ANATOMY

SHEET NO. 7

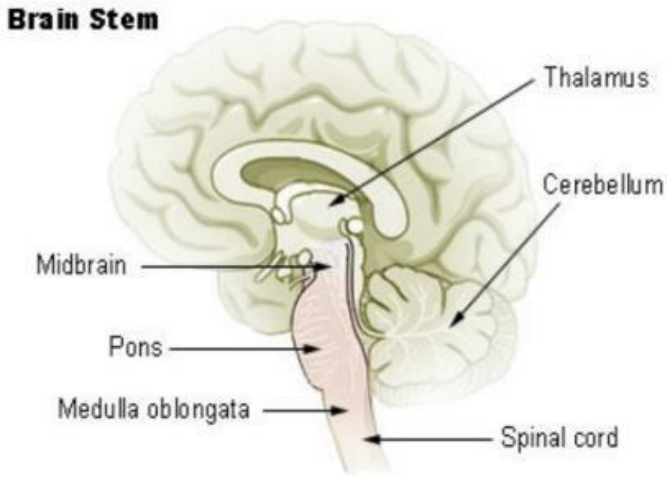
WRITER : Doctor 018

CORRECTOR : Bushra Salem

DOCTOR : Mohammad Alsalem

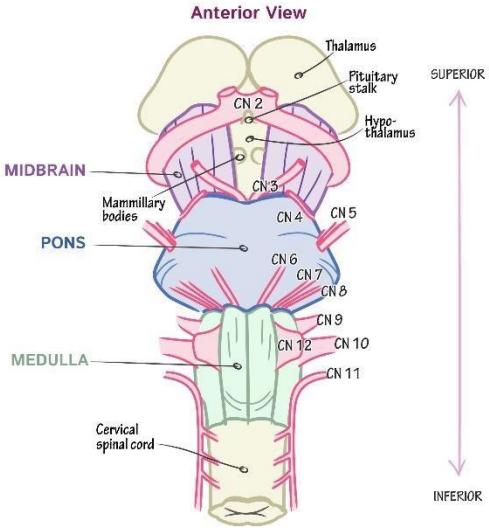
Brain Stem: is Stalk like in shape, and connects spinal cord to higher centers of forebrain.
-Reminder: Hindbrain consists of Medulla, Pons, and Cerebellum.

-**Brain stem** consists of:
1. Medulla oblongata (most inferior, just superior to the spinal cord)
2. Pons
3. Midbrain (most superior)



The fourth ventricle is the cavity of the hindbrain. It has:
a) Floor (anteriorly) related to the pons and medulla oblongata.
b) Roof (posteriorly) related to the cerebellum.

The brain stem is a passage for the ascending (e.g. DCMLT & ALST) and descending tracts (e.g. LCST).

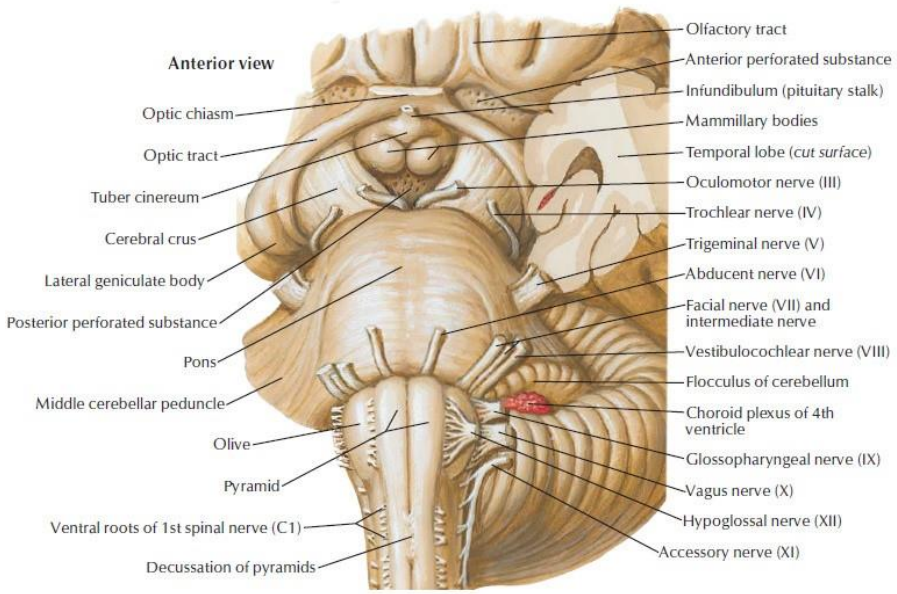


Origins of Cranial nerves (except CN1 & CN2):
The midbrain gives rise to CN3 & CN4
The mid-pontine area of the pons gives rise to CN5
The pontomedullary junction of the pons gives rise to CN6, CN7, CN8
The medulla oblongata gives rise to CN9, CN10, CN11, CN12

Unlike the spinal nerves, cranial nerves do not have dorsal, ventral, or lateral horns. Instead, the brainstem has nuclei that are either **sensory**, **motor**, or **PARASYMPATHETIC** nuclei. (brainstem does not have sympathetic nuclei).

The brainstem also has vital centers in reticular formation in the core. (controls basic functions such as cardiovascular and respiratory functions).

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



Pons is a bridge connect the cerebrum and cerebellum (it is not a bridge a between medulla oblongata and midbrain).

In the following figure you can see the 2 pyramids found in medulla oblongata separated by the anterior median fissure.
The olive is found on either side of pyramid. Deep to the olive we can find the olivary nuclear complex. Olive has a motor function.

To study the brainstem, it will be divided into 8 sections (4 in medulla, 2 in pons, 2 in midbrain).

Medulla oblongata is divided into 4 levels/sections (inferior to superior):

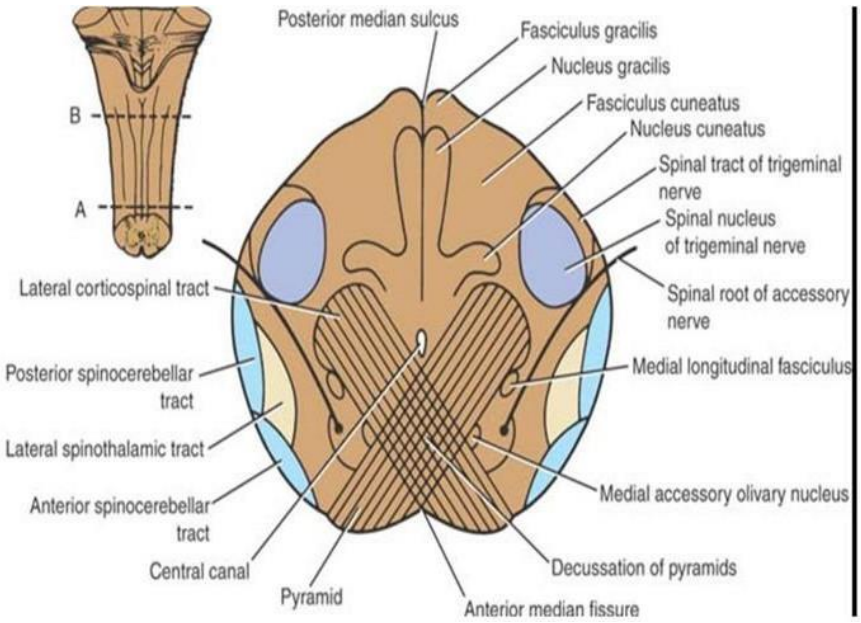
1. Level of decussation of pyramids (most inferior) (motor decussation) (closed medulla)
2. Level of decussation of lemnisci (sensory decussation) (closed medulla)
3. Level of olives (opened medulla)
4. Level Just Inferior to the Pons (There is a little difference between 3 and 4 so they can be considered as one section)

Before we go in details, keep in mind that the 4th ventricle is the cavity of the hindbrain. It is bounded anteriorly by pons and medulla oblongata, and posteriorly by cerebellum. Its tent-like cavity with **floor** (rhomboid -diamond-shaped) related to pons and upper part of medulla and **roof**.

The medulla oblongata is divided into 2 halves: Lower half is called **closed medulla** because it has a small cavity called *central canal* (the same as the central canal of the

spinal cord) and upper half is called **opened medulla** because it has a large cavity called *4th ventricle*.

Look at the top left of the figure. A is the level of the pyramidal decussation (most inferior level of the medulla oblongata)
B is the level of the sensory decussation (2nd level of the medulla oblongata)
between them is the level of the **closed medulla** (the section figure on the right)



Above level B is the **opened medulla**. (between the level of sensory decussation and the level of the olives & just inferior to the pons).

Now that we understand the difference between the opened and closed medulla, let us jump into more details.

1. **Level of decussation of pyramids** (refer to the figure above for this level)

The cavity of the section at this level will be the central canal (closed medulla).

Anterior to the central canal, there is **primary pyramidal decussation** which is for the fibers in the pyramid in descending tract, called lateral corticospinal fibers. Section was named according to it.

Posterior to the central canal, there is the nucleus gracilis (medially) and nucleus cuneatus (laterally) and their fasciculi posterior to them. This is where the synapse of the 1st order neurons and 2nd order neurons of the posterior column-medial lemniscal pathway occurs. The fasciculi are found toward outside (white matter) and the nuclei (gray matter) are found inside the section as in the figure.
Lateral to the **nucleus cuneatus** (posterolateral to the central canal), there is the **spinal nucleus of trigeminal nerve**.

We have stated previously that the trigeminal nerve (CN5) arises from the mid-pontine area of the **pons.** So why is there a nucleus for it in the medulla oblongata?

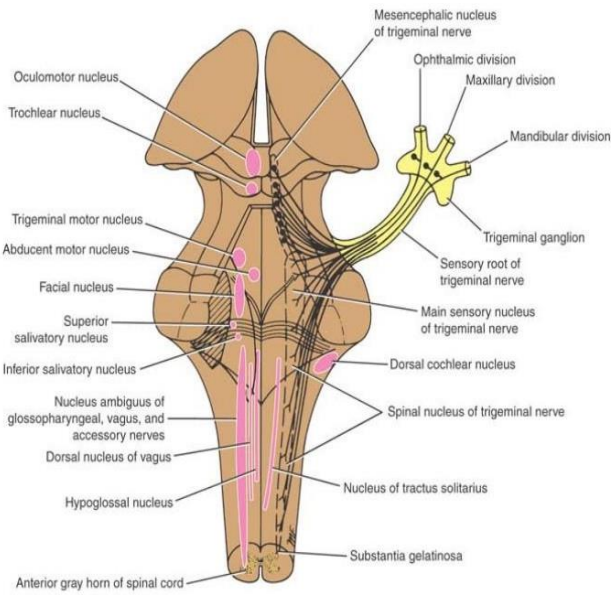
The trigeminal nerve is a mixed nerve containing mainly sensory fibers, as well as some motor fibers. Thus, the trigeminal nerve has 3 sensory nuclei and 1 motor nucleus (muscles of mastication).

Note: Trigeminal nerve have 4 nuclei, 1 motor (motor nucleus of trigeminal) and 3 sensory. • 3 sensory nuclei according to modality (NOT because it has 3 divisions, mandibular, maxillary and ophthalmic) which are: 1. Spinal nucleus of trigeminal 2. Principle nucleus 3. Mesencephalic nucleus.

The spinal nucleus of trigeminal nerve is one of the **sensory nuclei** of the trigeminal nerve. It is responsible for pain, temperature, and crude touch sensation (similar to ALST but for the head and neck area only).
The spinal part of the name of these nuclei is due to its longitudinal arrangement which extends from the upper cervical segments (from substantia gelatinosa), up to the level of the mid-pontine area (where it's replaced by the **principle -Main- 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.

Notice that the trigeminal originates mainly from the pons.



The **sensory nuclei** of the trigeminal nerve are:
(a) Mesencephalic nucleus of trigeminal nerve (in midbrain)
(b) Principle/main sensory nucleus (in pons)
(c) Spinal nucleus of trigeminal nerve

These nuclei are cell bodies of 2nd order neurons whereas the 1st order neurons are coming from the trigeminal nerve (**cell bodies in the trigeminal ganglion which is like the dorsal root ganglia**).

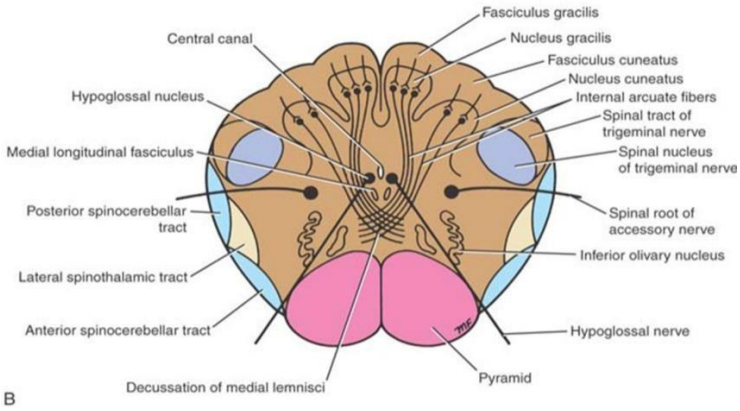
Finally, the anterolateral white column (lateral ST + Ant & Post spinocerebellar tracts) remain unchanged in this level.

2. Level of decussation of lemnisci (sensory decussation)

The cavity in this section is the central canal **(closed medulla).**

Anterior to the central canal, we find the **lemniscal decussation**.

Once the 1st order neurons synapse with the nucleus gracilis and cuneatus, 2nd order neurons arise and cross the midline anterior to the central canal. These fibers are known as the **internal arcuate fibers.** This crossing occurs between the central canal (posterior) and the pyramid (anterior). (remember that the corticospinal tract fibers in the pyramid are still uncrossed. They cross at the level of pyramidal decussation).



Lemnsisci are formed by internal arcuate fibers. In this section you still can't see medial lemniscus because its about to form following internal arcute fibers.

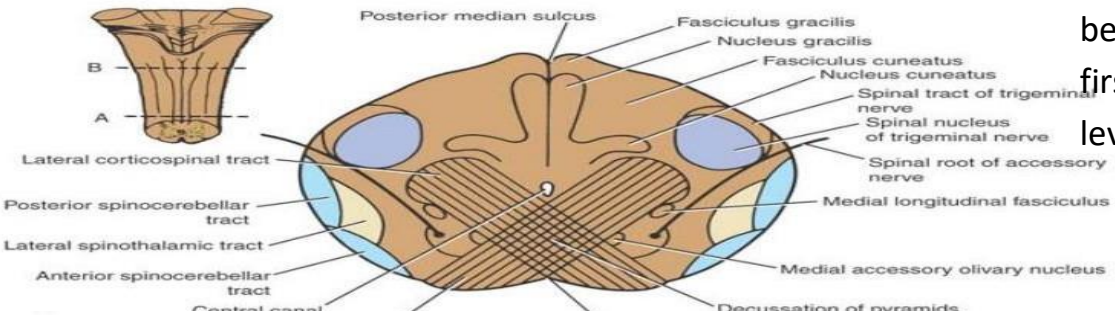
Spinal nucleus of trigeminal nerve can be seen posterolaterally to the central canal.

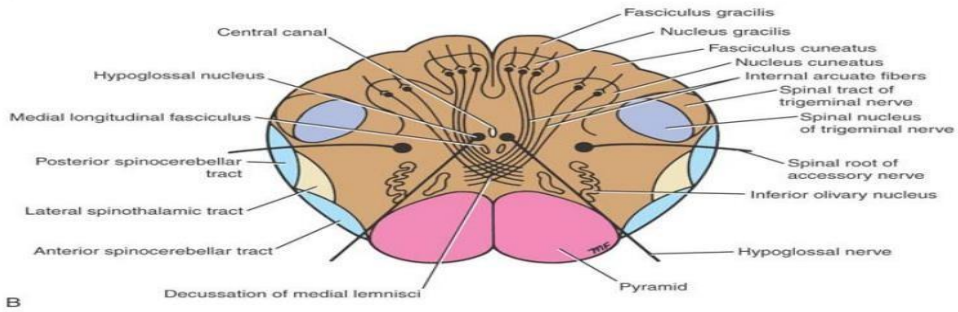
Spinal nucleus of the trigeminal nerve is lateral to the internal arcute fibers.

Anterolateral system remains unchanged at this level as well. But it starts to form **spinal lemniscus** with spinotectal tract.

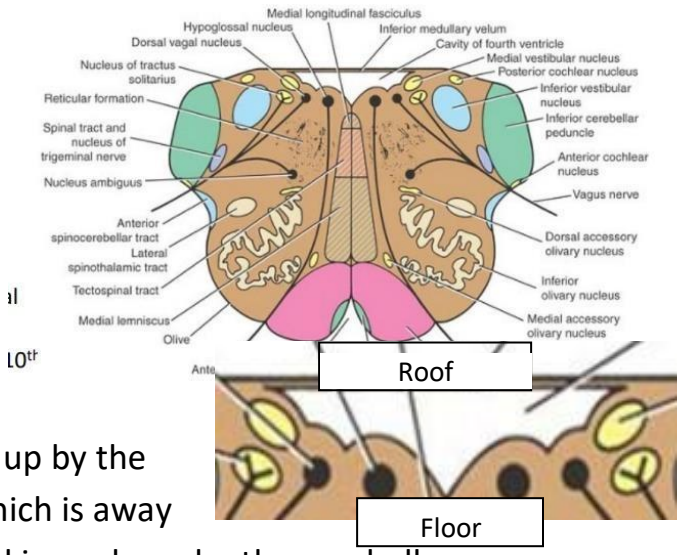
spinal lemniscus lateral to the decussation of the lemnisci. (from slides)

Comparison between the first two levels:





3. Level of olives (opened medulla)



Inferior part of 4th ventricle visible.
The inferior olivary nucleus, which is responsible for the olive bulge next to the pyramid, is now visible.

As you can see in the figure, the part of the fourth ventricle which is near the brainstem is the floor (anterior) that is made up by the medulla oblongata and pons, and the part which is away from the brainstem is the roof (posterior) and is made up by the cerebellum. (the 4th ventricle is tent-shaped)

The most anterior structure, which is also near the midline, is the pyramid (right & left)

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.

Check in the figure midline structures which include: (Refer to figure)

1. Medial lemniscus, which is the most anterior of those midline structures (posterior to the pyramid) (Remember it is above the level of sensory decussation and that it carries sensation from the contra-lateral part of the body)
2. Tectospinal tract, behind medial lemniscus (Remember it is for visual reflexes).
3. Medial longitudinal fasciculus, Small tract of nerve fibers • situated on each side of the midline • 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) (from slides). located behind tectospinal tract. (most posterior)

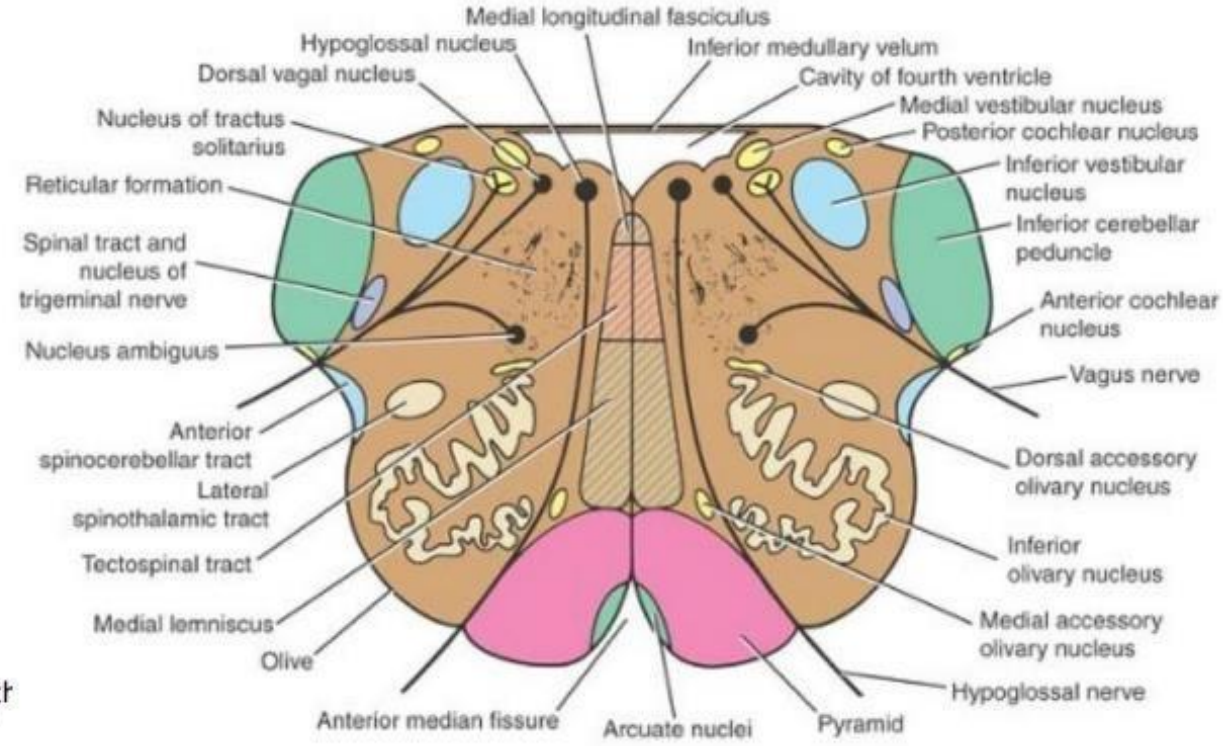
**Note: all these structures are made of white matter

Medial longitudinal fasciculus: (Remember fasciculus mean circular arrangement of fibers) is made up of white matter. It connects the motor nuclei of **oculomotor (CN3)**, **trochlear (CN4)**, and **abducent (CN6) nerves**. It also connects the **sensory** nuclei of **vestibular nerve (CN8)**, and even the **upper cervical segments** (which are responsible of the muscles of the neck).
They are responsible for movement of the eyeball and maintenance of balance.

The sensation associated with the vestibular nuclei is related to the sense of balance (it detects your relation to gravity).

The medial longitudinal fasciculus connects the nerves responsible of eyeball movement with the vestibular nuclei in order to coordinate the movement of eyeball while moving the head in different directions.

Humans have bi-ocular vision, meaning that the eyeballs are synchronized with each other so they cannot look at opposite directions. Contraction of lateral rectus muscle in one eyeball will cause the relaxation of the medial rectus in the same eye. And by default, cause medial rectus muscle contraction to occur on the other eyeball and relaxation of the lateral rectus in it. Therefore, your eyeballs cannot look in opposite directions normally.



Spinal nucleus of trigeminal nerve can be seen laterally (extends up to the level of the mid-pontine area).

Regarding the inferior olivary nucleus, it is responsible for the prominence of the olive. It contains gray matter and resembles a crumbled bag in its appearance. The opening of this bag is located medially. It has communication with the spinal cord, cerebellum and cortex. Its function is mainly related to the voluntary skeletal muscle movement.

Fibers that reach cerebellum are divided into 2 types: (will be discussed in more details later in the course)

1. Mossy fibers: like spinocerebellar tract.
2. Climbing fibers: From olive to cerebellum, for coordination of skeletal muscle movement.

There are more than one olivary nucleus. There is the dorsal olivary nucleus, medial olivary nucleus, and the inferior olivary nucleus (most important & largest). Collectively, they are known as the **olivary nuclear complex.**

The area beneath the floor of the fourth ventricle is known as the **Central gray matter.**

Nucleus ambiguus

Found deep within the reticular formation. It is a **motor** nucleus for 3 cranial nerves which are the **glossopharyngeal** (CN9), **vagus** (CN10), and the **accessory** (CN11) nerves.

The nucleus ambiguus is elongated within the brainstem.

It gives rise to the motor fibers of the glossopharyngeal, vagus, and accessory (cranial) nerves supplying striated muscle of the larynx and pharynx and soft palate.

Notice in the figure the elongated nucleus ambiguus and the elongated solitary nucleus.