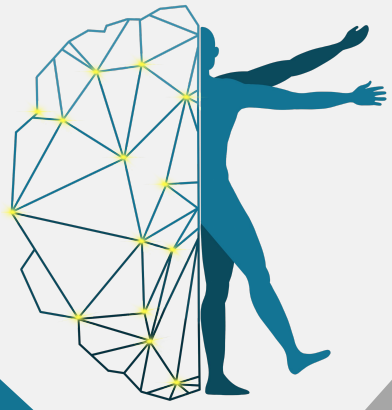
Physiology Team 439

MED439
KING SAUD UNIVERSITY

Revised & Approved
Abdullah Alsubaihi
Rania Almutiri



Physiology of consciousness

Special thanks to Fatimah Saad for all her hard work on this lecture!

Objectives:

- Define Consciousness and explain the different states of consciousness.
- Explain what is meant by “Reticular Activating System” RAS.
- Define the function and location of the bulboreticular Facilitatory.
- bulboreticular Facilitatory area, Thalamus and cerebral cortex subserves & sustains consciousness.
- Explain how a medical person can differentiate between conscious and unconscious person by means of outward behavior and physical signs
- Describe the role of EEG and evoked potentials in differentiating between a conscious person, a sleeping person, a comatose patient and a dead patient..

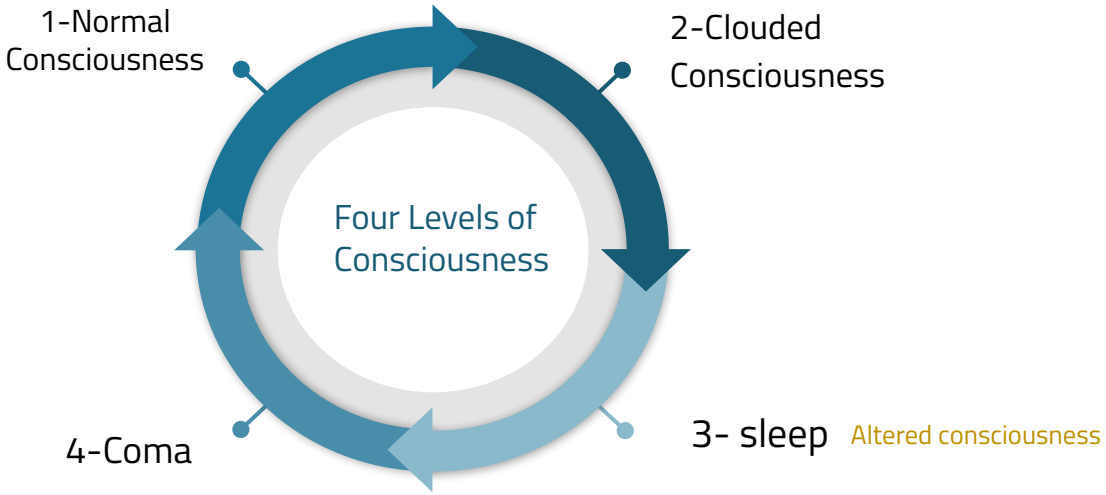
Color index:

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

Editing File

Consciousness

Is the brain state in which a person is being aware of the self and surroundings It is a product of electrical activity of the brain



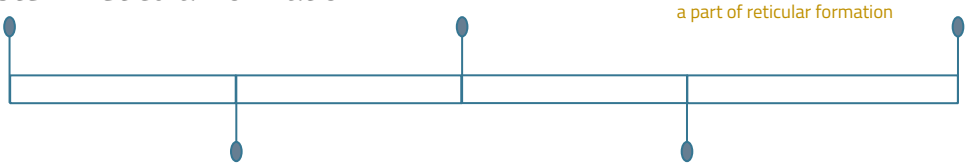
Normal Consciousness	Clouded Consciousness	Sleep	Coma
State of normal arousal, being fully awake and aware of the self and surroundings	aware of surroundings but confused person conscious but mentally confused.E.g: -in cases of drug or alcohol intoxication. -High fever associated (malaria or septicemia, dementia, etc) Hypothalamus play a role in body temperature and the development of fever	Person unconscious (in relation to the external world & surroundings), but is arousable	Person unconscious and not arousable

brain Structures involved in the conscious state:

most important
Brain stem Reticular formation

Hypothalamus

Ascending projection pathways it's not a part of reticular formation



Wide spread area in the cerebral cortex

Thalamus

In consciousness the 5 areas cooperate to form our state in both health and diseased conditions

Set of interconnected nuclei that are located throughout the brainstem (Pons, Midbrain, Upper medulla), and the thalamus reticular nuclei

1-Reticular formation

1- Role in behavioral arousal.(personality & reflexes)
2- Role in consciousness (sleep/awake cycle).
3- Connect the brainstem to the cerebral cortex.

consists of 3 parts:

1- Lateral Reticular Formation

-Has small neurons

-Receives information from ascending tracts for touch and pain (From skin & all sensory tracts)

-Receives vestibular information from median vestibular nerve.
For indication of Position of objects

-Receives auditory information from superior olivary nucleus.

-Visual information from superior colliculus.

-Olfactory information via medial forebrain bundle

2- Paramedian Reticular Formation

-Has large cells

- Receives signals from lateral reticular formation

-Contains noradrenergic (NA) & Dopaminergic (DA) neurons, projects onto cerebral hemispheres. *

-Cholinergic (Chl) neurones project onto the thalamus. *

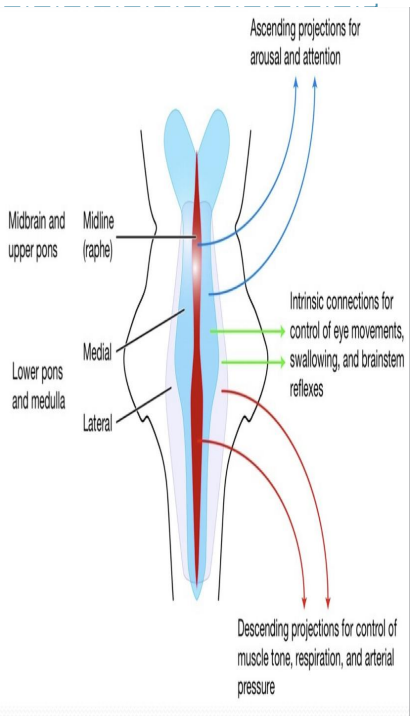
-Nucleus ceruleus which located bilaterally and posteriorly at junction between pons and midbrain ,contains noradrenergic neurons and projects onto the cerebral cortex. *

-Ventral tegmental nucleus contains dopaminergic neurons that project directly onto the cortex. *

-Acetyl choline secreted by cholinergic gigantocellular neurons project onto the thalamus *

3- Raphe Nuclei (Median RF)

In the midline of the reticular formation Contain serotonergic projections to the brain and spinal cord.



NE is an excitatory neurotransmitter
Dopamine is excitatory for the most part but can be inhibitory
ACH is important to stimulate the cerebral cortex
serotonin is an inhibitory neurotransmitter and it plays a role in pain modulation

Sensation is connected through the reticular formation to reach the cerebral cortex & give information about the surrounding.
Sensations of the lateral reticular formation are connected to the upper sphincter which are the thalamus & cerebral cortex.

Functions of reticular formation:

1

Somatic motor control

(Reticulospinal tracts)

They maintain the amount of muscle contraction needed for the body to function normally & to be in a good state with self & environment.

2

Cardiovascular control

Through cardiac and vasomotor centers of the medulla oblongata

3

Pain modulation raphe nuclei

▪Pain signals from the lower body >> >> RF >> >> cerebral cortex

▪ RF is origin of the descending analgesic pathways

▪ (act on the spinal cord to block the transmission of some pain signals to the brain)

If we have ascending pain sensation through the ascending sensory tract traveling towards the cerebral cortex of the spinal cord, it must travel through the Raphe Nuclei.
When pain becomes severe, the Raphe Nuclei will send inhibitory signals to inhibit the transmission of pain to the cerebral cortex causing the activation of the Internal Analgesic Tract.

4

Sleep and consciousness

The reticular formation has projections to the thalamus and cerebral cortex . It plays a central role in states of consciousness like alertness and sleep. Injury to the reticular formation can result in irreversible coma *.

5

Habituation

This is a process in which the brain learns to ignore repetitive, meaningless stimuli while remaining sensitive to others. A good example of this is when a person can sleep through loud traffic in a large city, but is awakened promptly due to the sound of an alarm . *

2-Thalamus

the thalamus stimulates the cortex then the cortex stimulate the thalamus, forming a positive feedback circuit

All ascending sensory tracts travel through the thalamus EXCEPT olfaction

Located in the mid-part of the diencephalon

Females

Cholinergic projections from the thalamus are responsible for :

- Activation of cerebral cortex
- Regulation of the flow of information through other Thalamic nuclei to the cortex via projections into reticular information.

Males

Almost every area of the cerebral cortex connects with its own highly specific area in the thalamus .These functional segments are called Thalamocortical Sectors They are made of:

- Thalamo-cortical (TC) fibers
- Cortico-thalamic (CT) fibers .These neural circuits between the thalamus & cortex are essential for determining the level of consciousness

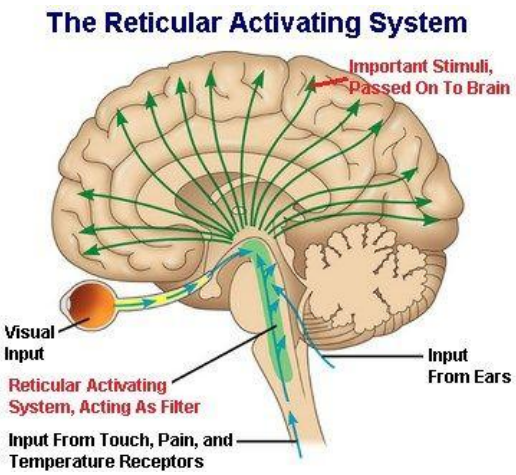
3-Hypothalamus

Hypothalamus maintains normal body temperature & facilitates the development of fever histamine is an excitatory neurotransmitter

Tuberomammillary nucleus in the hypothalamus projects to the cortex and is involved in maintaining the awake state.

Reticular Activating System (RAS)

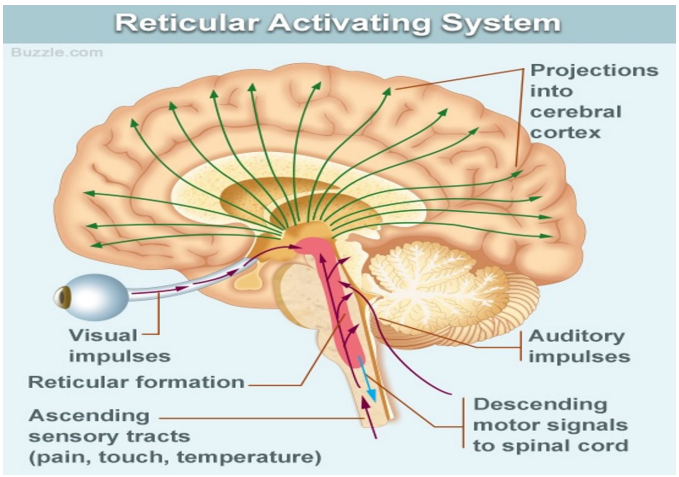
Anatomical components:



- A group of neuronal circuits connecting the brainstem to the cortex
- Originate in the **upper brainstem reticular core** and project through synaptic relays in the **thalamic nuclei** to the **cerebral cortex.**
- Pons (upper and middle) and the MidBrain are essential for wakefulness. If there is a lesion in the Mid-Pons, it will lead to unconsciousness.
- There are two main areas regarding consciousness. An Excitatory area Which is the Bulboreticular area (located in the upper ⅔ of pon + MidBrain) and an inhibitory area located in the medulla.
- If The Bulboreticular area sends impulses to the thalamus, the thalamus will excite almost all of the cerebral cortex.
- As a result, individuals with bilateral lesions of thalamic intralaminar nuclei are lethargic or drowsy (نعسان).
- The Reticular Activating System is composed of the Bulboreticular Facilitatory (excitatory) area + Thalamus, both form the RAS. The RAS is the system which keeps our cortex awake and conscious.

If the stimulation was in the inhibitory area in medulla, this will lead to reduction of the activity of RAS, therefore Sleeping. If the stimulation was in the Excitatory area, this will lead to maintaining the awake state.

Sensory inputs to RAS:



When RAS receives impulses (from the ascending tract for example) All these impulses stimulate the thalamus and the thalamus then stimulate cerebral cortex.

Attention is caused by a balance between excitatory & inhibitory signals.
For full attention: inhibitory signals decrease & excitatory signals increase in the cerebral cortex causing wakefulness & alertness

Functions of RAS:

1 Regulating sleep-wake transitions

If the stimulation is in the inhibitory area (Which is in medulla) this will lead to reduction of the activity of RAS>> Less afferent signals to the CC>> sleeping. If inhibitory area activity increase >>>> reduce the activity of RAS >>>>> less afferent signal to the CC >>>>> sleep.

2 Attention

-RAS mediate transitions from relaxed wakefulness to of high attention *
- There is increased regional blood flow in the midbrain reticular formation (MRF). And thalamic intralaminar nuclei during tasks requiring increased alertness and attention *

3 Learning

-The RAS is the center of balance for the other systems involved in learning, self-control or inhibition, and motivation
-When functioning normally, it provides the neural connections for processing and learning of information, and the ability to pay attention to the correct task.

Indices of Level of Consciousness

Appearance and behavior	Vital Signs	EEG	Evoked potentials (in cases of brain death).
- Posture (sitting ,standing?) -eyes (Open?) -Facial expression. -Responds to stimuli (including the examiner's questions about name, orientation in time & place. And other general Qs like: who is the president?)	-Pulse -BP -respiration -pupils fixed and dilated can indicated death -reflexes, particularly brainstem reflexes e.g. Vestibulo-ocular reflex & cephalo ocular reflex etc. calorie test, gag reflex, and other spinal reflexes	Each of these states (wakefulness, sleep, coma and death) has specific EEG patterns.	* Stimulation of a sense organ can evoke a cortical response that can be recorded by scalp electrode over the primary receiving cortical area for that particular sense. *

If RAS is depressed All functions related to the cerebral cortex will be depressed

-An under-aroused cortex
-Difficulty in learning
-Poor memory
-Little self-control
-lack of consciousness or even coma.

RAS Dysfunction:

-Over aroused cortex
-Hyper-vigilance (sensory sensitivity)
-Touching everything
-Talking too much
-Restless
-Hyperactive

People with excited RAS have exaggerated cerebral cortex activities. So they will become sensitive to touch, light, sound and other stimuli. It is seen in patients with ADHD.
ADHD: Attention deficit hyperactivity disorder is a disorder that causes above normal levels of hyperactive & impulsive behaviors.

If RAS is Excited

Electroencephalogram

a test that detects electrical activity in your brain using small, metal discs (electrodes) attached to your scalp. Your brain cells communicate via electrical impulses and are active all the time, even when you're asleep. This activity shows up as wavy lines on an EEG recording. **Here are 4 waves that you may find in an EEG recording:**

Alpha

-Recorded from the parietal & occipital regions
-Awake and relaxed + eyes closed
-Frequency of 10 to 12 cycles/second
Most common wave

Delta

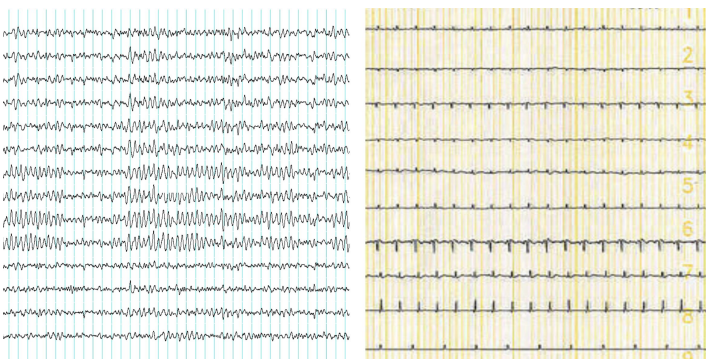
-From the cerebral cortex
-Frequency of 1 to 5 cycles/second (Very low).
-Sleep in adults and awake infants.
-In awake adults indicates brain damage.
Slowest wave

Beta

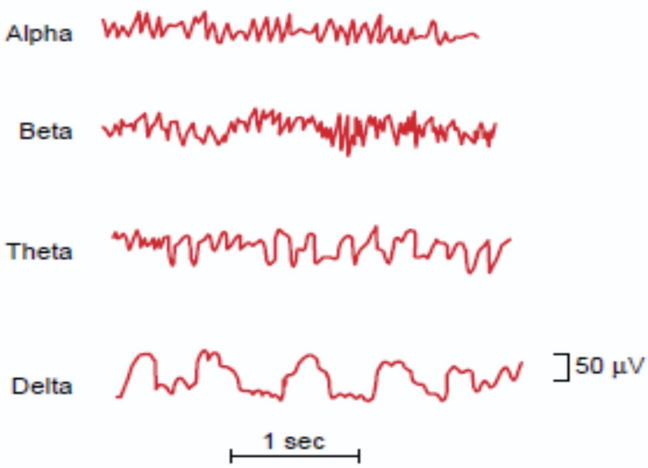
-Recorded from the Frontal lobe
-Produced by visual stimuli and mental activity.
-Frequency of 13 to 25 Cycles/second.
Wave with the highest frequency

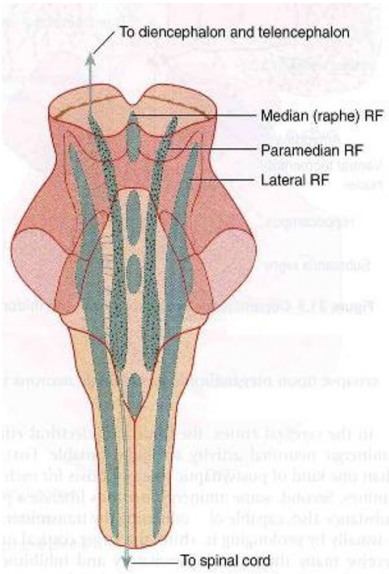
Theta

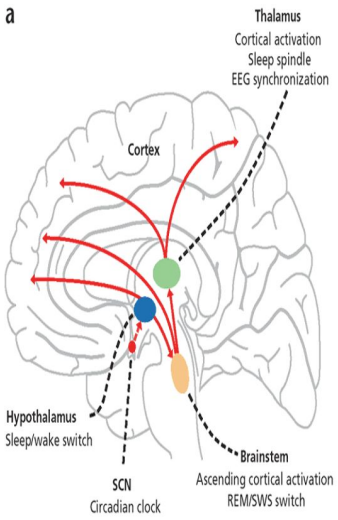
-Temporal and occipital lobes.
-Frequency of 5 to 8 cycles/second (low).
-Normal in newborn.
*Theta waves in adults indicates severe emotional stress awake adults, can indicate neurodegenerative diseases
Slower than alpha & beta waves



A comparison between a normal EEG (on the left: with normal magnification) and a Brain death EEG on the right. A person with a brain death will have flat EEG with very high magnification.







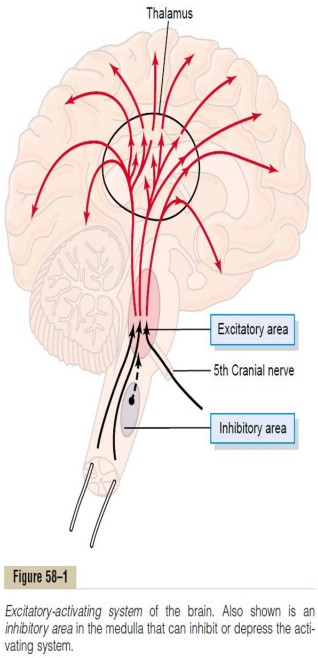
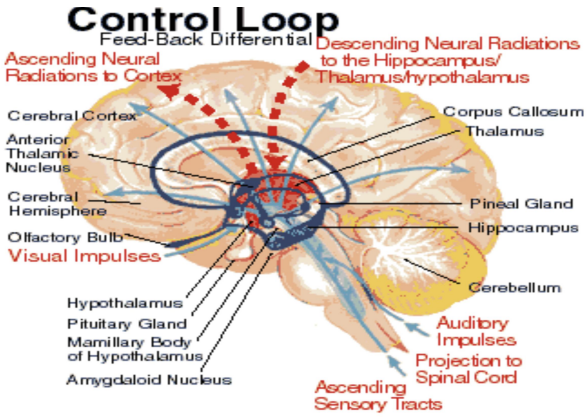
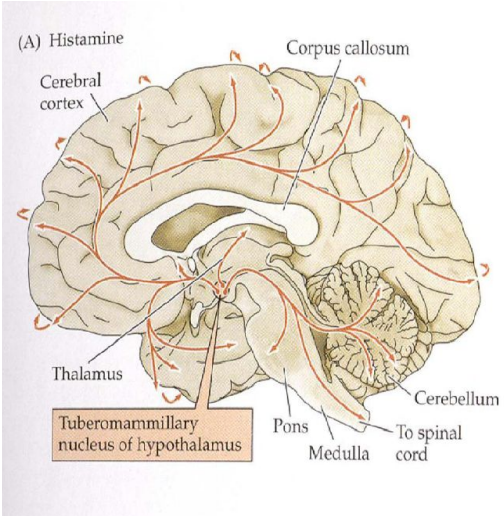
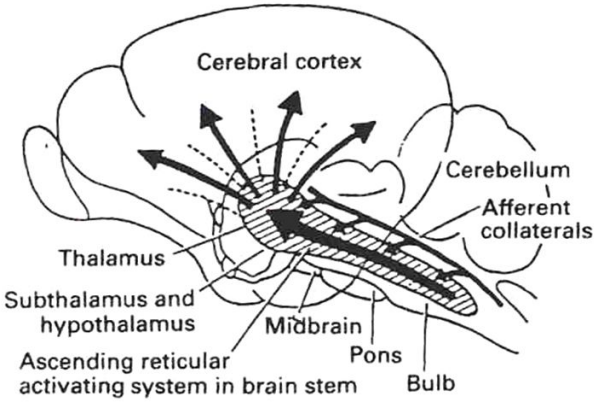


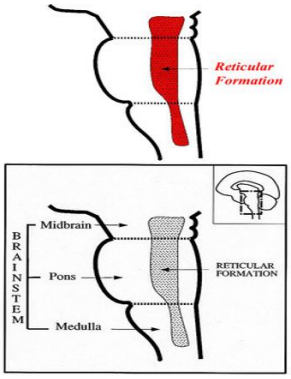
Figure 58–1

Excitatory-activating system of the brain. Also shown is an *inhibitory area* in the medulla that can inhibit or depress the activating system.









MCQ & SAQ:

Q1:Which one of the sentences is true? Paramedian reticular formation

A. Has small neurons
B.Contain serotonergic projections to the brain and spinal cord
C. Receives signals from lateral reticular formation
D. Receives information from ascending tracts for touch and pain

Q2: functions of reticular formations:

A.Attention
B. Learning
C. Regulating sleep-wake transitions
D. Cardiovascular control

Q3: which one contain Cholinergic projections

A.Thalamus
B. Hypothalamus
C. Reticular Activating System (RAS)
D. Raphe nuclei

Q4: Which of the following will happen if the RAS is depressed?

A. Restlessness
B. Hyperactivity
C. Little self-control
D. Talking too much

Q5: Which brain wave is of the lowest frequency?

A.Alpha
B.Beta
C.Theta
D.Delta

Q6: If an adult is having kind of a brain damage, what wave would you see in EEG?

A. Alpha
B. Beta
C. Theta
D. Delta

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

1- enumerate the 4 levels of Consciousness

2- whats the Functions of Reticular Formation

3-Where the excitatory (Facilitatory) area is located?

4- Enumerate the functions of RAS.

A1: 1) Normal Consciousness 2) Clouded Consciousness 3) Sleep 4) Coma
A2: 1. Somatic motor control (Reticulospinal tracts)
2. Cardiovascular control Through cardiac and vasomotor centers of the medulla oblongata
3. Pain modulation: Pain signals from the lower body reach the reticular formation then cerebral cortex.
4. Sleep and consciousness

A3: upper 2\3 of pons + Midbrain.

A4: 1- Regulating of sleep-wake transitions 2- Attention 3- Learning

Leaders:

- Abdulaziz Alsuhaim.
- Ghada Aljedaie.
- **Homoud Algadheb.**
- Raghad Albarrak.
- Samar Almohammedi.

Organizers:

- Basel Fakeeha.
- **Fatimah Saad.**
- Hessah Alalyan.
- Majed Alaskar.
- Mayasem Alhazmi.
- Mohamed Alquhidan.
- Sadeem Al Zayed.

Note takers:

- **Abeer Awwad.**
- **Fahad Alajmi.**
- Hessah Alalyan.
- Reem Aldosari
- Shuaa Khdary.

Revisers:

- **Abeer Awwad.**
- Saud Alrsheed.
- Teif Almutiri.

MEMBERS:

- Abdulaziz Alrabiah.
- Abdulaziz Alderaywsh.
- **Abdulaziz Alamri.**
- Abdulaziz Alomar.
- Abdullah Alburikan.
- Abdullah Binjadou.
- Abdullah Alanzan.
- Abdullah Alhumimidi.
- Abdulrahman Almegbel.
- Abdulrahman Barashid.
- Abdulrhman Alsuhaibany.
- Abeer Awwad.
- Ahmad Alkhayatt.
- Aljoharah Albnyan.
- Aljoud Algazlan.
- Almaha Alshathri.
- Arwa Al-Qahtani.
- Bader Alrayes.
- Bassam Alasmari.
- Bushra Alotaibi.
- Faisal Jazzar.
- Feras Alqaidi.
- Ghaida Alassiry.
- Ghaida Alshehri.
- Hamad Almousa.
- Haya Alanazi.
- Hind Almotywea.
- Ibraheem Altamimi.
- Ibrahim Alnamlah.
- Joud Alarifi.
- Khalid Altowaijeri.
- Khalid Almutlaq.
- Leen AlMadhyani.
- May Barakah.
- Mohamed Alquhidan.
- Mohammed Alkathiri.
- Murshed Alharby.
- Nada Bin Obied.
- Norah Alsalem.
- Norah Aldakhil.
- Nouf Alsubaie.
- Noura Alshathri.
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- Omar Alhalabi.
- Raed Alnutaifi.
- Rayan Jabaan.
- Reem Alqahtani.
- Sarah AlQuwayz.
- Saud Alhasani.
- Shaden Alobaid.
- Shahd Almezel.
- **Shatha Aldossary.**
- Shayma Alghanoum.
- Tarfah Alkaltham.
- Yara Alasmari.
- Yara Alomar.
- Yara Alzahrani.
- Yazeed Alqahtani.
- ziyad Alhosan.

Physiology439@gmail.com