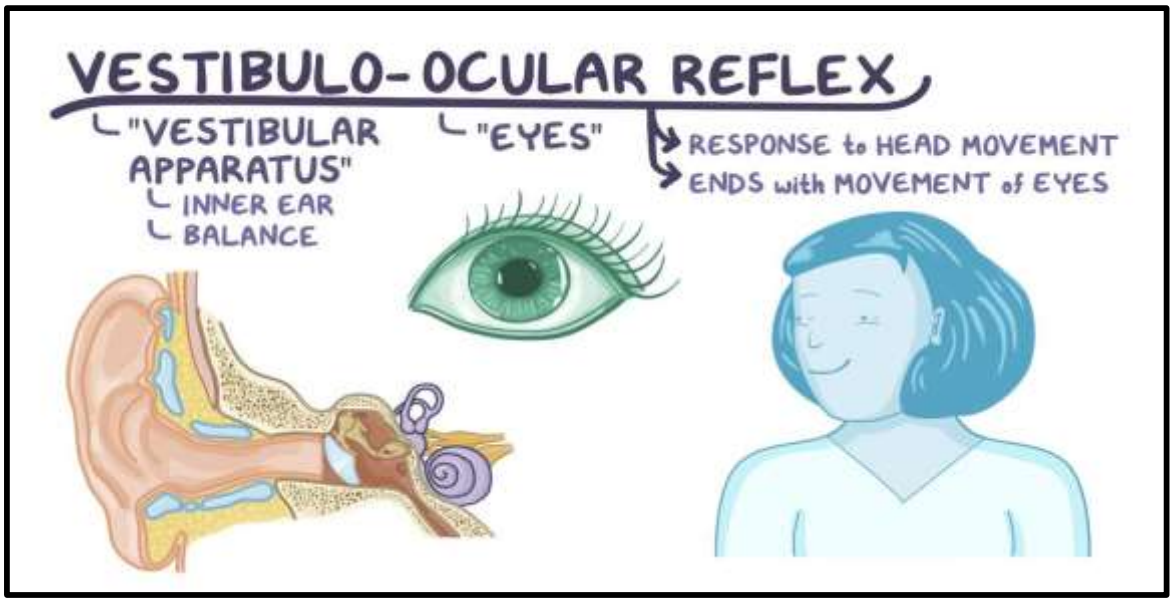
Vestibular Nuclei

MVN	Medial Vestibular Nucleus
LVN	Lateral Vestibular Nucleus
SuVN	Superior Vestibular Nucleus
IVN	Inferior Vestibular Nucleus

Thalamic Nuclei

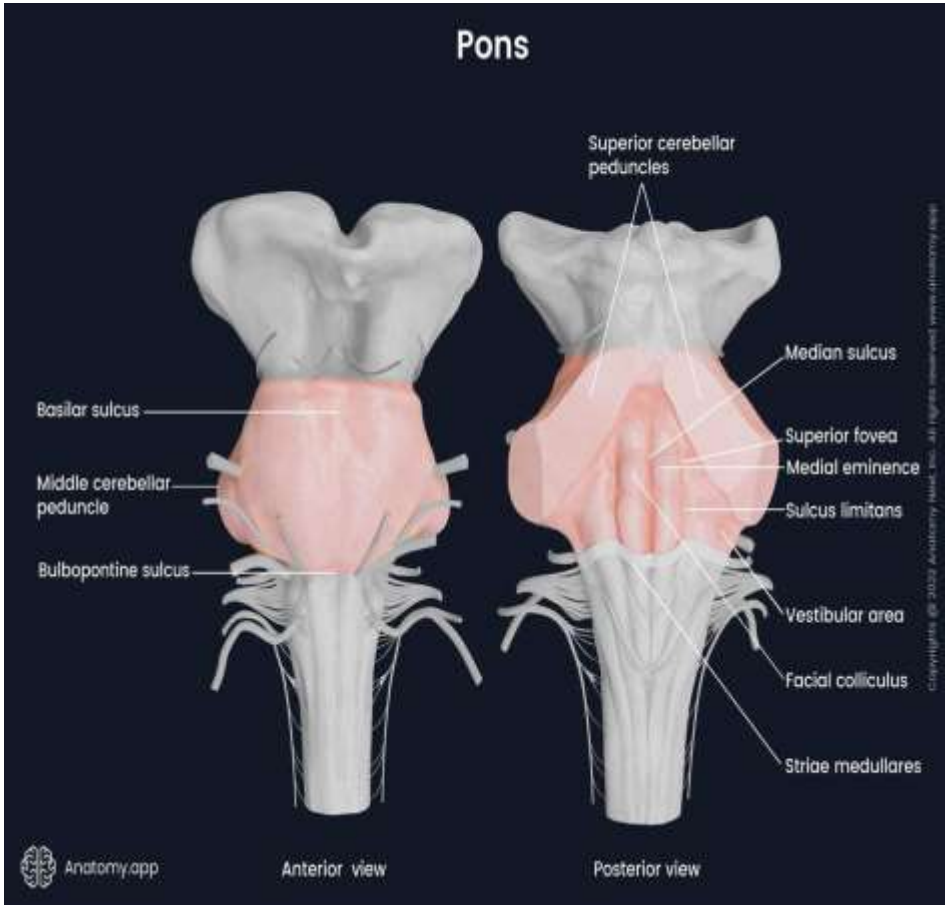
VP	Ventral Posterior Nucleus
VPM	Ventral Posteromedial Nucleus
VPL	Ventral Posterolateral Nucleus
LP	Lateral Posterior Nucleus
LD	Lateral Dorsal Nucleus
VL	Ventral lateral Nucleus
VA	Ventral Anterior Nucleus
VI	Ventral Intermediate Nucleus
IL	Interlaminar Nuclei
CM	Centromedian Nucleus

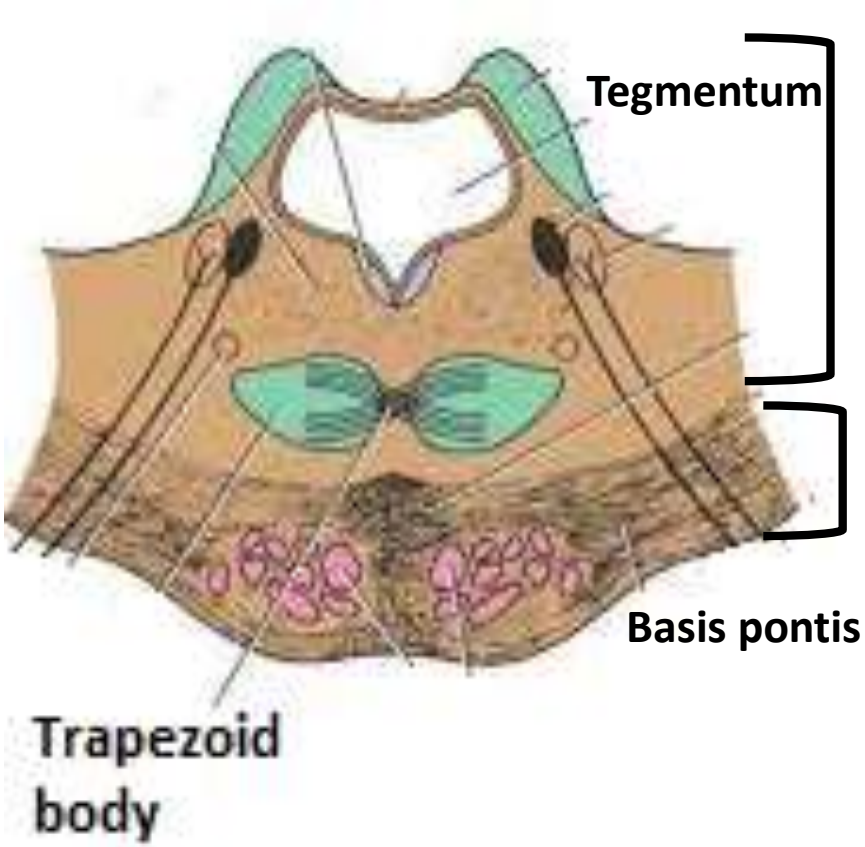
- All nuclei are connected with the vestibular apparatus, cerebellum, reticular formation, spinal cord, thalamus, cranial nuclei of extra ocular-muscles responsible for vestibule-ocular reflex (III, IV & VI) and motor nuclei of (VII, XI, XII)
- They are responsible for maintenance of equilibrium and posture, perception of head position and acceleration, as well as general muscle tone.
- All nuclei is consist of grey matter (bodies of nerve cells, dendrites, unmyelinated axons and neuroglia).



The pons

- The pons is divided into posterior part, tegmentum and an anterior part, basis pontis by the transversely running fibers of the trapezoid body.





A- The Basis Pontis:

- It is the same for all levels and contains:

1. Pontine nuclei: receive the corticopontine fibers from the cerebral cortex. They are motor nuclei and give pontocerebellar connections in the corticocerebellar pathway.

2. Transverse pontine fibers: they are axons from the pontine nuclei to the cerebellum through the middle cerebellar peduncle (M.C.P).

3. Pyramidal tract bundles: they are descending corticopontine fibers (which end on the pontine nuclei), cortico spinal fibers & cortico bulbar fibers which are separated into bundles by transverse pontine fibers.

4. Middle cerebellar peduncles.

B- The Tegmentum:

- In all levels of pons the tegmentum contains the following structures:

1– Medial longitudinal bundle.

2– Tectospinal tract.

3– Medial lemniscus which rotates so that its axis runs transversely.

4 – Spinal lemniscus.

Levels of pons:

- In addition to previous structures there are other structures which characterize each level of pons.

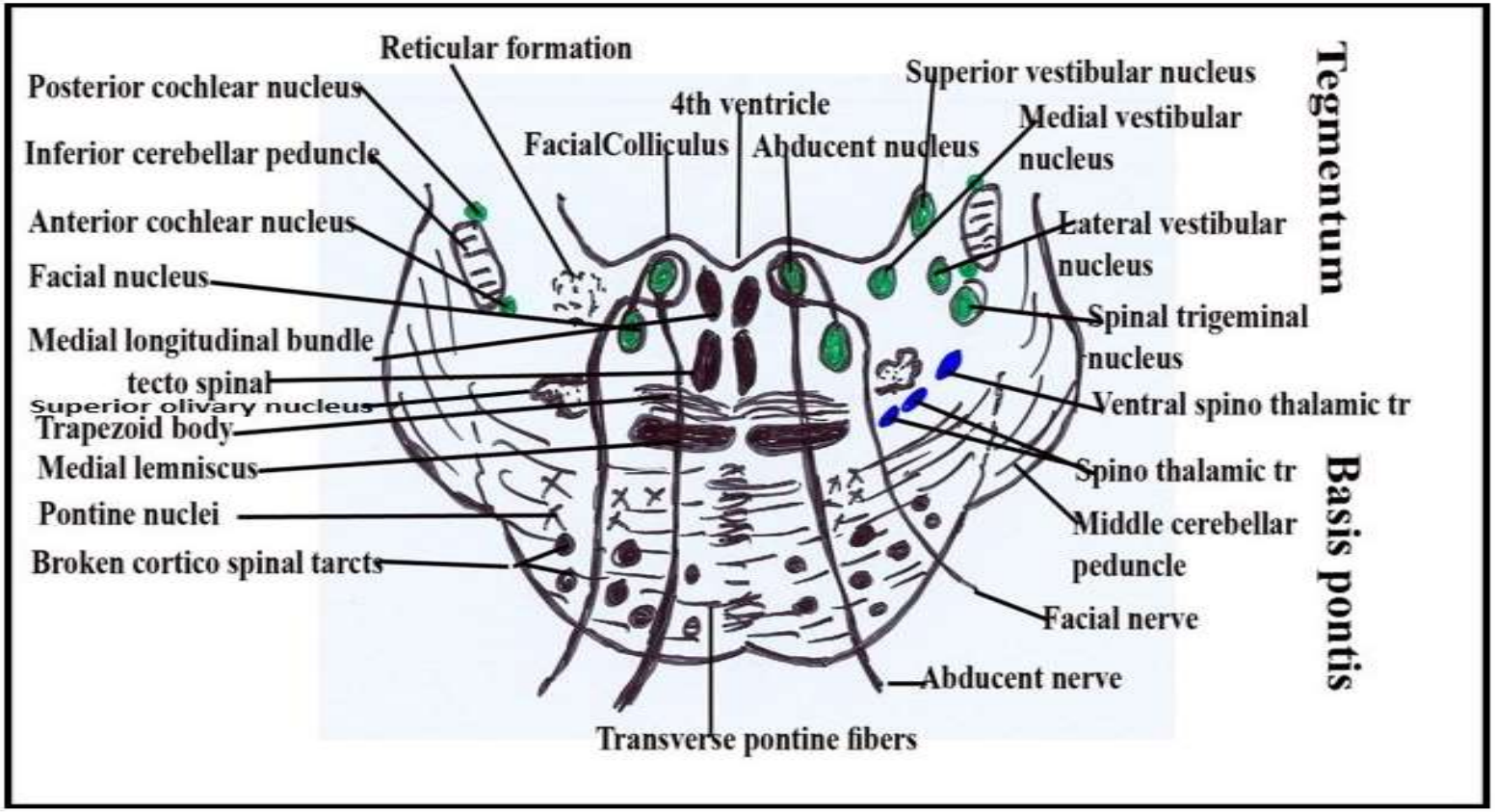
Levels of the pons:

1- Lower level at facial colliculus.

2- Middle level at trigeminal nuclei.

3- Upper level at the site of the four lemnisci.

1-Inferior level of pons (at facial colliculus):



1-Inferior level of pons (at facial colliculus):

It is characterized by the presence of:

1- Cavity of the 4th ventricle.

2- Spinal nucleus of trigeminal nerve (V), abducent nucleus (VI), Facial nerve nucleus (VII) and vestibulo-cochlear nerve nuclei (VIII).

NB. Facial nerve fibers loop around abducent nucleus to form facial colliculus.

3- Lateral lemniscus starts to appear.

4-Trapezoid body between tegmentum & basis pontis: it consists of transverse crossing fibers in auditory pathway.

5- Presence of inferior cerebellar peduncle (I.C.P.).

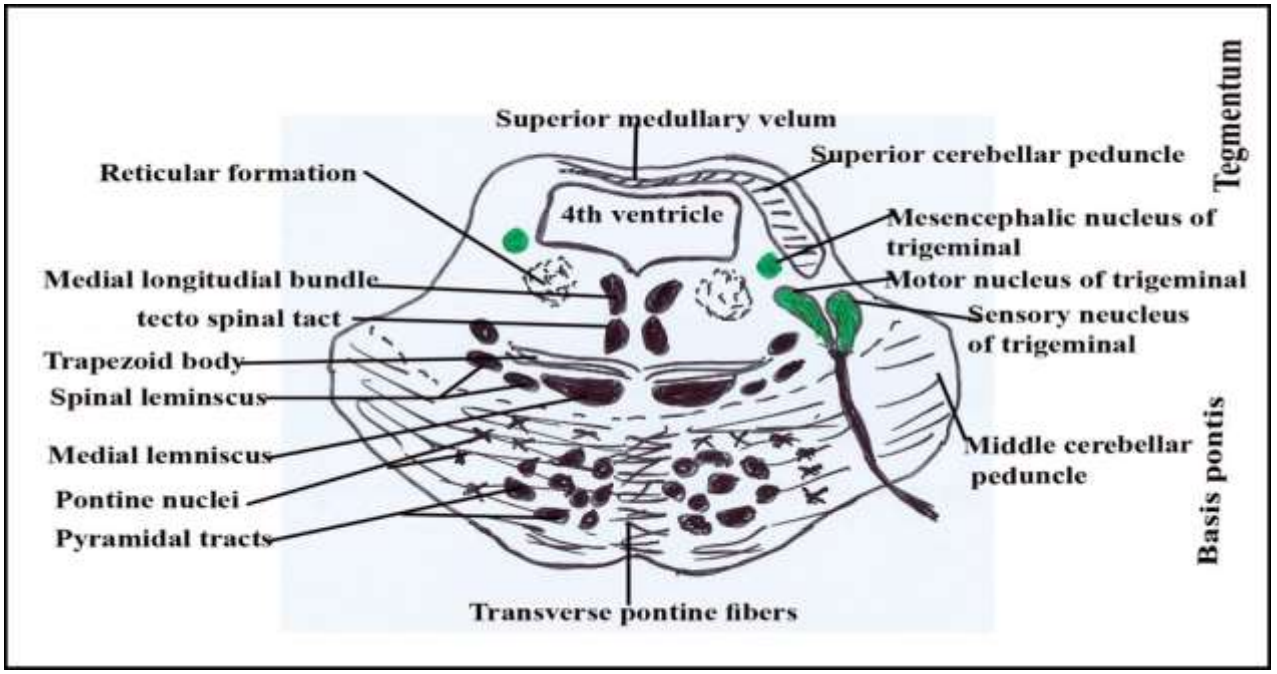
Middle level of pons (at the trigeminal nuclei):

It is characterized by the presence of:

1. 4th ventricle is closed. 2. Lateral lemniscus well be seen.

3. Trigeminal nuclei (motor, main sensory & mesenchephalic nuclei).

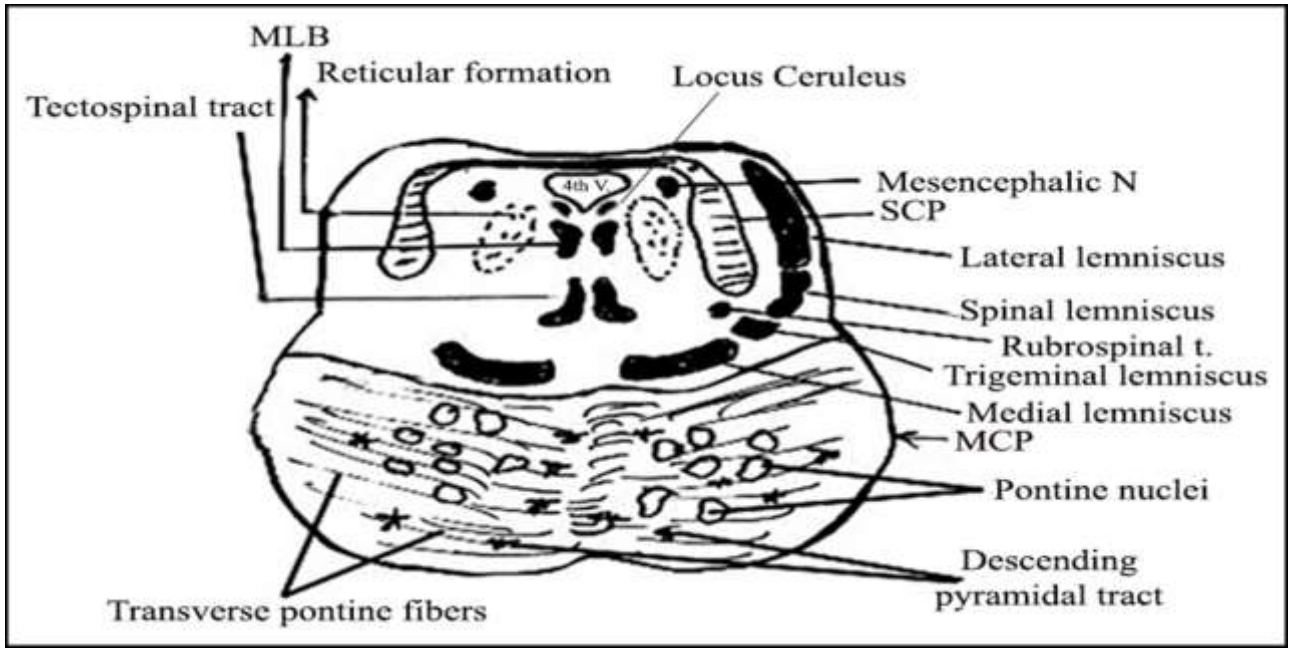
4. Trapezoid body. 5. Superior cerebellar peduncle (S. C. P.).



Superior level of pons (site of the four lemnisci):

- This level is characterized by:
- 1. **Trapezoid body disappears.** 2. Well-developed lateral lemniscus.
- 3. Presence of S. C. P.
- 4. Presence of **4 lemnisci** (Medial, trigeminal, spinal & lateral leminisci).

- 5. Presence of **Locus Ceruleus** nucleus (noradrenergic neurons)



Locus Ceruleus

1. It is a nucleus located in the posterior area of the rostral (superior) pons at the lateral edge of the 4th ventricle.

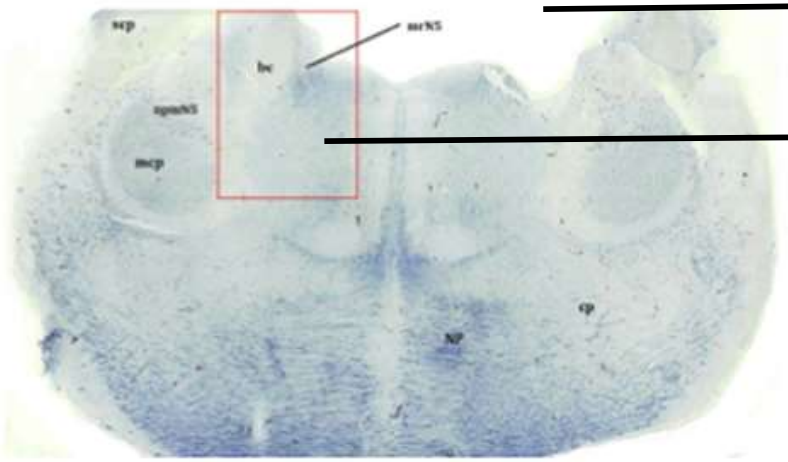
2. It is composed of medium-size pigmented neurons containing melanin granules.

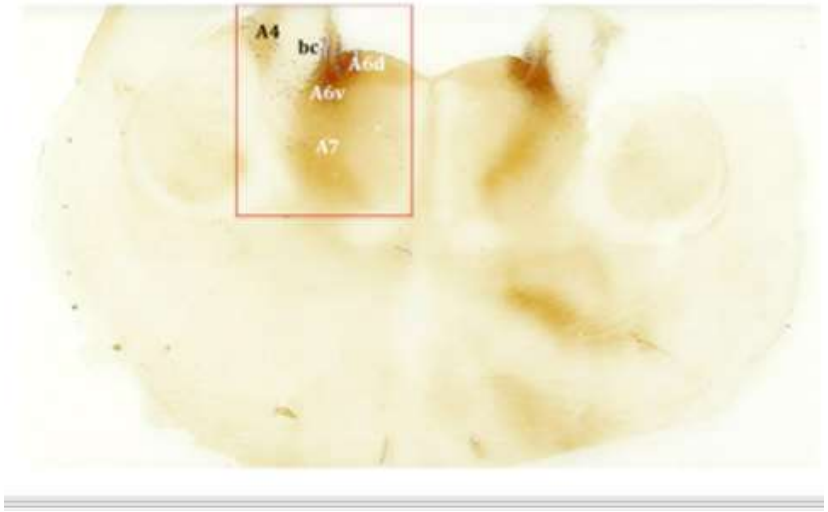
3. Locus ceruleus is the main source of noradrenaline supplying all the neuraxis that utilize norepinephrine as their primary neurotransmitter:

a) Cerebral Cortex b) Cerebellar cortex c) Thalamus, subthalamus

and hypothalamus d) Brain stem e) Spinal cord (sympathetic nuclei)

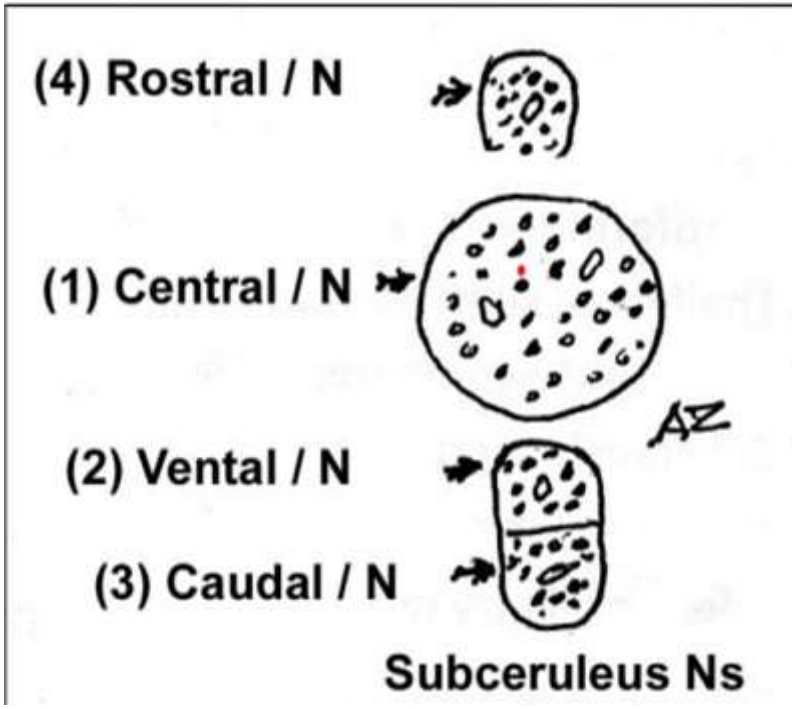
4. It is subdivided into four nuclei: **1-** Central nucleus **2, 3-** Subceruleus nuclei (ventral and caudal) **4-** Rostral nucleus. They contain 16.000-18.000 cells on each side





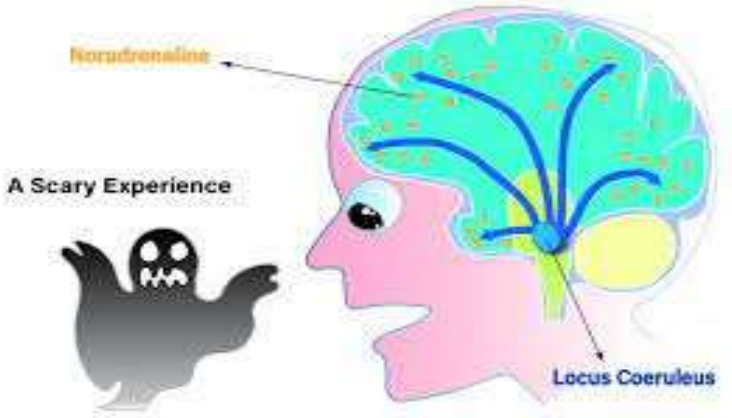
4th Ventricle

Locus cerulus



6. Microscopically, it consists of grey matter (bodies of nerve cells, dendrites, unmyelinated axons and neuroglia).

7. It is a part of the reticular activating system and involved with physiological responses to stress and panic.



8. Lesion of ascending supply leads to:

I- Alzheimer (Rostral part)

II-Parkinsonism (generalized loss)

III- Downs syndrome (With one transverse crease of hand)

9. Lesion of descending supply leads to Horner`s syndrome (miosis, anhydrosis and enophthalmos

The midbrain

The narrow cavity of the midbrain is aqueduct of sylvius which connects the 3rd and 4th ventricles.

-The mid brain consists of:

A) Tectum: It is posterior to aqueduct of sylvius. It consists of superior and inferior colliculi. The aqueduct is surrounded by a central grey matter.

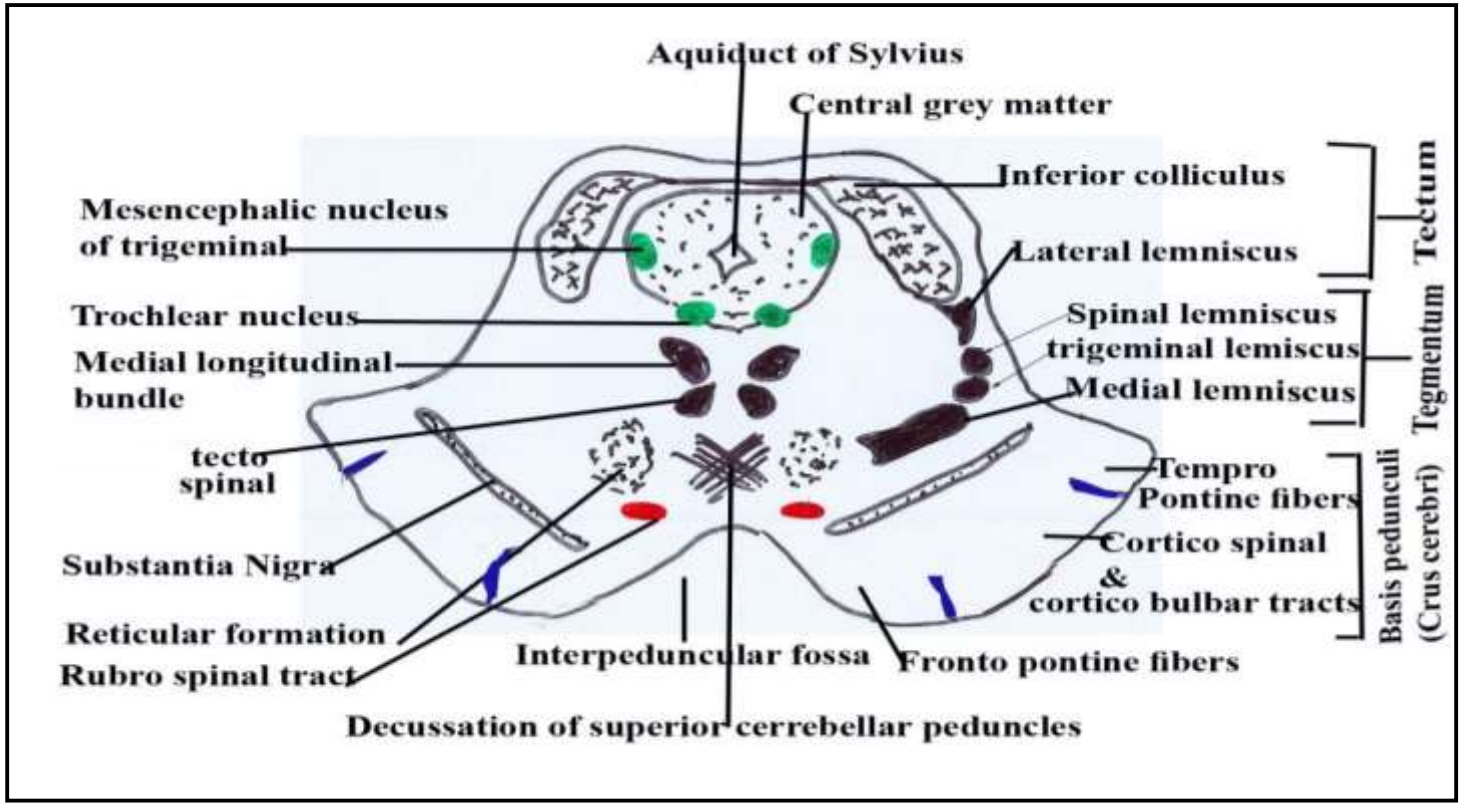
B) Cerebral peduncles: Each is divided into

1-Basis pedunculi (anterior part) crus cerebri which are separated by interpeduncular fossa.

2- Tegmentum (Posterior part) which is continuous across the median plane.

- Basis pedunculi and tegmentum are separated from each other by a pigmented area of grey matter (extrapyramidal tract), the substantia nigra in which the nerve cell bodies contain melanin granules.

Mid-brain at the level of inferior colliculus:



I- Mid-brain at the level of inferior colliculus

- It consists of the following structures:
- - The tectum contains the **inferior colliculi** which are the center for auditory reflexes (cochlear pathway). Histologically, the inferior colliculus consists of a central grey matter of nerve cell bodies (nuclei) surrounded by white matter of afferent nerves.
- - The aqueduct is surrounded with **quadrangular area** of grey matter which contains: 1. Trochlear nucleus (IV) 2. Mesencephalic nucleus of V nerve.
- Anterior to grey matter and close to **midline** there are:

o Medial longitudinal bundle (M.L.B) (posterior)

o Tecto-spinal tract (more anterior)

o Decussation of superior cerebellar peduncles (S.C.P) is present in midline of anterior part of tegmentum.

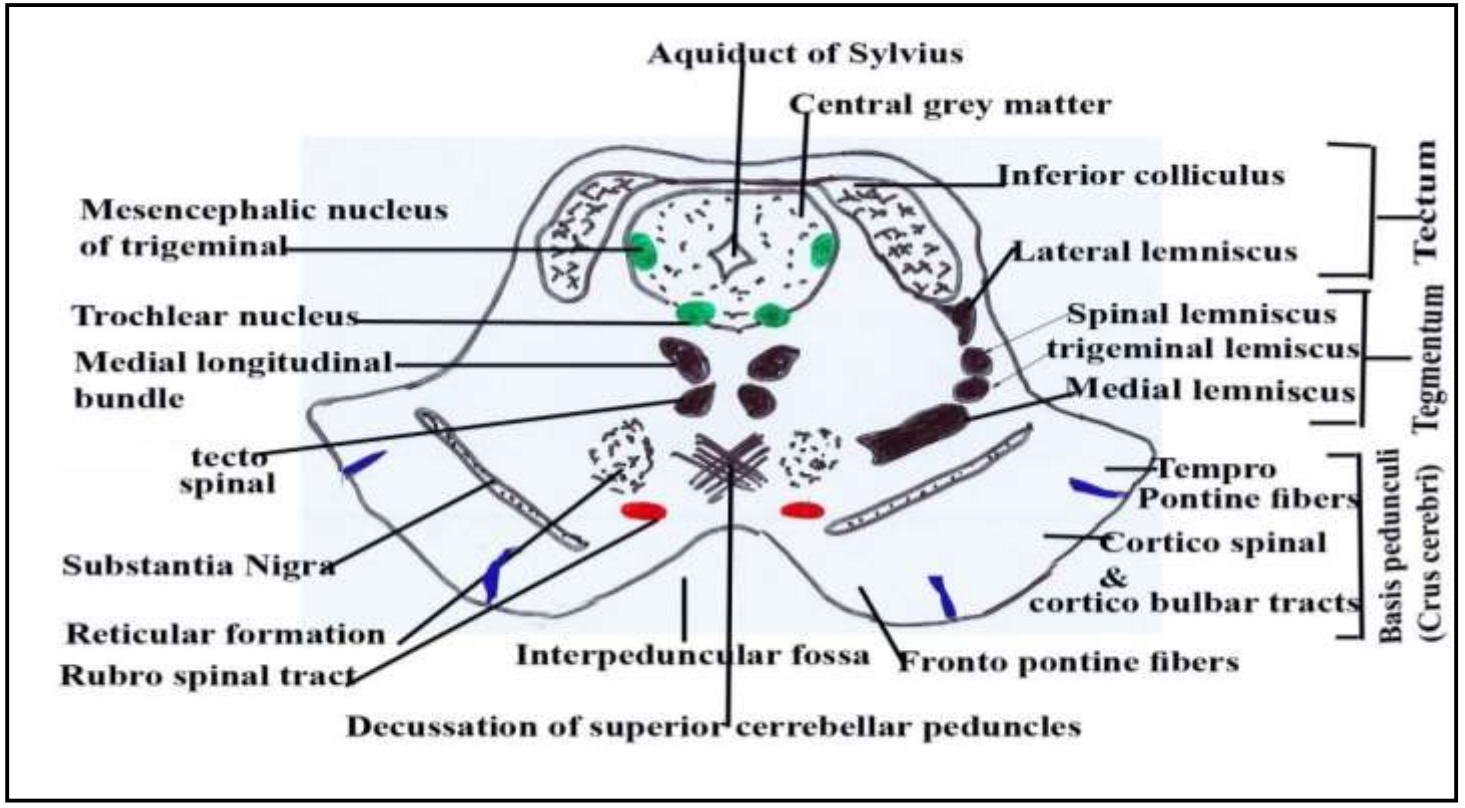
- **Reticular formation** is present lateral to the decussation of S.C.P.

- **The four leminisci** present in antero–lateral part of tegmentum namely:1. Medial lemniscus 2.Trigeminal lemniscus 3. Spinal lemniscus 4.Lateral lemniscus

- **Substantia nigra** separates the tegmentum & the Basis pedunculi (crus cerebri).

- **Basis pedunculi** consists of descending fibers from the cerebral cortex to the cranial nerve nuclei (corticobulbar), to the spinal nerve nuclei (corticospinal) & to the cerebellar cortex via pontine nuclei (corticopontine).
- They are arranged from medial to lateral as follow: 1. The frontopontine fibers. 2. The corticospinal and corticobulbar fibers (middle 3/5). 3. The tempropontine fibers

Mid-brain at the level of inferior colliculus:



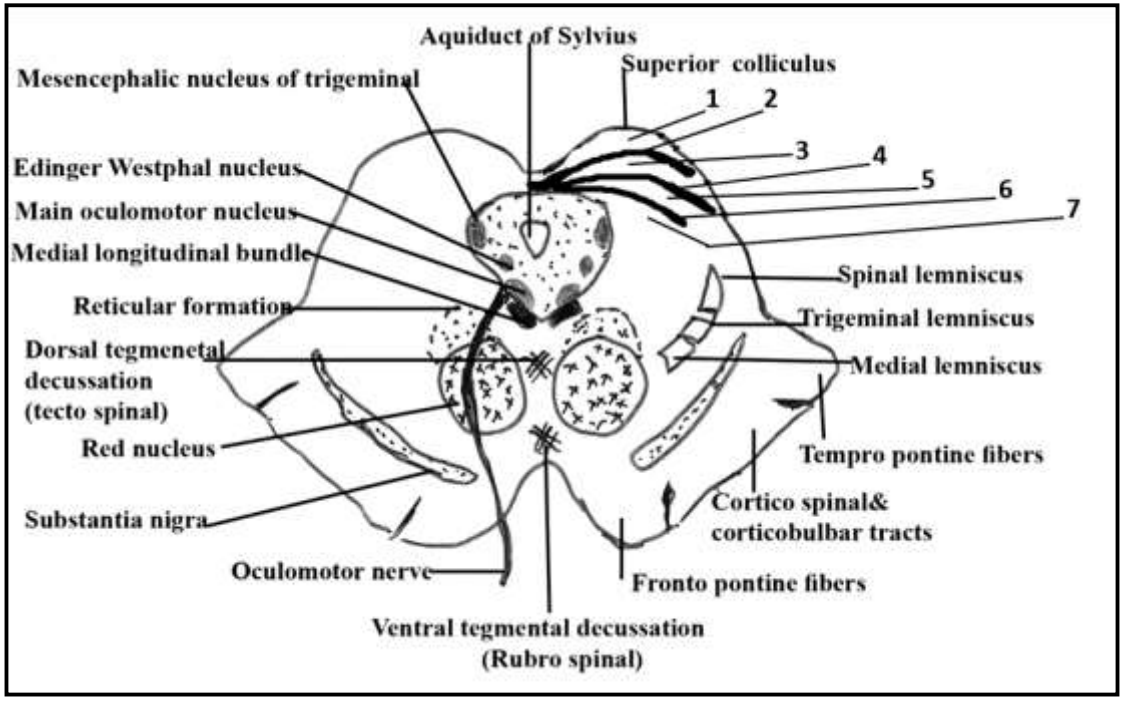
II – Midbrain at the level of superior colliculus

- It consists of the following structures:
- Tectum contains the **superior colliculi** which are center for vision reflexes (correlation of impulses from the retina with the body movements).
- The superior colliculus is formed of nerve tissue arranged **in 7 layers** or strata (4 are mainly white [album] & 3 are mainly grey [grisium]): 1. Stratum zonale. 2. Stratum grisium superficiale. 3. Stratum opticum. 4. Stratum grisium mediate. 5. Stratum album mediates (strata lemnisci). 6. Stratum grisium profundum. 7. Stratum album profundum.
- The aqueduct is surrounded by **pear shaped area** of grey matter which contains:

1. Main motor occulomotor nucleus III.
2. Edinger-Westphal nucleus III.
3. Mesencephalic nucleus of trigeminal nerve V.

- M.L.B. anterior to the gray matter and close to the midline.
- **Dorsal tegmental decussation** of tecto-spinal tract. Tectospinal tracts arise from the tectum and cross immediately, and then descend to the spinal cord.
- **Ventral tegmental decussation** of rubrospinal tracts. The rubrospinal tract arises from the red nucleus in the midbrain and crosses immediately in the ventral decussation then descend in the spinal cord.
- **Red nucleus**; two large masses of gray matter on either side of midline.
- Reticular formation present lateral & posterior to the red nucleus.
- Presence of **only 3 lemnisci**; medial lemniscus, trigeminal lemniscus and spinal lemniscus.
- Substantia nigra.
- The basis pedunculi.

Midbrain at the level of superior colliculus:



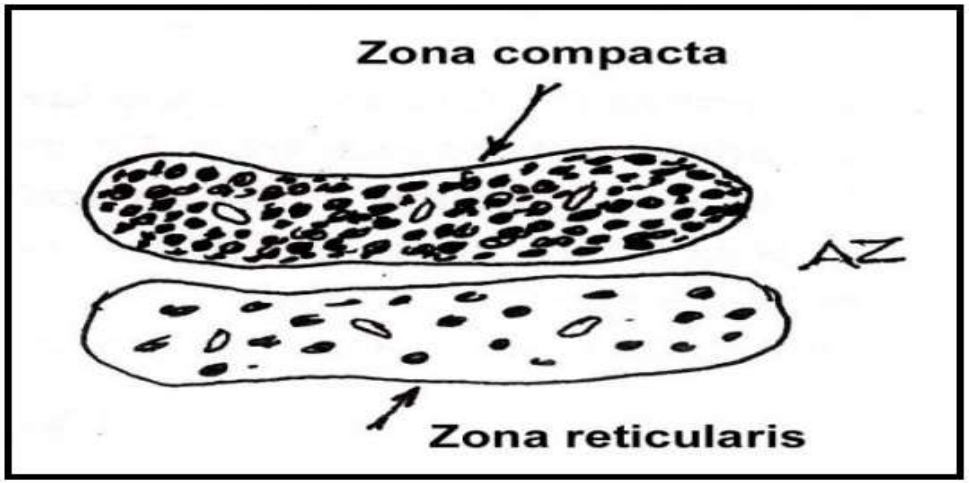
Substantia Nigra

- Dark pigmented motor nucleus between tegmentum and crus cerebri on each side, extends from lower midbrain to subthalamus and can be considered as part of basal ganglia.
- The neurons of substantia nigra are multipolar and its cytoplasm contains numerous membrane-bound granules of neuromelanin pigment.
- These pigments are very little at birth, increasing during childhood and thereafter rising with increasing age. Functionally, it may sequester metals such as iron, as well as toxic organic compounds.

2- It is divided into:

a) Dorsal compact part (Zona Compacta) rich in cells containing melanin pigment that form dopamine (inhibitory effects on corpus striatum).

b) Ventral reticular part (Zona Reticularis) poor in cells that contain iron compounds.



N.B.

- Loss of Dopamine leads to Parkinsonism treated by L-DOPA.
- Brain of a patient with Parkinson's disease shows abnormal pallor of the substantia nigra correlating with loss of the pigment-containing neurons.
- Lesion in zona reticularis leads to Huntington's disease

Red Nucleus

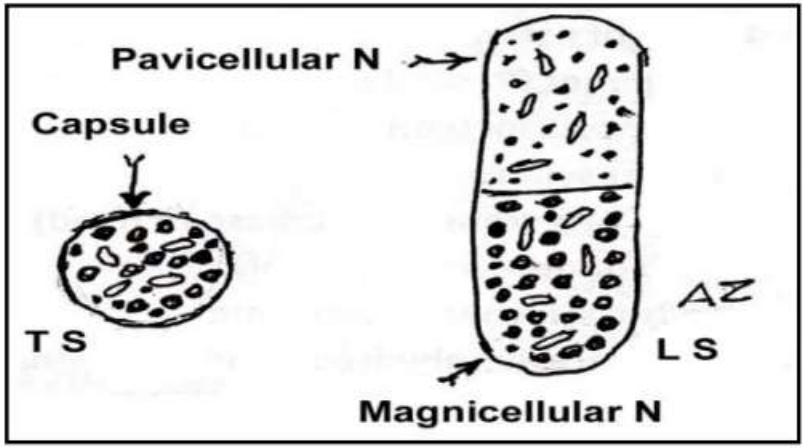
1- May be considered as a part of reticular formation or basal ganglia.

2- Red nucleus is a motor nucleus, red yellowish in color due to high vascularity and iron compounds. It extends from the upper part of midbrain to subthalamus. It is oval or rounded in shape in transverse section and has a capsule formed of the nerve fibers from superior cerebellar peduncle.

3- It is divided into:

a- Upper recent part formed of small cells (parvicellular nucleus)

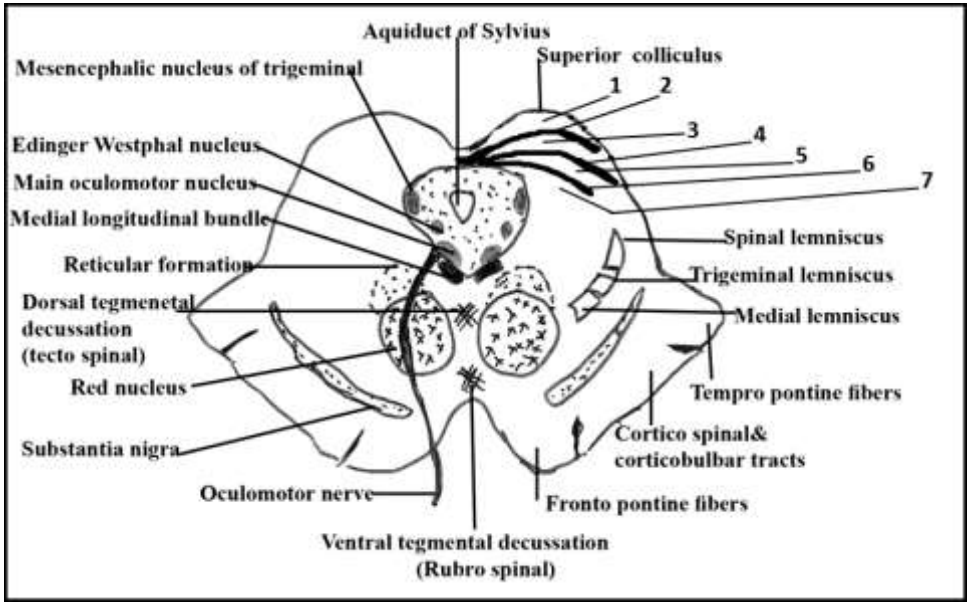
b- Older caudal part formed of large cells (magnicelluar nucleus).



4- The nucleus is traversed mainly by :

a) Occulomotor nerve roots

b) Superior cerebellar peduncle after decussation

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