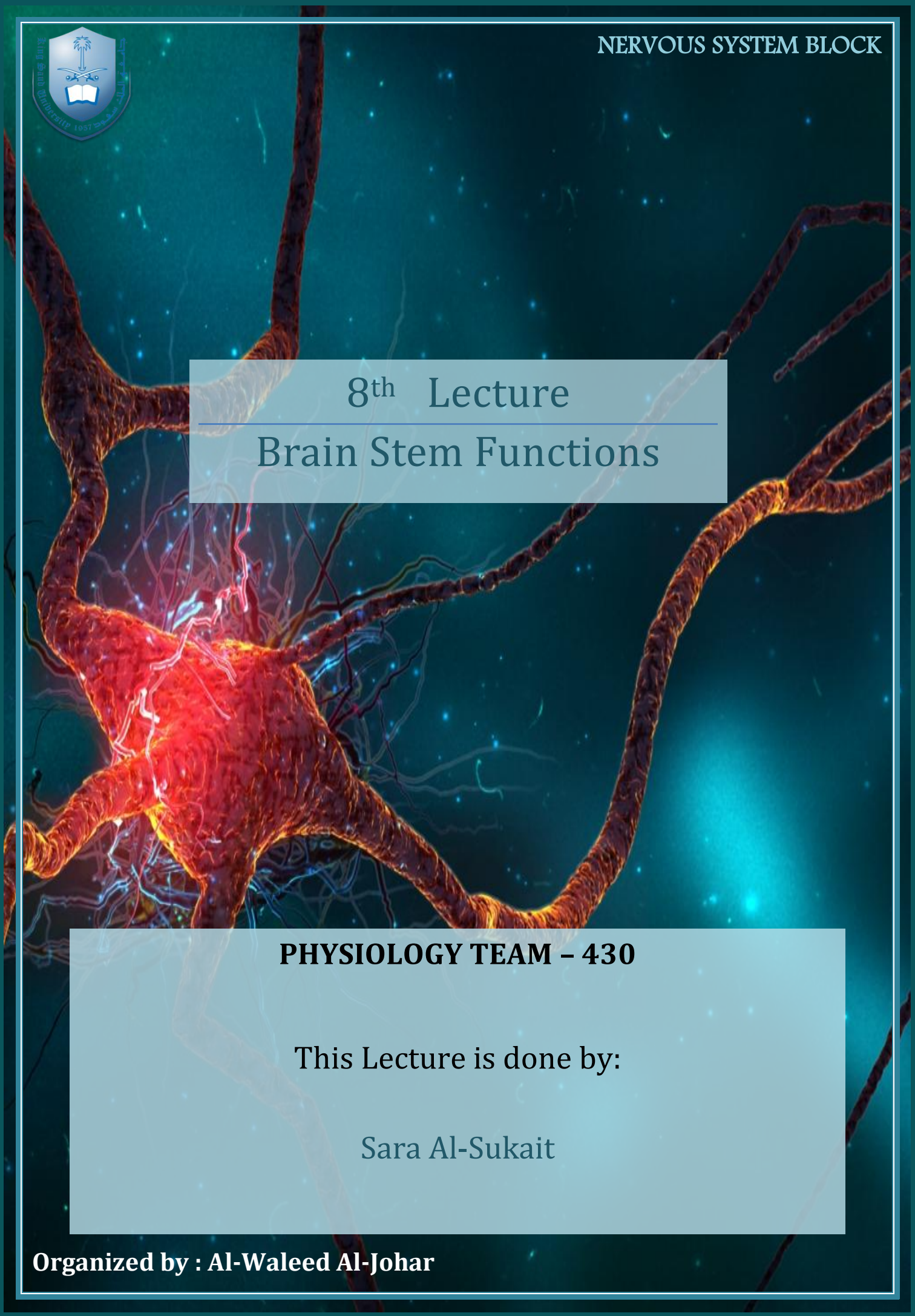

NERVOUS SYSTEM BLOCK

8th Lecture

Brain Stem Functions

PHYSIOLOGY TEAM – 430

This Lecture is done by:

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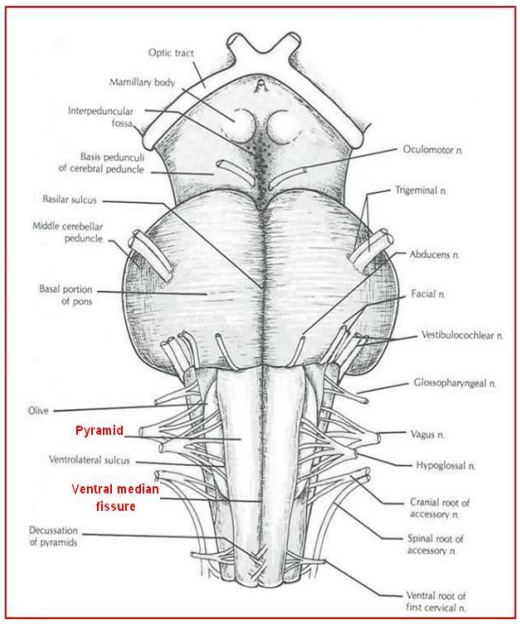
Organized by : Al-Waleed Al-Johar

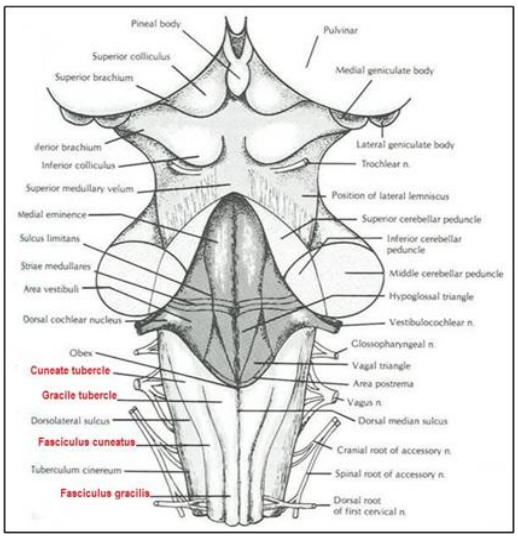
An overview on the Anatomy of the brain stem

- **Brain Stem:**

- It is the lower part of the brain, adjoining and structurally continuous with the spinal cord.
- Cerebellum is attached to the brainstem through cerebellar peduncle to convey information to and from the cerebellum.
- It is subdivided into: Mid Brain, Pons and Medulla Oblongata.



Ventral View



Dorsal View

1- Mid Brain: Divided into 3 parts:

1) **Tectum:** it is the dorsal portion of mid brain, it includes:

A. **The superior colliculus**, which is involved in vision and sends its superior brachium to the lateral geniculate body of the thalamus.

B. **The inferior colliculus**, which is involved in hearing and sends its inferior brachium to the medial geniculate body of the thalamus.

The cerebral aqueduct runs through the midbrain, beneath the colliculi.

2) **Tegmentum:** it lies ventral to the cerebral aqueduct. Several nuclei, tracts and reticular formation are located here.
3) **Paired Cerebral Peduncles:** on the ventral side, they transmit axons to UMN (Upper Motor Neurons).

- **Internal structures of Midbrain:**

  Periaqueductal gray - Oculomotor and Trochlear nerve nuclei - Red nucleus - Substantia nigra - Reticular formation - Central tegmental tract

  Note: Central tegmental tract: Directly anterior to the floor of the 4th ventricle, this is the pathway by which many tracts project up to the cortex and down to the spinal cord.

2- Pons:

- **Ventral View:**

- Between the basal pons, cranial nerve 6, 7 and 8 emerge (medial to lateral).
- At the level of the mid-pons, the large trigeminal nerve emerges.

3- Medulla Oblongata:

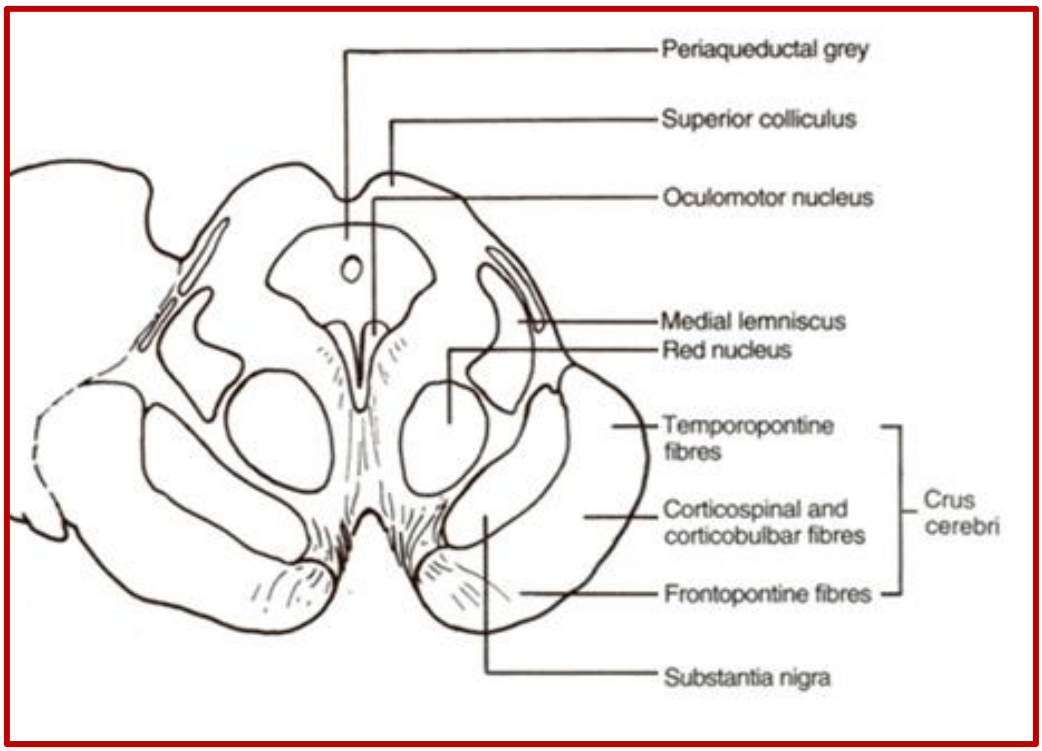
- **Ventral View:**

- Anterior median fissure.
- The pyramids contain the fibers of the corticospinal tract as they head inferiorly to synapse on LMN (Lower Motor Neurons) within the ventral horn of the spinal cord.
- The antero-lateral sulcus is lateral to the pyramids. Emerging from the antero-lateral sulci are the hypoglossal nerve bodies.
- The olives contain the inferior olivary nuclei. Lateral and dorsal to the olives are the rootlets of the cranial nerves 9 and 10.

- **Dorsal View**

- The posterior median fissure
- Moving laterally on each side is the fasciculus gracilis, and 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.

Functional Anatomy of the brain stem:



- **Brain Stem In General:**

- Ventral layer of brain stem is **Motor** in function.
- Middle layer is **Sensory** in function and contains the medial lemniscus, which conveys sensory information from dorsal column.

- **Functional Anatomy Of The Mid-Brain:**

- **External structures:**

1. **Inferior and superior colliculi** and is involved in auditory and visual processing required for head movements.

- **Superior colliculus** → concerned with **visual reflex**
  (Superior colliculi receive afferent fibers from the optic and the visual cortex. The efferent fibers form the tectospinal and tectobulbar tracts, which are responsible for the reflex movements of the eyes, head, and neck in response to visual stimuli)
- **Inferior colliculus** → forms part of the **auditory pathway**

2. **Trochlear (IV)** nerve emerges from dorsal surface of the midbrain.
3. **Oculomotor (III)** nerve emerges from ventral surface of the midbrain
4. **Paired cerebral peduncles** which **transmit axons** to the UMN.
   (Crus cerebri consists of descending cortical fibers that initiate all Motor movements)

- **Internal structures:**

1. **Substantia Nigra :**

   This is a concentration of neurons in the ventral portion of the midbrain and it is a part of the basal ganglia. It is involved in **control of movement** and it is very rich in dopamine. Its degeneration is associated with Parkinson's disease.

2. **Red Nucleus:**

   This is a **motor** nucleus that sends a descending tract (rubrospinal tract) to the LMN. It regulates the **motor activity** through the cerebellum.

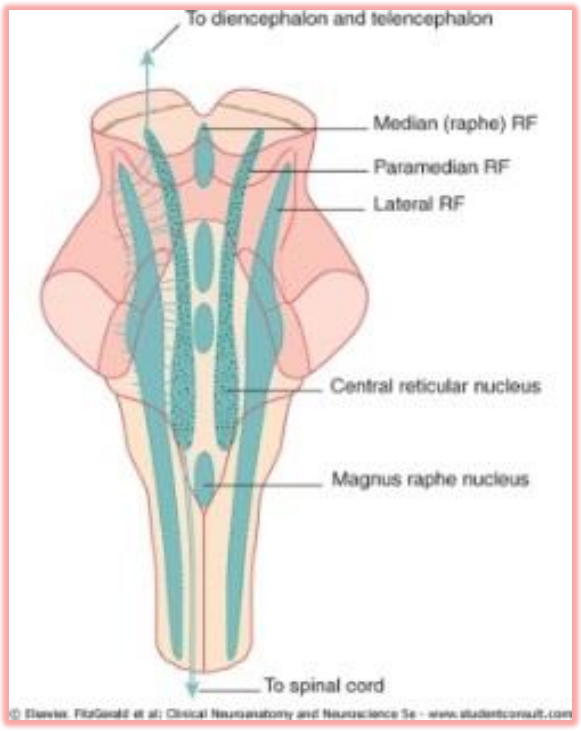
3. **Periaqueductal Grey Matter:**

   It lies around the cerebral aqueduct, contains neurons involved in the pain desensitization pathway (**controls pain sensitivity**). An area rich in endogenous opioid and is important in modulation of painful stimuli.

4. **Reticular Formation:**

- A large area extends throughout the brain stem. It has many functions:

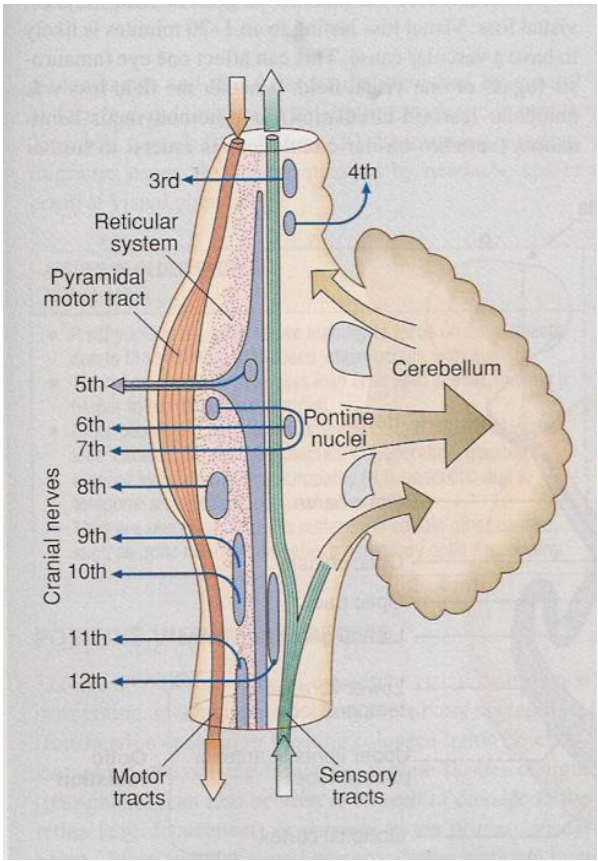
1) Controls the **arousal and consciousness** system (will be explained later).
2) The **respiratory and CVS centers** are located In medullary and pontine reticular formation.
3) It is involved in pain desentization pathway (**modulation of pain**).
4) It has an influence on **muscle tone and posture** (via reticulospinal tracts).
5) Locus ceruleus is located within the reticular formation, which is involved in intensive alertness modulation and in autonomic reflexes.
6) It contains lower motor neurons.



- **Notes:**
- The Thalamus is the junction of all sensory information.
- Reticular Ascending (Activating) System (RAS):

✓ It is a very necessary system, its function is to keeps us awake and alert
✓ If that system stops, the individual will go in a coma
✓ If the individual wants to sleep, he should avoid stimulation of Afferents

- **Brain Stem Functions:**



1) Conduct Functions

- All incoming and outgoing fibers traversing between the periphery and higher brain centers must pass through the brain stem, with incoming fibers relaying sensory information to the brain and outgoing fibers carrying command signals from the brain for efferent output.
- Thus, the brain stem is a critical connecting link between the rest of the brain and the spinal cord.

A. Descending fibers:

Descending fiber systems both pass through the brain stem and originate within it:

1. The corticospinal tract (UMN):

Runs through the crus cerebri, the basal part of the pons and the medullary pyramids; 70-90 % of fibers cross In the pyramidal decussation to form the lateral corticospinal tract which is destined to synapse on lower motor neurons in the ventral horn of the spinal cord.

2. Upper motor neurons:

That originate in the brain stem's vestibular, red, & reticular nuclei, which also descend & synapse in the spinal cord.

B. Asending fibers:

The ascending sensory pathways coming from the body to the brain include:

1. The spinothalamic tract:

for pain and temperature sensation

2. The dorsal column:

fasciculus gracilis, and cuneatus for touch, proprioceptive and pressure sensation

2) Vestibular Functions (Sense Of Balance):

Vestibular nucleus, which is essential for balance of the body posture, is located in the brainstem.

Vestibular nuclei selectively control the excitatory signals to the different antigravity muscles to maintain equilibrium in response to signals from the inner ear vestibular apparatus (a sensory organ for detecting sensations of equilibrium). In addition, the reticular formation has a role in maintaining the tone of the antigravity muscles while standing.

3) Centers for gag, cough, swallow and vomit

4) Center for cardiovascular, respiratory and autonomic nervous system:

Collected within the brain stem are neuronal clusters or centers that control heart rate and blood vessel function, respiratory rate and some digestive activities

- **Additional details:**

- **Respiratory centers:**

A. Medullary respiratory centers:

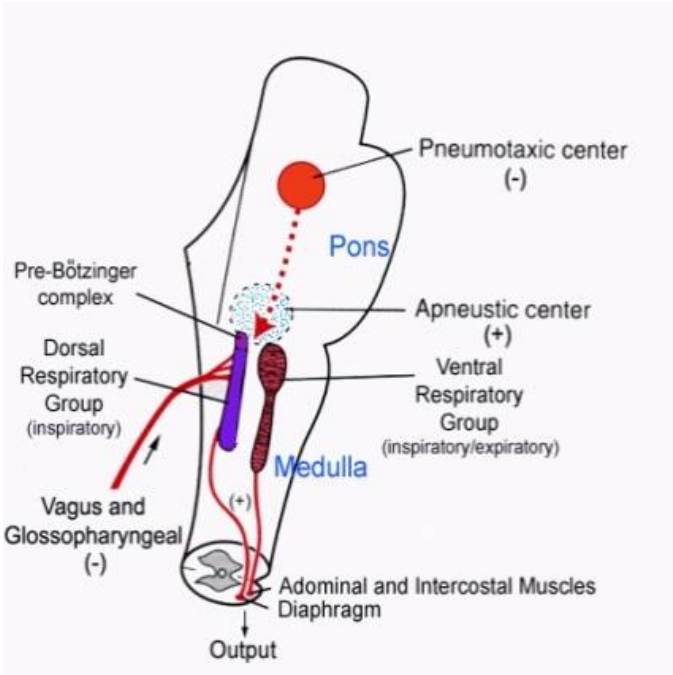
Basic rhythm of breathing is controlled by medullary rhythmicity area through the dorsal respiratory group and the ventral respiratory group.

B. Pontine respiratory centers:

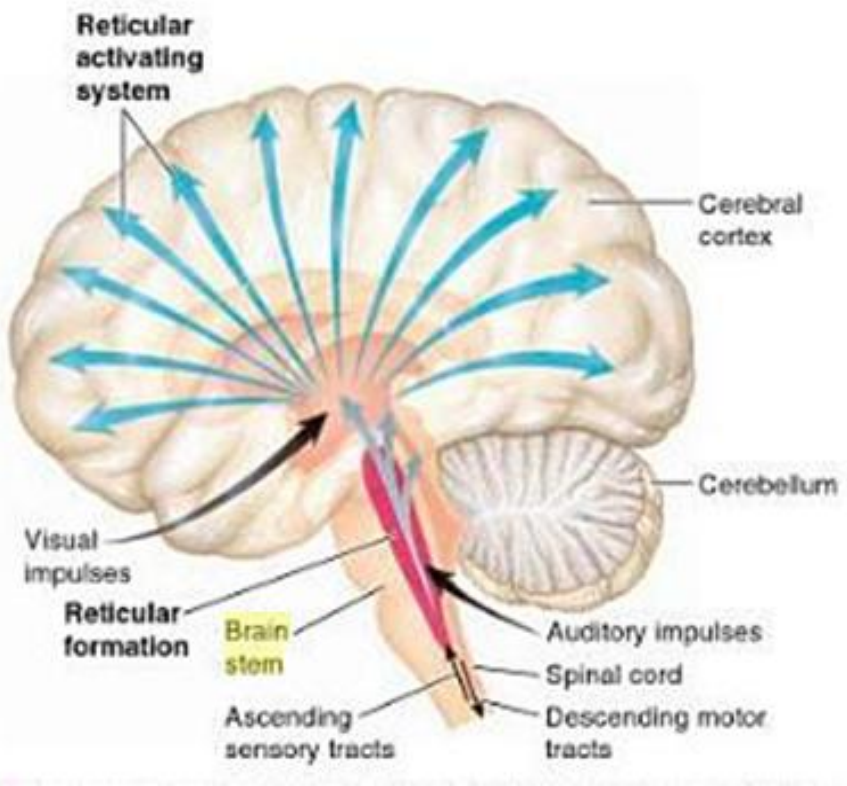
Control the transition between the inhalation and exhalation through the apneustic and pneumotaxic centers.

- **Cardiovascular centers:**

Found in medulla. Regulate the autonomic control of the heart and blood vessels (the heart rate and arterial blood pressure)



5) It controls consciousness and sleep cycle (Arousal and alertness) through the reticular formation:



- **Additional details:**

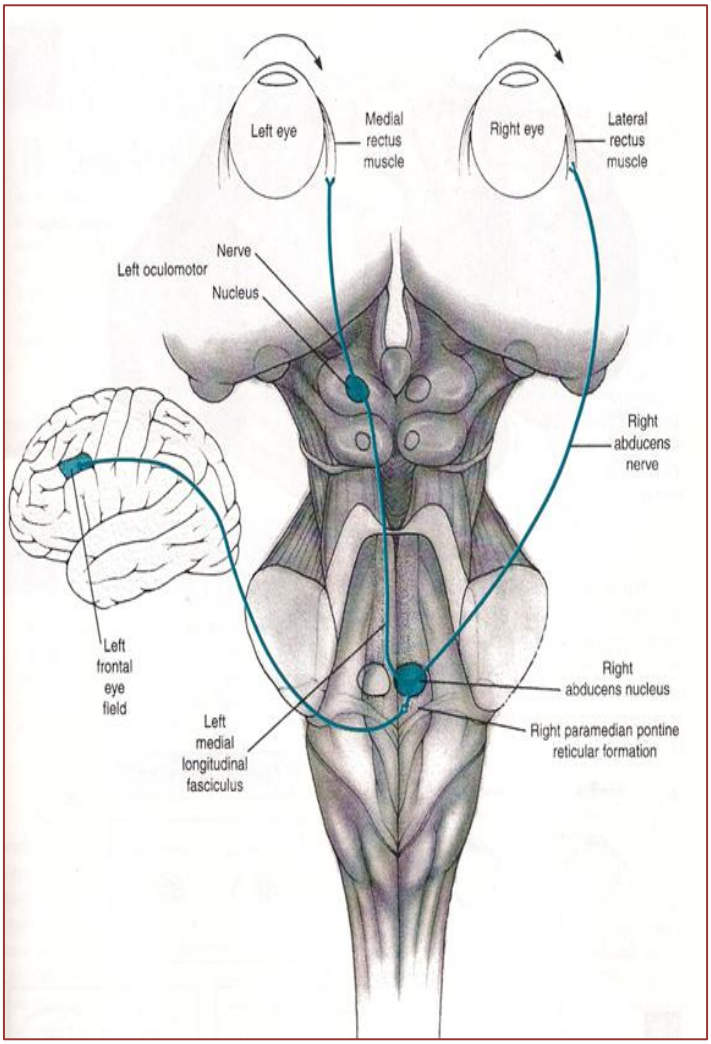
- **The role of reticular formation in arousal and alertness:**

- Reticular formation is a complex matrix of nerve fibers and small groups of nerve cells of diffused boundaries that extends throughout the brain stem and into the thalamus. This network receives and integrates all incoming sensory synaptic inputs. Ascending fibers originating in the reticular formation carry signals upward to arouse and activate the cerebral cortex causing a sleeping person to awaken and maintaining the state of consciousness.
- These ascending fibers compose the reticular activating system (RAS), which controls the overall ability to direct attention.

Attention-getting sensory synaptic input → energizes RAS → and subsequently CNS level of activity as a whole → alertness

- **Clinical aspect:** Coma can be caused by brain stem damage that interferes with the reticular activating system.

6) Conjugate eye movements:



- When you move both eyes left and then right, a conjugate eye movement is made.
- Contraction of lateral rectus muscle & medial rectus muscle
- **Mechanism:**
  Voluntary horizontal gaze in one direction begins with downward projections from the cortex (left frontal eye field) to the opposite paramedian pontine reticular formation (pontine gaze center). The PPRF projects to the ipsilateral abducens nucleus which innervates the lateral rectus muscle(causing eye abduction on that side) and it projects fibers to the contralateral oculomotor nucleus via the medial longitudinal fasciculus. The oculumotor nucleus then activates the medial rectus muscle (causing eye adduction in order to follow the abducting eye).
- **Control of eye movements:**
  All muscles of the eyes are supplied by the 3rd cranial nerve except for the lateral rectus muscle & superior oblique muscle which are innervated by the abducens nerve and trochlear nerve, respectively.

7) It contains the important nuclei of cranial nerves from 3rd to 12th:

- The brain stem provides the main motor and sensory innervation to the face and neck via the cranial nerves (CN 3rd – 12th)

Mid-brain

1. *Trochlear nerve IV from the dorsal aspect.*

2. *Oculomotor nerve III from the ventral aspect*

Pons

1. *Trigeminal nerve V*
2. *Abducent nerve VI from the posterior margin of the pons at the junction between pons and medulla*

From <u>Cerebellopontine</u> angle:

1. *Facial VII nerve.*

2. *Vestibulocochlear VIII nerve*

Medulla Oblongata

1. *Glossopharyngeal IX nerve*

2. *Vagus nerve X*

3. *Accessory nerve XI (Cranial part)*

4. *Hypoglossal nerve XII*

1. Memorize the 12 cranial nerves and their functions. Ribald mnemonics will not help. You must know the individual cranial nerves and their functions on instant recall.

CN1:	Smells
CN2:	Sees
CNs 3, 4 and 6:	Move eyes; CN3 constricts pupils, accommodates
CN5:	Chews and feels front of head
CN7:	Moves the face, tastes, salivates, cries
CN8:	Hears, regulates balance
CN9:	Tastes, salivates, swallows, monitors carotid body and sinus
CN10:	Tastes, swallows, lifts palate, talks, communication to and from thoraco-abdominal viscera
CN11:	Turns head, lifts shoulders
CN12:	Moves tongue

SENSORY	CN I	Olfactory
	CN2	Optic
	CN8	Vestibulococh
MOTOR	CN3	Oculomotor
	CN4	Trochlear
	CN6	Abducens
	CNII	Accessory
	CNI2	Hypoglossal
MIXED	CN5	Trigeminal
	CN7	Facial
	CN9	Glossopharyng
	CNIO	Vagus

- **Summary of Brain Stem Functions:**

- Alertness & arousal
- Breathing , Heart rate, and digestion.
- Blood Pressure
- Contains Most of the Crainal Nerves
- Other Autonomic Functions
- Relays Information Between the Peripheral Nerves and Spinal Cord to the Upper Parts of the Brain
- Sense of Balance (Vestibular Functions)
- Conjugate eye movements
- Contains motor and sensory systems.

- **Brain Stem Function Tests:**

- To test **Reticular Formation**: Alertness, consciousness and sleep
- To test **Corticospinal Tract**: Motor power, reflexes
- To test **Pain** response: Facial grimacing on firm pressure over the supra orbital ridge
- To test **Respiratory** center: look for the normal pattern of respiration
- To test **CVS** center: look for normal circulatory function
- To test **Brainstem Reflexes** (Discussed in details)

- **To Test Brainstem Reflexes:**

1) Pupillary reflex:

It is a reflex that controls the diameter of the pupil, in response to the intensity of light that falls on the retina of the eye. The normal response would be the reduction of pupil size in both eyes in response to light (direct and consensual response).

Note: Cranial nerve 3 innervates the sphincter pupillae muscle which constricts the pupils.

2) Corneal reflex:

Light touching of the cornea which overlies the iris (with a cotton wisp) results in blinking of the eyelids. The afferent impulses travel through the ophthalmic division of the trigeminal nerve. Inter-neurons connect with the motor nucleus of the facial nerve which supplies the muscle that causes the closure of the eyelids.

3) Vestibulo-ocular reflex:

Can be investigated with caloric tests which involves injection of iced water into the ear (external auditory meatus) and that should produce eye movements.

4) Oculo-cephalic reflex (Doll's eye reflex):

The Eyes will be fixed when head is moved in one or another directions.

5) Cough reflex can be tested by using bronchial suctioning.

6) Gag reflex:

This may be tested by touching the lateral wall of the pharynx with tongue depressor. This should immediately cause the patient to gag; that is, the pharyngeal muscles will contract. The afferent neurons of this reflex run in the glossopharyngeal nerve, & the efferent neurons run in the glossopharyngeal nerve (to stylopharyngeaus muscle) & vagus nerve (to pharyngeal constrictor muscles)

- **Brain Death:**

  Brain death means loss of cortical functions , loss of spontaneous breathing & no brain stem function.

- **Medical criteria:**

1. **Irreversible structural brain damage**:
   A disorder that can cause brain stem death.

2. **Coma/unresponsiveness:**
   no motor response to any stimulus (pain) in all extremities and no motor function (i.e. if we lift his hand it'll fall).

3. **Absence brain stem reflexes:**

- Pupils fixed and unresponsive to light.
- No deviation of the eyes to irrigation in each ear with cold water (no vestibulocochlear reflex).
- Absent corneal, oculo-cephalic, gag and cough reflexes.
- An essential component in clinical determination of brain death is detection of apnea. Loss of brain stem function definitively results in loss of centrally controlled breathing, with resultant apnea.

How to do an Apnea test?

- Remove the ventilator → deliver 100% oxygen → observe the patient closely for respiratory movement → measure PCO2, PO2 and pH.
- If any respiratory movements/any attempt of breathing is present → the patient is NOT dead.