CNS Module

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Midbrain

Midbrain

- **By the end of this session, you should be able to :**

1. *Connection, External, and internal Features of the Midbrain.*

2. *Location, Connections, and Functions of the Reticular Formation of the Brain Stem.*

Midbrain

- Connects the pons and cerebellum with the diencephalon.

- The midbrain or ***mesencephalon*** is a portion of the central nervous system associated with ***vision, hearing, motor control, sleep/wake, arousal (alertness), and temperature regulation.***

Midbrain

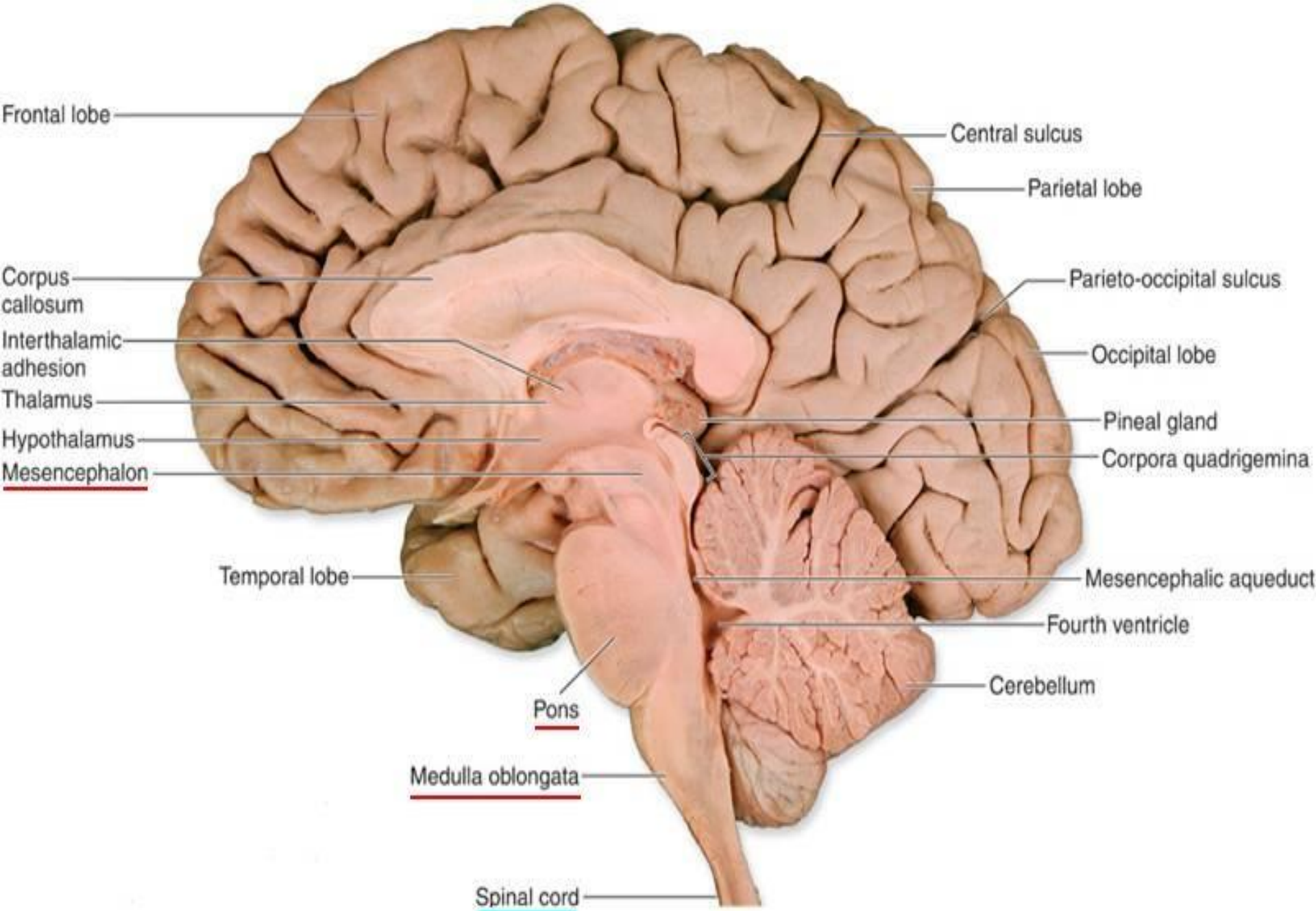
It is the shortest and most superior portion of the brainstem.

It is traversed by the **cerebral aqueduct of Sylvius** which divides it into:

1. **Tectum (dorsally).**
2. **Two cerebral peduncles (ventrally).**

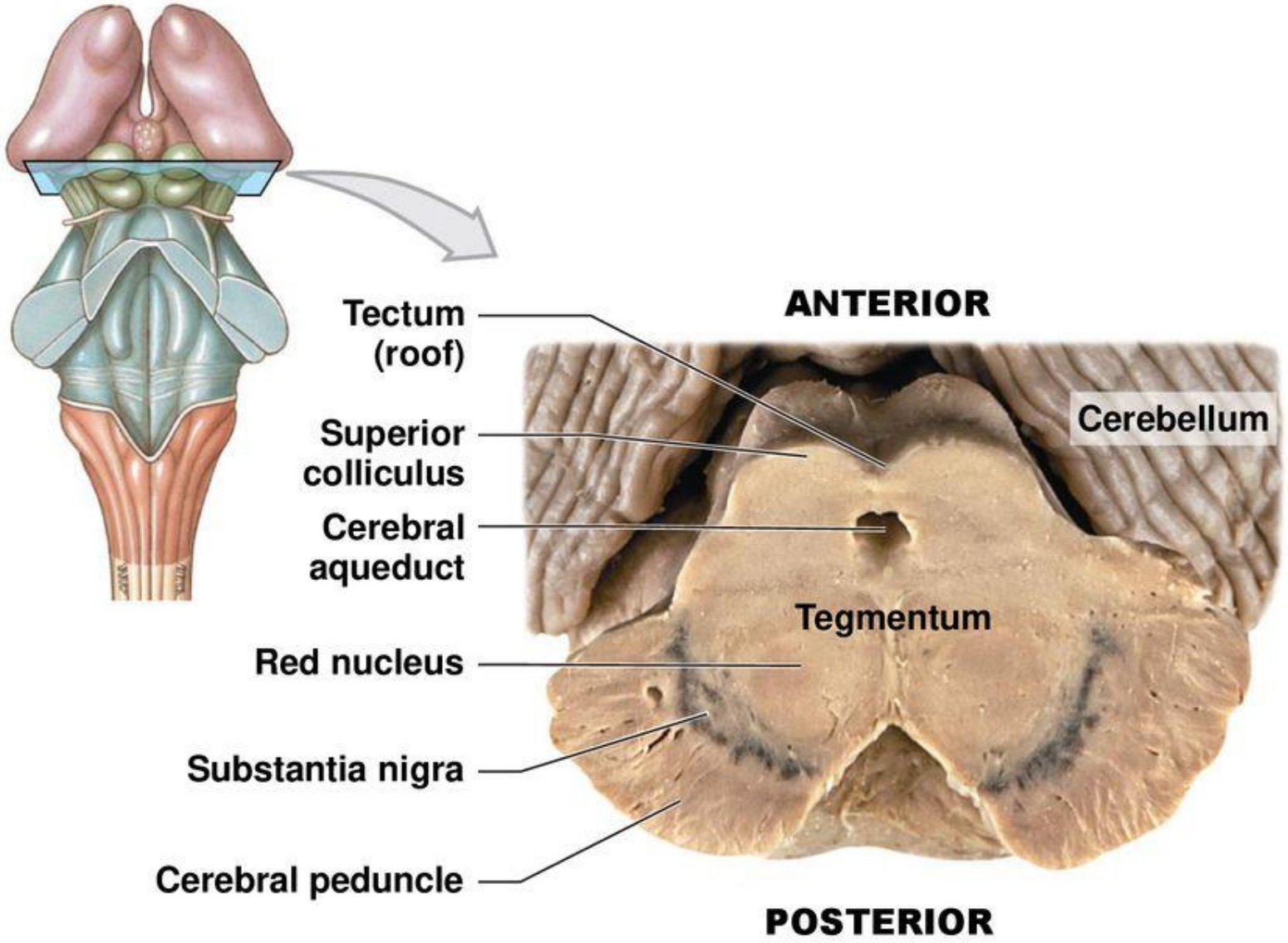
Each cerebral peduncle is divided by a pigmented sheet of grey matter called **substantia nigra into:**

1. **Tegmentum (dorsally).**
2. **Crus cerebri (ventrally)**



Midsagittal view

Figure 14–8c The Midbrain.



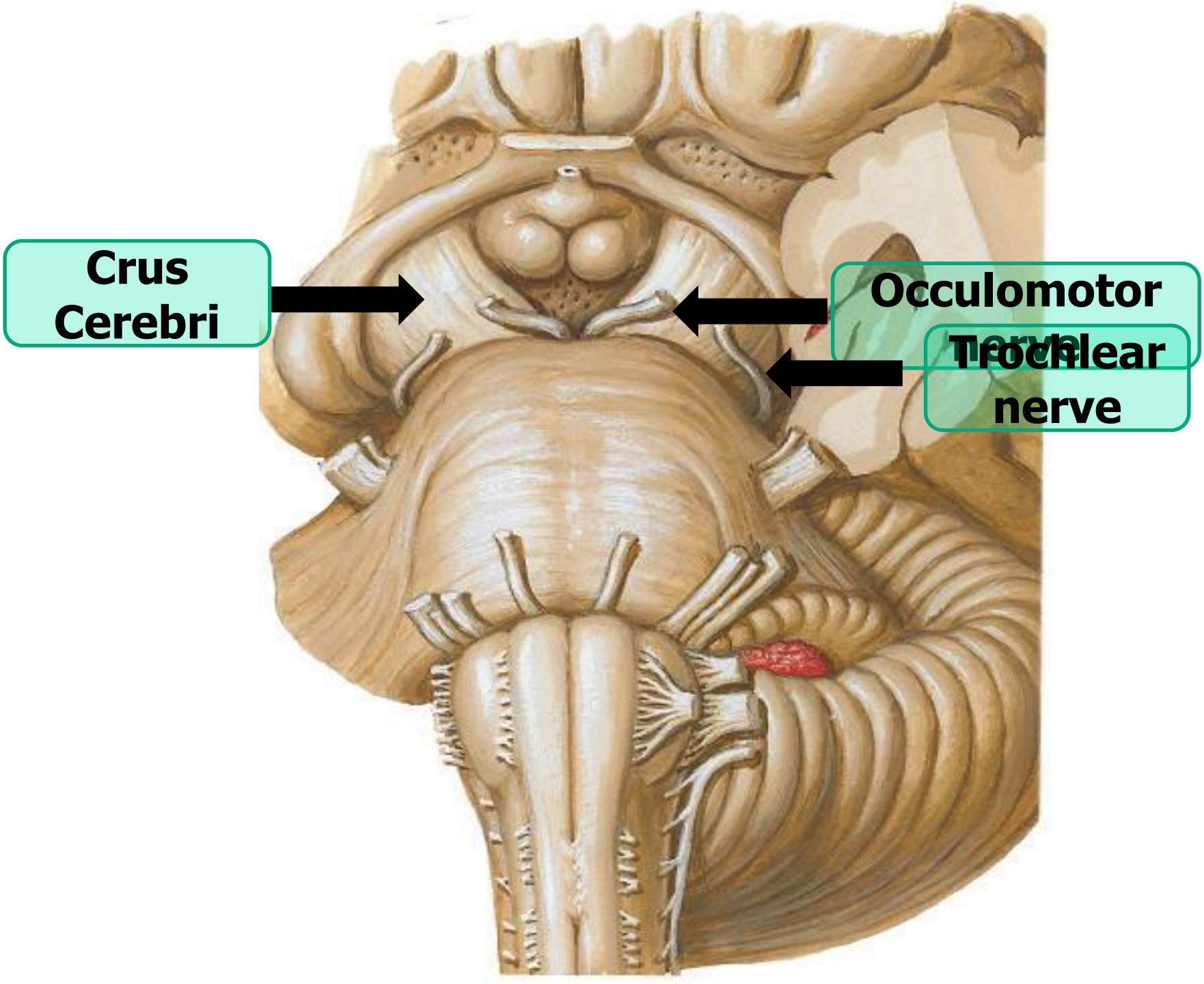
C A superior view of a transverse section at the level of the midbrain.

Midbrain - Anterior

Marked by large column of descending fibers (**crus cerebri or basis pedunculi**), on either side, separated by a depression called the **interpeduncular fossa.**

The ***Oculomotor nerve*** (3^{rd}) emerges from the medial side of the crus cerebri.

The ***trochlear nerve*** (4^{th}) emerges from the lateral side of the crus cerebri .


Crus Cerebri
Occulomotor nerve
Trochlear nerve

The Interpeduncular Fossa

It is a trapezoid depression between the two cerebral peduncles.

It does not belong to the midbrain but to the hypothalamus.

Boundaries:

Anteriorly: optic chiasma.
Anterolaterally: optic tract.
Posterolaterally: cerebral peduncle.
Posteriorly: upper border of pon

The Interpeduncular Fossa

Contents:

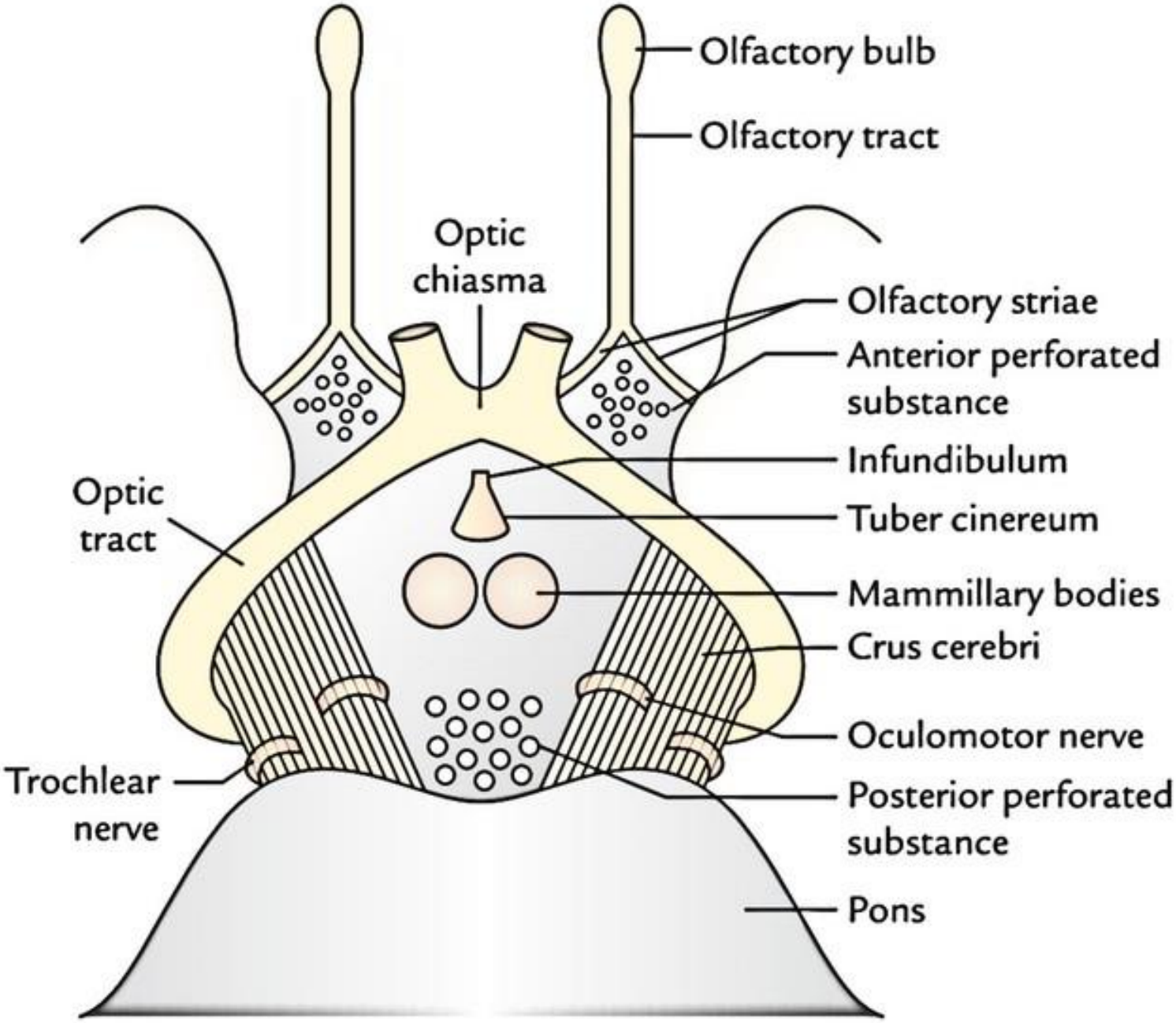
Tuber cinereum: **convex mass of grey matter (= the median** eminence of hypothalamus). The infundibulum (or pituitary stalk) connects it with the posterior lobe of pituitary gland.

Mammillary bodies: **two rounded nuclei of hypothalamus.**

Posterior perforated substance: **an area of grey matter showing** small holes pierced by the central branches of posterior cerebral artery.

Oculomotor nerve: **emerges from the medial surface of the** cerebral peduncle.

***N.B: an anterior perforated substance is situated lateral to the optic** chiasma & is pierced by the central branches of anterior and middle cerebral arteries.


Olfactory bulb
Olfactory tract
Optic chiasma
Olfactory striae
Anterior perforated substance
Infundibulum
Optic tract
Tuber cinereum
Mammillary bodies
Crus cerebri
Oculomotor nerve
Trochlear nerve
Posterior perforated substance
Pons

Midbrain - Posterior

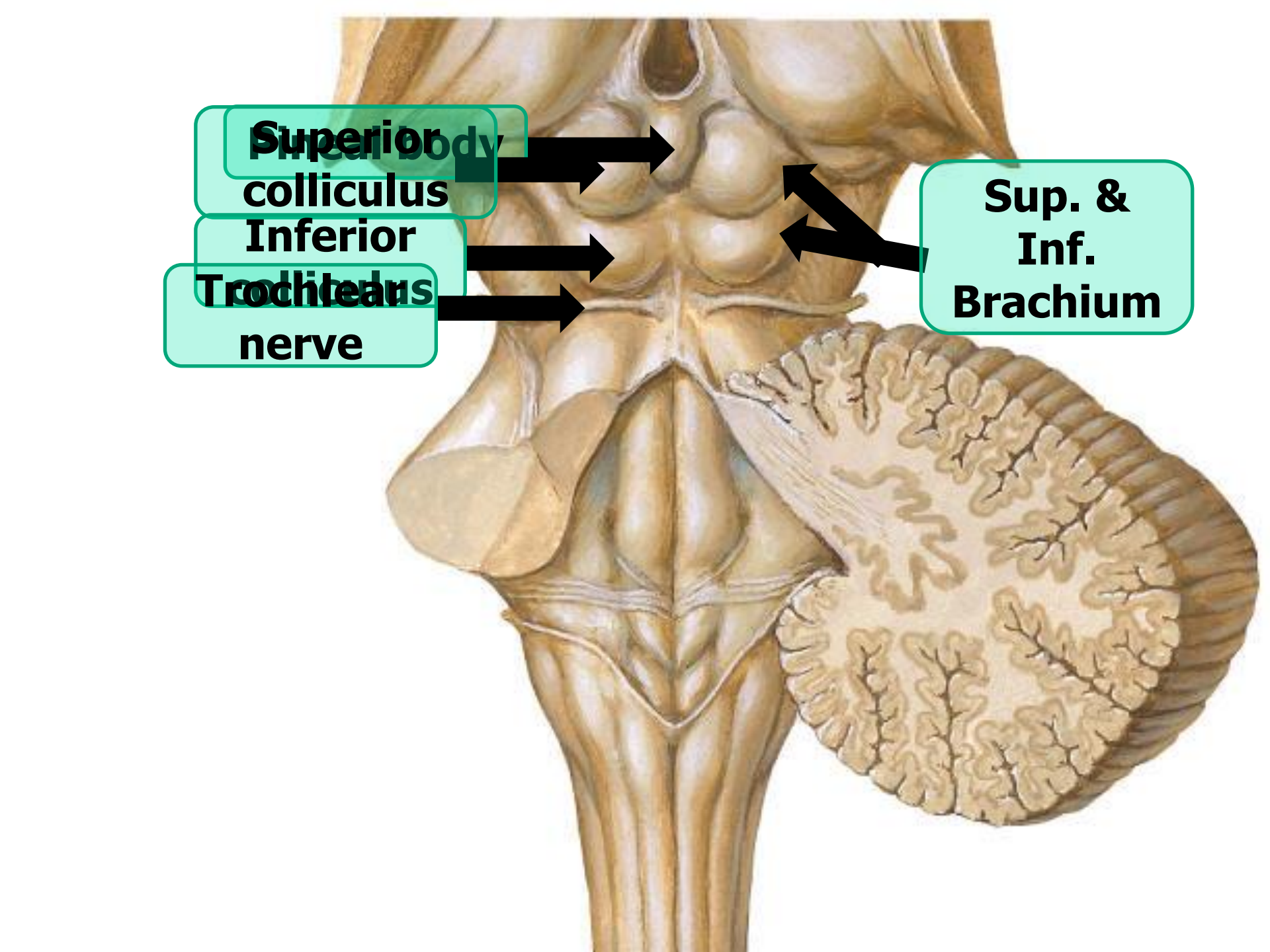
Marked by 4 colliculi (corpora quadrigemina):

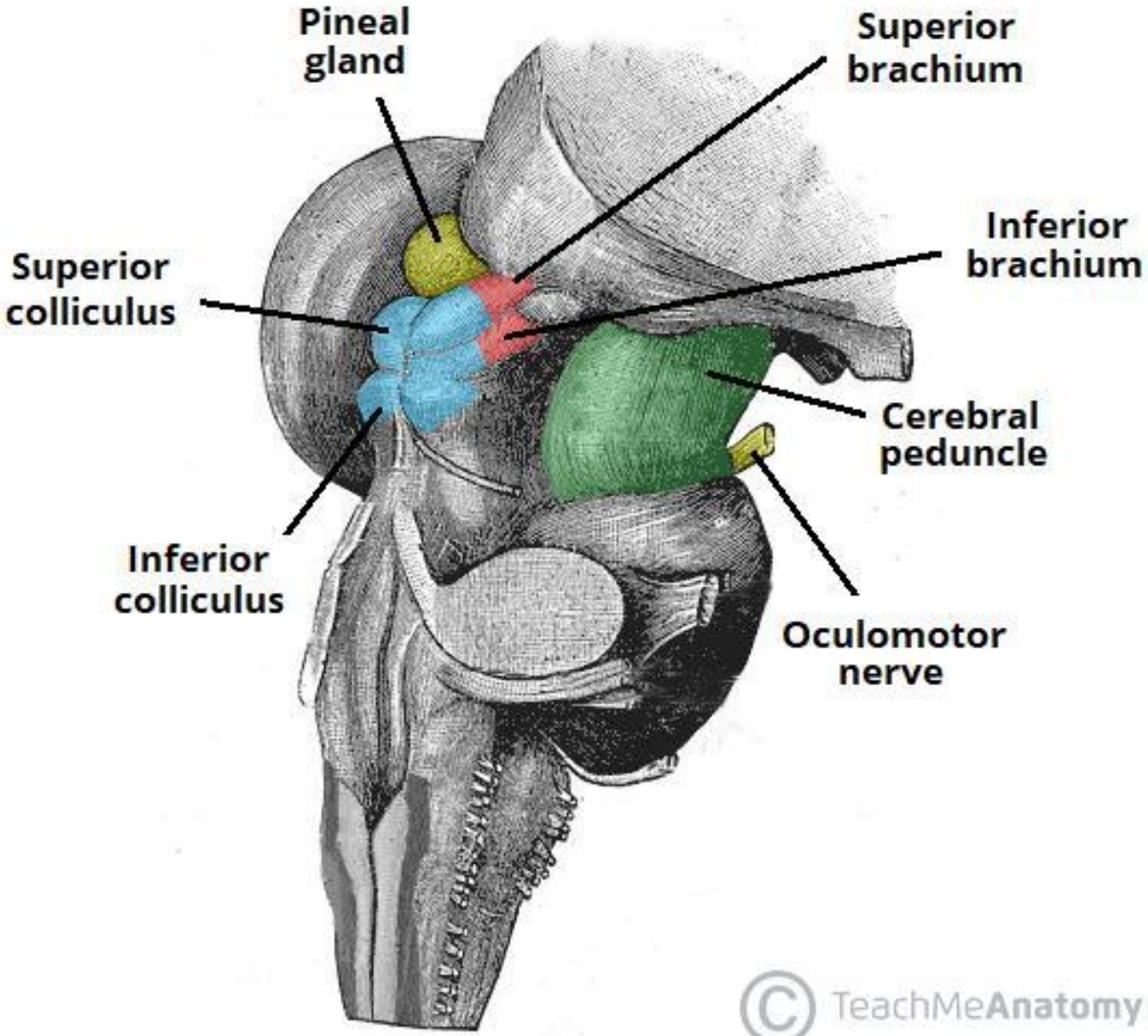
1. ***Superior colliculi- Visual***
2. ***Inferior colliculi- auditory***

Each colliculus is related laterally to a ridge called the brachium:

1. The brachium of sup. colliculus connects the superior colliculus to the lateral geniculate body (LGB).
2. The brachium of inf. colliculus connects the inferior colliculus to the medial geniculate body (MGB).

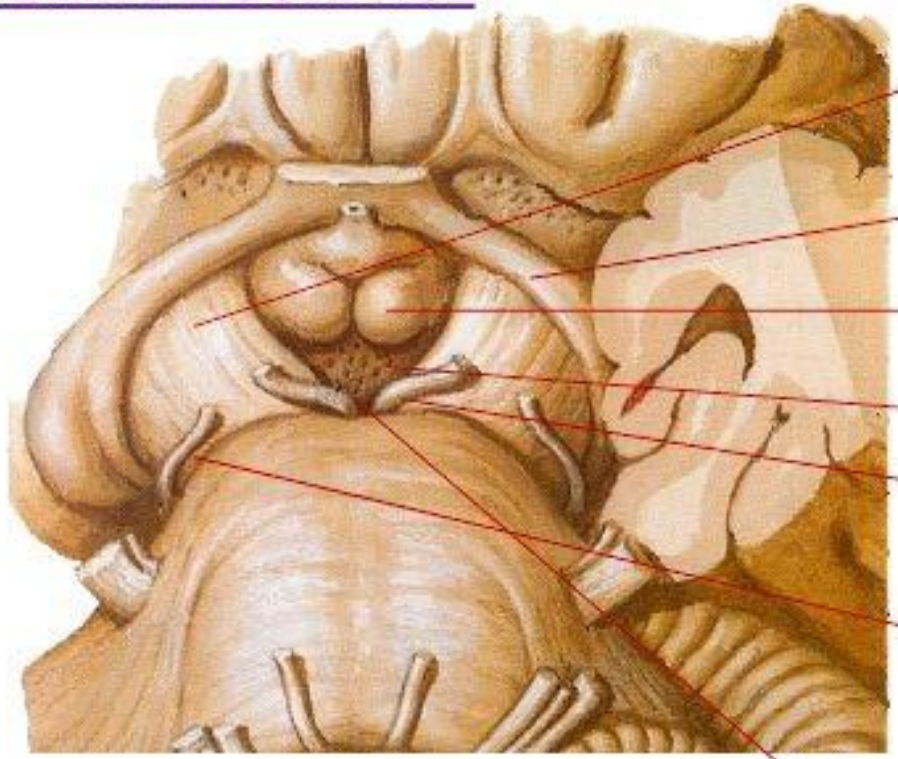
In the midline below the Inferior colliculus the trochlear nerves emerge


Superior colliculus
Inferior colliculus
Trochlear nerve
Sup. & Inf. Brachium



MIDBRAIN

VENTRAL SURFACE



Crus cerebri of midbrain

Optic tract

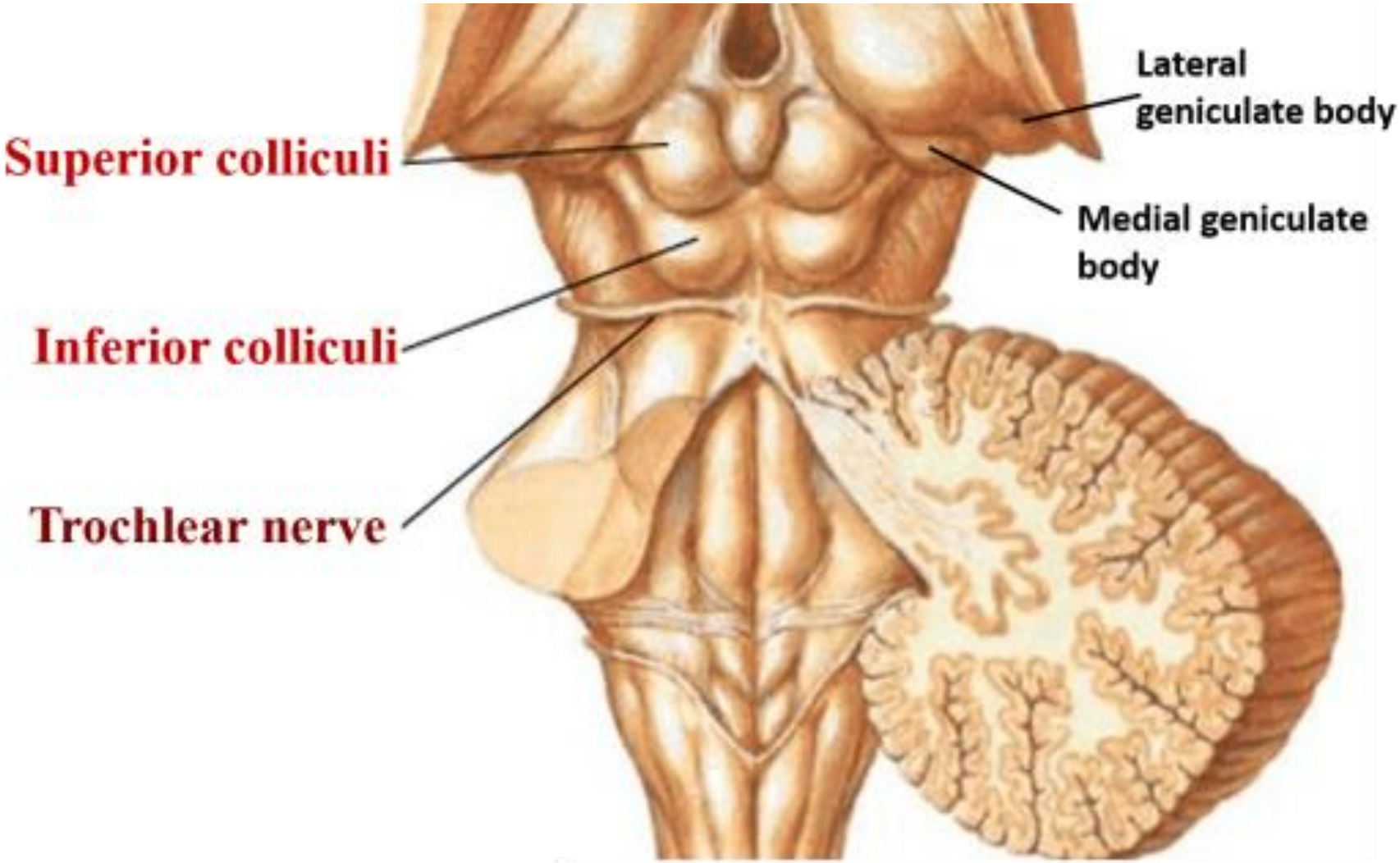
Mammillary body

Posterior perforated substance

Oculomotor nerve

Trochlear nerve

Interpedencular fossa


Lateral geniculate body
Superior colliculi
Medial geniculate body
Inferior colliculi
Trochlear nerve

Internal Structures of Midbrain

We divided the midbrain anatomically into two levels:

1. ***Level of Inferior Colliculi***
2. ***Level of superior Colliculi***

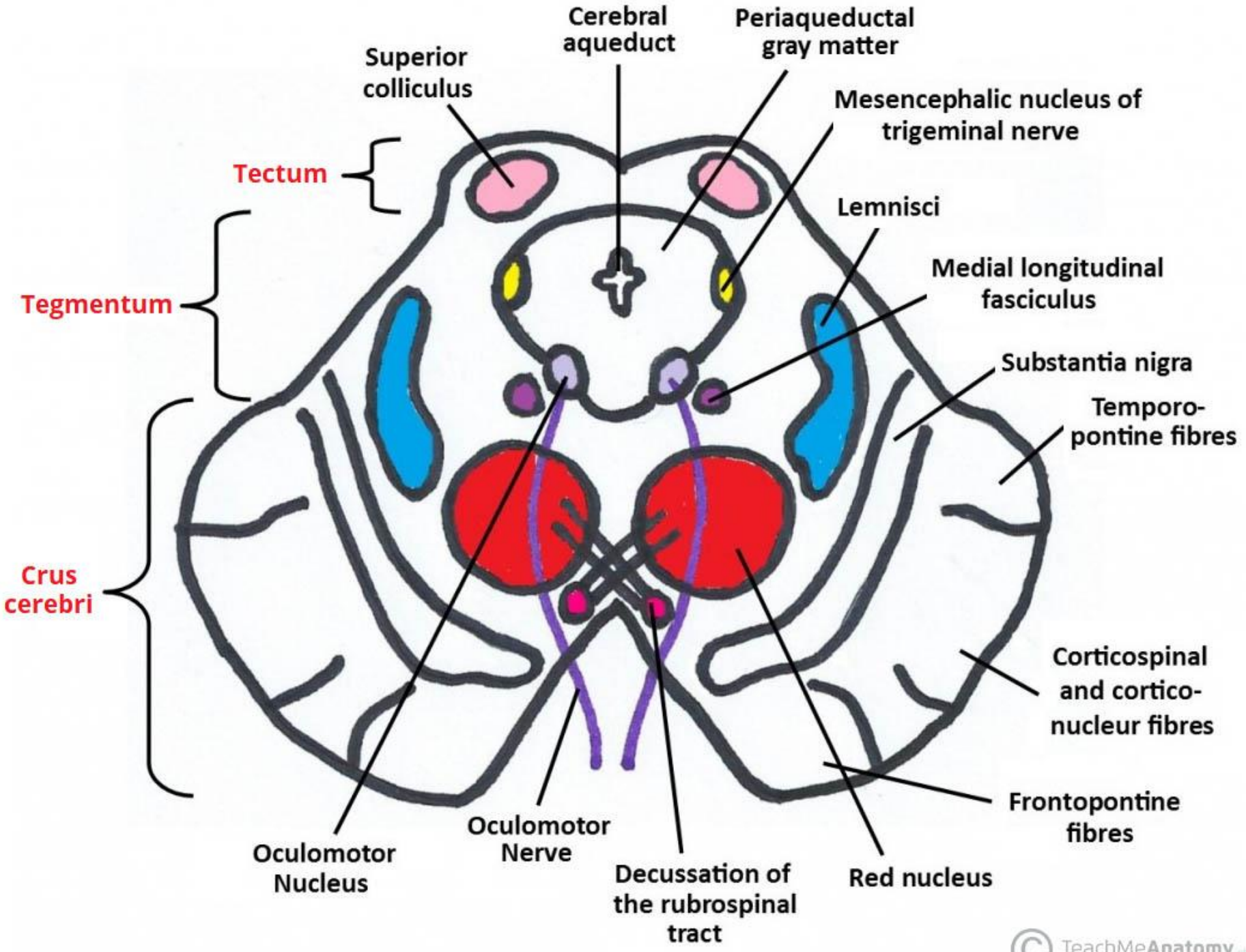
Midbrain

- **In each level, the midbrain consists of :**

1. ***Tectum "Corpora quadrigemina"*** containing ***superior colliculi*** **"Vision"**, ***inferior colliculi*** **"Hearing",** **which is present at its posterior aspect**

2. ***Cerebral peduncle***

3. ***Cerebral aqueduct:*** connect the 3rd and 4th ventricles, in-between the previous 2 parts



Cerebral Peduncles

- Two cylindrical masses situated at the base of the brain largely hidden by the temporal lobes

- They emerge from the upper surface of the pons & diverge as they pass upward to disappear into the substance of the cerebral hemispheres

Cerebral Peduncles

- The interpeduncular fossa between them is occupied by the posterior perforated substance

- They are surrounded by the parahippocampal gyrus & optic tracts

Cerebral Peduncles

- ***Cerebral peduncles*** include the
  1. Crus cerebri (***Most anterior***)
  2. Substantia nigra (***Middle***)
  3. Tegentum (***Most Posterior***)

- They contain the large ascending (sensory) and descending (motor) nerve tracts that run to and from the cerebrum and from the pons.

- Mainly, the three common areas that give rise to the cerebral peduncles are the ***cerebral cortex***, the ***spinal cord*** and the ***cerebellum***.

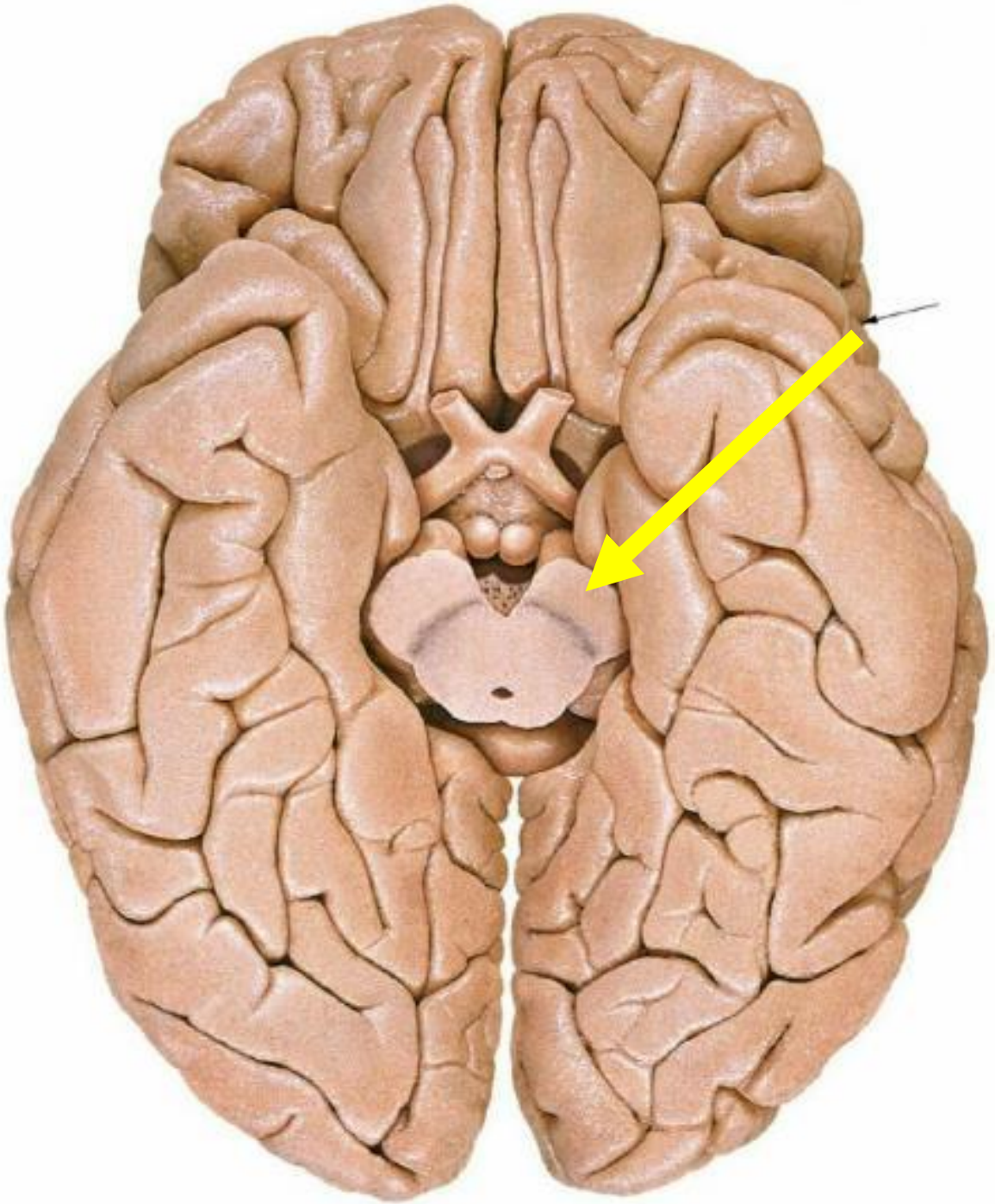
Crus Cerebri
Level of Inferior Colliculus

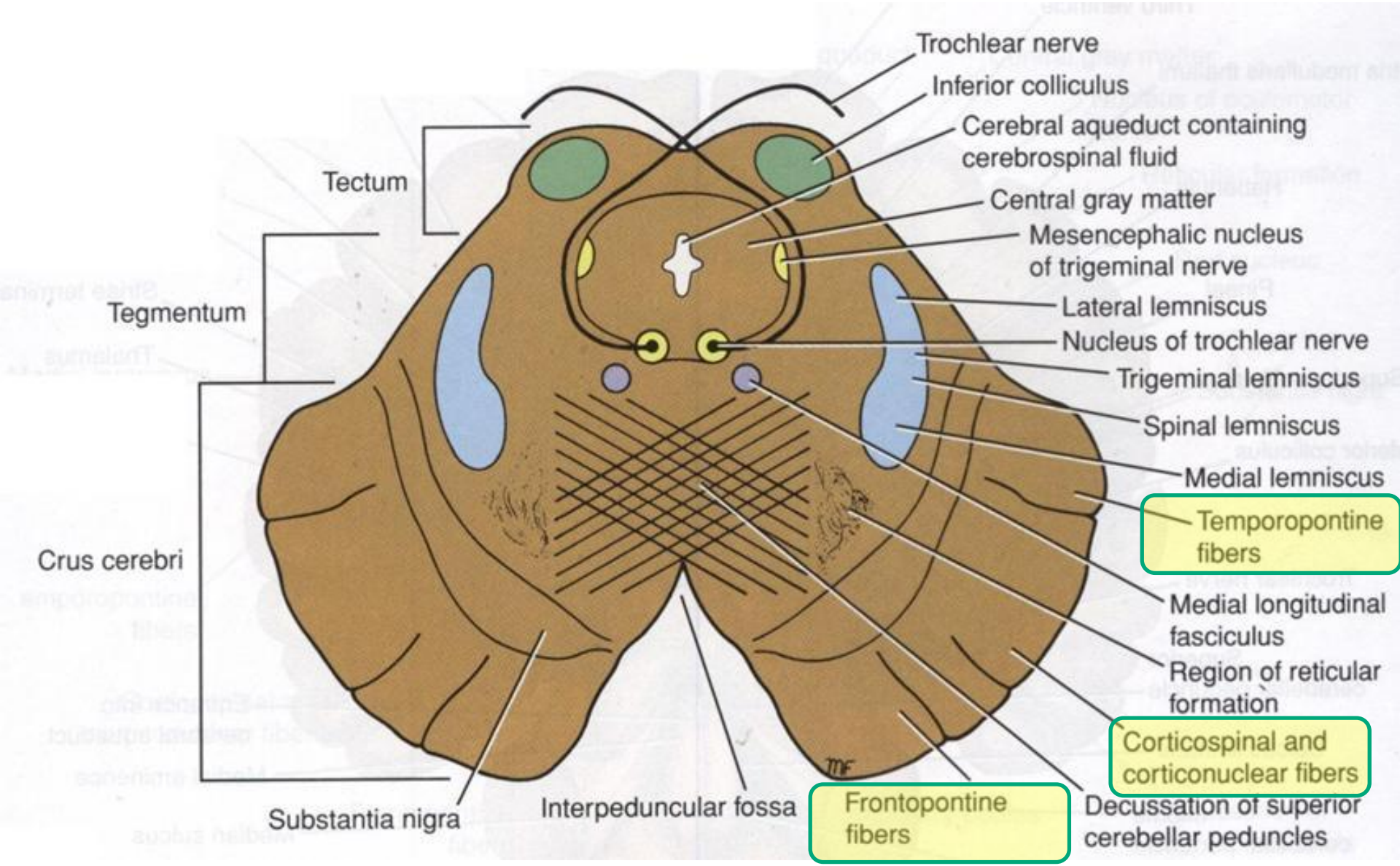
- The cerebral crus (crus cerebri) is the anterior portion of the cerebral peduncle which contains the motor tracts

- **So, cerebral crus composed of nerve fibers (It is a white mater)**

1. ***The medial 1/6:*** corticopontine fibers from the frontal lobe.
2. ***The lateral 1/6:*** corticopontine fibers from the temporal, occipital and parietal lobes.
3. ***The intermediate 4/6:*** corticospinal and corticonuclear fibers.

- All parts of motor way




Trochlear nerve
Inferior colliculus
Cerebral aqueduct containing cerebrospinal fluid
Tectum
Central gray matter
Mesencephalic nucleus of trigeminal nerve
Tegmentum
Lateral lemniscus
Nucleus of trochlear nerve
Trigeminal lemniscus
Spinal lemniscus
Medial lemniscus
Temporopontine fibers
Crus cerebri
Medial longitudinal fasciculus
Region of reticular formation
Corticospinal and corticonuclear fibers
Substantia nigra
Interpeduncular fossa
Frontopontine fibers
Decussation of superior cerebellar peduncles

Substantia Nigra (Level of Inferior Colliculus)

- The **substantia nigra** lies immediately behind and medial to the Crus cerebri. It appears dark in unstained sections as neurons within it contain pigment (**neuromelanin**)

- The ***substantia nigra*** is divisible into a dorsal part, the ***pars compacta*****;** and a ventral part, the ***pars reticularis***

- **Its degeneration is associated with Parkinson's disease**

Substantia Nigra

- The ***pars compacta*** contains ***dopaminergic*** and ***cholinergic*** neurons, while most of the neurons in the ***pars reticularis*** are ***GABAergic***.

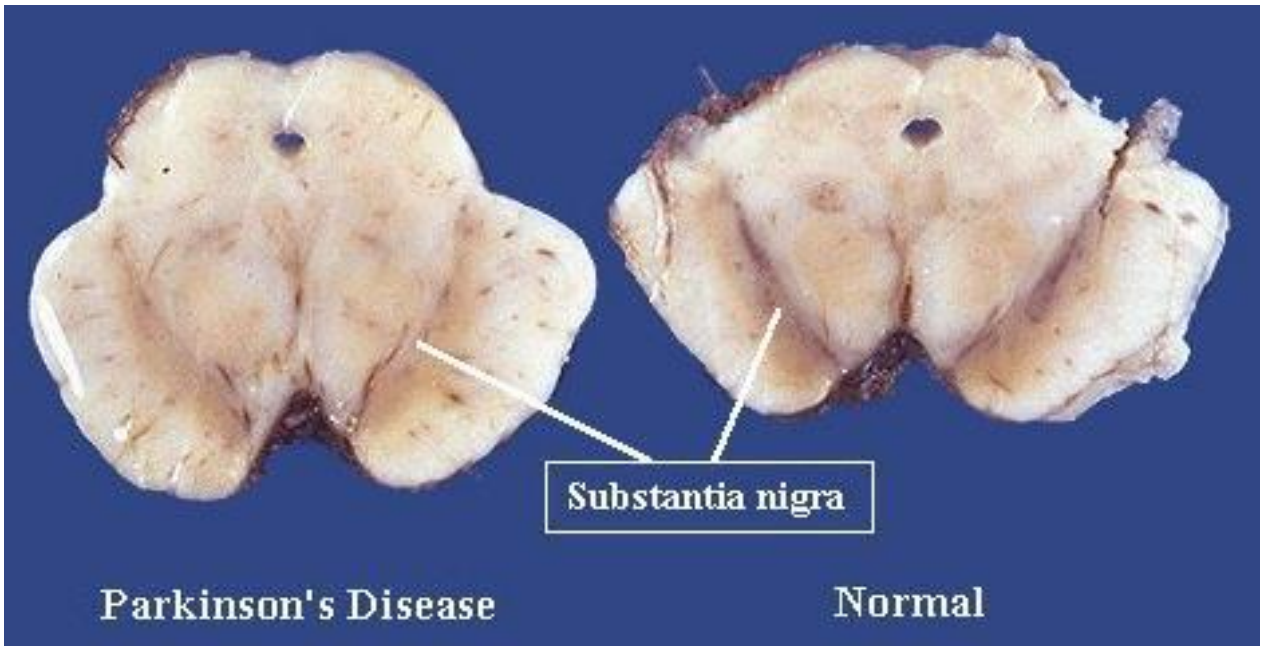
- Superiorly, the ***pars reticularis*** becomes continuous with the ***globus pallidus***. The ***substantia nigra*** is closely connected, functionally, with the ***corpus striatum***.

Substantia Nigra

Main afferent : corpus striatum (basal ganglia)

Main efferent : thalamus

Functionally linked to the extrapyramidal system ..

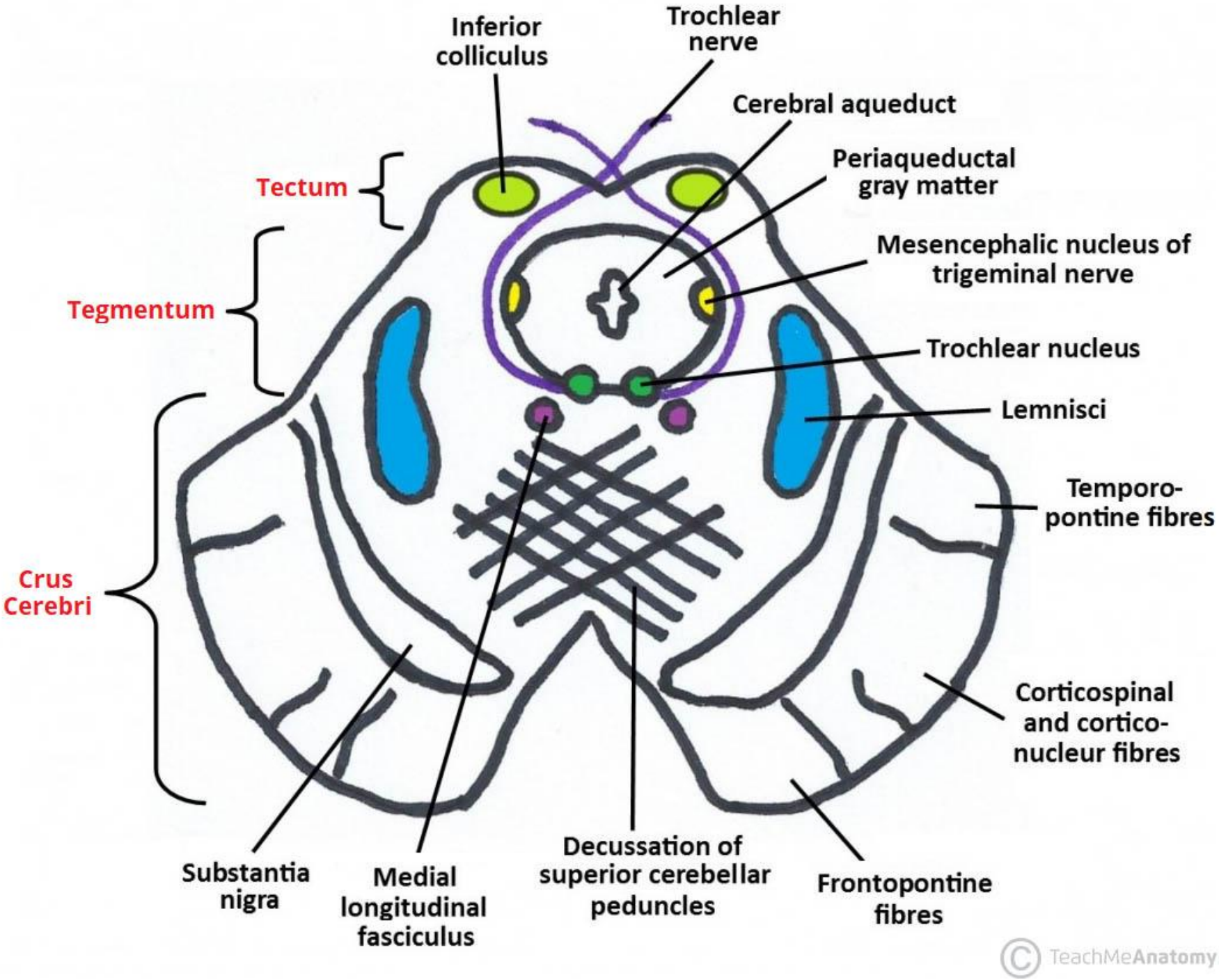


Tegmentum – White Mater

- ***The superior <u>cerebellar</u> peduncle***
  1. Enter the midbrain tegmentum
  2. ***<u>Decussate at the level of the inferior colliculi on their way to the red nuclei</u>***

- ***The medial longitudinal fasciculus (MLF):***
  1. In the mid-brain it is situated on the ventral aspect of the cerebral aqueduct
  2. It consists largely of fibers which connect the nuclei of the pons and mid-brain to each other

- **MLF is the main central connection for the *<u>oculomotor nerve, trochlear nerve, and abducens nerve</u>*.**

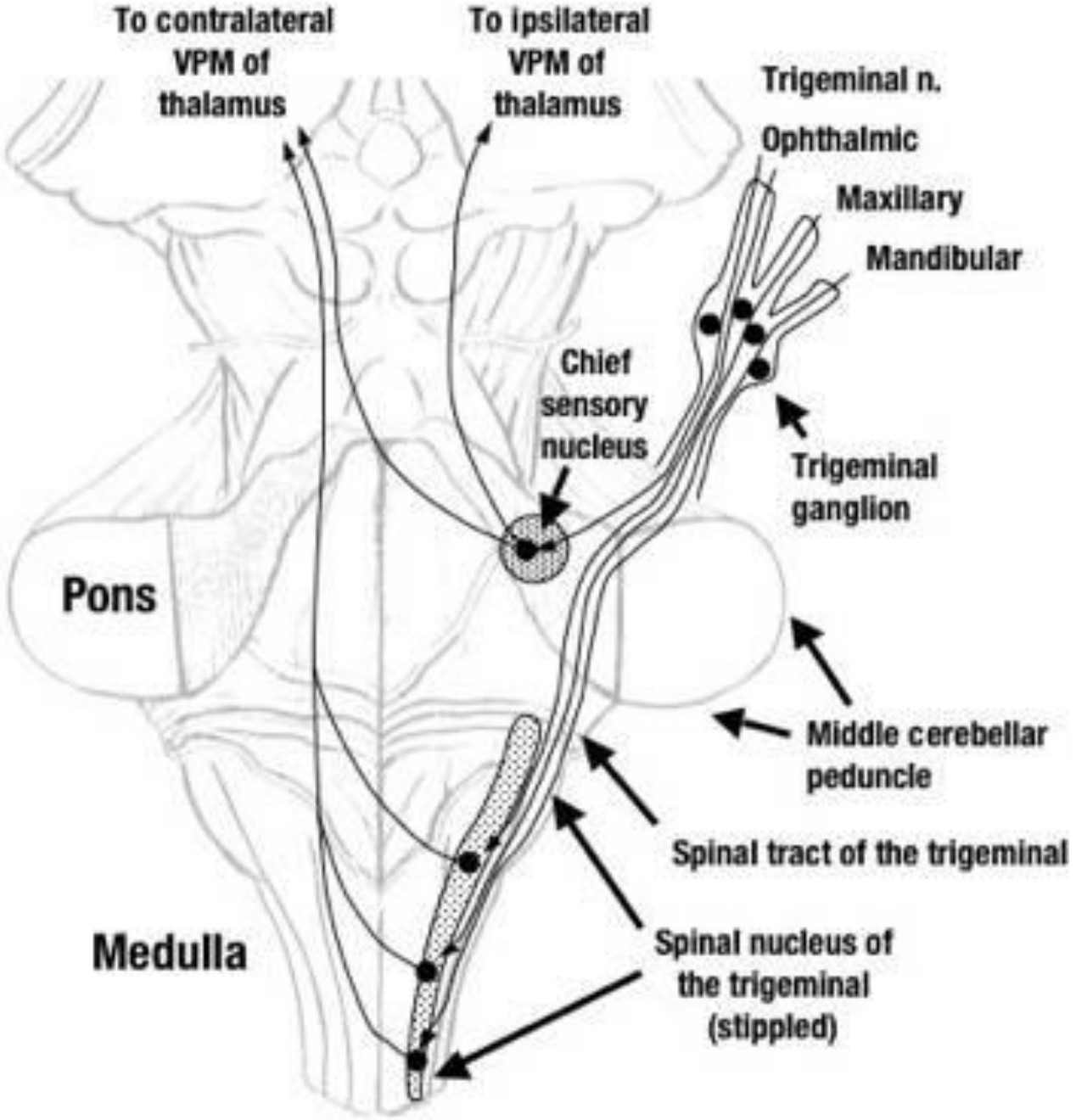


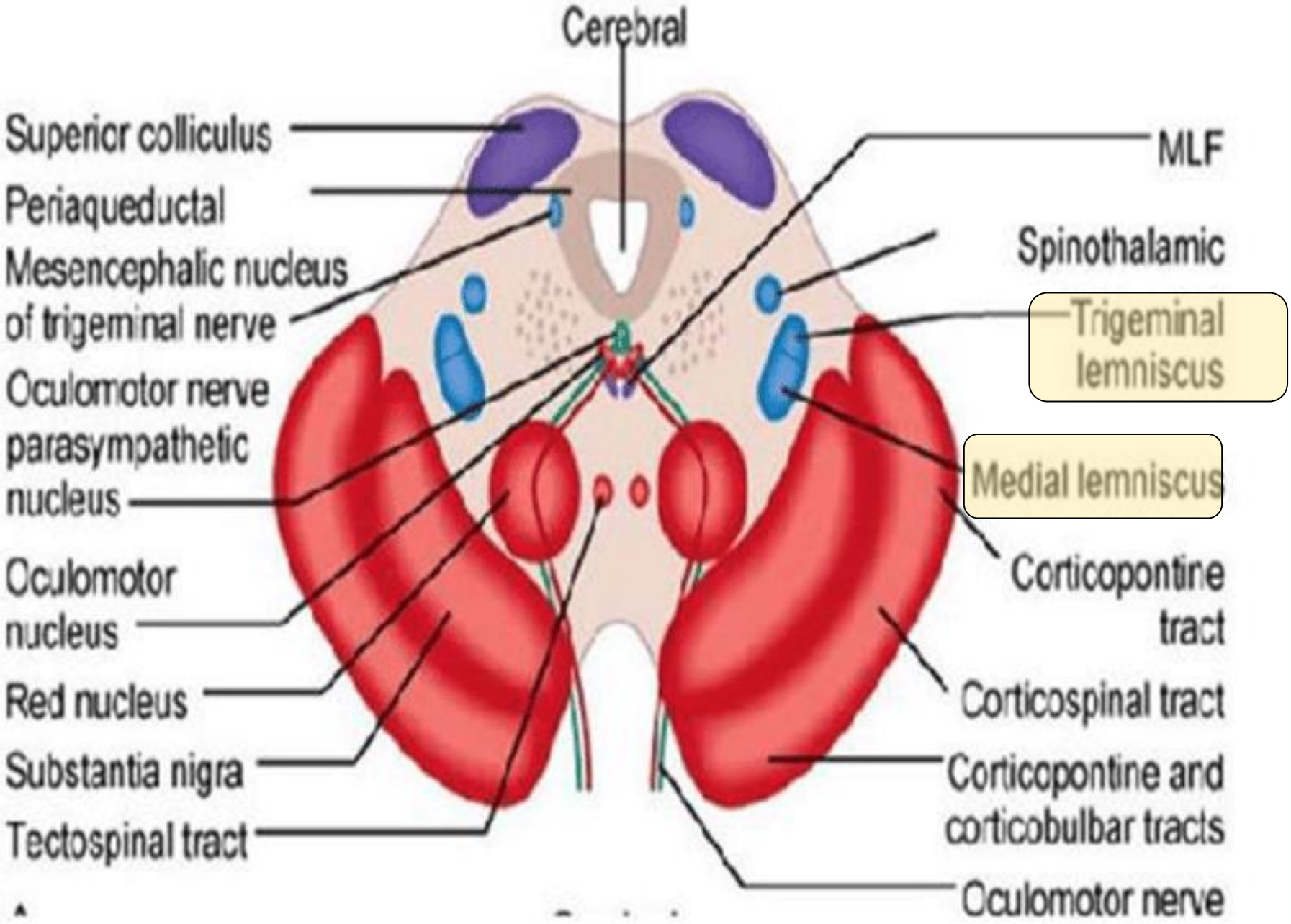
Tegmentum – White Mater

- ***The medial lemniscus:***
  1. Arise in the ***gracile & cuneate nuclei*** of the ***medulla*** (of opposite site) & decussate there as internal arcuate fibers.
  2. In the midbrain it attains dorsolateral position

- ***The trigeminal lemniscus:***

  Arising from the spinal nucleus of trigeminal nerve and heading towards the thalamus same side


To contralateral VPM of thalamus
To ipsilateral VPM of thalamus
Trigeminal n.
Ophthalmic
Maxillary
Mandibular
Chief sensory nucleus
Trigeminal ganglion
Pons
Middle cerebellar peduncle
Spinal tract of the trigeminal
Medulla
Spinal nucleus of the trigeminal (stippled)


Cerebral
Superior colliculus
Periaqueductal
Mesencephalic nucleus of trigeminal nerve
Oculomotor nerve parasympathetic nucleus
Oculomotor nucleus
Red nucleus
Substantia nigra
Tectospinal tract
MLF
Spinothalamic
Trigeminal lemniscus
Medial lemniscus
Corticopontine tract
Corticospinal tract
Corticopontine and corticobulbar tracts
Oculomotor nerve

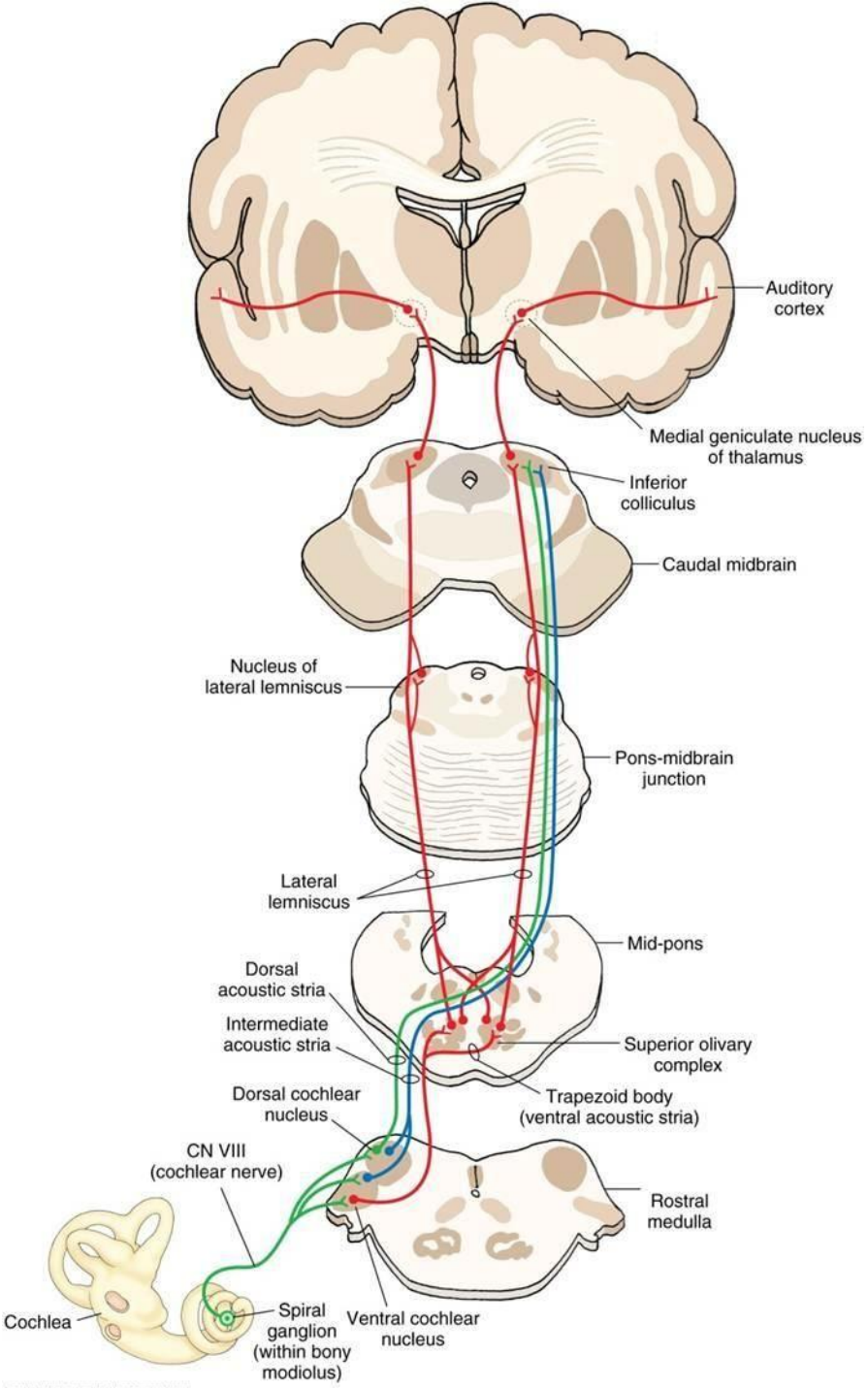
Tegmentum – White Mater

- ***The lateral lemniscus:***

1. From ***trapezoid body*** terminates on cells of the ***inferior colliculus*** and ***medial geniculate body*** for auditory reflexes

2. Both the trapezoid body and lateral lemniscus contain cell stations which make connection with the extraocular nuclei via the medial longitudinal bundle.

Lateral lemniscus ends in the inferior colliculus, thus is not seen in the upper level

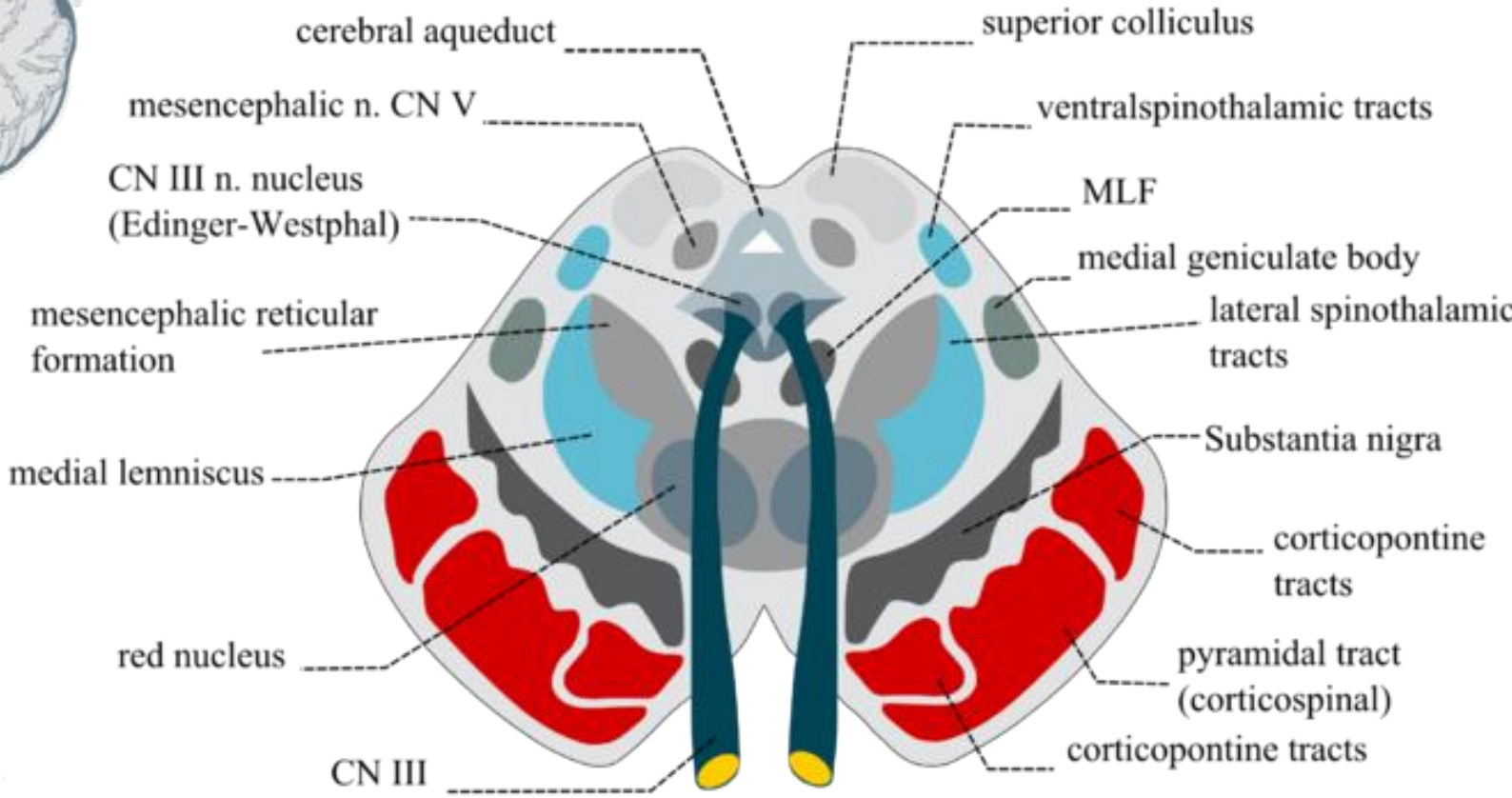

Auditory cortex
Medial geniculate nucleus of thalamus
Inferior colliculus
Caudal midbrain
Nucleus of lateral lemniscus
Pons-midbrain junction
Lateral lemniscus
Mid-pons
Dorsal acoustic stria
Intermediate acoustic stria
Superior olivary complex
Trapezoid body (ventral acoustic stria)
Dorsal cochlear nucleus
CN VIII (cochlear nerve)
Rostral medulla
Cochlea
Spiral ganglion (within bony modiolus)
Ventral cochlear nucleus

Tegmentum – White Mater

- ***The vestibulospinal tract:***
  1. Arise in the vestibular nuclei (**Mainly in Pontomedullary junction**)
  2. Some of them descend in the spinal cord & ***some ascend in the tegmentum of the midbrain***

- ***The tectospinal tract:***
  1. Arise in the superior colliculi - Decussate & descend near the midline (**DORSAL TEGMENTAL DECUSSATION**)

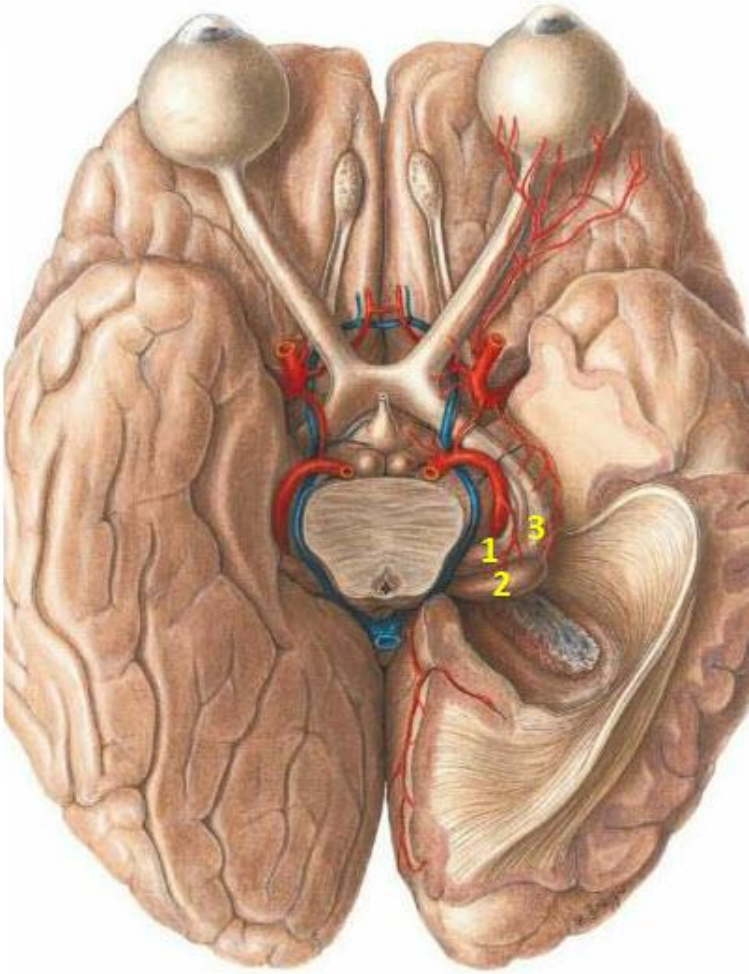
- ***The rubrospinal tract:***
  1. Arise in the red nucleus
  2. Cross the midline & descends into the lateral column of the spinal cord (**VENTRAL TEGMENTAL DECUSSATION**)


cerebral aqueduct
superior colliculus
mesencephalic n. CN V
ventralspinothalamic tracts
CN III n. nucleus
(Edinger-Westphal)
MLF
medial geniculate body
mesencephalic reticular
formation
lateral spinothalamic
tracts
Substantia nigra
medial lemniscus
corticopontine
tracts
red nucleus
pyramidal tract
(corticospinal)
corticopontine tracts
CN III

Superior Colliculus

- Each colliculus is related laterally to a ridge called the ***brachium.***

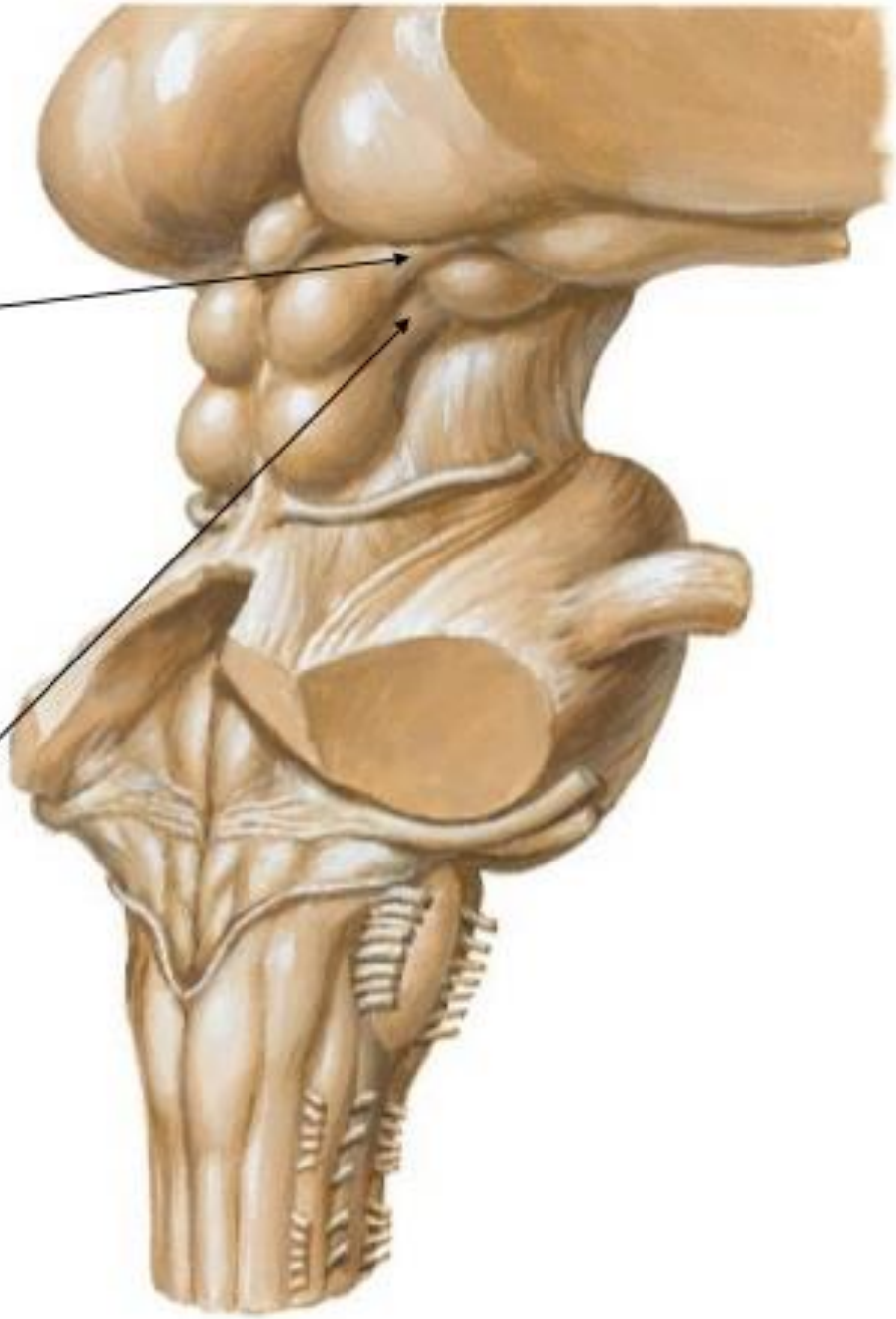
- The superior brachium coming from the colliculus extends laterally to connect the superior colliculus to the ***lateral geniculate body***..



- On the lateral aspect of the midbrain,

3. Superior brachium passes from the superior colliculus to the lateral geniculate body and the optic tract.

4. Inferior brachium connects the inferior colliculus to the medial geniculate body.



Superior Colliculus

Function: **reflex turning of eyes and neck in response to visual, auditory and cutaneous stimuli.**

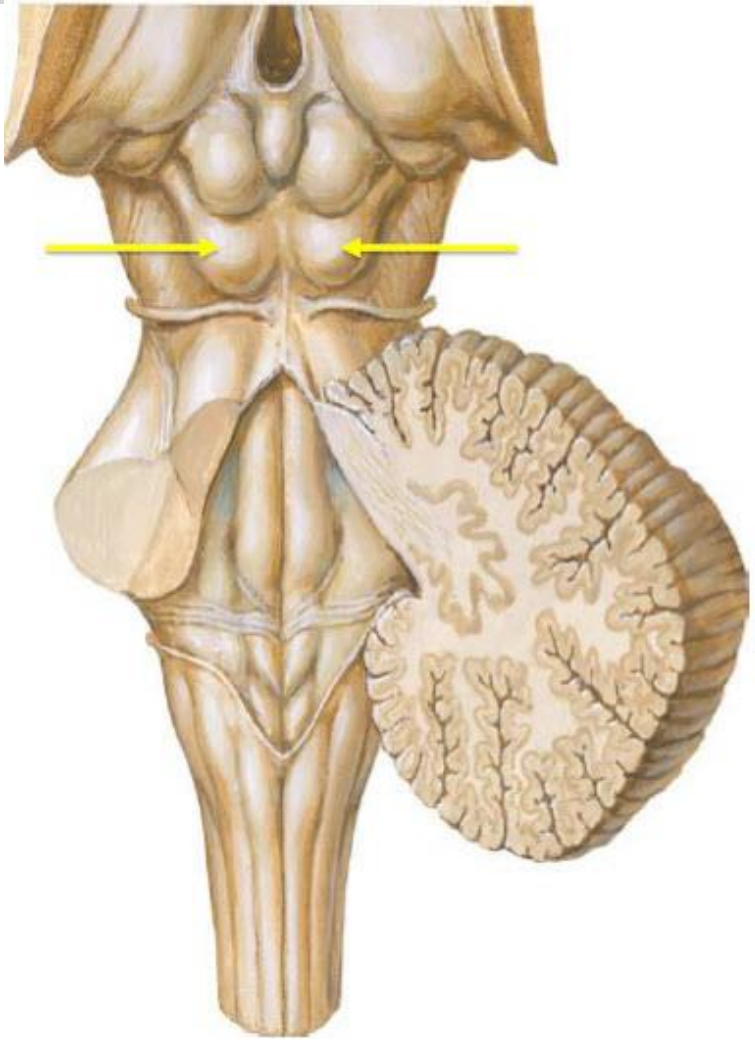
Afferent: **LGB (vision), inferior colliculus (auditory) and spinotectal tract (cutaneous).**

Efferent: **tectospinal & tectonuclear** (to 3rd , 4th , 6th) both cross in the dorsal tegmental decussation

Inferior Colliculus

- Principal midbrain nucleus of the auditory pathway and receives input from several peripheral brainstem nuclei in the auditory pathway (***lateral Lemniscus***), as well as inputs from the auditory cortex. ***(Afferents)***

- Inferior colliculus pass to the ***medial geniculate body*** and to the ***superior colliculus*** for reflex turning of neck and eyes via the tectospinal & tectonuclear tracts ***(Efferents)***

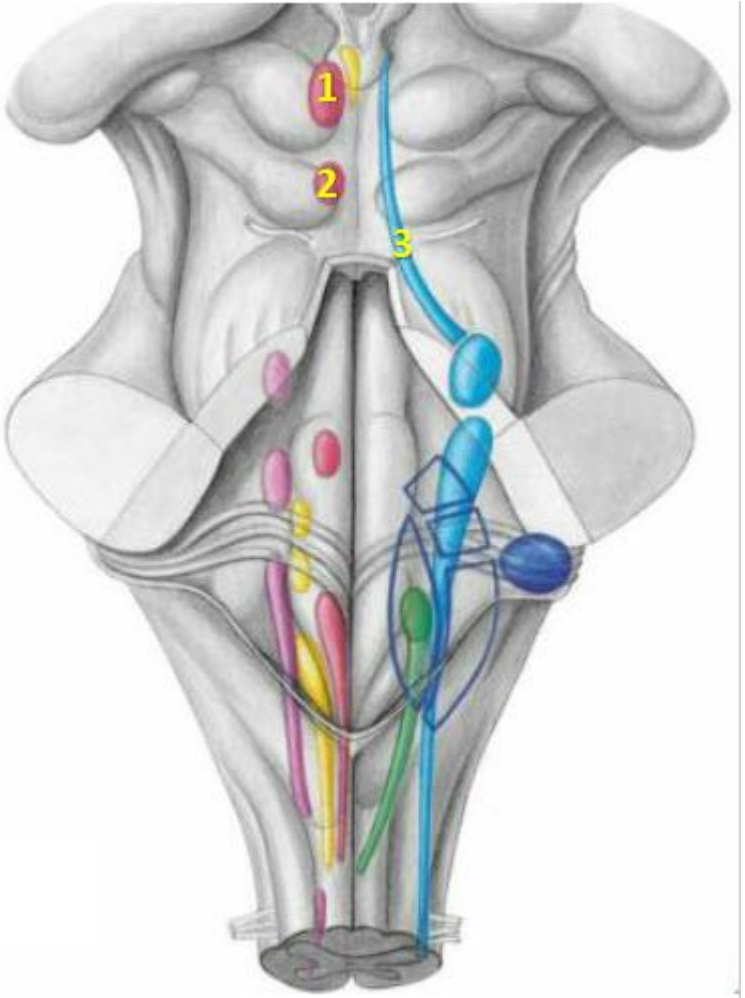


Nuclei of Midbrain – Level of Inferior Colliculus

1. ***The nucleus of the trochlear nerve*** (level with the inferior colliculi). The fibers of the ***trochlear nerve decussate in the superior medullary velum***

2. ***The mesencephalic nucleus of the trigeminal nerve*** extends along the entire length of the aqueduct in the whole length of the midbrain

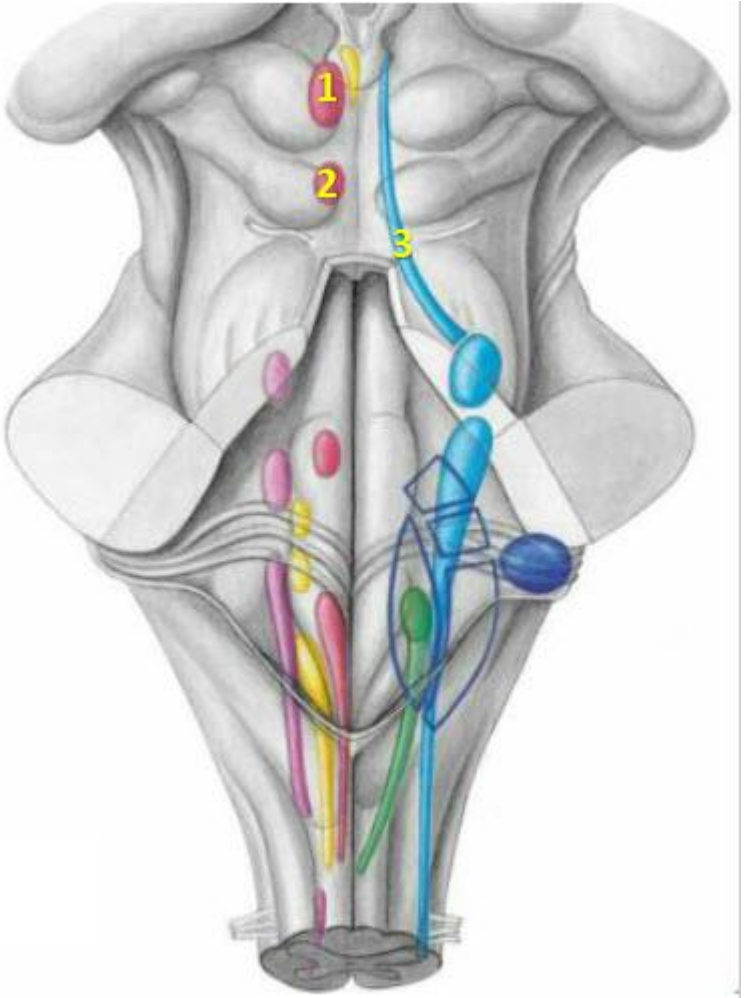
3. **Decussation of the superior cerebellar peduncles** (dentato-thalamic fibers) in the midline.



Nuclei of Midbrain – Level of Superior Colliculus

1. ***The nuclei of oculomotor nerve*** fibers of the oculomotor nerve passes anteriorly through the red nucleus to emerge on the medial side of the crus cerebri

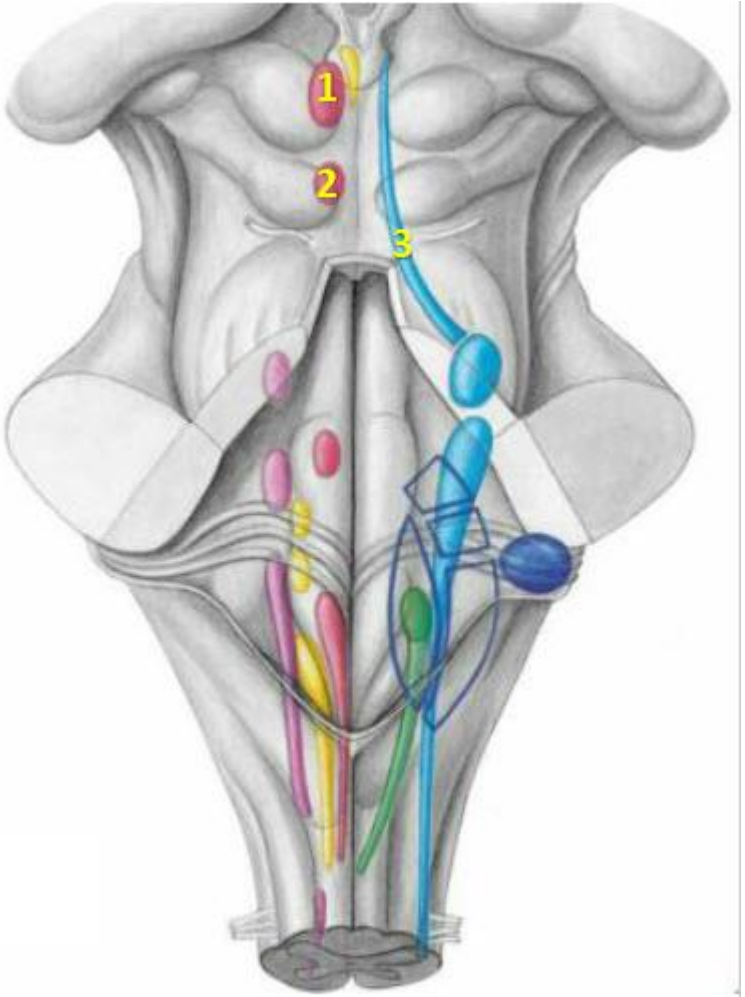
2. ***Pretectal nucleus:*** Lies just rostral to the superior colliculus, receives fibers from ipsilateral retina and send fibers to Edinger-Westphal nucleus of both sides



Nuclei of Midbrain – Level of Superior Colliculus

3. Edinger-Westphal nucleus

Part of oculomotor nucleus, send parasympathetic fibers with oculomotor nerve the ciliary and constrictor pupillary muscles of the eye



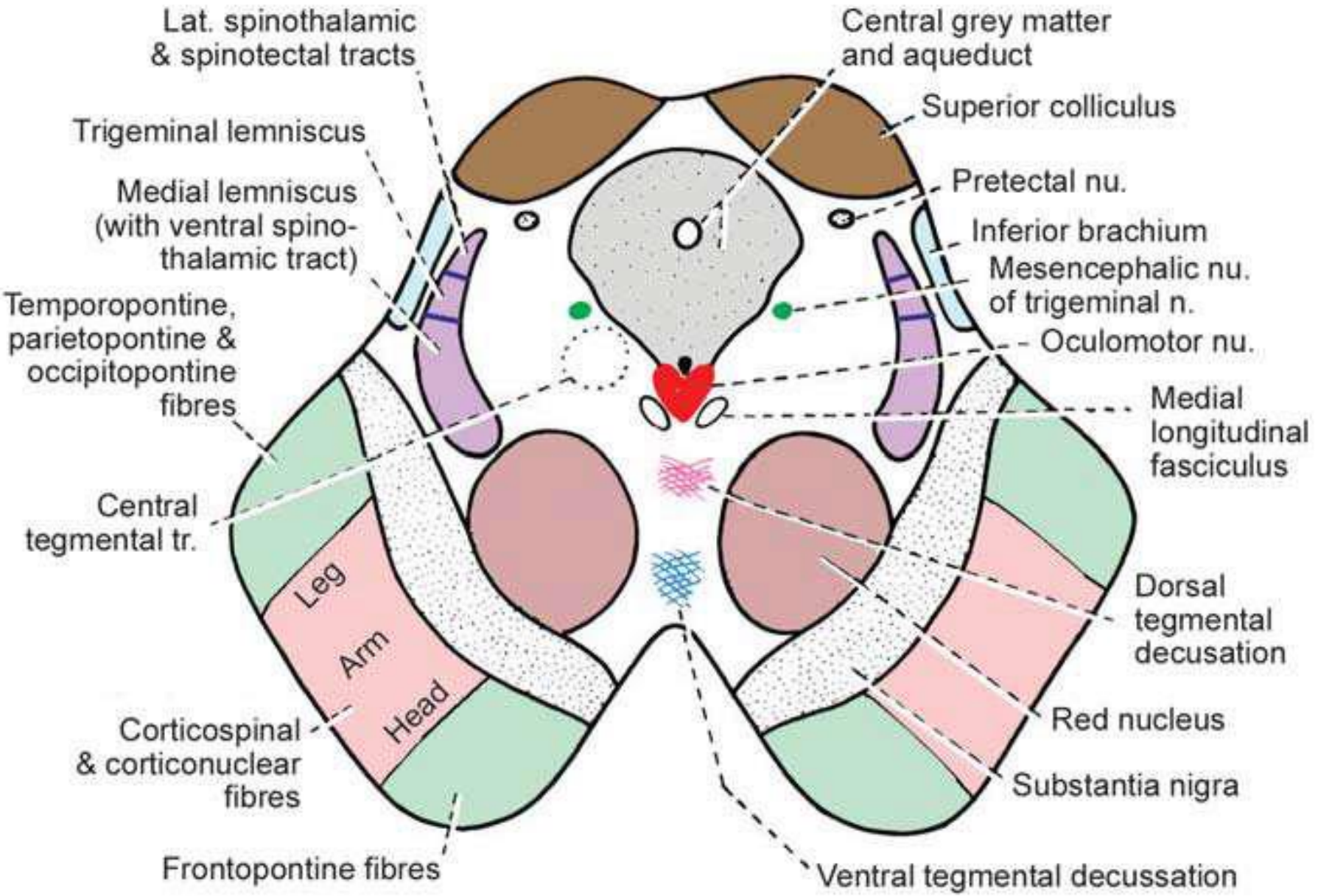
The structures (pretectal nucleus and Edinger-Westphal nucleus) are parts of the ***pupillary light reflex.***

Tegmentum – Red Nucleus

- It is located in the tegmentum of the midbrain next to the substantia nigra. (***Most posterior to the cerebral peduncle***)

- Structure present in the superior midbrain involved in motor coordination

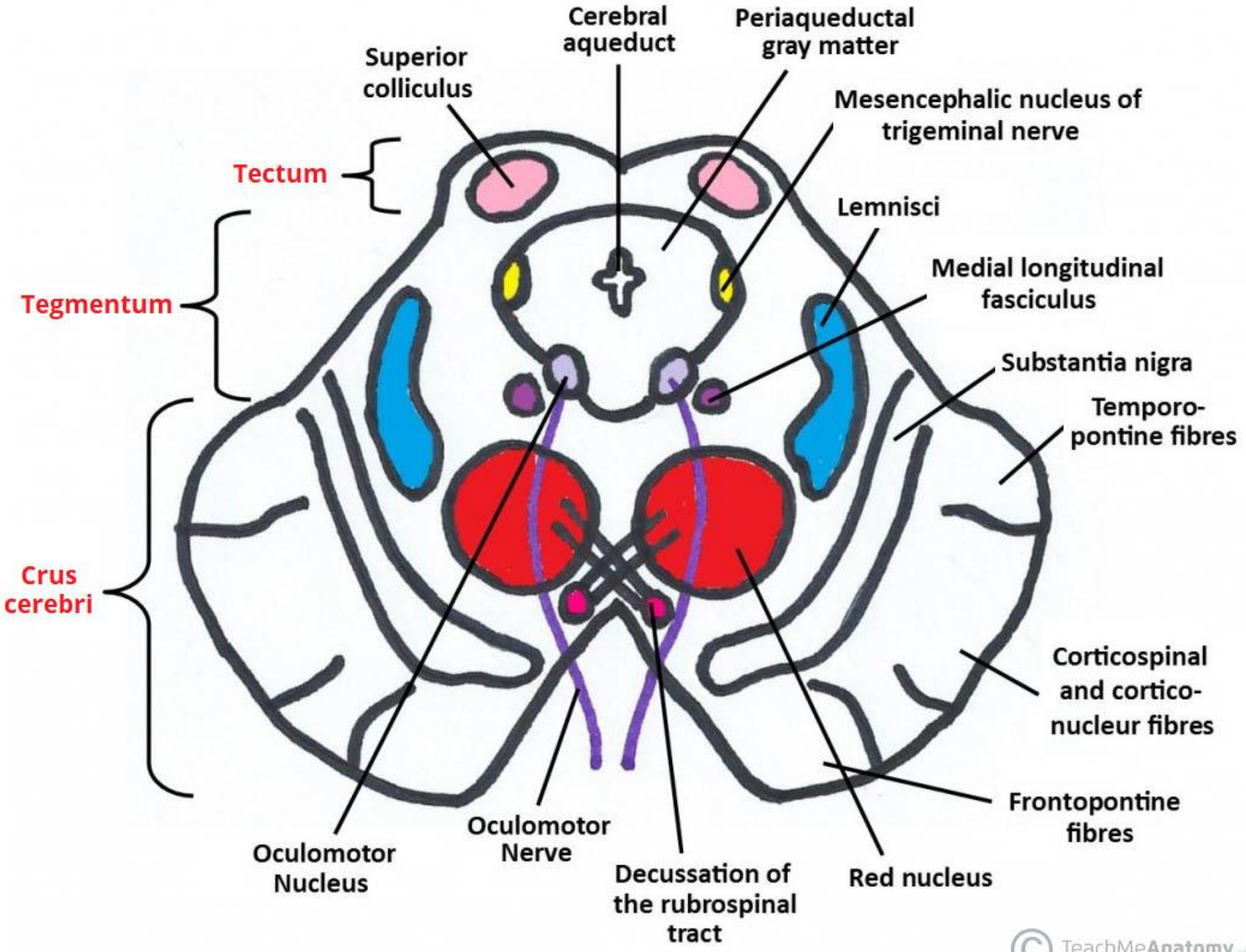
- The red nucleus and substantia nigra are subcortical centers of the extrapyramidal motor system.


Lat. spinothalamic & spinotectal tracts
Central grey matter and aqueduct
Superior colliculus
Trigeminal lemniscus
Medial lemniscus (with ventral spino-thalamic tract)
Pretectal nu.
Inferior brachium
Mesencephalic nu. of trigeminal n.
Temporopontine, parietopontine & occipitopontine fibres
Oculomotor nu.
Medial longitudinal fasciculus
Central tegmental tr.
Leg
Arm
Head
Dorsal tegmental decusation
Red nucleus
Corticospinal & corticonuclear fibres
Substantia nigra
Frontopontine fibres
Ventral tegmental decussation

Tegmentum – Red Nucleus

- It is pale pink in color; the color is believed to be due to iron, which is present in the red nucleus in at least two different forms: ***hemoglobin and ferritin***

- The red nucleus is less important in motor functions than in many other mammals where the corticospinal is more dominant.



Red Nucleus

- The red nucleus plays an additional role in controlling muscles of the shoulder and upper arm.

- Therefore, the crawling of babies is controlled by the red nucleus and movements as in arm swinging of typical walking.

Red Nucleus

Caudal magnocellular part:

➢ Receives cerebro-rubral and cerebello-rubral fibers and sends rubro-spinal tract that crosses in the ventral tegmental decussation.

➢ ***Function:*** facilitation of flexor muscles in distal limbs.

Cranial parvocellular part:

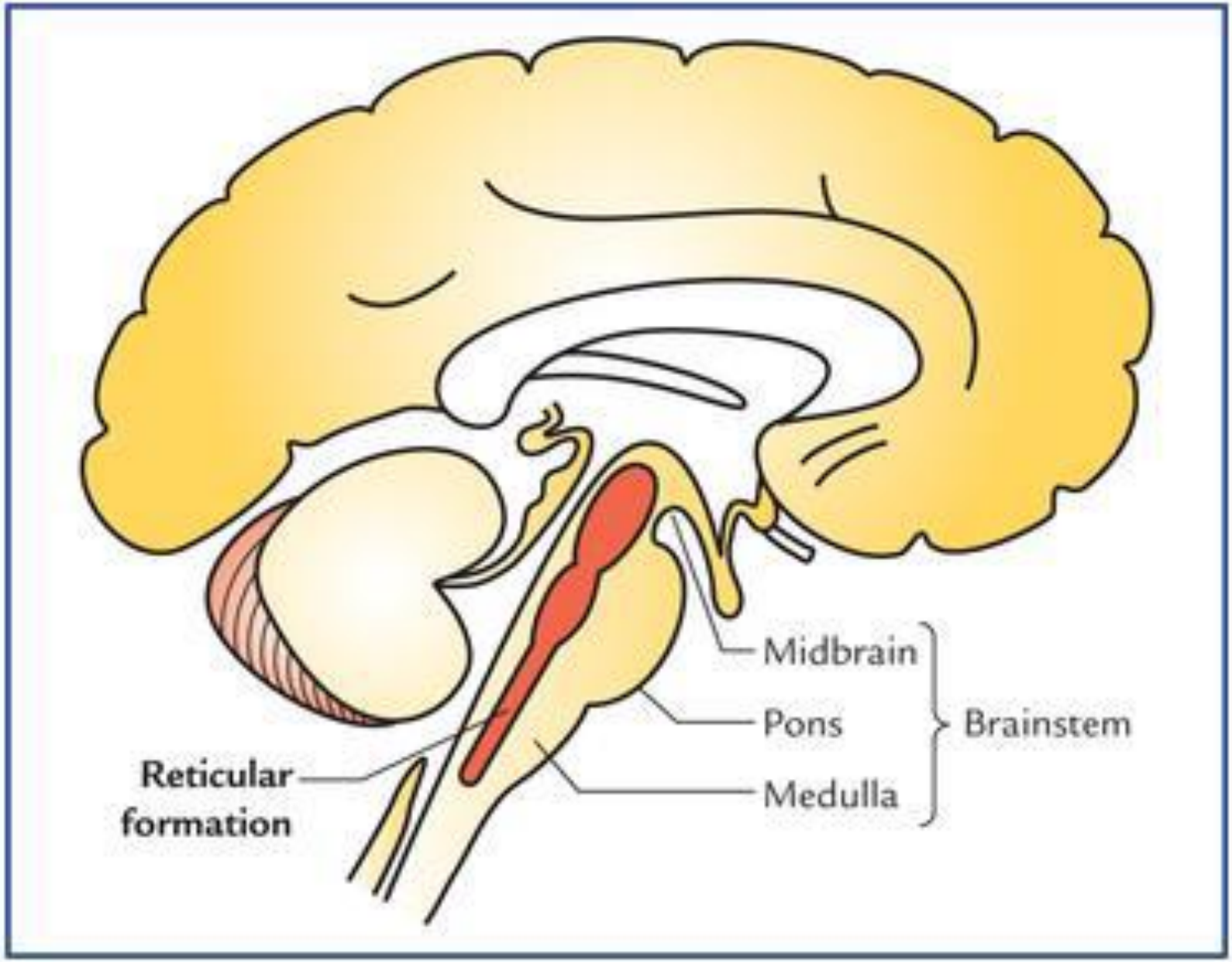
➢ Connects the motor cortex with the cerebellum via the inferior olive.

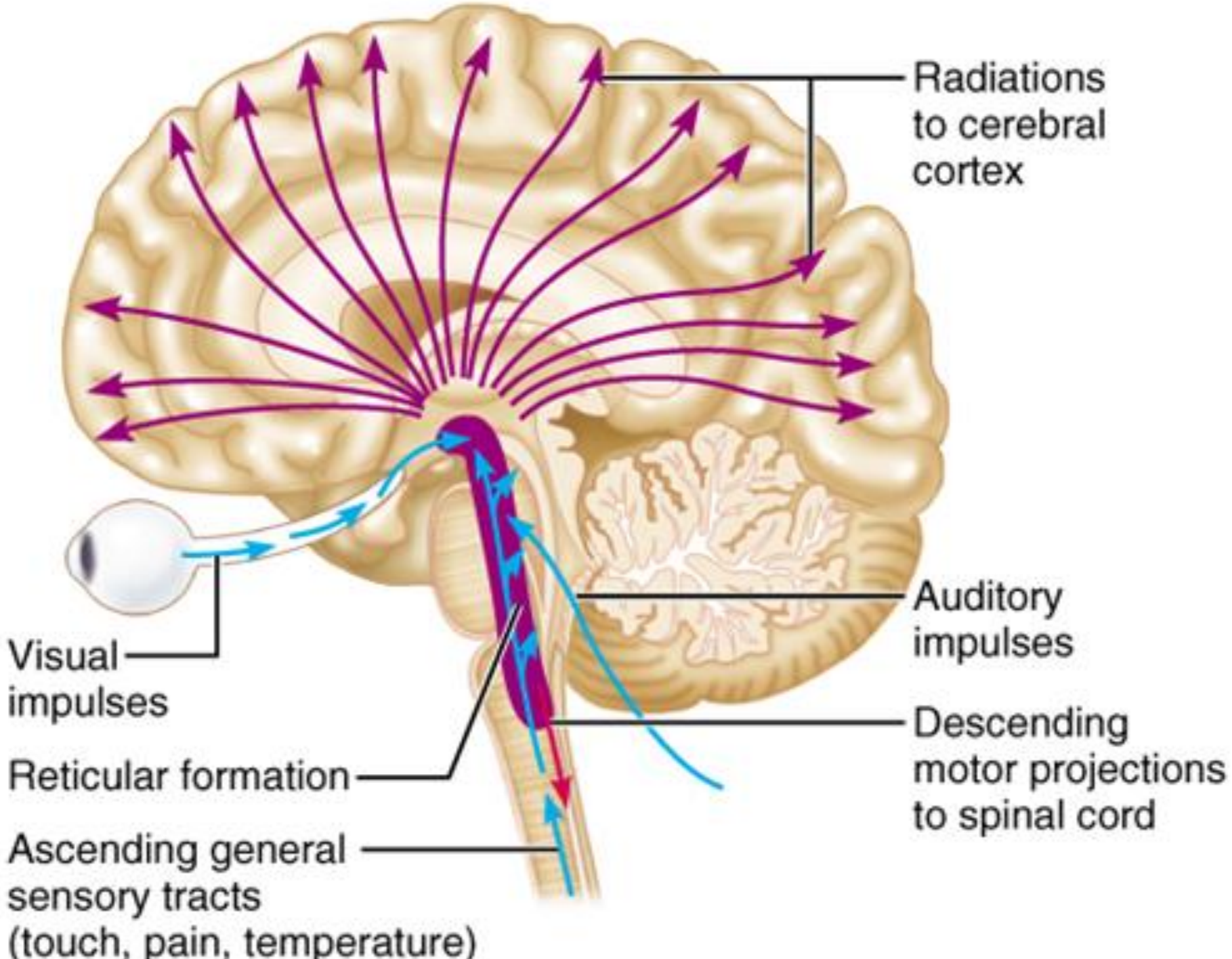
➢ ***Function:*** motor learning

Reticular Formation

- The term reticular formation was originally used to designate areas of the central nervous system which were ***not occupied by well defined nuclei or fiber bundles***, but consisted of a network of fibers within which scattered neurons were situated.

Such areas are to be found at all levels in the nervous system


Midbrain
Pons
Medulla
Brainstem
Reticular formation


Radiations to cerebral cortex
Auditory impulses
Descending motor projections to spinal cord
Visual impulses
Reticular formation
Ascending general sensory tracts (touch, pain, temperature)

Reticular Formation (RF)

- Gray and white mater
- More in the tegmentum (midbrain)
- Upward connection thalamus and cortex ***"reticular activating system (RAS)"***
- Downward connection -> to spinal cord (***reticulospinal tracts***).

RF is filter for stimuli !!

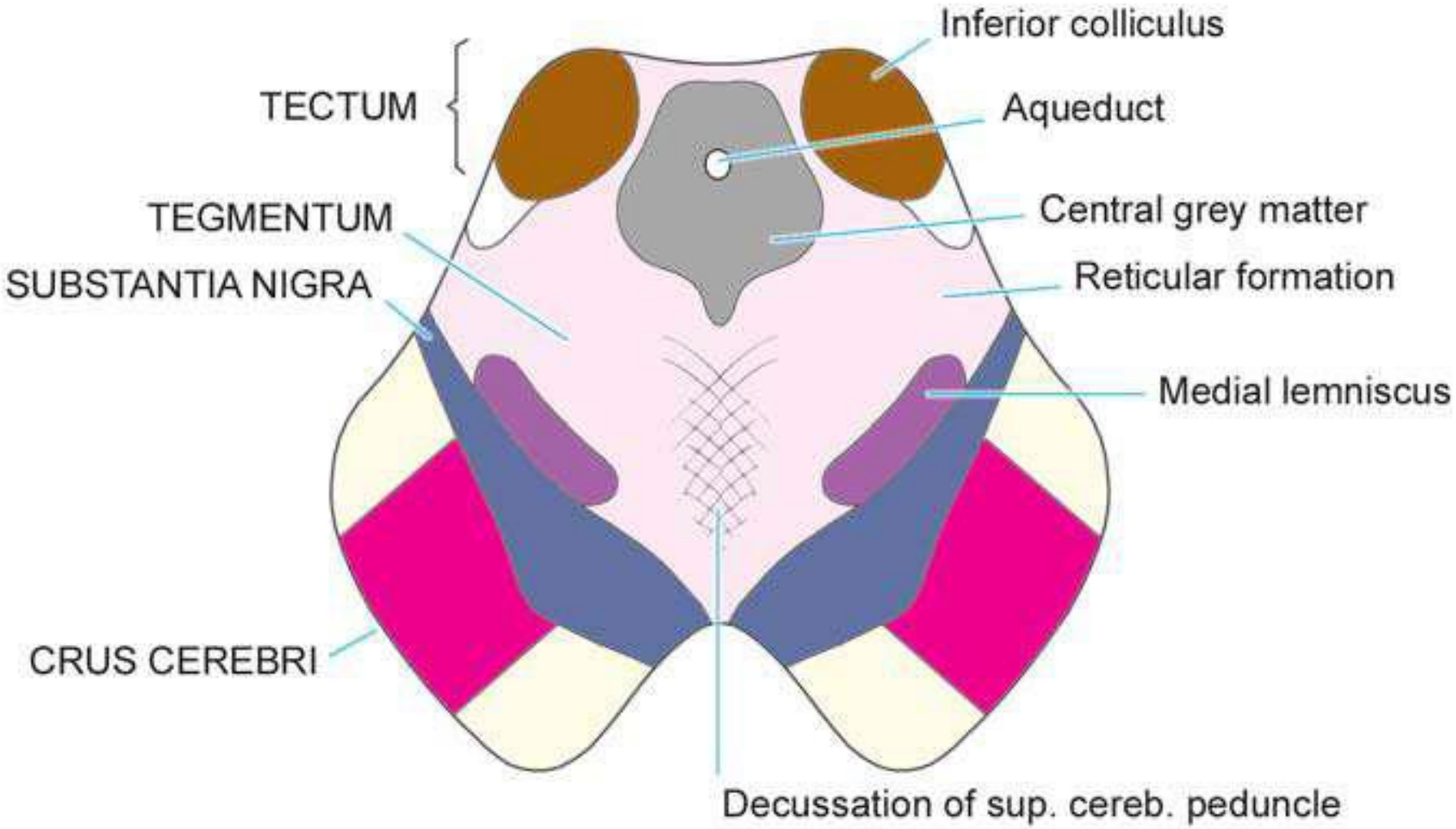
Reticular Formation (RF)

It has a number of important functions i.e. ***Respiratory and Cardio- vascular centers*** are located in the medullary and caudal pontine reticular formation.

Reticular neurons have ***long ascending*** and ***descending axons*** that allow profuse interaction with other neuronal systems.

Reticular Formation (RF)

- Prevent repetitive stimuli, Enhance infrequent stimuli, allow important repetitive stimuli for example the pain stimuli and involved with sleep
- General anesthesia drugs act on reticular formation
- Unless inhibited by other brain regions, it activates the cerebral cortex – keeping it alert and awake.
- Analgesic drugs have one of its mechanism action through the RF


Inferior colliculus
TECTUM
Aqueduct
TEGMENTUM
Central grey matter
SUBSTANTIA NIGRA
Reticular formation
Medial lemniscus
CRUS CEREBRI
Decussation of sup. cereb. peduncle

Reticular Formation (RF)

Raphe Nuclei:

- Midline reticular nuclei.
- 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***.

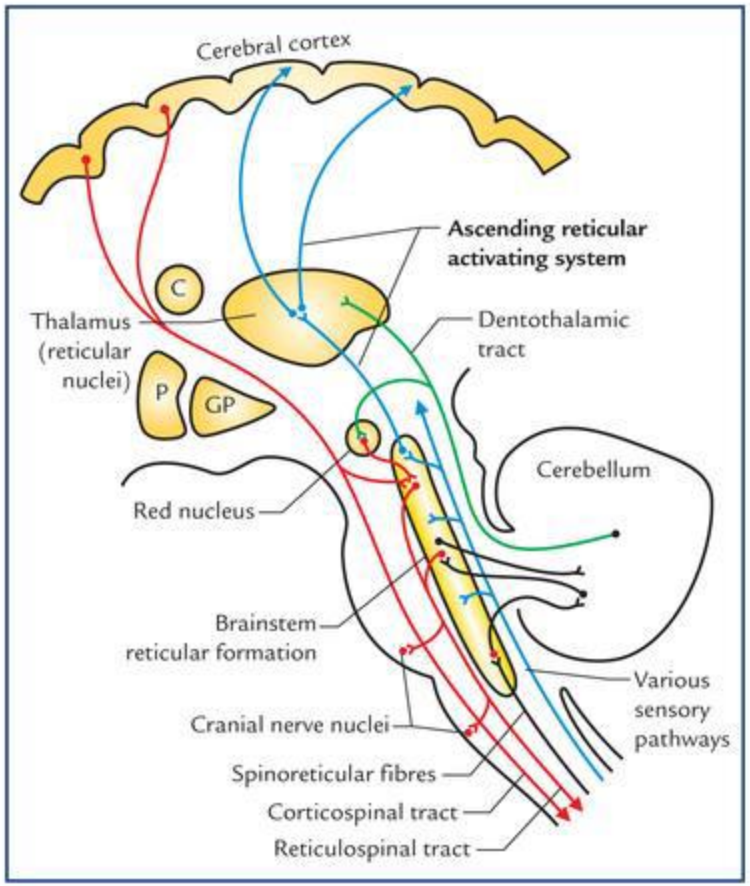
Locus Coeruleus:

- Pigmented neurons that lie in the tegmentum of the lower mid brain & upper pons
- It is the main noradrenergic cell group of the brain. The locus coeruleus is the ***principal site for brain synthesis of norepinephrine***

RF - Connection

- ***Afferent from***

1. Various sensory pathways and systems
2. Other parts of CNS
3. Factors influencing the activity of RF (e.g. drugs and hormones)

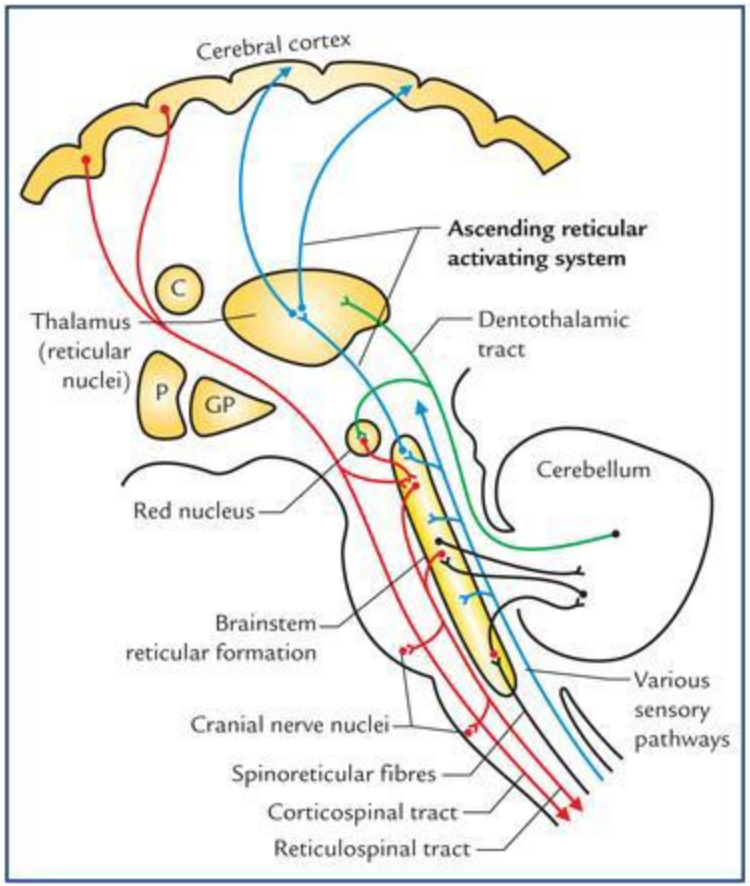


RF - Connection

- ***Efferent to***

1. Autonomic and locomotor control centers of brainstem and spinal cord.

2. Cranial nerve nuclei, e.g. dorsal nucleus of vagus.

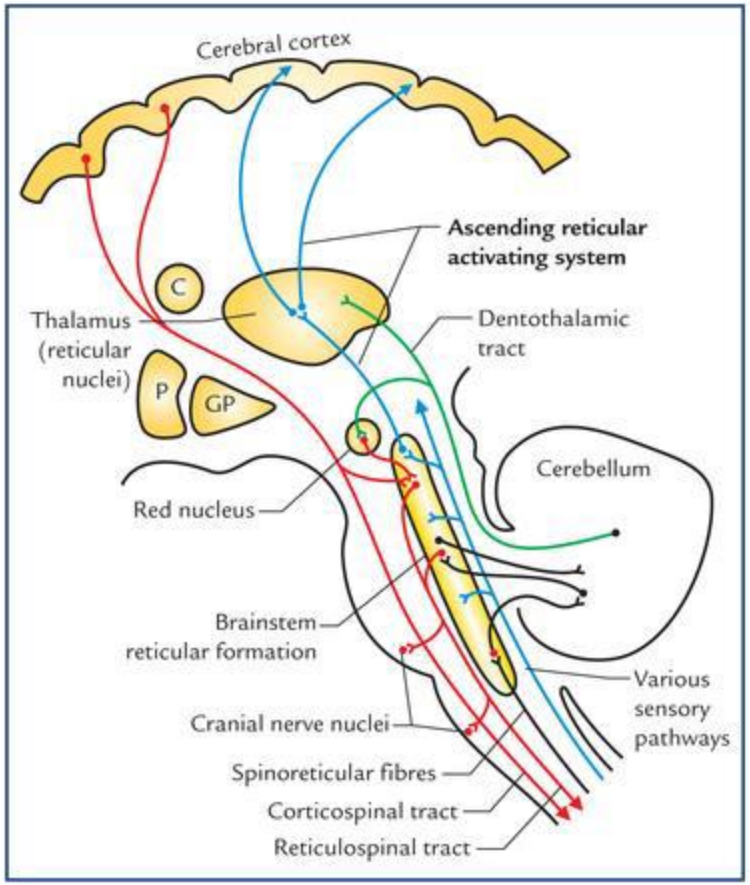


RF - Connection

- ***Efferent to***

3. Cerebral cortex—indirectly through diencephalic nuclei.

4. Red nucleus, substantia nigra and tectum of midbrain.



RAS - Functions

1- Control of consciousness

Promotes wakefulness by generalized activation of the entire brain

1. The RF receives fibers the reticulospinal tract and collateral from all major ascending sensory tracts.

2. Certain reticular neurons send a continuous stream of impulses to the cerebral cortex either directly or by relay in the thalamus; thereby maintaining the cerebral cortex in an alert state (the arousal of the brain).

Unless inhibited by other brain regions, the RAS activates the cerebral cortex, keeping it alert and awake

RAS - Functions

The activity of the RAS is ***inhibited by sleep centers in the hypothalamus*** and other neural regions.

It can be affected by general anesthesia, alcohol, tranquilizers, and sleep-inducing drugs.

Damage to the RAS limits arousal and can result in coma.

RAS - Functions

2- Habituation

The RAS also acts as a filter to dampen repetitive, familiar, or weak signals.

In this process the brain learns to ignore repetitive, meaningless stimuli while remaining sensitive to others.

It is estimated that 99% of all sensory stimuli is disregarded as unimportant

Reticulospinal Tracts

3- Control of voluntary muscles

The RF mediate indirect effect of each of the cerebral cortex, basal ganglia and the cerebellum to the lower motor neuron in the ventral horn of the spinal cord. (via medial and lateral reticulospinal tracts).

Reticulospinal Tracts

2- Control of involuntary muscles

The RF mediate indirect effect of the hypothalamus on the ***sympathetic and parasympathetic centers*** which supply the voluntary muscles.

The hypothalamus send fibers to the RF, at the same time the RF through the lateral reticulospinal tract to the sympathetic (T1-L2) and parasympathetic (S2-S4) horns in spinal cord.

The RF also send fibers to the parasympathetic nuclei in the brain stem.

Reticulospinal Tracts

3- Control of respiration

Decrease oxygen in blood → stimulate the **chemoreceptors carotid body** → send impulse via glossopharyngeal to solitary nucleus → the **solitary nucleus** send fibers to the **respiratory center in the RF** of medulla → The respiratory center sends reticulospinal fibers to **stimulate the spinal segments that supply the respiratory muscles** (ex: C3-C5: phrenic neve) → increase respiratory rate.

Reticulospinal Tracts

4- Control of cardiovascular activity

High blood pressure → stimulate the ***baroreceptors*** in ***carotid sinus*** and aortic arch → send impulse via ***glossopharyngeal*** and ***vagus*** nerves to ***solitary nucleus***, which indirectly via RF, ***stimulate*** in the ***parasympathetic*** neurons in the dorsal motor nucleus of ***vagus nerve***, and ***inhibit*** the ***sympathetic neurons*** in the spinal cord → ***decrease heart rate*** and cause ***vasodilatation***.

Reticulospinal Tracts

5- Pain Modulation

The RF has inhibitory effect on pain transmission in the dorsal horn of spinal cord.

Fibers arise from raphe nuclei descend to the ***dorsal horn of spinal cord*** where they inhibit pain transmission.

Midbrain Lesions

Weber's syndrome

Midbrain Lesion that destroy the **oculomotor nerve and the corticospinal tract, leads to:**

IPSI LATERALLY

Squint with lateral deviation caused by paralysis of the eye muscles supplied by the oculomotor nerve due to the effect of unopposed action of lateral rectus muscle (supplied by the abducent nerve).

Midbrain Lesions

Weber's syndrome (Cont.)

Ptosis due to paralysis in levator palpebrae superioris.

Mydriasis due to paralysis of the constrictor pupillary muscle.

CONTRALATERALY

Hemiplegia due to damage of the corticospinal tract, characterized by contralateral spastic paralysis with increased muscle tone and exaggerated tendon jerks.

- For further inquiries ***PLZ*** feel free to contact at any time through email

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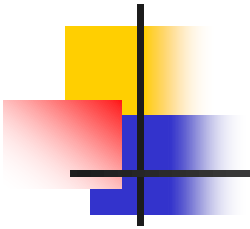

Thank You