

Physiology of the Brainstem

Objectives:

- ❖ Enumerate components of Brainstem
- ❖ List important structures in Brainstem
- ❖ Describe functions of the Brainstem
- ❖ Describe signs & symptoms of the Brainstem lesion
- ❖ Understand Brainstem function test

Good news!

This lecture is almost like a **revision** of anatomy.

Ninja nerd goes over the anatomy and physiology of the brainstem (In detail) over 3 videos. They can be really helpful!

Midbrain



Pons



Medulla



Color index:

- ❖ Important.
- ❖ Girls slide only.
- ❖ Boys slide only.
- ❖ Dr's note.
- ❖ Extra information.



Editing File

Introduction of Brainstem

Brainstem

- ❖ The brainstem is the lower part of the brain
- ❖ It is adjoining and structurally continuous with the spinal cord.

Component of Brain stem

1

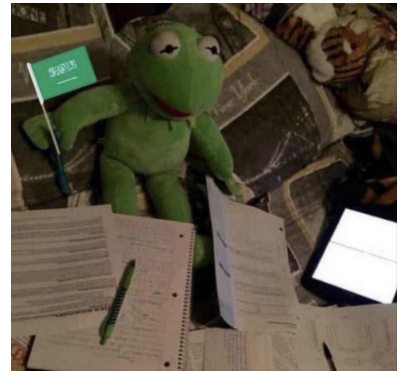
Midbrain

2

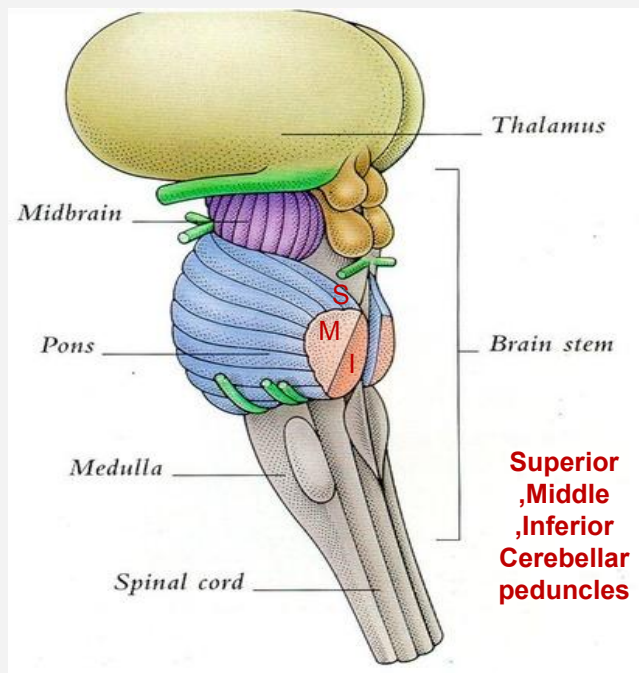
Pons

3

Medulla Oblongata

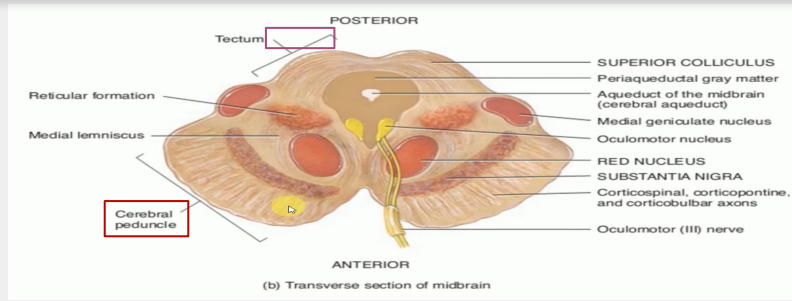


- ❖ The **midbrain, pons** and **medulla** connect to the cerebellum via the **superior, middle and inferior peduncles** respectively.
- ❖ The upper relation → thalamus
- ❖ The lower relation → spinal cord



Midbrain

Cross section



Superior colliculus

- It constitutes center for visual reflexes.
- It sends its superior brachium to the **lateral geniculate body** of the thalamus.

Inferior colliculus

- It is the principal midbrain nucleus of the auditory pathway.
 - It sends its inferior brachium to the **medial geniculate body** of the thalamus.
- N.B: The cerebral aqueduct runs through the midbrain, beneath the colliculi.

The Tectum ("roof" in latin) is the dorsal part of the midbrain, includes:

Tegmentum
Covering in latin

- is the ventral part of the midbrain , ventral to the cerebral aqueduct.
- Several nuclei, tracts and the reticular formation is contained here.

Cerebral peduncles

The ventral side of the midbrain is comprised of paired These transmit axons of upper motor neurons (UMN).

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

Nerves:

- 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:

- A concentration of neurons in the ventral portion of midbrain
- It is involved in **motor function**.

Central Tegmental Tract:

- Directly anterior to the floor of the 4th ventricle.
- It 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 lower motor neurons (LMN)
 - It is involved in the pain desensitization pathway
 - It is involved in the arousal and consciousness systems
 - It contains the locus coeruleus, which is involved in intensive alertness modulation and in autonomic reflexes.

General Internal structure

The pons

At the level of the mid pons, trigeminal nerve (CN V) emerges.

Between the basal pons, cranial nerve 6 (abducens), 7 (facial) & 8 (vestibulocochlear) emerge (medial to lateral).

The medulla

Medulla

Ventral view

Dorsal view

The most medial part of the medulla is the **anterior median fissure**.

The most medial part of the medulla is the **posterior 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.

Moving laterally on each side is the **fasciculus gracilis**.

The **anterolateral sulcus** is lateral to the **pyramids**.

Lateral to that is the **fasciculus cuneatus**.

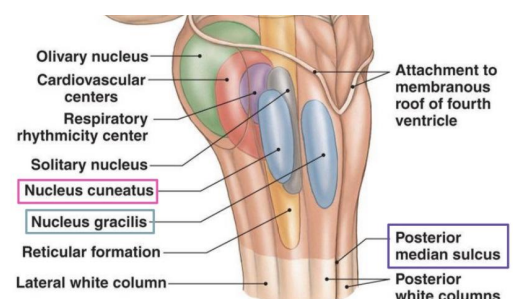
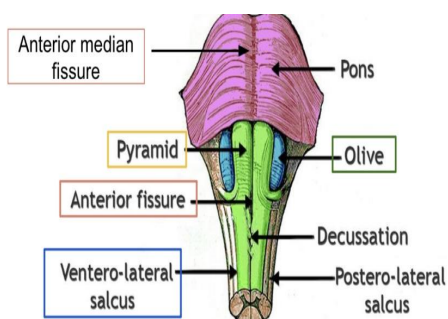
Emerging from the **anterolateral sulci** are the hypoglossal nerve (CN XII) rootlets.

Superior to each of these, are the gracile and cuneate tubercles, respectively. Underlying these are their respective nuclei.

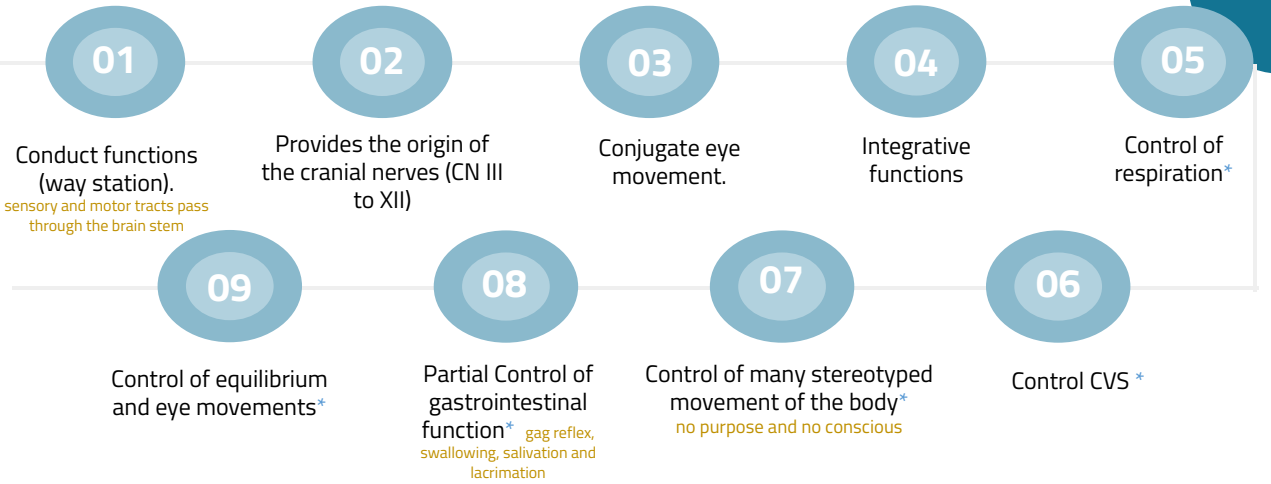
Lateral to the **anterolateral sulci** are the **olives** (containing underlying inferior olivary nuclei and afferent fibers).

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.

Lateral (and dorsal) to the olives are the rootlets for glossopharyngeal (IX) & vagus (X) cranial nerves.



Functions of the BrainStem



Other Brain Stem functions

Functions of Brain Stem Nuclei in Controlling Subconscious, Stereotyped Movements [crying, yawn, suckling, stretch] (anencephaly)*

anencephaly means absence of cerebral cortex, but they still cry meaning its controlled by the brain stem

Vasomotor centers for CV control (Baroreceptors) in medulla and Respiratory Nuclei

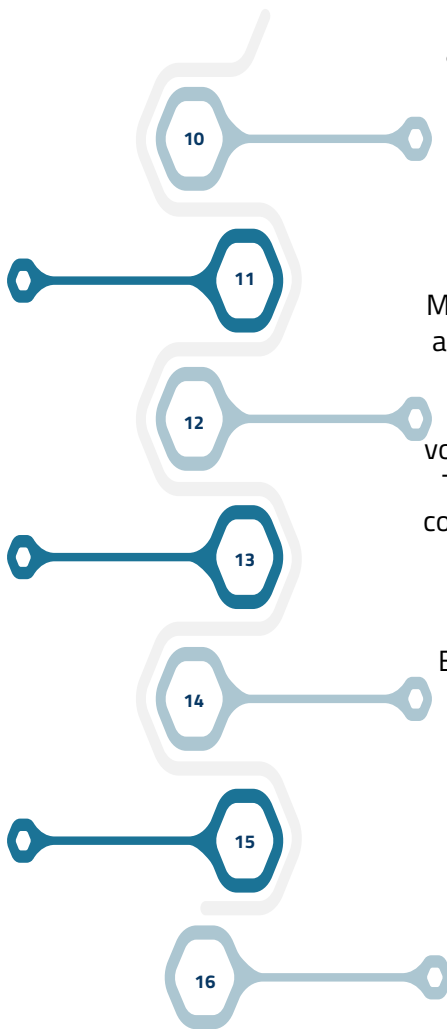
Control of Cerebral Activity by Continuous Excitatory Signals from the Brain Stem (Reticular Excitatory Area of the Brainstem) → bulbotreticular facilitatory area → it is the same brain stem reticular area that transmits facilitatory signals to maintain tone in the antigravity muscles and spinal cord reflexes.*

The autonomic nervous system is activated mainly by centers located in the spinal cord, brain stem, and hypothalamus (Cardiovascular Gastrointestinal Autonomic Reflexes.)

Motor branch of the fifth cranial nerve, and the chewing process is controlled by nuclei in the brain stem and also swallowing, salivary secretion, vomiting (chemoreceptor trigger zone). The actual mechanics of feeding are controlled by centers in the brain stem.

Brain stem Neurohormonal Systems in the human brain for activating four neurohormonal systems*
like sleep and wake cycle, pain

Many of the behavioral functions elicited from the hypothalamus and other limbic structures are also mediated through the reticular nuclei in the brainstem and their associated nuclei.*
like anger



Other Brain Stem functions

Accommodation Is Controlled by Parasympathetic Nerves by 3rd CN*
Accommodation: Adjustment of the eyeball structures to focus on near objects



Although the micturition reflex is an autonomic spinal cord reflex, it can also be inhibited or facilitated by centers in the cerebral cortex or brain stem in pons*



Neural Pathways for Control of Eye Movements .also shows brainstem nuclei for the third, fourth, and sixth cranial nerves by medial longitudinal fasciculus*
conjugate and separate eye movements



Auditory Nervous Pathways → superior olivary nucleus *



Nucleus of tractus solitarius →Taste pathway→Sup & Inf Salivatory Nuclei*



Bulboreticular facilitatory area of brain stem for gamma efferent system (stabilizes joints)*



It controls consciousness & sleep cycle (alertness and arousal) through reticular formation.



It has centers for cough, gag, swallowing and vomiting.



Sense of body balance (Vestibular functions)



Substantia nigra which is a part of the basal ganglia is present in midbrain and is involved in control of movements.



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.



Midbrain also contain red nucleus which regulate the motor activity through cerebellum.



*Male slides only

Functions of the Brain Stem (cont.)

1-Conduct Functions

All information related from the body to the cerebrum and cerebellum and vice versa, must traverse the brain stem. *والعكس صحيح يعني اللي من cerebrum/cerebellums الى الجسم بتمر من خلال البرين ستم*

The ascending sensory pathways		Descending tract	
Coming from the body to the brain includes :		Corticospinal tract (UMN)	Upper motor neurons
The spinothalamic tract for pain and temperature sensation + crude touch	The dorsal column , fasciculus gracilis, and cuneatus for fine touch , proprioceptive and fine pressure sensation	runs through crus cerebri (the anterior portion of the cerebral peduncle), basal part of pons and medullary pyramids; 70-90 % of fibers cross in pyramidal decussation to form the lateral corticospinal tract, synapse on LMN in ventral horn of spinal cord. pyramidal	originate in brain stem's vestibular, red, and reticular nuclei, which also descend and synapse in the spinal cord. Extrapyramidal

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

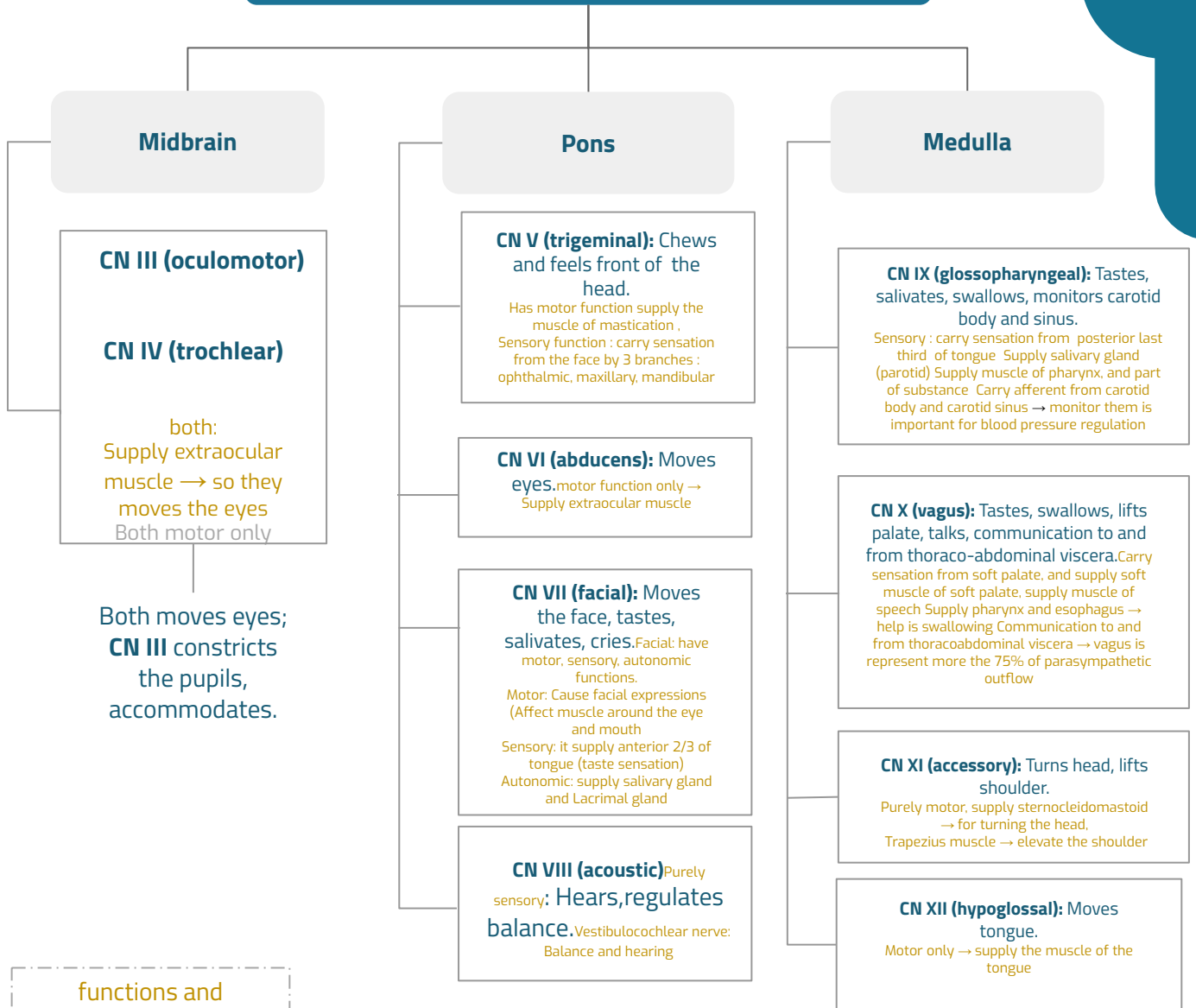
2-Provides the origin of the cranial nerves (CN-III-XII)

The fibers of cranial nerve nuclei (except for olfactory & optic nerve) either originate from, or terminate in the cranial nerve nuclei in brainstem.

- 1-2 CN Directly from brain.
- 3 to 12 from brainstem

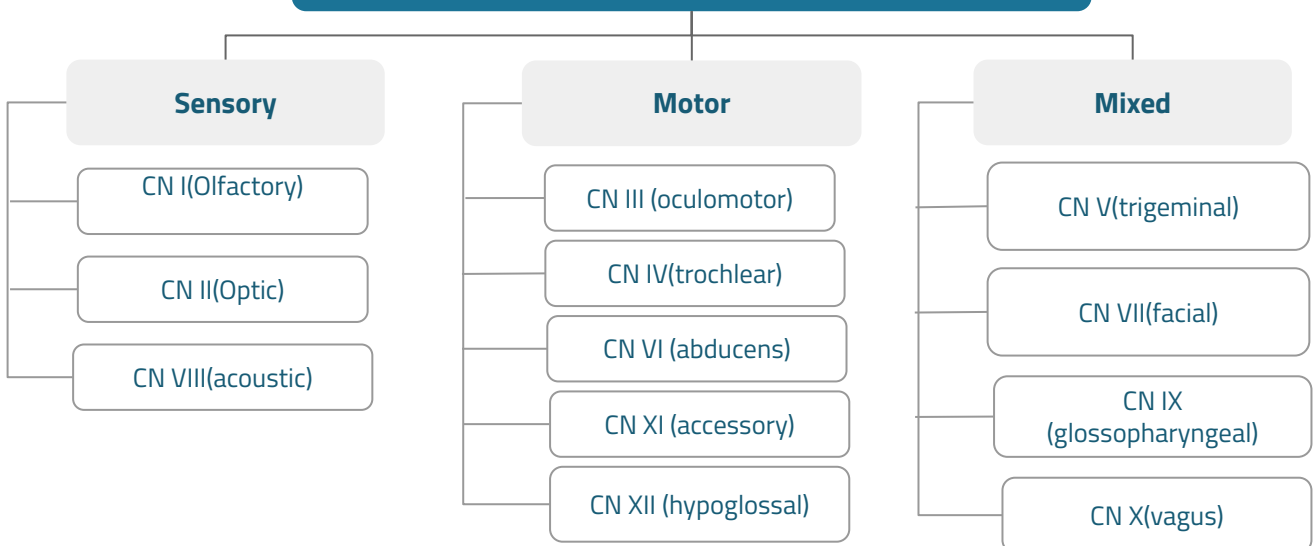
sometimes these tracts synapse, but others don't but passes through the brain stem

Origin and function of cranial nerves



functions and properties

Classification of the cranial nerve according to functions



Function and Lesion

What are the functions of the Midbrain?

Function:

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)

Auditory and Visual reflex centers

Nerve pathway to cerebral hemispheres



Symptoms and signs of midbrain Lesion

Cranial Nerve (CN) deficits:
Ipsilateral (why? لأن تونا ماصار? decussation.)
CN III, CN IV palsy and ptosis (drooping of eyelids).

Pupils: Midposition to dilated.
Reactivity is sluggish to fixed.
لما يحطون مصدر ضوء عند عيونهم مفروض
Eye accommodate by constriction
With lesion: weak or sluggish response to the light ,Or no response at all (fixed)

Posture: Abnormal extensor response (Decorticate: Decorticate means a position where there is hyperextension of lower limb, flexion and supination of the upper limb Decerebrate is the same except there is pronation of the upper limb instead of supination)

Respiratory: Hyperventilating.

Level of consciousness (LOC):
Varies (semiconscious, confused or unconscious)

Function:

CN V-Trigeminal [motor and sensory]. (Skin of face, tongue, teeth; muscle of mastication)

CN VII - Facial [motor and sensory].
(Muscles of facial expression).

CN VIII - Acoustic [sensory]. (Hearing)

CN VI - Abducens [motor]. (Lateral rectus muscle of eye which rotates eye outward & laterally)

Respiratory center



Symptoms and signs of pons Lesion

Pupils size: Pinpoint

Posture: Abnormal extensor response (Decerebrate)

CN Deficits: CN V, CN VI, CN VII, CN VIII

Respiratory: Apneustic (Abnormal respiration marked by sustained inhalation); or Hyperventilation.

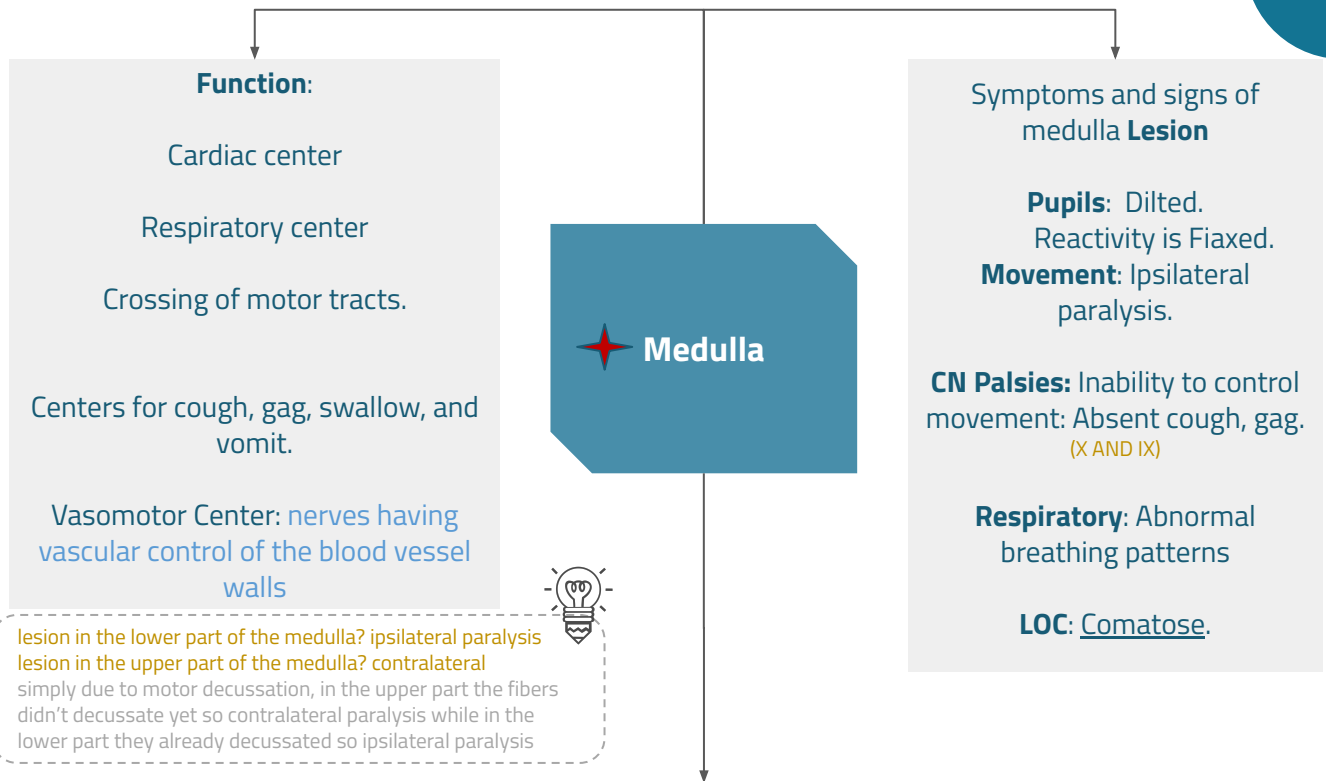
LOC: Semi-coma



What does decerebrate and Decorticate look like?

Function and Lesion Cont.

Male dr: If you understand the functions (and lesions) of the brainstem, You can answer any Question



Cranial nerves (9-12)

- CN IX Glossopharyngeal [Mixed]:** Muscles & mucous membranes of pharynx, the constricted openings from the mouth & oral pharynx and the posterior third of the tongue
- CNX Vagus [Mixed]:** Pharynx, Larynx, Heart, Lungs & Stomach
- XI Accessory [Motor]:** Rotation of the head and shoulders
- CN XII Hypoglossal [Motor]:** Intrinsic muscles of the tongue

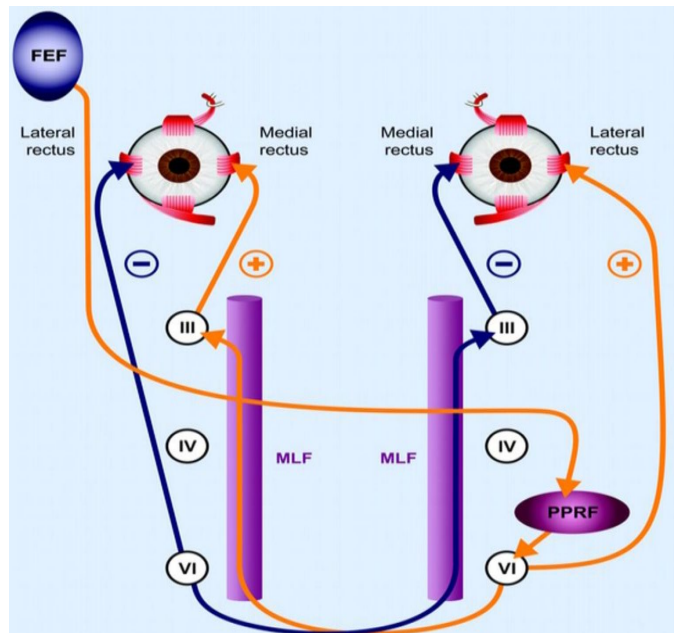
Conjugate Eye Movement

Female slides only
Was explained by a student [here](#)

This part will be discussed in detail with **special sense lecture**

It refers to motor coordination of the eyes that allows for bilateral fixation on a single project.

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, projection directly innervate **the lateral rectus** (contralateral to FEF) and **the medial rectus** muscle (ipsilateral to FEF). **The left FEF** command to trigger conjugate eye movements to the right.



Integrative functions

L6

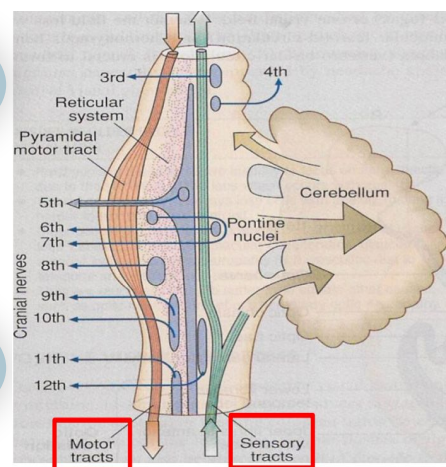
List 5 integrative functions

- ❖ 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 function).
- ❖ **Substantia Nigra** 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.
- ❖ Superior and inferior colliculi are situated on the dorsal surface of the midbrain and is involved in visual & auditory 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:
Motor in function

Middle layer:
Sensory in function & contains medial lemniscus (which conveys sensory info from dorsal column)



Brain Stem Function Tests:

1

To test reticular formation

Alertness, consciousness & sleep.

2

Corticospinal tract

Motor power and reflexes

3

Pain response

Facial grimacing on firm pressure over the supraorbital ridge.

4

To test respiratory center

Look for the normal pattern of respiration.

5

To test cardiovascular center

Look for normal circulatory function.

6

To test brainstem reflexes

- Pupillary and corneal reflexes.
- Vestibulo-ocular reflex: Injection of iced water into the ear will produce eyes movement.
- Oculocephalic reflex: Eyes will be fixed when head is moved in or another direction.
- Gag & cough reflexes.

The Rule of 4 of The Brain Stem

Females doctor: this is to help you to study the physiological function of brain stem -as a summary-

4 structures in "midline" and begin with "M" :	<ul style="list-style-type: none"> -Motor pathway (Contralateral weakness). -Medial lemniscus (Contralateral proprioception/vibration lose). -Medial longitudinal fasciculus (Ipsilateral internuclear ophthalmoplegia). -Motor nucleus and nerve (Ipsilateral CN function loss).
4 motor nuclei in midline and are those that divisors of 12 (3,4,6,12):	<ul style="list-style-type: none"> -CN Number can divide the number 12 -Nuclei of CN 3,4,6,12 are midline. -Nuclei of CN 5,7,9,11 are lateral
4 structures of the "side" (lateral) and begin with "S":	<ul style="list-style-type: none"> -Spinocerebellar pathway (Ipsilateral ataxia). -Spinothalamic pathway (Contralateral pain/temp sensory loss). -Sensory nucleus of CN5 (Ipsilateral pain/temp loss in face). -Sympathetic pathway (Ipsilateral Horner's Syndrome).
4 CN in medulla (9,10,11,12): *	<ul style="list-style-type: none"> -Glossopharyngeal CN9 (Ipsilateral pharyngeal loss). -Vagus CN10 (Ipsilateral palatal weakness). -Spinal accessory CN11 (Ipsilateral shoulder weakness). -Hypoglossal CN12 (Ipsilateral weakness of tongue).
4 CN in Pons (5,6,7,8): *	<ul style="list-style-type: none"> -Trigeminal CN5 (Ipsilateral facial sensory loss). -Abducent CN6 (Ipsilateral eye abduction weakness). -Facial CN7 (Ipsilateral facial weakness) -Auditory CN8 (Ipsilateral deafness)
4 CN in above pons "Midbrain" (3,4): *	<ul style="list-style-type: none"> -Olfactory CN1 (not in the midbrain). -Optic CN2 (not in the midbrain). -Oculomotor CN3 (eye turned out and down). -Trochlear CN4 (eye unable to look down when looking towards nose).

*Description is from the female slides only

A sample case

A 58 y/o female patient was referred to you because of recent onset of left hemiparesis, left-sided loss of proprioception and right-sided tongue deviation.

History	Fiber	Location
Left hemiparesis	Motor (corticospinal tract), Right	Medial
left-sided loss of proprioception	Medial lemniscus, Right.	Medial
right-sided tongue deviation	Hypoglossal nerve CN12, Right	Medulla Medial

Answers: [Click here for an illustration of the answer from the male doctor](#)

-Medial medullary syndrome. (R) -Vertebral artery, medullary branch (R)

hypoglossal involvement so upper part of medulla = contralateral

MCQ & SAQ:

Check this summary file made by the male doctor
(Try to fill in the missing parts to test yourself)

L6

Q1: Which CN originates at the level of mid pons?

- A. CN V
- B. CN VI
- C. CN VII
- D. CN VIII

Q3: which one of the following is purely motor ?

- A. glossopharyngeal
- B. Hypoglossal
- C. Vagus
- D. Facial

Q5: The method used in testing the brainstem reflexes:

- A. Motor power test
- B. Facial grimacing test
- C. Alertness and consciousness test
- D. Oculo-cephalic reflex test

Q2: which CN originates from medulla?

- A. CN VI
- B. CN VII
- C. CN VIII
- D. CN IX

Q4: If there is a lesion in the Vagus cranial nerve, the patient will mostly develops:

- A. Ipsilateral facial sensory loss
- B. Ipsilateral palatal weakness
- C. Contralateral palatal weakness
- D. Ipsilateral shoulder weakness

Q6: Which of the following is a sign or symptom can be seen in midbrain Lesions:

- A. Decerebrate posture
- B. Decorticate posture
- C. Pinpoint pupils
- D. Comatose

6: B
5: D
4: B
3: B
2: D
1: A
key:
answer

1- list the sensory CN.

2- what is the conduct functions?

3-A patient came to the neurologic clinic and the neurologist found that he has abnormal extensor response and abnormal respiration marked by sustained inhalation.a)Which part of the brain is involved?b)Enumerate the cranial nerves present in this part of brain?

4- mention two functional organization of the brainstem and the function of each?

A1: CN I (Olfactory) , CN II (Optic) , CN VIII (acoustic).

A2: All information related from the body to the cerebrum and cerebellum and vice versa , must traverse the brain stem.

A3: a)Pons of the brainstem.

b)CN V trigeminal, CN VI abducens, CN VII facial, CN VIII acoustic.

A4: 1-ventral layer: motor in function

2-Middle layer: sensory in function

I've got a breaking news for you



You are amazing don't let anyone tell you otherwise

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