Revised By
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Physiology of brainstem

Objectives:

- What is brainstem
- What are its internal structures
- What are its functions
- What will happen if damaged e.g brain death.

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Colour index:
important
Numbers
Extra

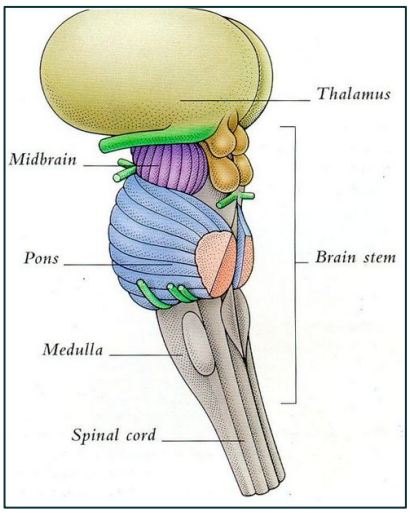
وَأَن لَّيْسَ لِلْإِنسَانِ إِلَّا مَا سَعَىٰ

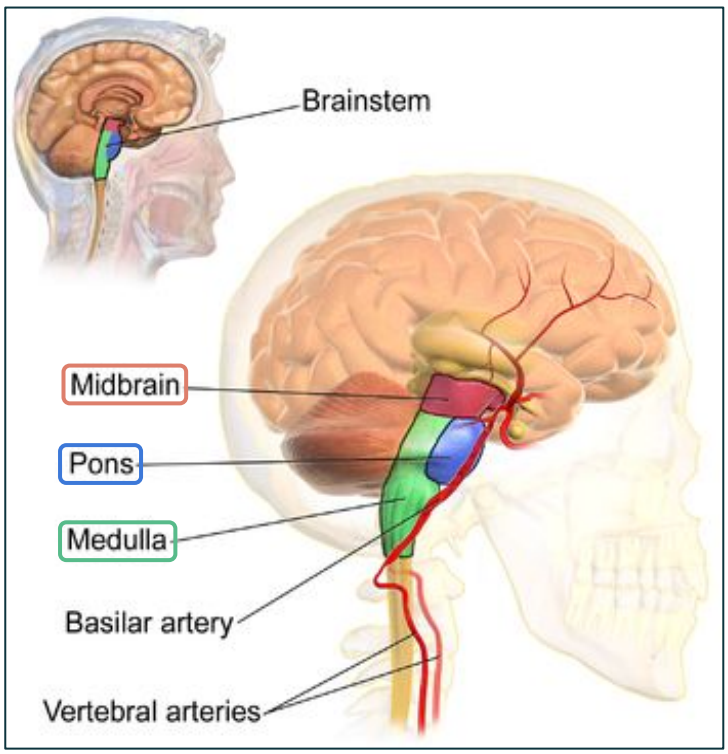
The Brainstem

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

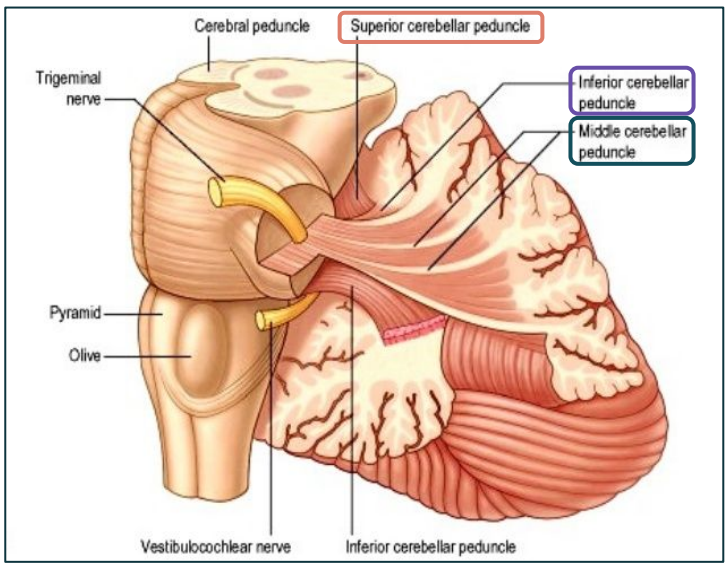
Components of Brainstem

- Midbrain.
- Pons.
- Medulla Oblongata.





- The midbrain, pons and medulla connect to the cerebellum via the superior, middle and inferior peduncles respectively.



The Midbrain

Is divided into three parts:

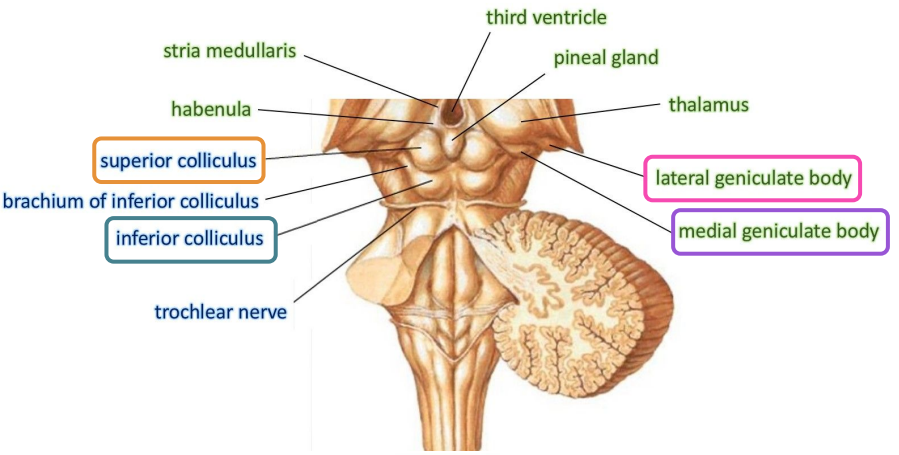
1. The Tectum
("roof" in latin), includes:

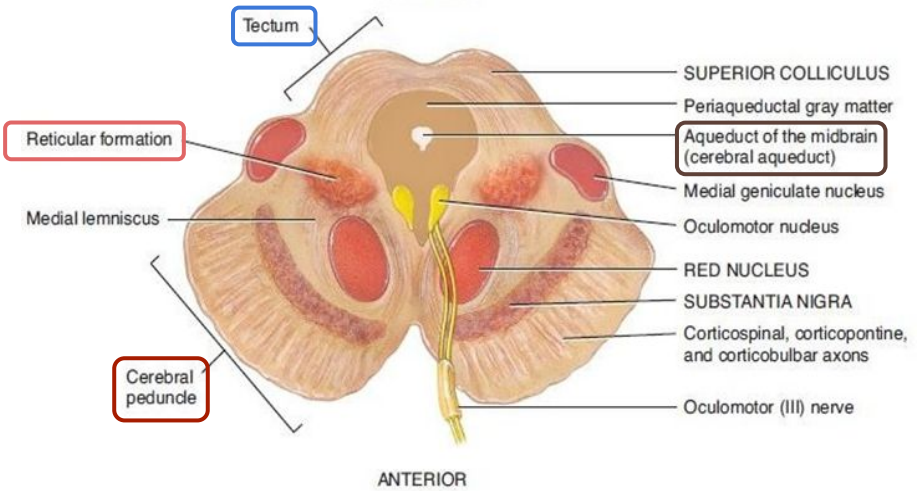
A) The superior colliculus:
- It constitutes center for visual reflexes.
- It sends its superior brachium to the lateral geniculate body of the thalamus.

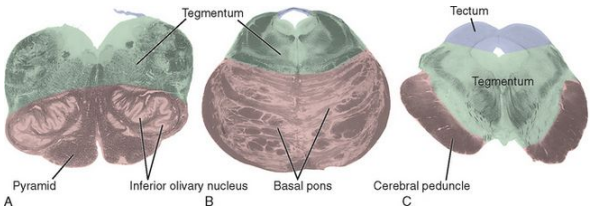
B) The inferior colliculus:
- It is associated with auditory pathway
- It sends its inferior brachium to the medial geniculate body of the thalamus.
- The cerebral aqueduct runs through the midbrain, beneath the colliculi.

2. The Tegmentum
- Ventral to the cerebral aqueduct.
- Several nuclei, tracts and the reticular formation is contained here.

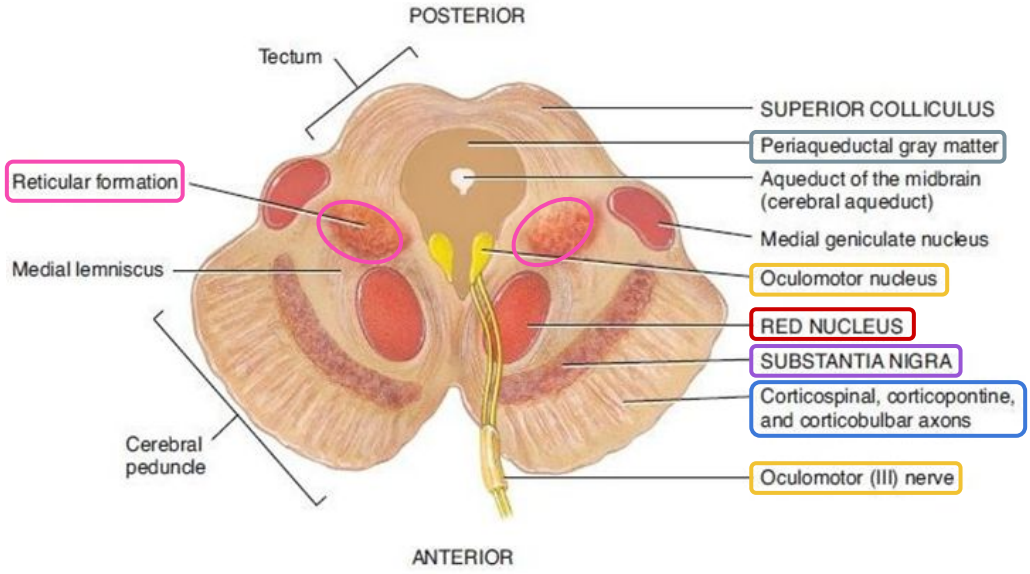
3. Cerebral Peduncles
- The ventral side of midbrain is comprised of paired **Cerebral Peduncles**
- These transmit axons of UMN (Upper Motor Neuron).







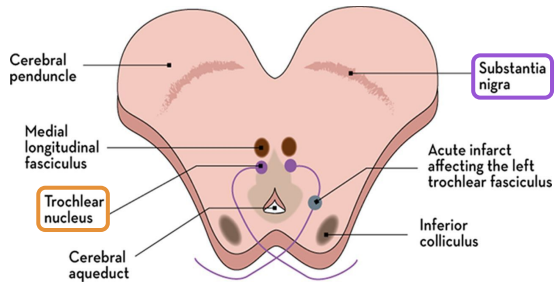
Midbrain Internal Structures



(b) Transverse section of midbrain

Reticular Formation:

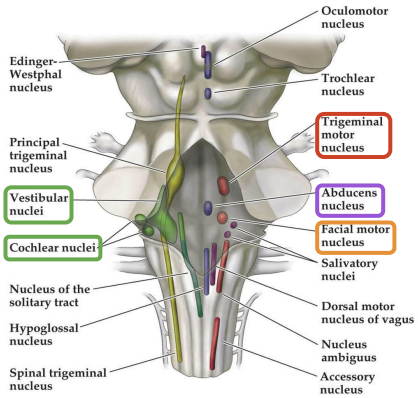
- A large area that is involved in various important functions of the midbrain:
  - It contains LMN.
  - It is involved in the pain desensitization pathway.
  - It is involved in the arousal and consciousness systems.
  - It contains the locus ceruleus, which is involved in intensive alertness modulation and in autonomic reflexes.



Periaqueductal Grey matter:	Oculomotor Nerve:	Red Nucleus:	Substantia Nigra:	Central Tegmental Tract:
Around the cerebral aqueduct, contains neurons involved in the pain desensitization pathway.	(CN III) nucleus.	This is a motor nucleus that sends a descending tract to the lower motor neurons.	- A concentration of neurons in the ventral portion of midbrain. - It is involved in motor function.	- 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.
	Trochlear Nerve:			
	(CN IV) nucleus.			

The Pons

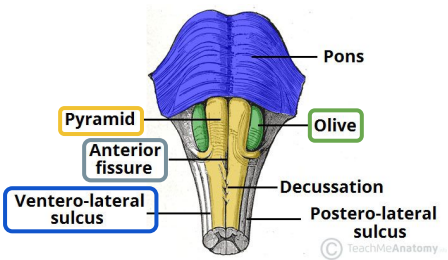
- At the level of the mid pons:
  - Trigeminal nerve (CN V) emerges.
    - Between the basal pons:
  - Cranial nerve 6 (abducens), 7 (facial) & 8 (vestibulo- cochlear) emerge (medial to lateral).



The Medulla

Ventral view

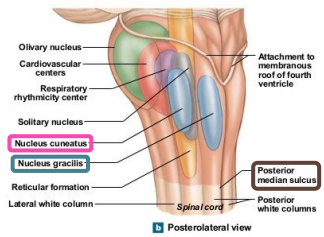
- The most medial part of the medulla is the anterior median fissure.
- Moving laterally on each side are the pyramids.
- They contain the fibers of the corticospinal (pyramidal) tract as they head inferiorly to synapse on lower motor neuronal cell bodies within the ventral horn of the spinal cord.



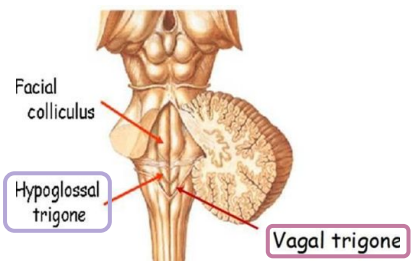
- The anterolateral sulcus is lateral to the pyramids.
- Emerging from the anterolateral sulci are the hypoglossal nerve (CN XII) rootlets.
- Lateral to the anterolateral sulci are the olives containing underlying inferior olivary nuclei and afferent fibers).
- Lateral (and dorsal) to the olives are the rootlets for glossopharyngeal (IX) & vagus (X) cranial nerves.

Dorsal view

- The most medial part of the medulla is the posterior median fissure.
- Moving laterally on each side is the fasciculus gracilis.
- Lateral to that is the fasciculus cuneatus.
- Superior to each of these, are the gracile and cuneate tubercles, respectively.
- Underlying these are their respective nuclei.



- 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.



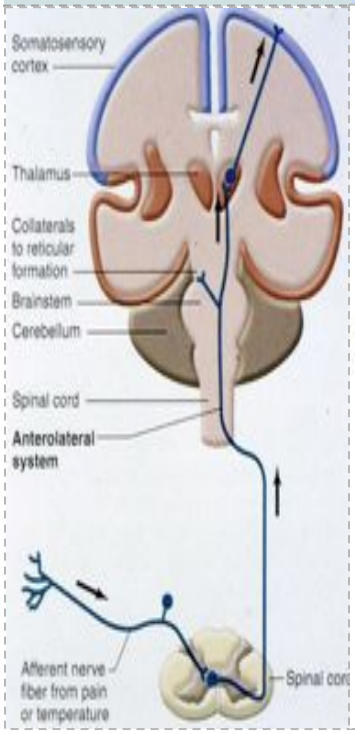
Brain Stem function

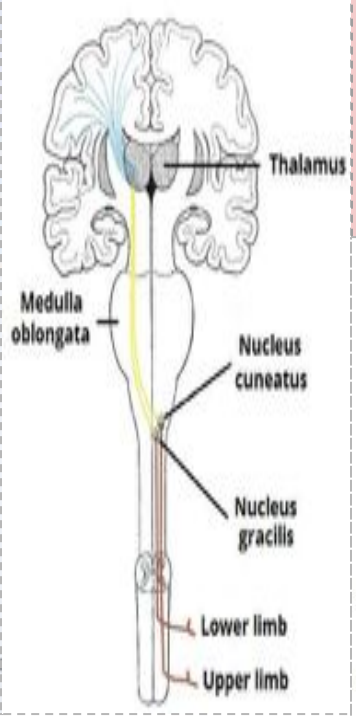
Though small, brain stem is an extremely important part of the brain:
1.Conduct functions.
2.Provides the origin of the cranial nerves (CN-III-XII).
3.Conjugate eye movement.
4.Integrative functions.

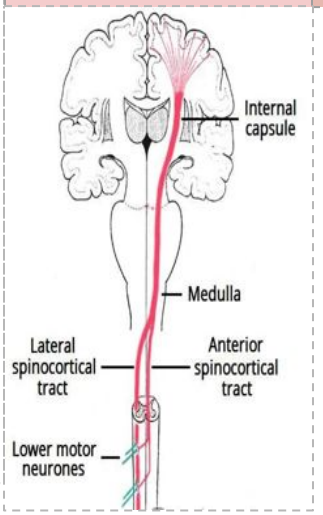
1. Conduct functions

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

The ascending sensory pathways		Descending tracts	
coming from the body to the brain includes:		Corticospinal tract (UMN)	Upper motor neurons
The spinothalamic tract for pain and temperature sensation	The dorsal column, fasciculus gracilis, and cuneatus for touch, proprioceptive and 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.	originate in brain stem's vestibular, red, and reticular nuclei, which also descend and synapse in the spinal cord.







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

- The brain stem provides the main motor and sensory innervation to the face and neck via the cranial nerves (CN III-XII).
- The fibers of cranial nerve nuclei except for olfactory & optic nerve either originating from, or terminating in the cranial nerve nuclei in brainstem.

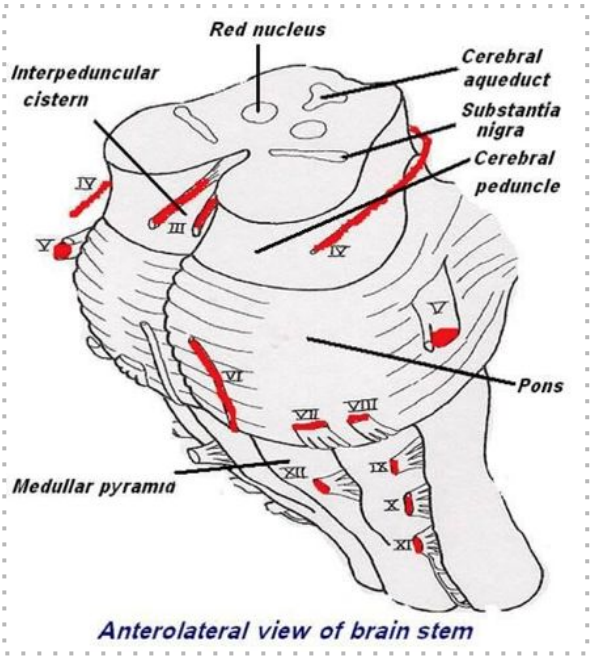
Origin and function of the cranial nerve

Origin	CN number	Function
Midbrain	CN III(oculomotor)	Both moves eyes; CN III constricts the pupils, accommodates.
	CN IV(trochlear)	
Pons	CN V (trigeminal)	Chews and feels front of the head.
	CN VI (abducens)	Moves eyes
	CN VII (facial)	Moves the face, tastes, salivates, cries.
	CN VIII (acoustic)	Hears, regulates balance.
Medulla	CN IX (glossopharyngeal)	Tastes, salivates, swallows, monitors carotid body and sinus.
	CN X (vagus)	Tastes, swallows, lifts palate, talks, communication to and from thoraco-abdominal viscera.
	CN XI (accessory)	Turns head, lifts shoulder.
	CN XII (hypoglossal)	Moves tongue.

*Note that the origin of CN I and II are not in the brain stem

Classification of the cranial nerve according to function (Motor-Sensory-Mixed)

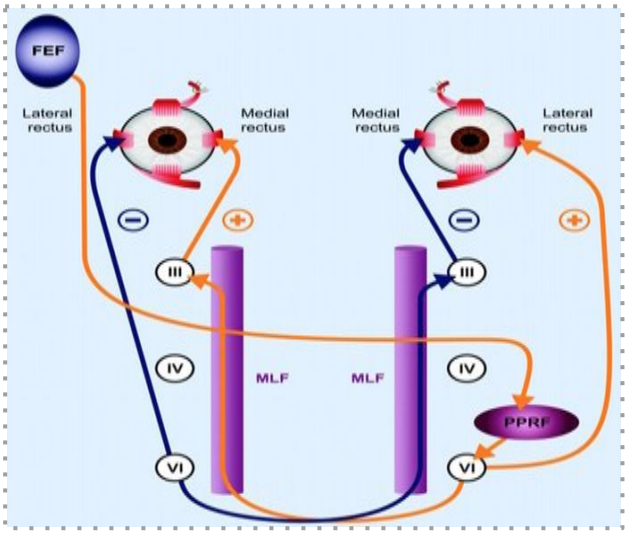
Function	Cranial nerve
Sensory	CN I (Olfactory)
	CN II (Optic)
	CN VIII (acoustic)
Motor	CN III (oculomotor)
	CN IV (trochlear)
	CN VI (abducens)
	CN XI (accessory)
	CN XII (hypoglossal)
Both (mixed)	CN V (trigeminal)
	CN VII (facial)
	CN IX (glossopharyngeal)
	CN X (vagus)



Mnemonic :
Some **S**ay **M**y **M**other **B**ought **M**y **B**rother **S**ome **B**ad **B**eer **M**y **M**y
S: sensory. M: motor. B:both.

3.Conjugate eye movement

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



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, projections 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.

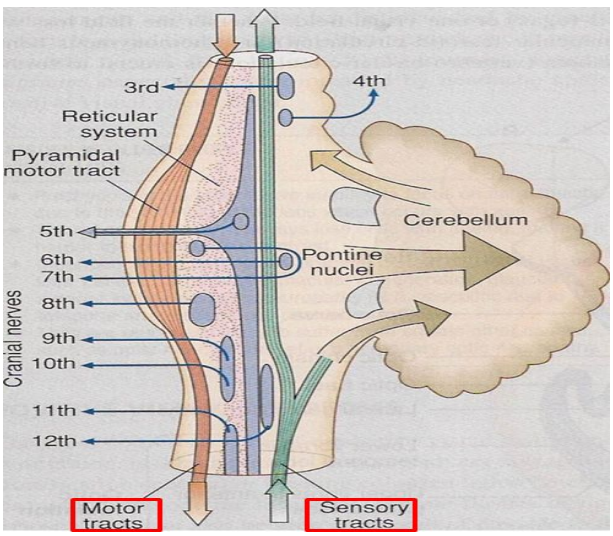
4. Integrative functions

1. It controls consciousness & sleep cycle (alertness and arousal) through reticular formation.
2. It has got center for cardiovascular, respiratory & autonomic nervous system.
3. It has centers for cough, gag, swallow, and vomit.
4. Sense of body balance (Vestibular functions)
5. Plays role in motor control:
   a. Substantia Nigra (which is a part of the basal ganglia) is involved in control of movement.
   b. Red nucleus in Midbrain which regulate the motor activity through cerebellum.
6. 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.
7. auditory & visual processing required for head movements, in the Inferior and superior colliculi which are situated on the dorsal surface of the midbrain.

Functional organization of the Brain stem

1- Ventral :
- Motor in function

2- Middle:
- Sensory in function
- Contains medial lemniscus which conveys sensory information from dorsal column.



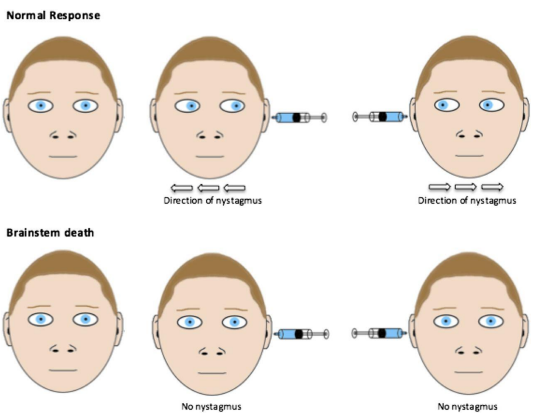
Brainstem IMPORTANT!!

Part	Midbrain	Pons	Medulla oblongata
Function	1- Nerve pathway to cerebral hemispheres. 2- Auditory and Visual reflex centers.	•Respiratory Center.	1. Crossing of motor tracts. 2. Cardiac Center. 3. Respiratory Center. 4. Vasomotor Center (nerves having muscular control of the blood vessel walls) 5. Centers for cough, gag, swallow, and vomit.
Cranial nerves	Two: •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).	Four: •CN V - Trigeminal [motor and sensory]. (Skin of face, tongue, teeth; muscle of mastication). •CN VI - Abducens [motor]. (Lateral rectus muscle of eye which rotates eye outward). •CN VII - Facial [motor and sensory]. (Muscles of facial expression). •CN VIII - Acoustic [sensory]. (Hearing)	Four: •CN IX - Glossopharyngeal [mixed]. (Muscles & mucous membranes of pharynx, the constricted openings from the mouth & the oral pharynx and the posterior third of tongue). •CN X - Vagus [mixed]. (Pharynx, larynx, heart, lungs, stomach). •CN XI - Accessory [motor]. (Rotation of the head and shoulder). •CN XII - Hypoglossal [motor]. (Intrinsic muscles of the tongue).
Signs and symptoms of lesion	•Cranial Nerve (CN) deficits: Ipsilateral CN III, CN IV palsy and ptosis (drooping). •Pupils: - Size: Midposition to dilated. - Reactivity: Sluggish to fixed. •Movement: Abnormal extensor. •Respiratory: Hyperventilating. •Loss of consciousness (LOC): Varies	•CN Deficits: CN V, CN VI, CN VII, CN VIII. •Pupils size: Pinpoint •Movement: Abnormal extensor. •Respiratory: -Apneustic (Abnormal respiration marked by sustained inhalation). -Hyperventilation. •LOC: Semi-coma	•Movement: Ipsilateral paralysis. •Pupils: - Size: Dilated. - Reactivity: Fixed. •Respiratory: Abnormal breathing patterns •CN Palsies: Inability to control movement. Absent cough, gag. •LOC: Comatose.

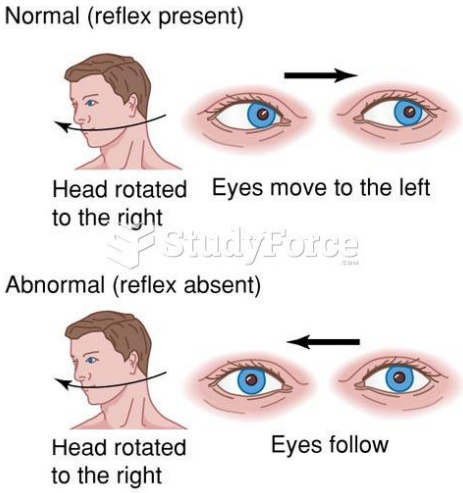
Brainstem function tests

- To test reticular formation:
  - A. Alertness, Consciousness & Sleep.
  - B. Corticospinal tract: by Motor power, reflexes.
  - C. Pain response: Facial grimacing on firm pressure over the supraorbital ridge.
- To test respiratory center:
  - Look for the normal pattern of respiration.
- To test Cardiovascular center:
  - Look for normal circulatory function.
- 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 one or another directions.
  - Gag reflex.
  - Cough reflex.

Vestibulo-ocular reflex



Oculocephalic reflex



Deficits of Brainstem Structures

*All of them are ipsilateral except 3

Midline Structures

- Motor pathway (Corticospinal Tract) → Deficit → Contralateral weakness
- Medial lemniscus → Deficit → Contralateral proprioception/ vibration loss
- Medial longitudinal fasciculus → Deficit → Ipsilateral internuclear ophthalmoplegia
- Motor nucleus and nerve → Deficit → Ipsilateral CN function loss

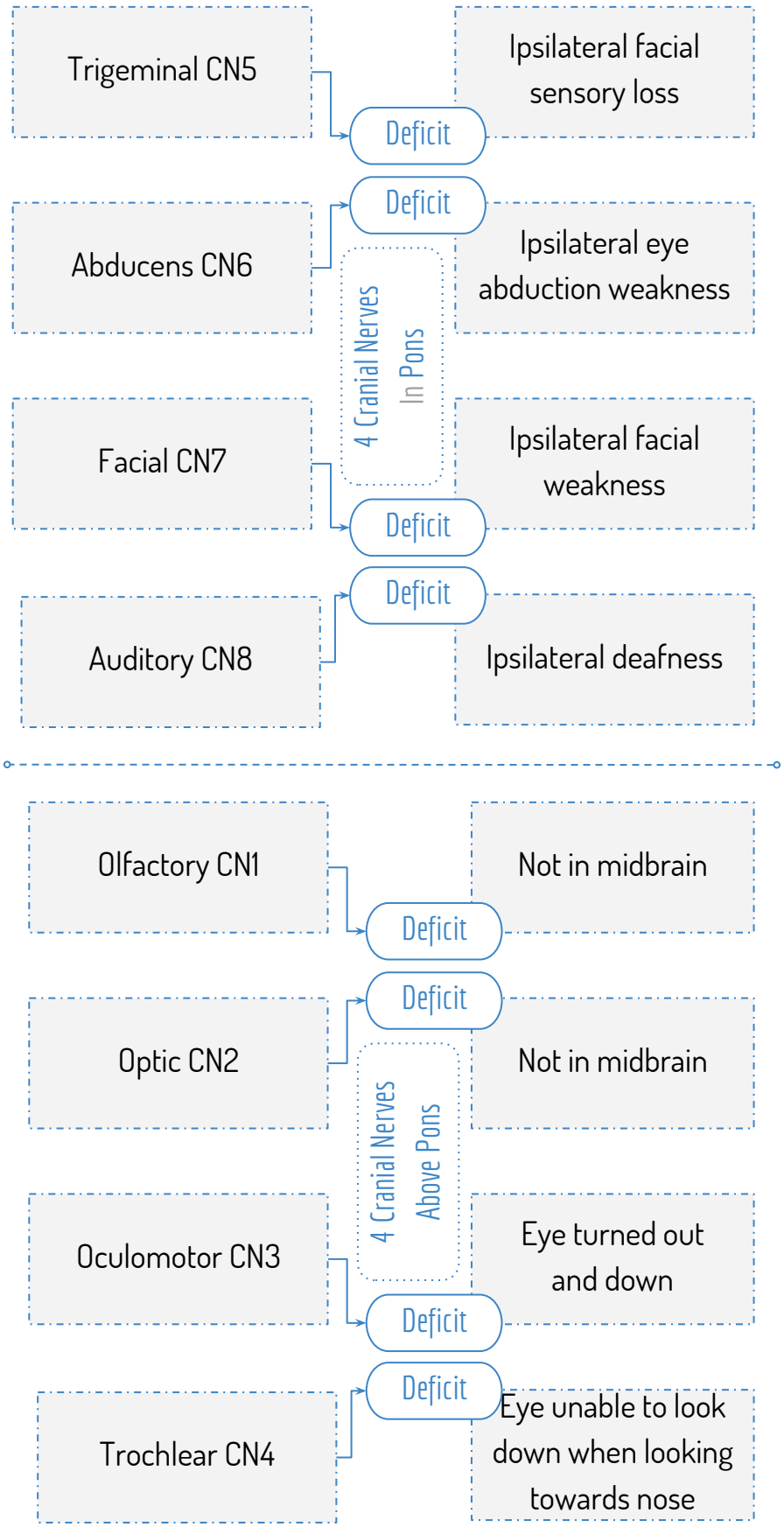
Lateral Structures

- Spinocerebellar pathway → Deficit → Ipsilateral ataxia
- Spinothalamic → Deficit → Contralateral pain/ temp sensory loss
- Sensory nucleus of CN5 → Deficit → Ipsilateral pain/ temp loss in face
- Sympathetic pathway → Deficit → Ipsilateral Horner's syndrome

4 Cranial Nerves In Medulla

- Glossopharyngeal CN9 → Deficit → Ipsilateral pharyngeal sensory loss
- Vagus CN10 → Deficit → Ipsilateral palatal weakness
- Spinal accessory CN11 → Deficit → Ipsilateral shoulder weakness
- Hypoglossal CN12 → Deficit → Ipsilateral weakness of tongue

Deficits of Brainstem Structures Cont.



Sample Cases

Sample case 1:

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
58 year old woman		- Medial
- Left hemiparesis	- motor (corticospinal tract), right	- Medial
- Left-sided loss of proprioception	- medial lemniscus, right	- Medulla
- Right-sided tongue deviation	- CN12, right	- Medial

Answers:

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

Sample case 2:

A 58 y/o female patient was referred to you because of recent onset of Left sided miosis, anhydrosis, ptosis, left-sided ataxia, Uvula deviated to right.

History	Fiber	Location
58 year old woman	Sympathetic tract, Left	- Side, left
- Left-sided meiosis, anhydrosis, ptosis Left-sided ataxia.	- Spinocerebellar	- Side, left
- Uvula deviated to right.	- CN10, Left	- Medulla

Answers:

- Lateral medullary syndrome (L)
- Posterior inferior cerebellar artery (L)

1.structure in midbrain is associated with auditory pathway?

A. Inferior colliculus
B. Superior colliculus
C. Tegmentum
D. Substantia nigra

2.Which one of the following Cranial Nerves is pure Sensory?

A. Abducents
B. Accessory
C. Trochlear
D. Olfactory

3.Which of the following is rich in endogenous opioid?

A. Substantia nigra
B. Red nucleus
C. Periaqueductal grey matter
D. Superior rectus

4.Pinpoint pupil size, hyperventilation and sustained inhalation is a characteristic of?

A. Lesion in medulla oblongata
B. Lesion in cerebral peduncles
C. Lesion in midbrain
D. Lesion in pons

5.A patient with a lesion in Trochlear nerve , which muscle nerve supply is affected?

A. Superior oblique
B. Inferior oblique
C. Lateral rectus
D. Superior rectus

6.which of the following cranial nerve is responsible of rotation of head?

A. Optic nerve
B. Trigeminal nerve
C. Accessory nerve
D. hypoglossal nerve

7.Which brainstem structure is a center for gag reflex?

A. Midbrain
B. Pons
C. Medulla oblongata
D. Thalamus

8.which of the following muscle is contracted as a part of the pupillary reflex?

A. Ciliary muscle
B. Pupillary dilator muscle
C. Pupillary sphincter muscle
D. Superior oblique muscle

9.if there is a lesion in the Vagus cranial nerve it will cause.....?

A. Contralateral palatal weakness defect
B. Ipsilateral palatal weakness defect
C. Contralateral pain loss in the face
D. Ipsilateral pain loss in the face

Answers:
1.A
2.D
3.C
4.D
5.A
6.C
7.C
8.C
9.B