

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

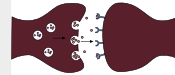


Brain Stem (pt. 1)

MID | Lecture 6

إِنِّي تَوَكَّلْتُ عَلَى اللَّهِ رَبِّي وَرَبِّكُمْ مَا مِنْ دَابَّةٍ إِلَّا هُوَ آخِذٌ بِنَاصِيَتِهَا إِنَّ رَبِّي عَلَى صِرَاطٍ مُسْتَقِيمٍ

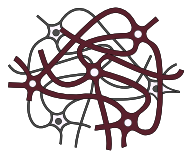
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ANATOMY



رحلة اليقين مع سورة يس

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وَمَا لِي لَا أَعْبُدُ الَّذِي فَطَرَنِي وَإِلَيْهِ تُرْجَعُونَ (٢٢)

فكأن قومه لم يقبلوا نصحه، بل عادوا لائمين له على اتباع الرسل، وإخلاص الدين لله وحده، فقال: { وَمَا لِي لَا أَعْبُدُ الَّذِي فَطَرَنِي وَإِلَيْهِ تُرْجَعُونَ } أي: وما المانع لي من عبادة من هو المستحق للعبادة، لأنه الذي فطرنى، وخلقني، ورزقني، وإليه مآل جميع الخلق، فيجازيهم بأعمالهم، فالذي بيده الخلق والرزق، والحكم بين العباد، في الدنيا والآخرة، هو الذي يستحق أن يعبد، ويثنى عليه ويمجد، دون من لا يملك نفعا ولا ضرا، ولا عطاء ولا منعا، ولا حياة ولا موتا ولا نشورا.

Introduction

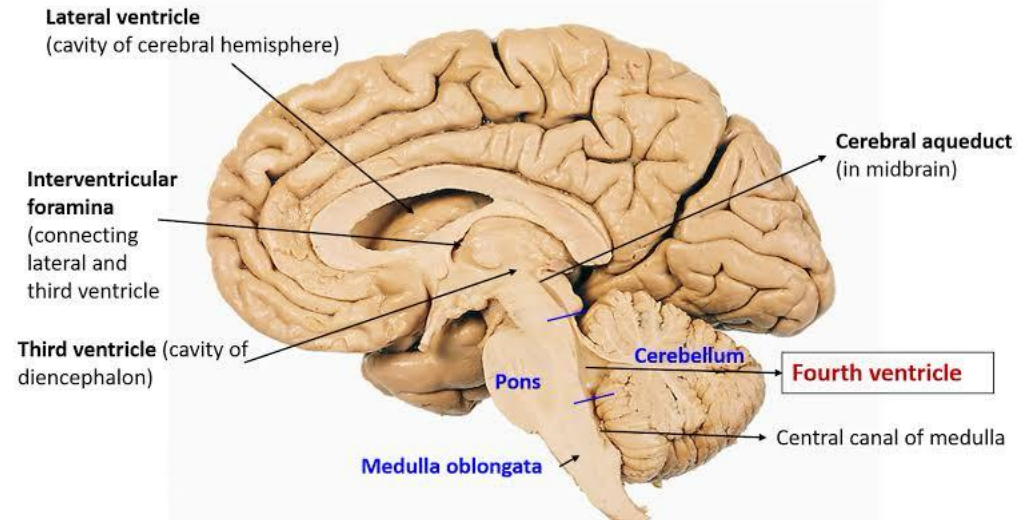
➤ Brain is divided into hindbrain, midbrain, forebrain.

➤ Hindbrain consists of:

1) cerebellum

2) Pons

3) medulla oblongata



➤ The cavity of hindbrain is called: fourth ventricle, which separates Cerebellum from pons and medulla oblongata anteriorly

Brain stem

- Stalk like in shape
- Connects spinal cord to higher centers of forebrain

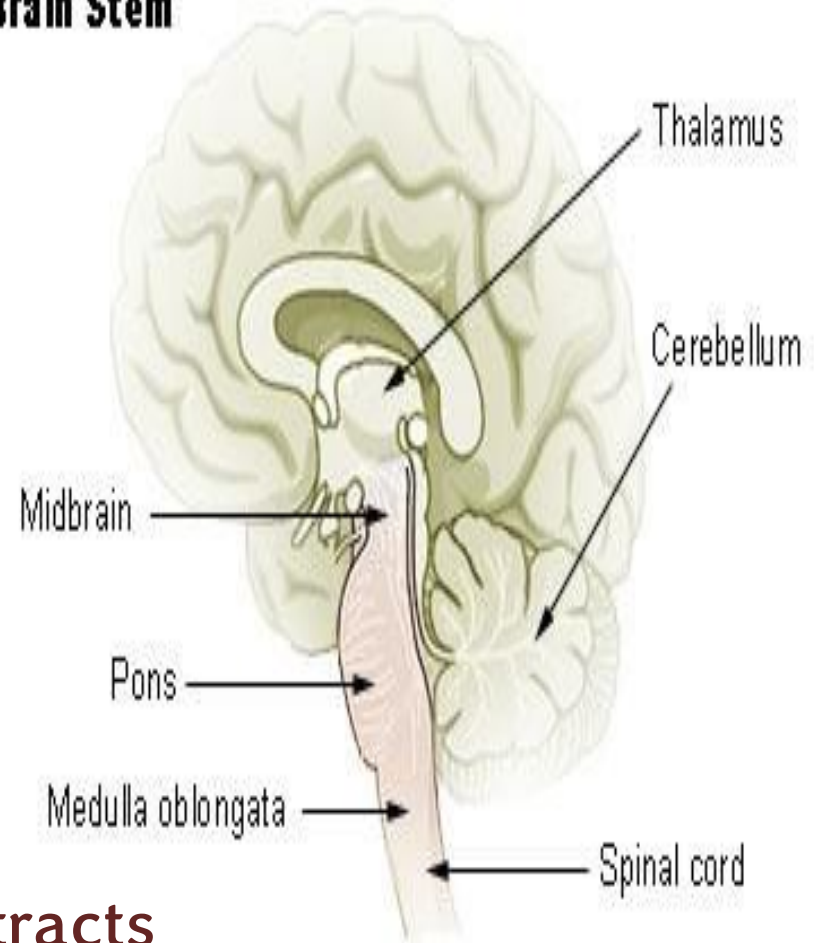
Parts:

1. Medulla oblongata (lowest level)
2. Pons
3. Midbrain (highest level)

These parts are **functionally similar** in :

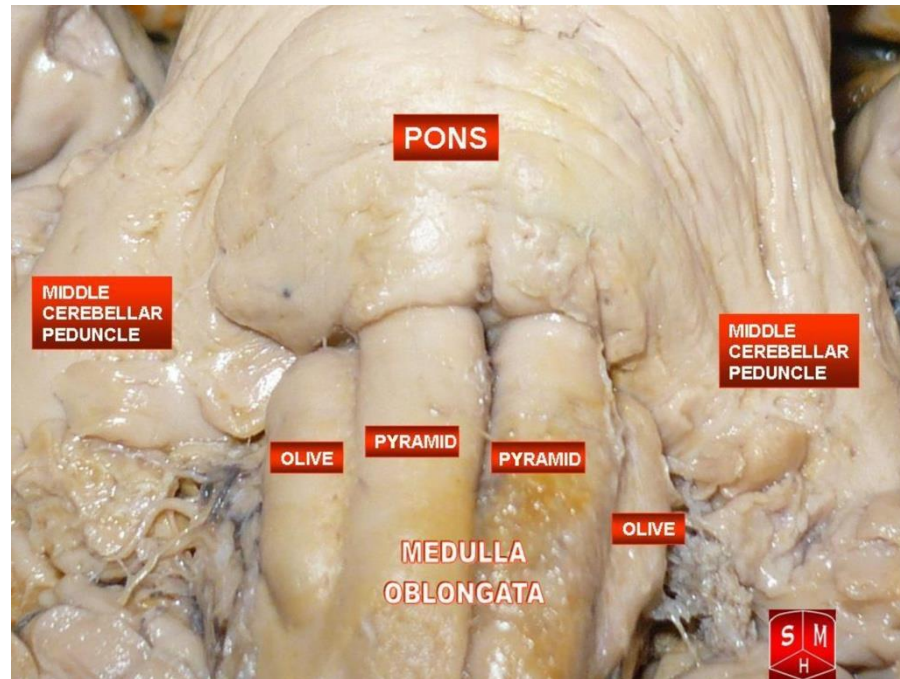
- passage of ascending and descending tracts
- nuclei of cranial nerves, 10 out of 12 cranial nerves originate from brainstem
- vital centers.

Brain Stem



Brain stem

- **Pyramids:** 2 bulges on the anterior surface of medulla oblongata, which corticospinal (pyramidal) tracts are related to.
- **Olives:** 2 bulges lateral to pyramids, far away from midline.
- **Pontomedullary junction :** separates medulla oblongata from pons.

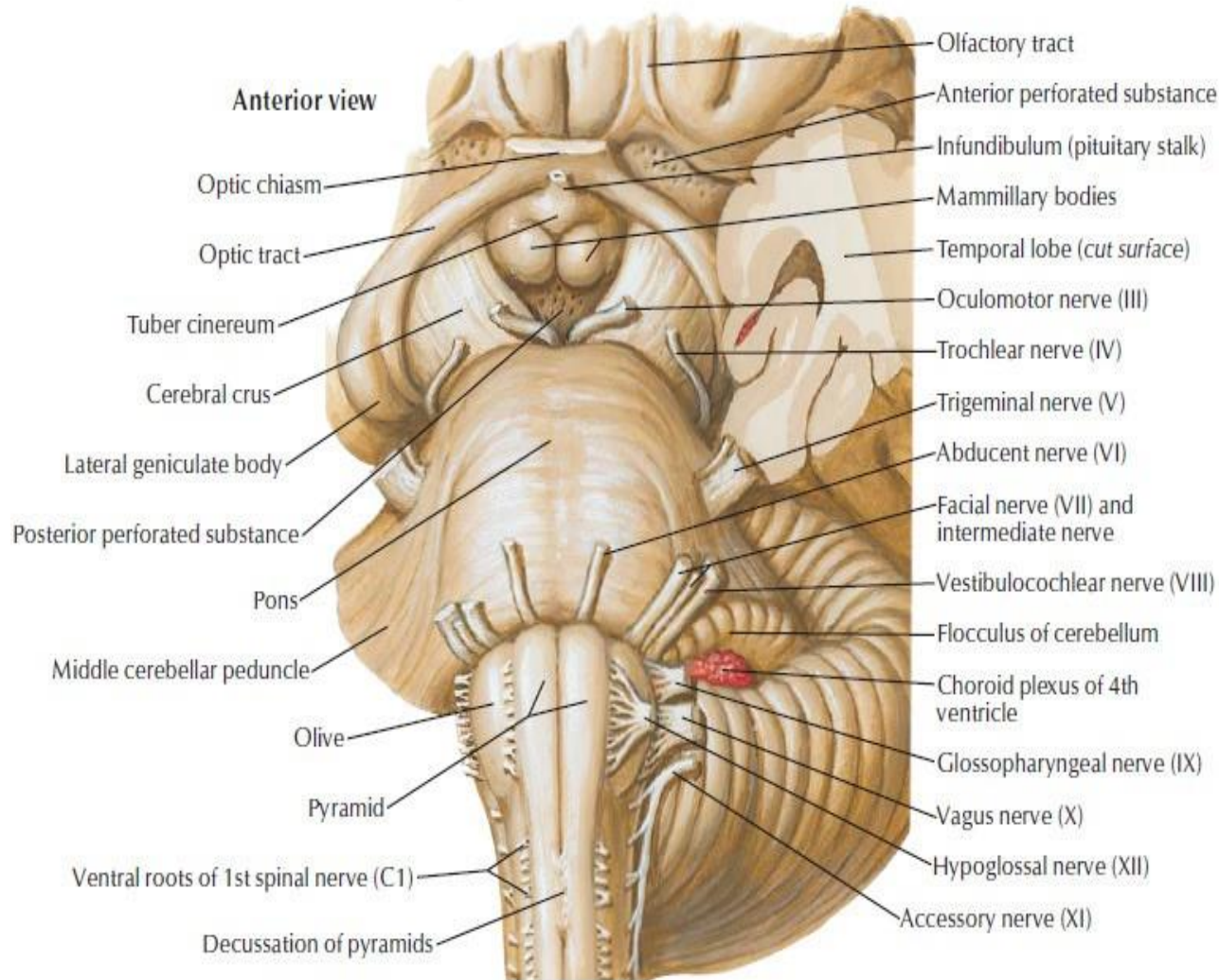


Cranial nerves in the brain stem region

- The midbrain gives rise to CN3 & CN4.
- The mid-pontine area of the pons gives rise to CN5.
- The pontomedullary junction of the pons gives rise to CN6, CN7, CN8
- The medulla oblongata gives rise to CN9, CN10, CN11, CN12.

- The trochlear nerve (CN4) is the only nerve that arises from the posterior aspect of the brainstem (midbrain).

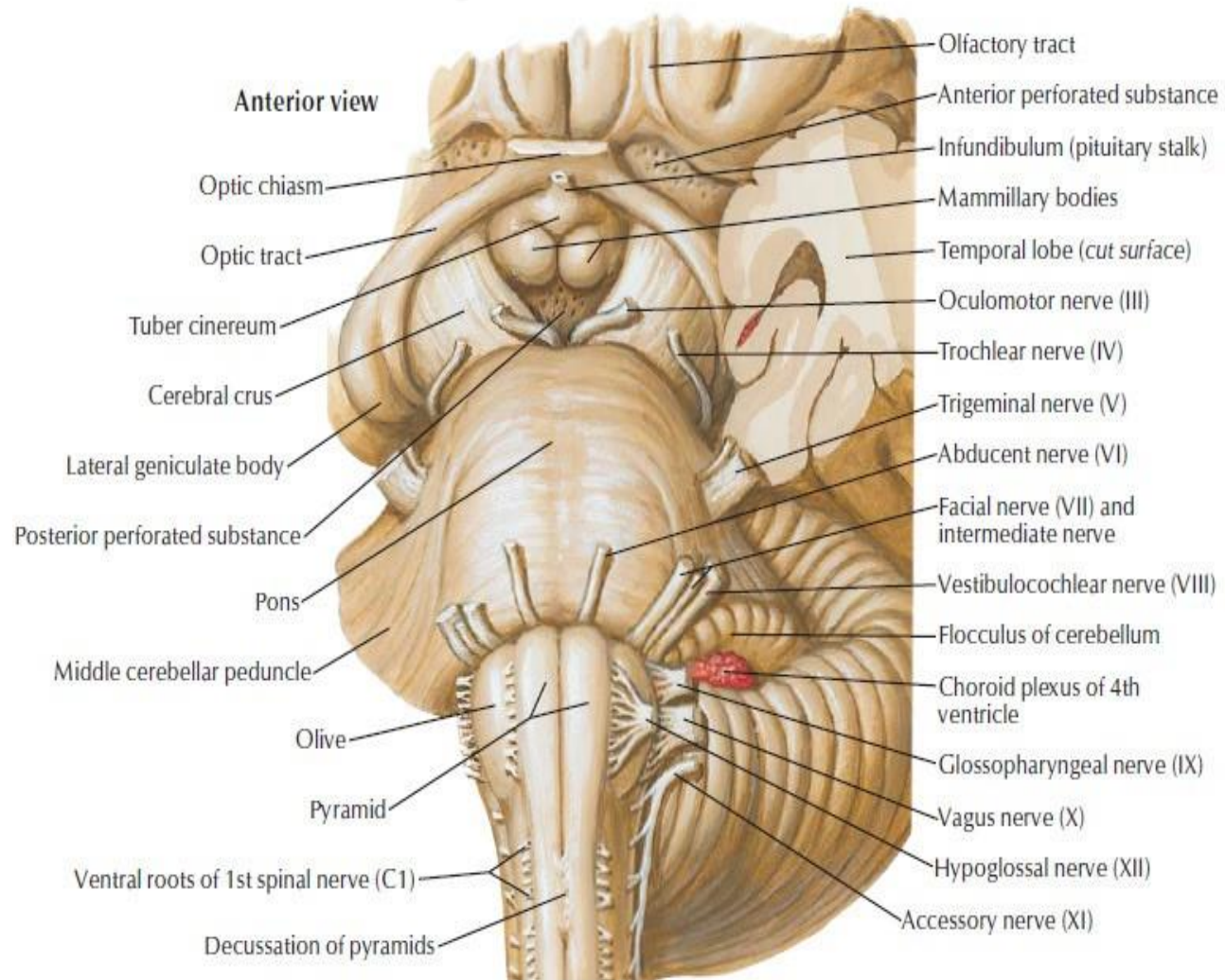
- The oculomotor (CN3) arise from interpeduncular fossa which is called cerebral (not cerebellar) peduncles, which represent the anterior aspect of midbrain.



I	Olfactory nerve	VII	Facial nerve
II	Optic nerve	VIII	Vestibulocochlear nerve
III	Oculomotor nerve	IX	Glossopharyngeal nerve
IV	Trochlear nerve	X	Vagus nerve
V	Trigeminal nerve	XI	Accessory nerve
VI	Abducens nerve	XII	Hypoglossal nerve

Cranial nerves in the brain stem region

- The hypoglossal nerve is the only nerve that arises from the groove found between the olive and the pyramid (anterolateral groove). Whereas the glossopharyngeal (CN9), Vagus (CN10), and Accessory (CN11) all arise from the groove between the inferior cerebellar peduncle and the olive (posterolateral groove).



I	Olfactory nerve	VII	Facial nerve
II	Optic nerve	VIII	Vestibulocochlear nerve
III	Oculomotor nerve	IX	Glossopharyngeal nerve
IV	Trochlear nerve	X	Vagus nerve
V	Trigeminal nerve	XI	Accessory nerve
VI	Abducens nerve	XII	Hypoglossal nerve

Internal structure of medulla

- Levels of medulla oblongata from the inferior to the superior:
 1. Level of decussation of pyramids (motor / close medulla)
 2. Level of decussation of lemnisci (sensory/ close medulla)
 3. Level of olives (open medulla)
 4. Level Just Inferior to the Pons
- **Note:** Sometimes we can consider them 3 layers as 3&4 are functionally similar.

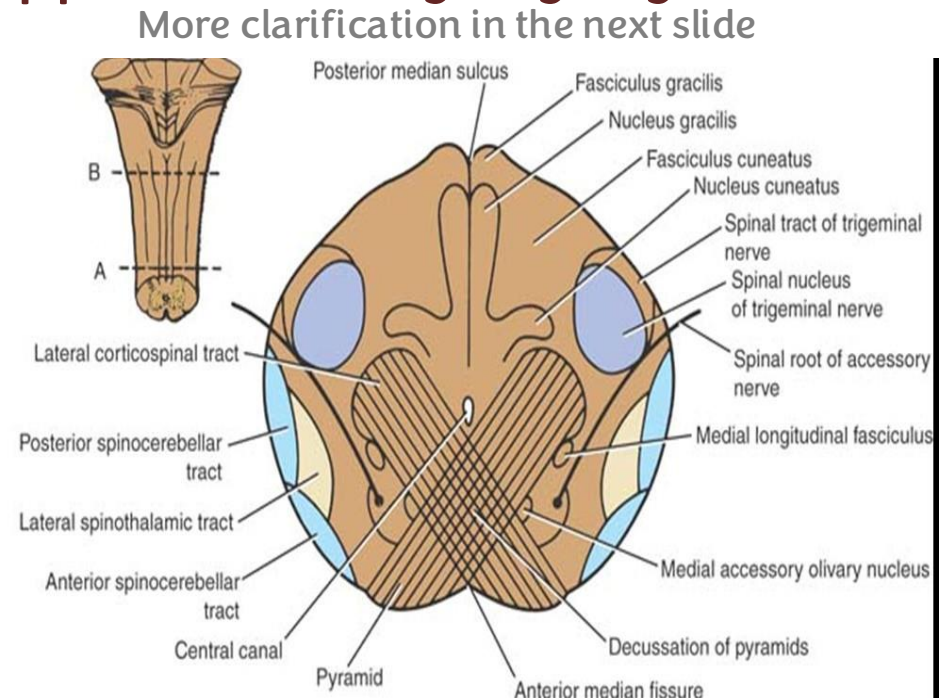
Before we discuss the medullary internal structure you should know :

- The 4th ventricle is bounded anteriorly by pons and medulla oblongata, and posteriorly by cerebellum.

So the ventricle has

a) Floor related to the pons and only the upper part of the medulla oblongata. (If you take a cross section of pyramidal and sensory decussations, you won't see the 4th ventricle; instead, the central canal appears. The 4th ventricle appears at a slightly higher level.)).

b) Roof related to the cerebellum



Before we discuss the medullary internal structure you should know :

The CNS embryological origin is a tube, so wherever a cross section is taken along the CNS, you will see a cavity.

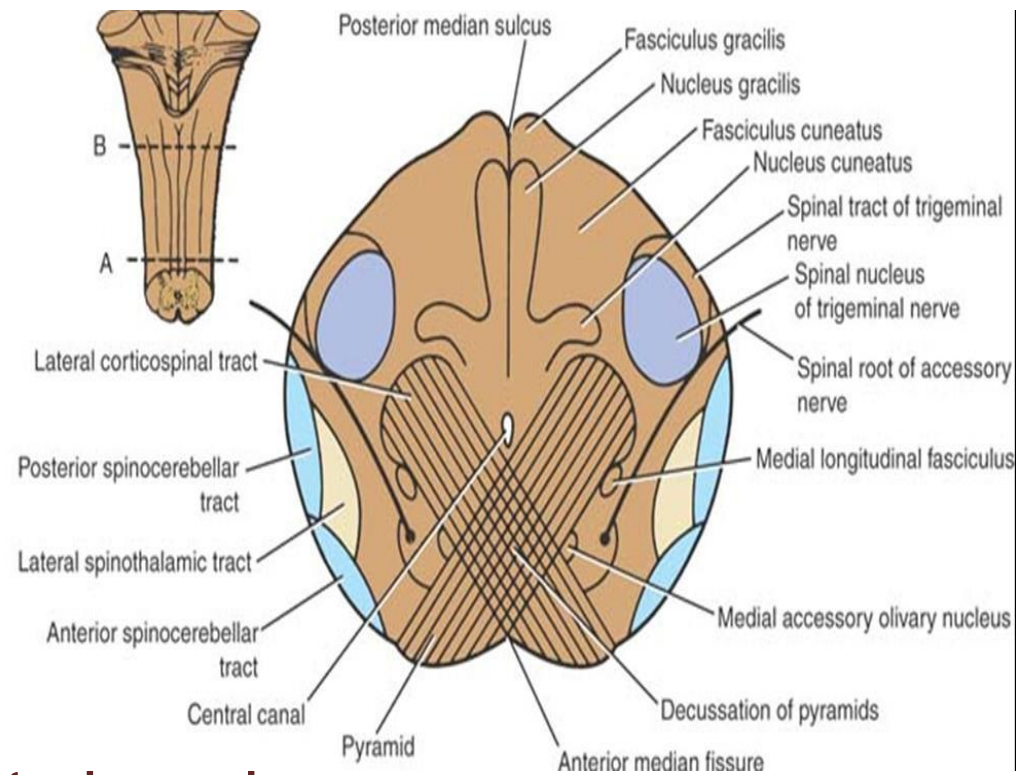
If you take a section in... you will see...:
spinal cord → central canal

Lower part of medulla oblongata → central canal

Upper part of medulla oblongata → ventricle

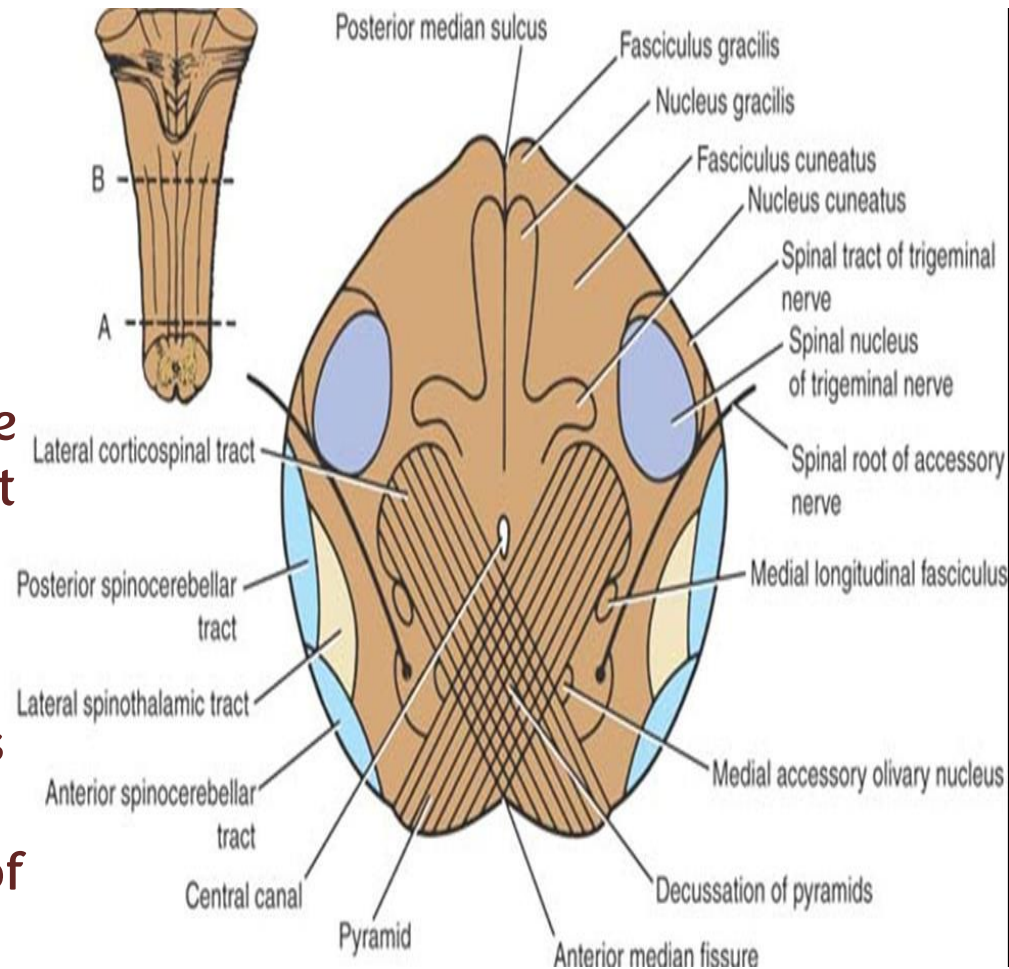
That means if you take a section in...

pyramidal or lemniscate (sensory) decussation, you will see the central canal; here, it is called **closed medulla**. But if the section is taken at the level of olives and inferior pons, you see the 4th ventricle, which is called **open medulla**.



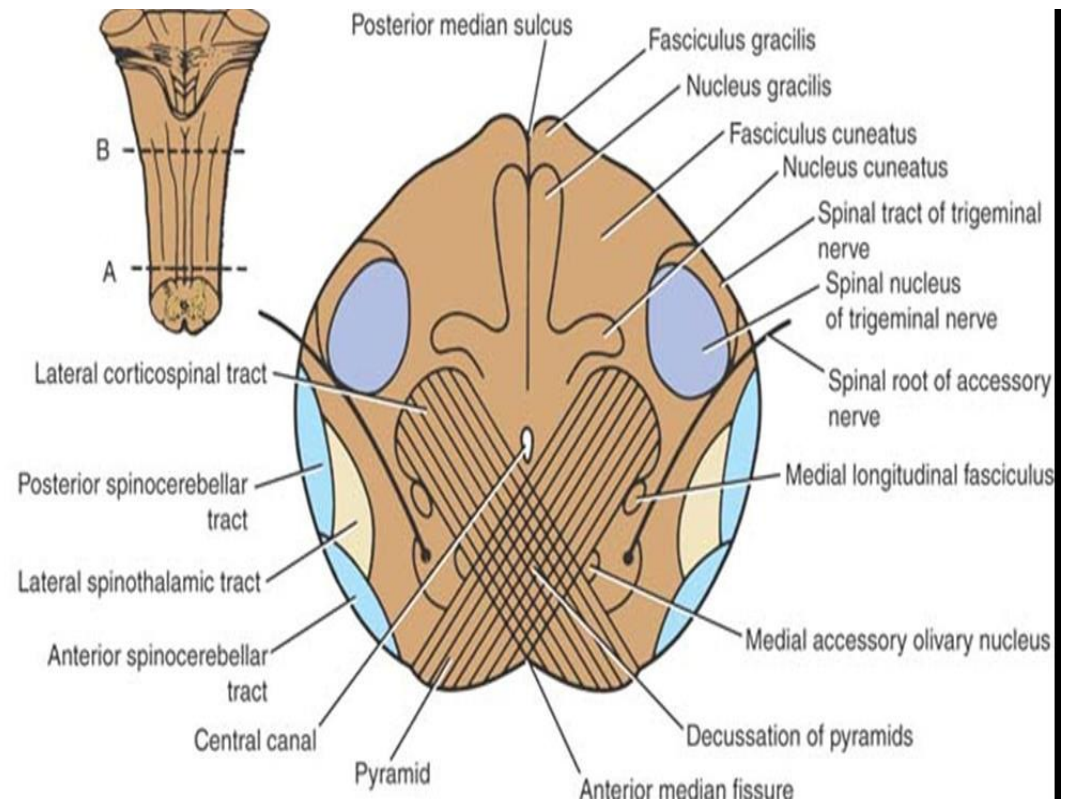
Level of decussation of pyramids

- The cavity of this level is the **central canal**.
- Posterior to the central canal, there is the **nucleus gracilis**, **nucleus cuneatus**, **fasciculus gracilis**, and **fasciculus cuneatus**.
- This level of decussation resembles the spinal cord; changes are not dramatic; the only difference is the nuclei that appear at this level.
- The name of this level comes from the pyramidal decussation in the midline; this decussation takes place anterior to the central canal. These fibers are the fibers of the lateral corticospinal tract.
- The anterolateral system remains almost unchanged.
- The **spinal nucleus of trigeminal** appears (discussed in the upcoming slides).



Level of decussation of pyramids

- Decussation of pyramids
- Posterior to the central canal, there are: Fasciculus gracilis and the fasciculus cuneatus (as in the spinal cord), nucleus gracilis and the nucleus cuneatus (posterior to the central gray matter; these are not seen in the spinal cord) .
- Spinal nucleus of the trigeminal nerve Go to next slide for details
- Central canal Cavity at this level
- The lateral and anterior white columns of the spinal cord are unchanged.

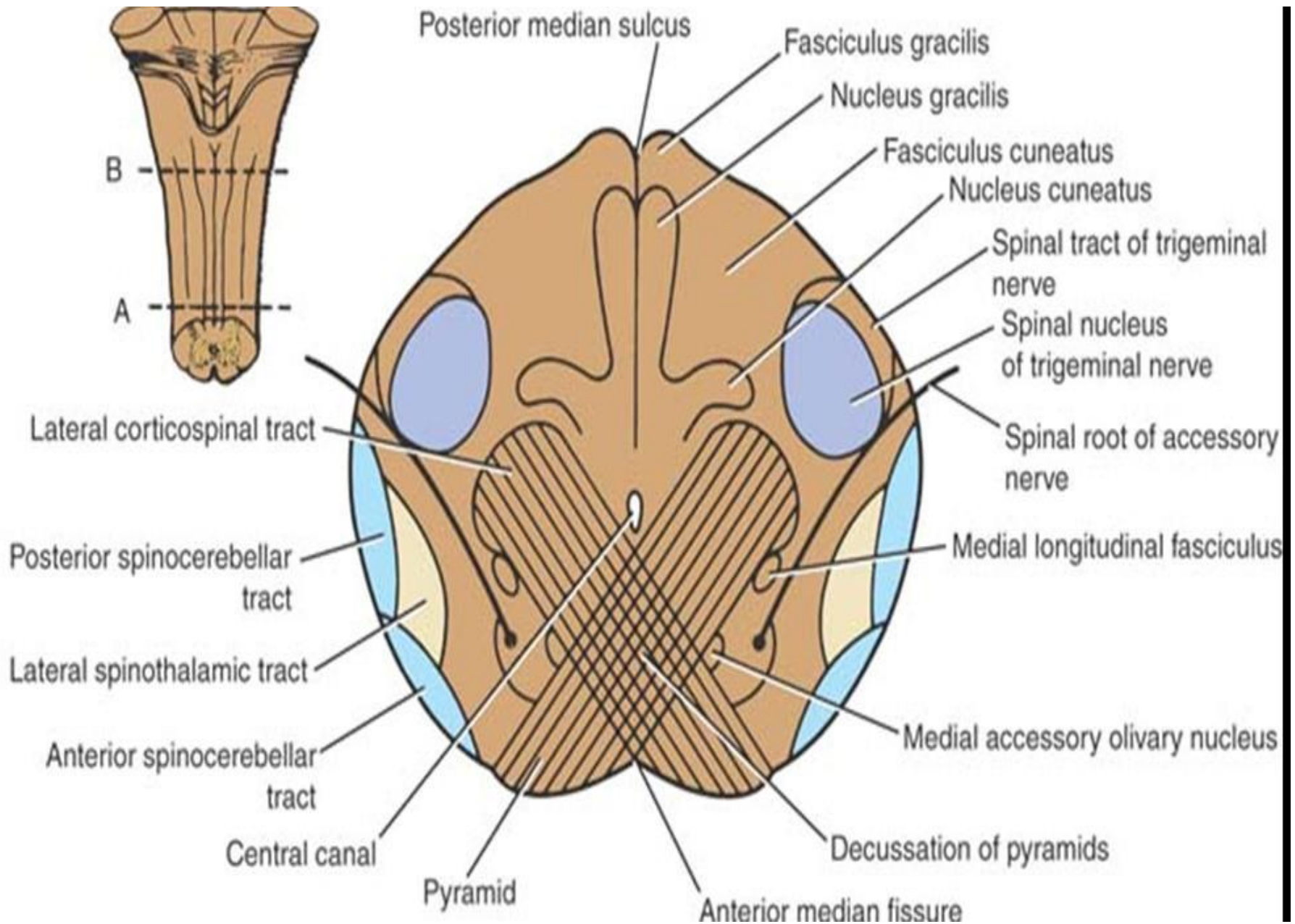


Trigeminal nerve and medulla oblongata

- the trigeminal nerve (CN5) arises from the mid pontine area of the pons but is there a nucleus for it in the medulla oblongata.
- The trigeminal nerve is a mixed nerve containing mainly sensory fibers for head and neck area, as well as some motor fibers (muscles of mastication). Thus, the trigeminal nerve has 3 sensory nuclei and 1 motor nucleus.
- The sensory nuclei (divided according to **modality, not by its divisions**) are :
 - (a) Mesencephalic nucleus of trigeminal nerve (in midbrain)
 - (b) Main sensory nucleus (in pons)
 - (c) Spinal nucleus of trigeminal nerve
- **The spinal nucleus of trigeminal** nerve is one of the sensory nuclei of the trigeminal nerve. It is responsible for pain, temperature similar to ALST* but for the head and neck area.
 - It is seen in this section due to its longitudinal arrangement which extends from the spinal cord (from substantia gelatinosa in laminae 1&2) hence its name, then to upper cervical segments up to the level of the mid-pontine area (where it's replaced by the main sensory nucleus).
 - Other cranial nerves, such as the Vagus, Glossopharyngeal, and the Facial nerve can relay some sensation to the spinal nucleus of trigeminal nerve. However, the majority of sensations to this nucleus is from the trigeminal nerve.

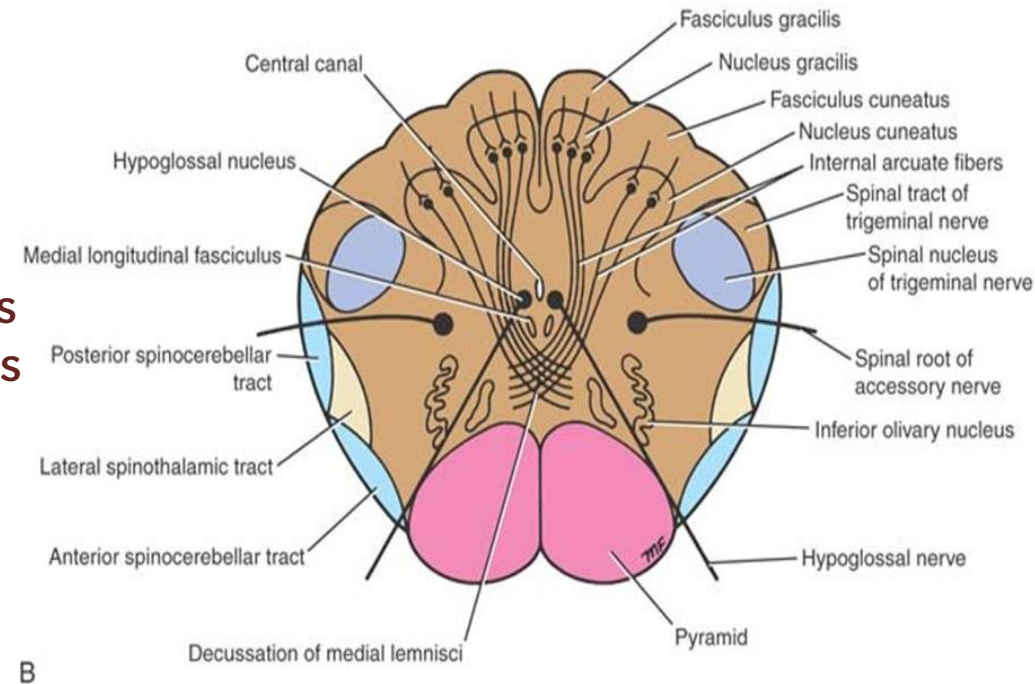
ALTS: anterolateral spinothalamic

Level of decussation of pyramids



Level of decussation of lemnisci

- The cavity of this section is: central canal.
- The most anterior and medial part of the section: pyramids.
- Nucleus gracilis, nucleus cuneatus, fasciculus gracilis, fasciculus cuneatus still visible at this level.
- The spinal lemniscus remains unchanged, (which is the spinothalamic and spinotectal pathways).
- Named lemniscal decussation because of the fibers that cross midline at this level, which are the internal arcuate fibers.
- Decussation takes place between central canal and pyramids.
- Spinal nucleus of trigeminal still visible due to its longitudinal shape.



Level of decussation of lemnisci

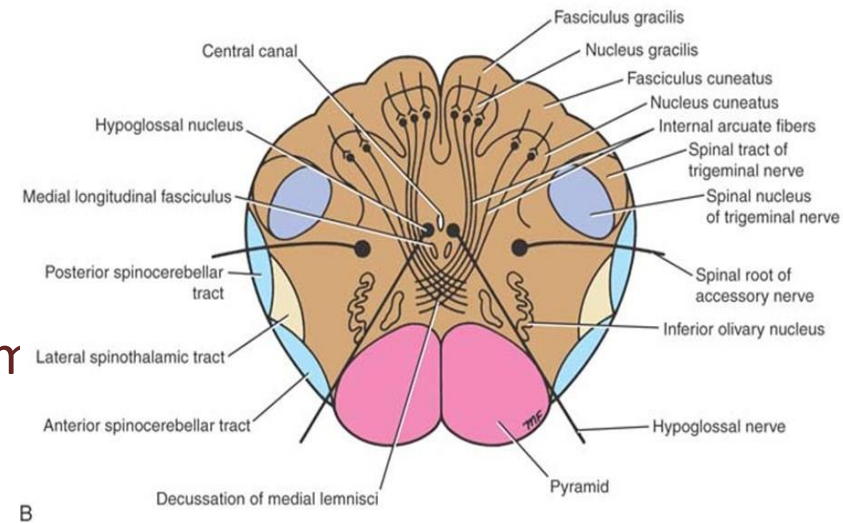
- What is the deficit if injury happened the right pyramid at the level of sensory decussation?
- Ans: motor deficit in the contralateral side(left side of the body), because the pyramidal corticospinal (motor) decussation below this level, they haven't crossed yet, and fibers are interrupted before they cross. In a nutshell, the fibers have not yet crossed at this level.

Short high-yield rule:

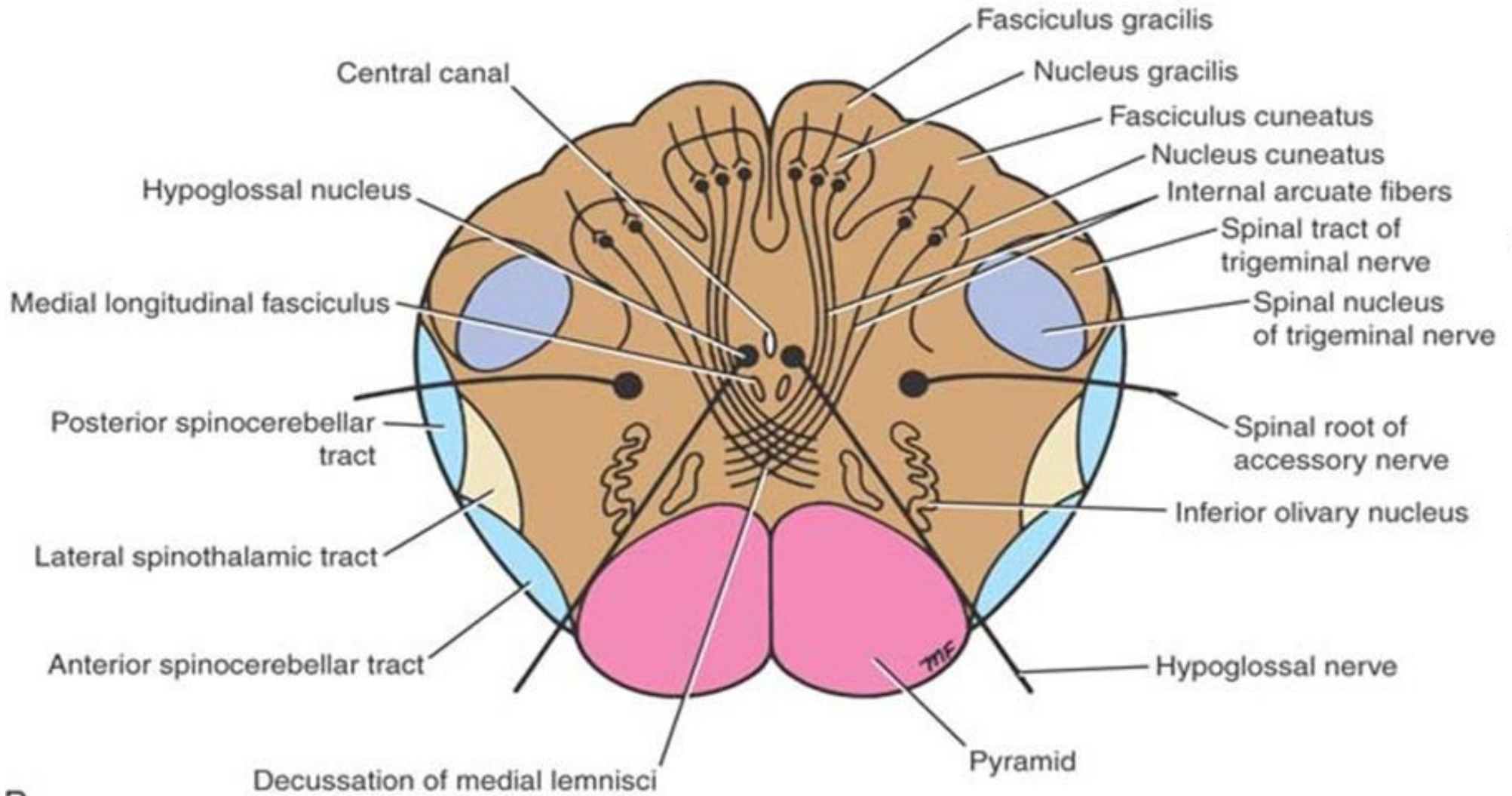
- Lesion ABOVE pyramidal decussation → Contralateral weakness
- Lesion BELOW pyramidal decussation → Ipsilateral weakness

Level of decussation of lemnisci

- Sensory decussation
- Lemnisci are formed by internal arcuate fibers
- internal arcuate fibers emerge from anterior aspect of nucleus gracilis and nucleus cuneatus, these fibers cross the midline and they are the second order neurons in posterior column system
- Decussation takes place posterior to pyramids, anterior to central canal
- Spinal nucleus of the trigeminal nerve (lateral to the internal arcuate fibers) still can be seen due to its longitudinal arrangement
- spinal lemniscus lateral to the decussation of the lemnisci (recall it is the spinothalamic and spinotectal anterolateral system)
- In this level the Anterolateral white column also remain unchanged
- The spinocerebellar vestibulospinal, and therubrospinal tracts (anterolateral)
- Central canal its cavity, also called closed medulla



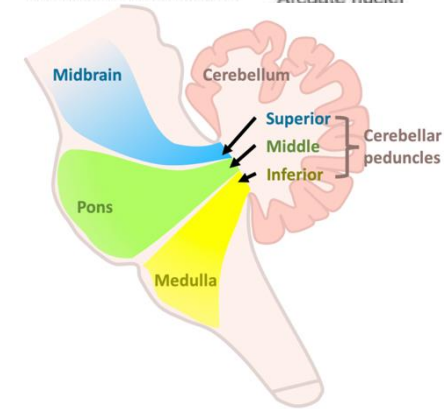
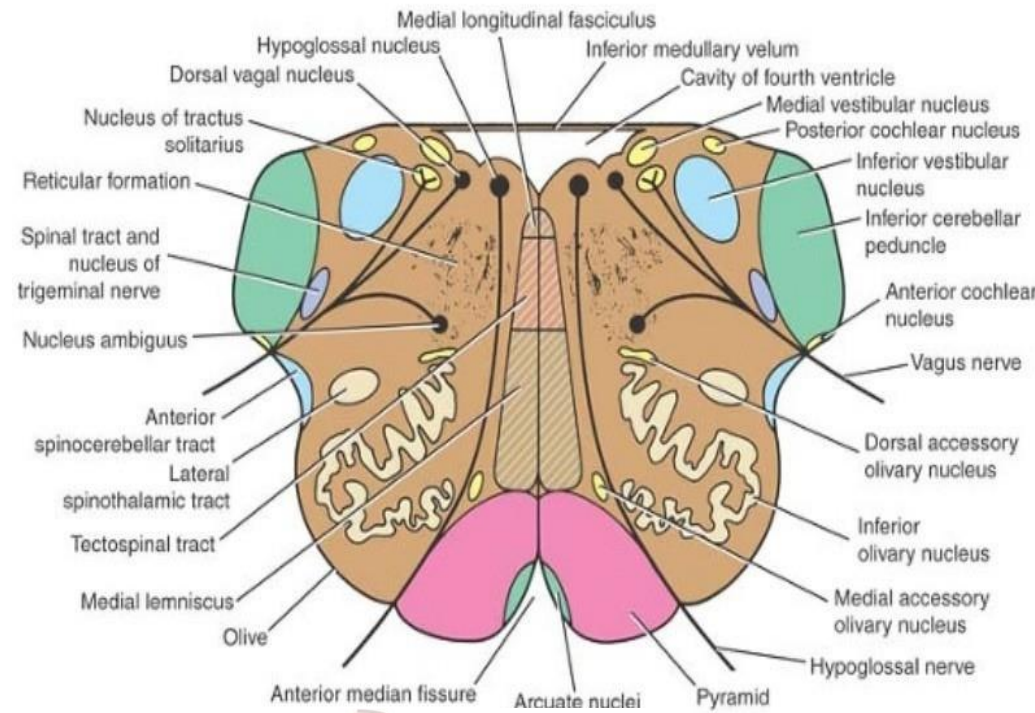
Level of sensory decussation



B

Level of olives (open medulla)

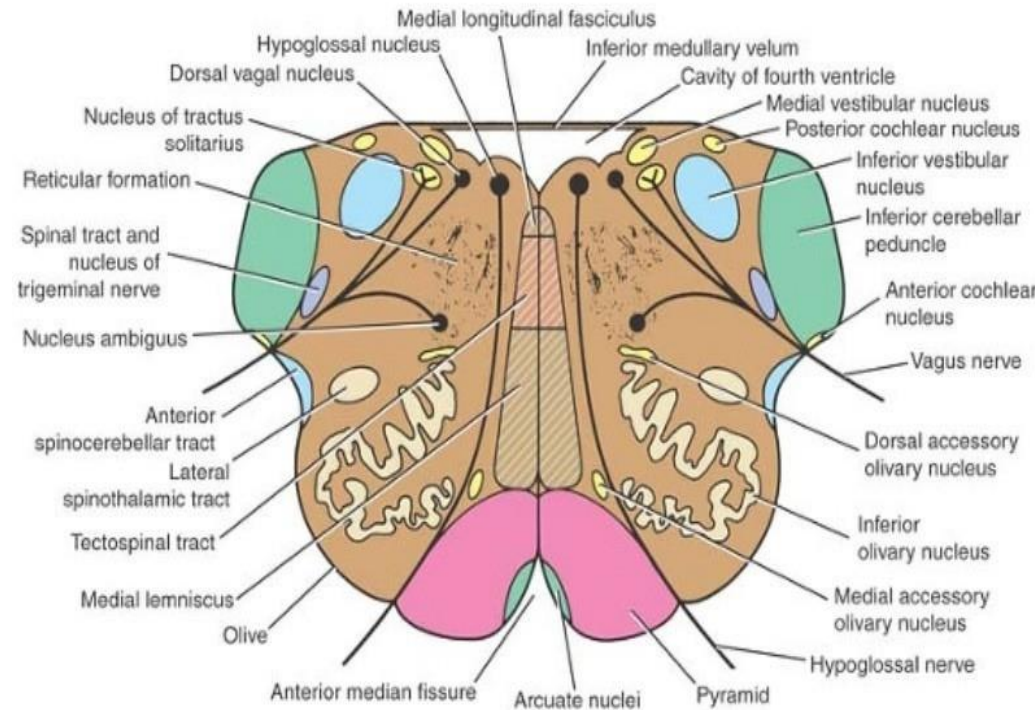
- Cavity is the 4th ventricle (recall medulla oblongata is the floor of 4th ventricle)
- Pyramids are most anterior and medial structures
- Posterior to pyramids we have medial lemniscus.
- There are prominent bulges on the anterior surface of medulla, these bulges are called olives, these bulges are produced by an internal structure called inferior olivary nucleus (which is part of olivary nucleus complex, more details later) hence its name.
- The inferior olivary nucleus has a special shape, it resembles a crumpled bag that is opened medially.
- On the posterolateral corners, you can find the inferior cerebellar peduncle. Which connects the medulla oblongata with the cerebellum.
- The posterior spinocerebellar tract passes through the inferior cerebellar peduncle.



لا إله إلا أنت سبحانك
إني كنت من الظالمين

Level of olives (open medulla)

- inferior part of 4th ventricle
- The most anterior and medial structure: Pyramids
- ICP (posterolateral corner)
- Medial lemniscus
- RF = Reticular Formation
- Spinal nucleus of trigeminal and its tract (anteriomedial to ICP – inferior cerebellar peduncle-)
- Nuclei of 12th 11th 10^t & 9th
- Inf Olivary nucleus
- Medial longitudinal fasciculus



Level of olives (open medulla)

- When identifying structures located near the midline, they should be approached in an anterior-to-posterior sequence.

1. Pyramid

2. Medial Lemniscus

- A part of the posterior column–medial lemniscus pathway.
- It carries discriminative (fine) touch sensation and conscious proprioception.
- **Clinical correlation:**
A lesion of the right medial lemniscus results in loss of fine touch and vibration on the left side of the body. This occurs because decussation has already taken place at a lower level. Therefore, this tract carries sensation from the **opposite (contralateral) side** of the body.

3. Tectospinal Tract (visuospatial)

- It is a descending tract and part of the extrapyramidal system.
- It is involved in reflex head movements in response to visual stimuli.
- Example: Reflex turning of the head toward a sudden object (efferent limb of the reflex).

Level of olives (open medulla)

4. Medial Longitudinal Fasciculus (MLF)

- The **medial longitudinal fasciculus (MLF)** is a longitudinal tract composed of white matter fibers located near the midline of the brainstem. (*Fasciculus* refers to a bundle or organized arrangement of nerve fibers.)
- The MLF connects:
 1. The motor nuclei of:
 - Oculomotor nerve (CN III)
 - Trochlear nerve (CN IV)
 - Abducens nerve (CN VI)
 2. The sensory nuclei of:
 - Vestibular nerve (component of the eighth cranial nerve (CN VIII)).
 3. The upper cervical spinal cord segments (C1–C5)
- Cranial nerves III, IV, and VI control movements of the eyeball. The vestibular system regulates balance and orientation relative to gravity. Upper cervical spinal cord segments (C1–C5) control head and neck muscles.

Level of olives (open medulla)

Functional Significance of the MLF:

1. Synchronization of Eye Movements

- The medial longitudinal fasciculus (MLF) coordinates the activity of cranial nerves III, IV, and VI to ensure synchronized movement of both eyeballs.
- The skeletal muscles responsible for movement of the eyeball are supplied by these cranial nerves:
 - Most extraocular muscles are supplied by the **oculomotor nerve (CN III)**.
 - The **lateral rectus muscle**, which produces abduction of the eye, is supplied by the **abducens nerve (CN VI)**.
 - The **superior oblique muscle** is supplied by the **trochlear nerve (CN IV)**.
- Humans have **binocular vision**, meaning both eyes function together to produce a single image. Therefore, The eyeballs must move in a coordinated manner. They cannot normally look in opposite directions.
- During lateral gaze: Contraction of the lateral rectus muscle in one eye is accompanied by relaxation of the medial rectus in the same eye. Simultaneously, contraction of the medial rectus occurs in the opposite eye, with relaxation of its lateral rectus.
- This coordinated activity prevents divergence of gaze and allows perception of a single image. If this coordination is disrupted, **diplopia (double vision)** occurs. This may be seen in lesions affecting cranial nerves III, IV, or VI.

Level of olives (open medulla)

2. Coordination of Eye and Head Movement

- The MLF connects ocular motor nuclei with the vestibular nuclei in order to coordinate eye movement with head movement.
- Since the vestibular system detects changes in position relative to gravity, it provides input necessary for maintaining visual stability during motion.
- The MLF ensures that eye movement remains synchronized with head movement.
- **Examples:**
 - Fixing the gaze on an object while moving the head.
 - Maintaining visual fixation briefly while moving in a car.
- The MLF also connects with the upper cervical spinal cord segments (C1–C5). These segments innervate the muscles responsible for movement of the head and neck. It is important to distinguish that muscles of facial expression and certain head structures are supplied by cranial nerves, whereas the primary muscles responsible for moving the head and neck region are controlled by the upper cervical spinal segments. Therefore, when the head moves, cervical motor activity must remain synchronized with ocular motor activity.

Level of olives (open medulla)

Central Gray Matter

The central gray matter is located beneath the floor of the fourth ventricle.

Within this region, the nuclei are arranged **from medial to lateral** as follows:

1. Motor Nucleus of the Hypoglossal Nerve

- The most medial nucleus.
- Belongs to the hypoglossal nerve (cranial nerve XII).
- The hypoglossal nerve is purely motor.
- It possesses a single motor nucleus, It exits the brainstem between the pyramid and the olive.
- The fibers arising from this nucleus are **lower motor neurons** that supply the muscles of the tongue, with the exception of the palatoglossus muscle.
- Upper motor neurons originate from the cerebral cortex and descend as corticonuclear fibers.
- In the brainstem, motor nuclei replace the function of anterior horn cells found in the spinal cord.

2. Dorsal Motor Nucleus of the Vagus

- Located lateral to the hypoglossal nucleus.
- Parasympathetic in function.
- Associated with the vagus nerve (cranial nerve X).
- The vagus nerve extends to the thorax and abdomen.
- The neurons in this nucleus are **preganglionic parasympathetic neurons**. They synapse in peripheral ganglia, after which postganglionic fibers supply smooth muscle and glands.

Level of olives (open medulla)

3. Nucleus of the Tractus Solitarius

- Located lateral to the dorsal motor nucleus of the vagus.

This nucleus:

- Receives **taste sensation** from cranial nerves VII, IX, and X.
- Receives **visceral sensory input**.
- An example of visceral sensory input is information from carotid sinus baroreceptors that detect blood pressure. This type of sensation is not consciously perceived.

4. Medial Vestibular Nucleus

- The most lateral nucleus within the central gray matter.
- Related to the vestibular component of cranial nerve VIII.
- Functions as a second-order neuron in the vestibular (balance) system.

Level of olives (open medulla)

Reticular Formation

- The reticular formation is a network-like structure extending throughout the brainstem.
- It plays an essential role in **consciousness and arousal**.
- Within the reticular formation lies the **nucleus ambiguus**.

Nucleus Ambiguus

- A motor nucleus.
- Associated with cranial nerves IX, X, and XI.
- These nerves exit the brainstem between the inferior cerebellar peduncle and the olive.
- The nucleus ambiguus supplies **skeletal muscles**:
- Glossopharyngeal nerve (IX): stylopharyngeus muscle.
- Vagus nerve (X): pharyngeal and laryngeal muscles.
- Thus, the nucleus ambiguus is a motor nucleus serving three cranial nerves.

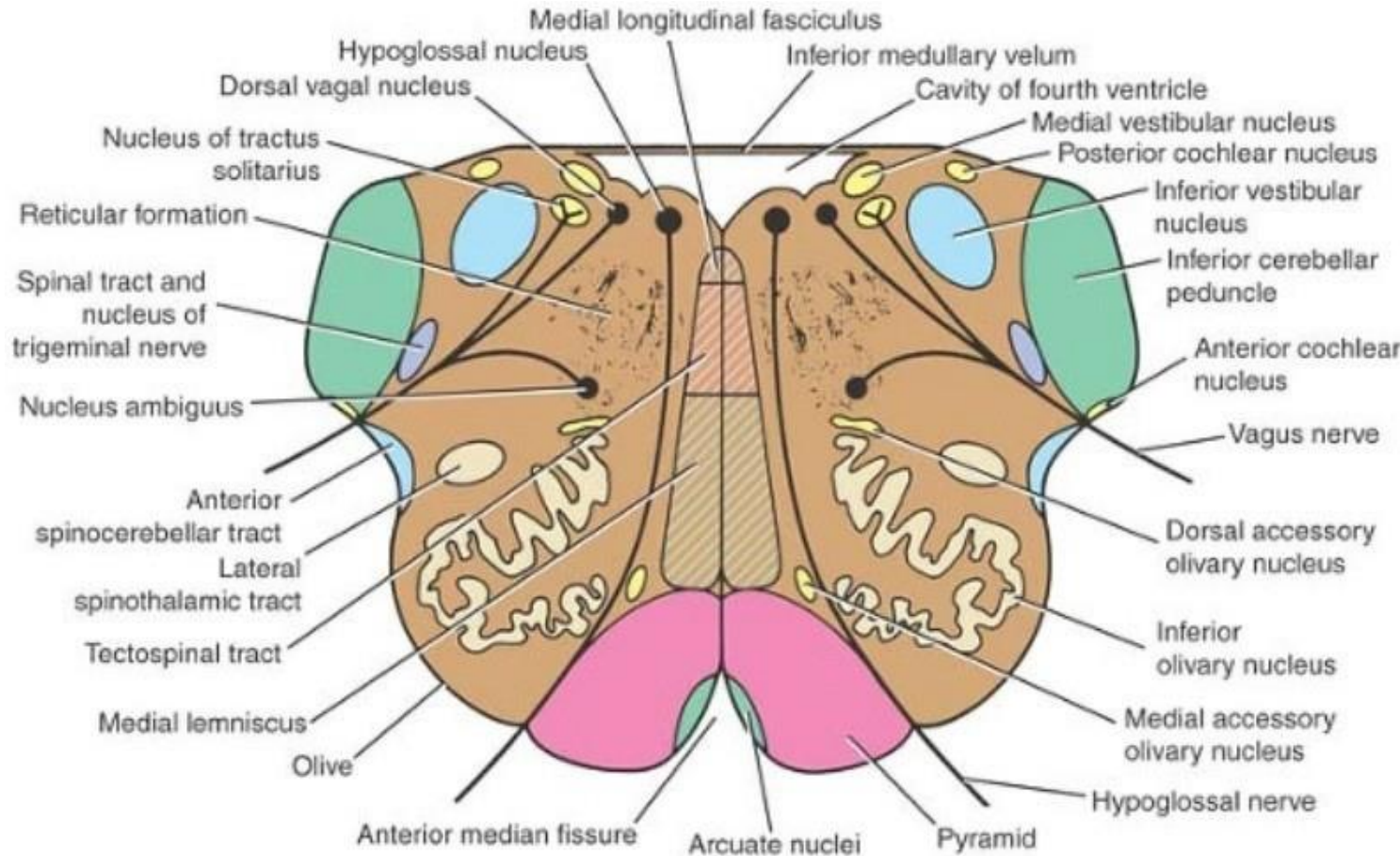
Level of olives (open medulla)

Olivary Nuclear Complex

- The olivary nuclear complex is located in the medulla. Its largest component is the **inferior olivary nucleus**.
- The inferior olivary nucleus has a motor function.
- It has a strong connection with the cerebellum.
- Fibers projecting from the olive to the cerebellum are known as **climbing fibers**.
- Most other fibers entering the cerebellum are referred to as **mossy fibers**.
- A lesion of the inferior olivary nucleus produces signs similar to a cerebellar lesion due to its close functional relationship with the cerebellum.

Olivary nuclear complex

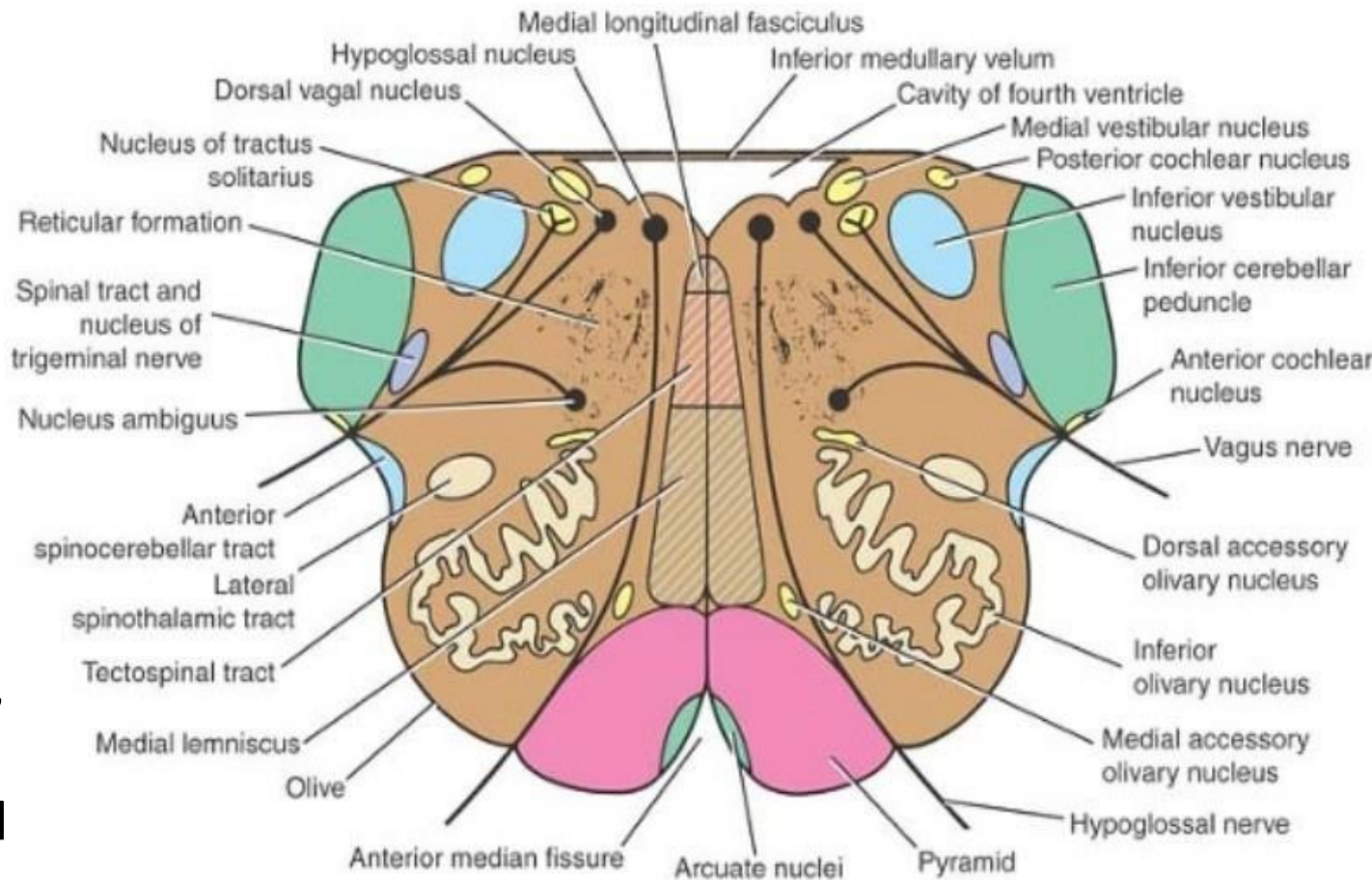
- Mainly Inf. Olivary nucleus
- Gray matter is shaped like a crumpled bag with its mouth directed medially
- Responsible of the elevation olive
- Has communications with spinal cord, cerebellum & cortex
- Function is associated with voluntary muscle movement



اللهم إني أستودعك ما قرأت وما حفظت وما تعلمت فرده عند حاجتي إليه إنك على كل شيء قدير، حسبنا الله ونعم الوكيل.

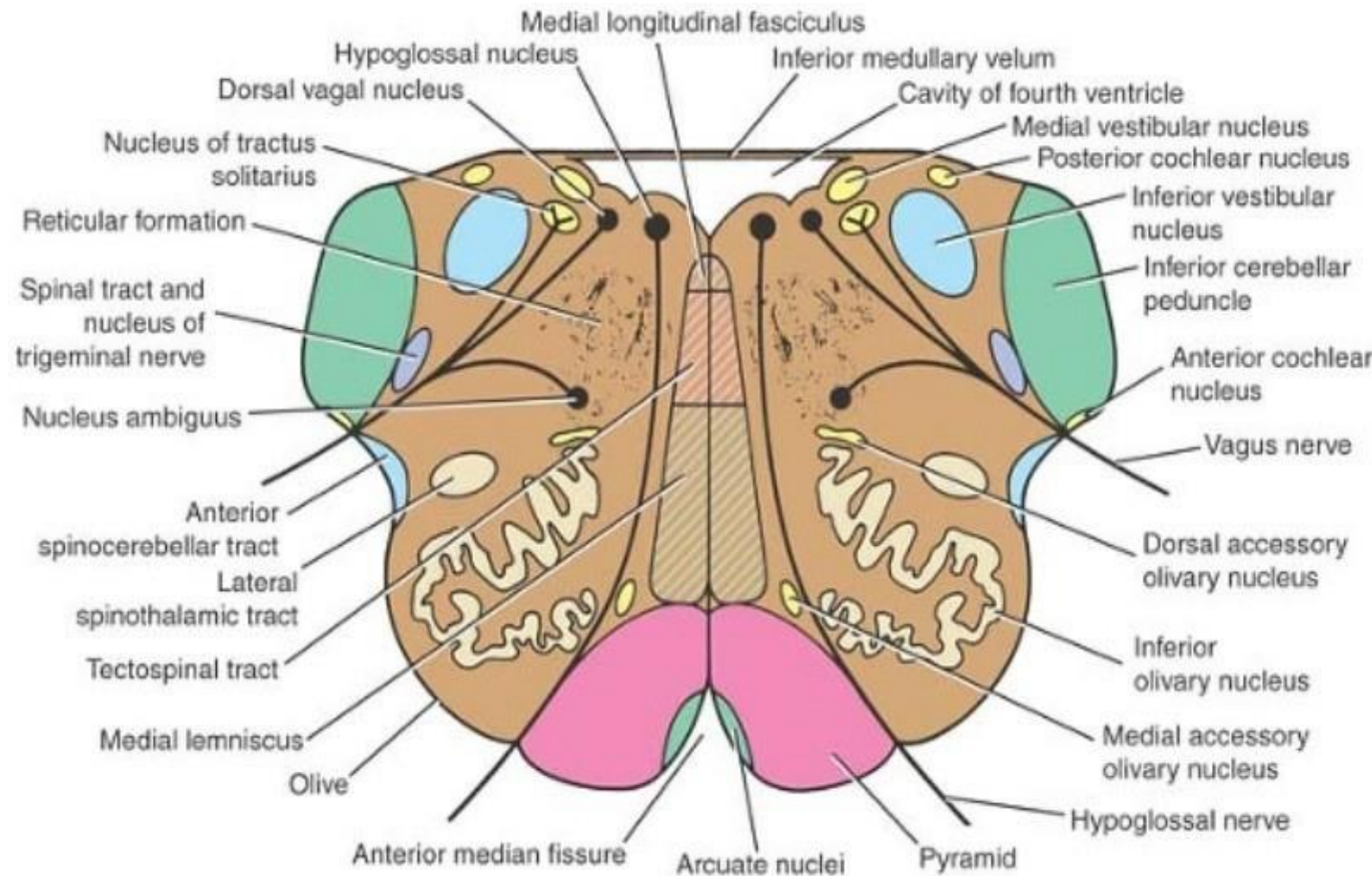
Nucleus ambiguus

- Large motor neurons
- Situated deep in RF
- Emerging fibers join 9th, 10th and 11th (cranial root of accessory)
- An elongated nucleus in the medulla oblongata that gives rise to the motor fibers of the glossopharyngeal, vagus, and accessory (cranial) nerves supplying striated muscle of the larynx and pharynx and soft palat



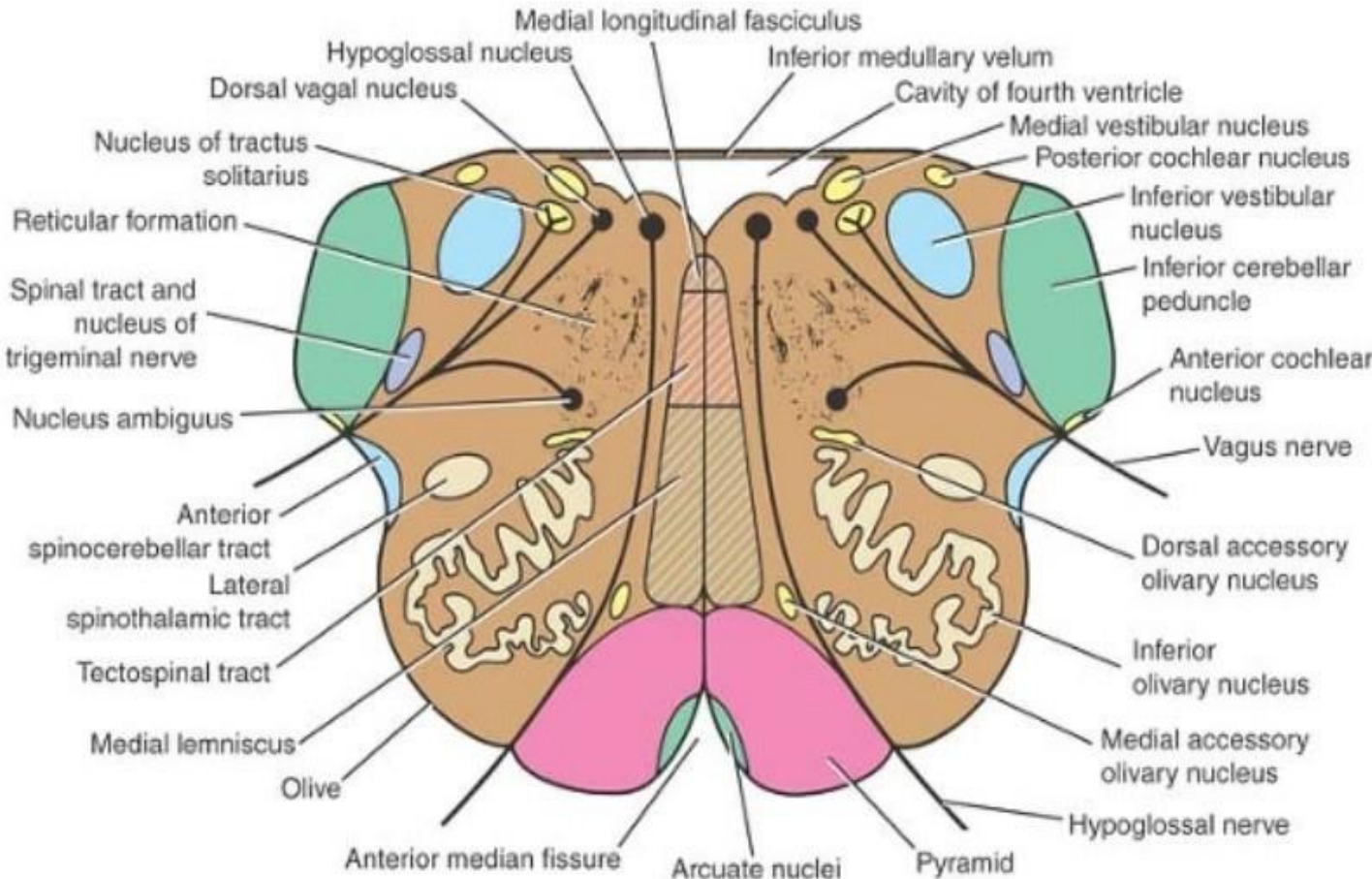
Medial longitudinal fasciculus

- Small tract of nerve fibers
- situated on each side of the midline
- Posterior to med. Lemniscus
- Anterior to 12th nucleus
- It is composed largely of ascending fibers from the vestibular nuclei and cochlear nuclei ascending to the motor nuclei (third, fourth and sixth)

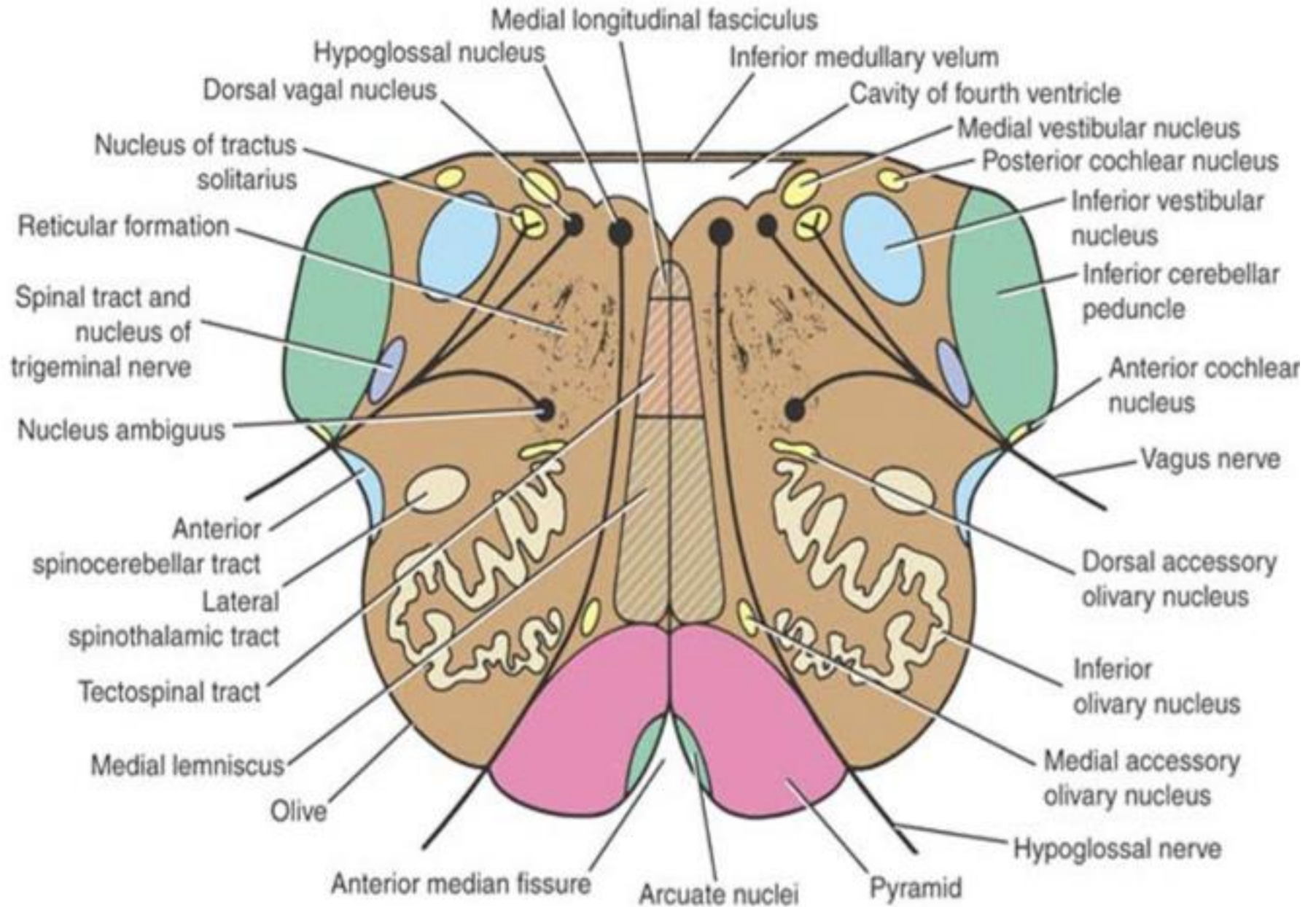


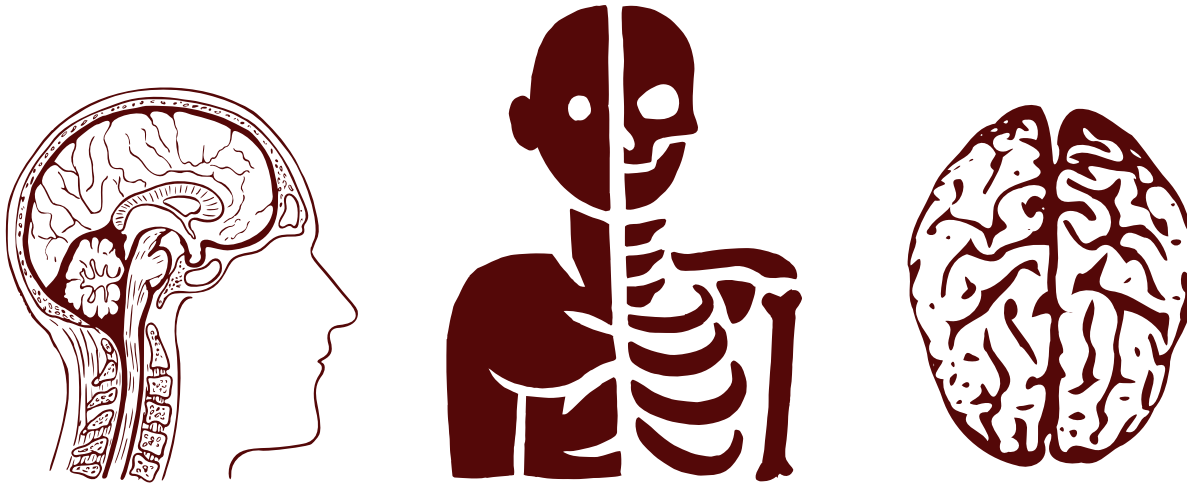
Central gray matter

- Lies beneath the floor of 4th ventricle
- Passing from M to L:
 1. Hypoglossal nucleus
 2. Dorsal nucleus of vagus
 3. Solitary nucleus
 4. Vestibular nuclei (medial and inferior)



Medulla oblongata at the level of olives





**ANATOMY
QUIZ
LECTURE 6**

رسالة من الفريق العلمي

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقه من فتنة القبر وعذاب النار،
أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

" لو أن الناس كلما استصعبوا أمراً تركوه،
ما قام للناس دنيا ولا دين "



For any feedback, scan the code or click on



Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	30-33	Slides were missing	Slides were added; the doctor didn't cover them in the lecture
V1 → V2			