BASIC SCIENCE OF SLEEP

OUTLINE

- Definition Of Sleep
- Difference Between Sleep and Coma
- Mechanism Of Sleep
- EEG Waves
- Types and Stages of Sleep [REM and NREM]
- Physiology of Sleep
- Sleep Deprivation
- Sleep disorders related to psychiatric disorders

DEFINITION OF SLEEP

- Sleep is a state of decreased awareness of Environmental stimuli that is distinguished from states such as Coma or Hibernation by its relatively rapid reversibility.

DIFFERENCE BETWEEN SLEEP AND COMA

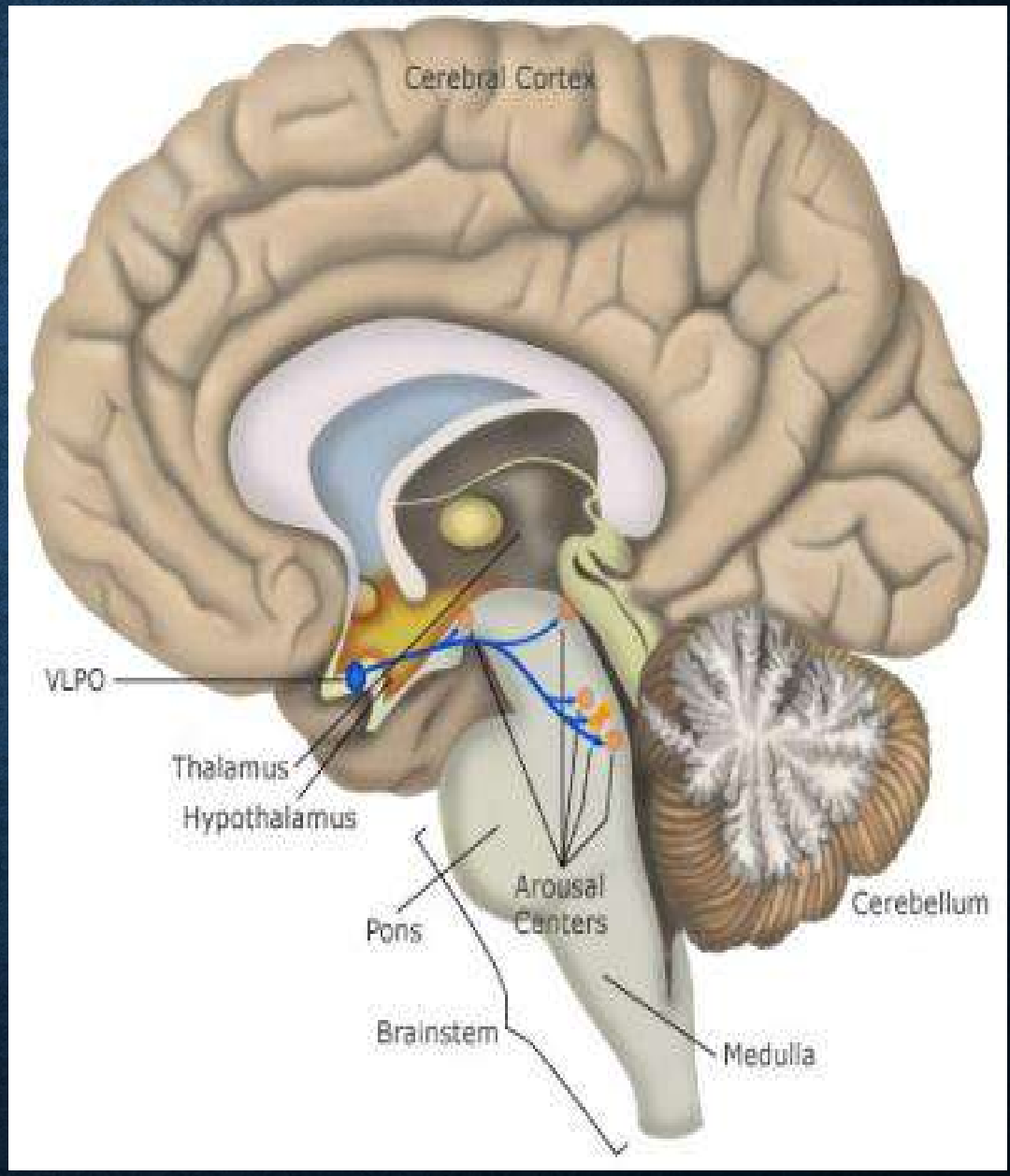
Sleep	Coma
• Subject can be aroused by an appropriate Stimulus.	• Subject cannot be aroused by any stimulus.
• Subject is aware that they have been asleep at the termination of an episode	• Subject is unaware of the episode.
• EEG shows various waves which are characteristic of different stages of sleep	• EEG is dominated by slow waves

MECHANISM OF SLEEP

The Ventrolater Preoptic Nucleus [VLPO or VLPN] of the Hypthalamus helps to Promote sleep by inhibiting :

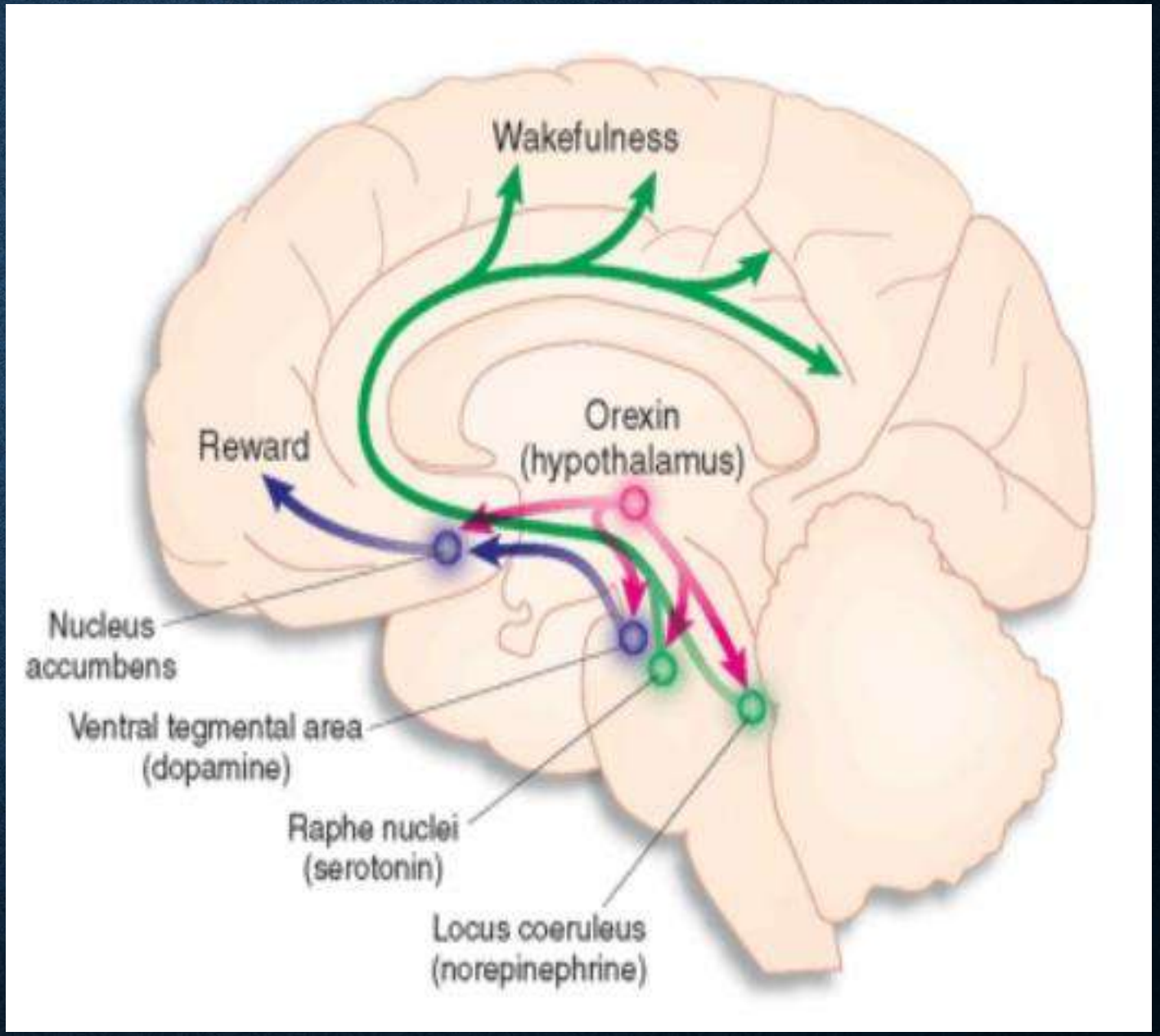
- Tuberomamillary Nucleus containing Histamine.
- Raphe Nuclei containing Serotonin.
- Laterodorsal Tegmental and Pediculopontine tegmental nuclei containing Acetylcholine.
- Nucleus of Locus Coeruleus containing Noradrenaline

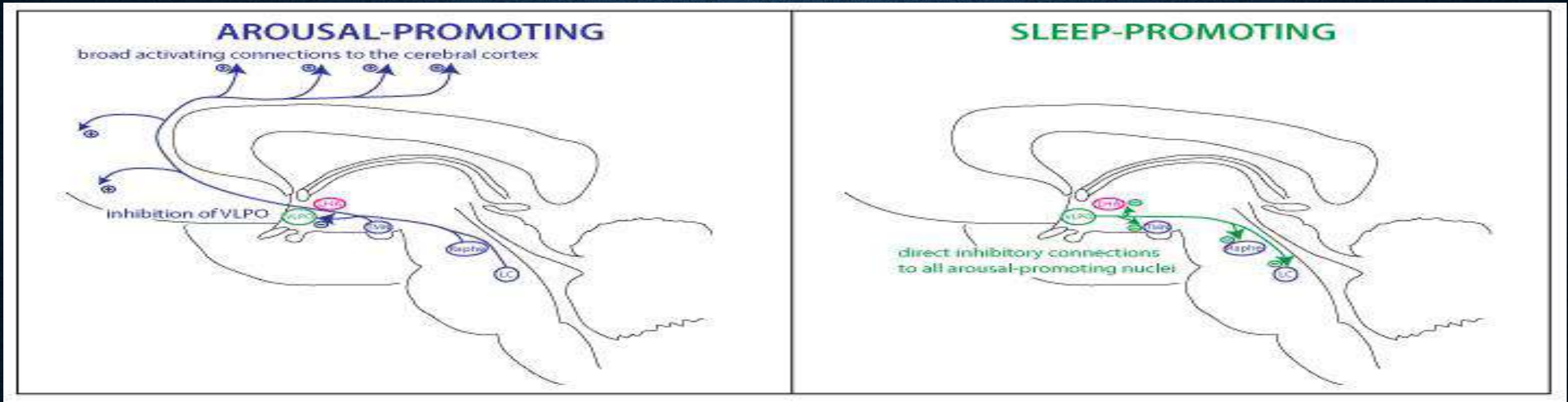
Histamine in particular is sometimes referred to as the ‘ Master Wakefulness Promoting Neurotransmitter ‘



MECHANISM OF SLEEP

- **Orexin** [Also called as **Hypocretin**] is a neurotransmitter that regulates arousal and wakefulness
- **Orexin** is produced by about 10,000 - 20,000 neurons is the hypothalamus region of the brain which triggers **Wakefulness**.





Category	Nucleus	Neuro-transmitter	Level of activity during arousal	Level of activity during sleep
Sleep Promoting	• VLPO	GABA	0	++
Arousal Promoting	• LC	Norepinephrine	++	0
	• Raphe	Serotonin	++	0
	• TMN	Histamine	++	0
	• LHA	Orexin	++	0

THEORIES OF SLEEP

The Older Theory Of Sleep [Passive Process]

- Discharging of RAS (Reticular Activating System) neurons for several hours during wakefulness caused fatigue of these neurons which in turn led to sleep.

The New Theory Of Sleep [The Active Sleep - inducing Inhibitory Process]

- Different Mediators actively inhibit the RAS which lead to Sleep
- For Example, Serotonin secreting raphe fibres inhibit the RAS which leads to sleep and Melatonin [which is secreted by the pineal gland] during darkness inhibits the RAS's which leads to sleep.

EEG WAVES , TYPES AND STAGES OF SLEEP

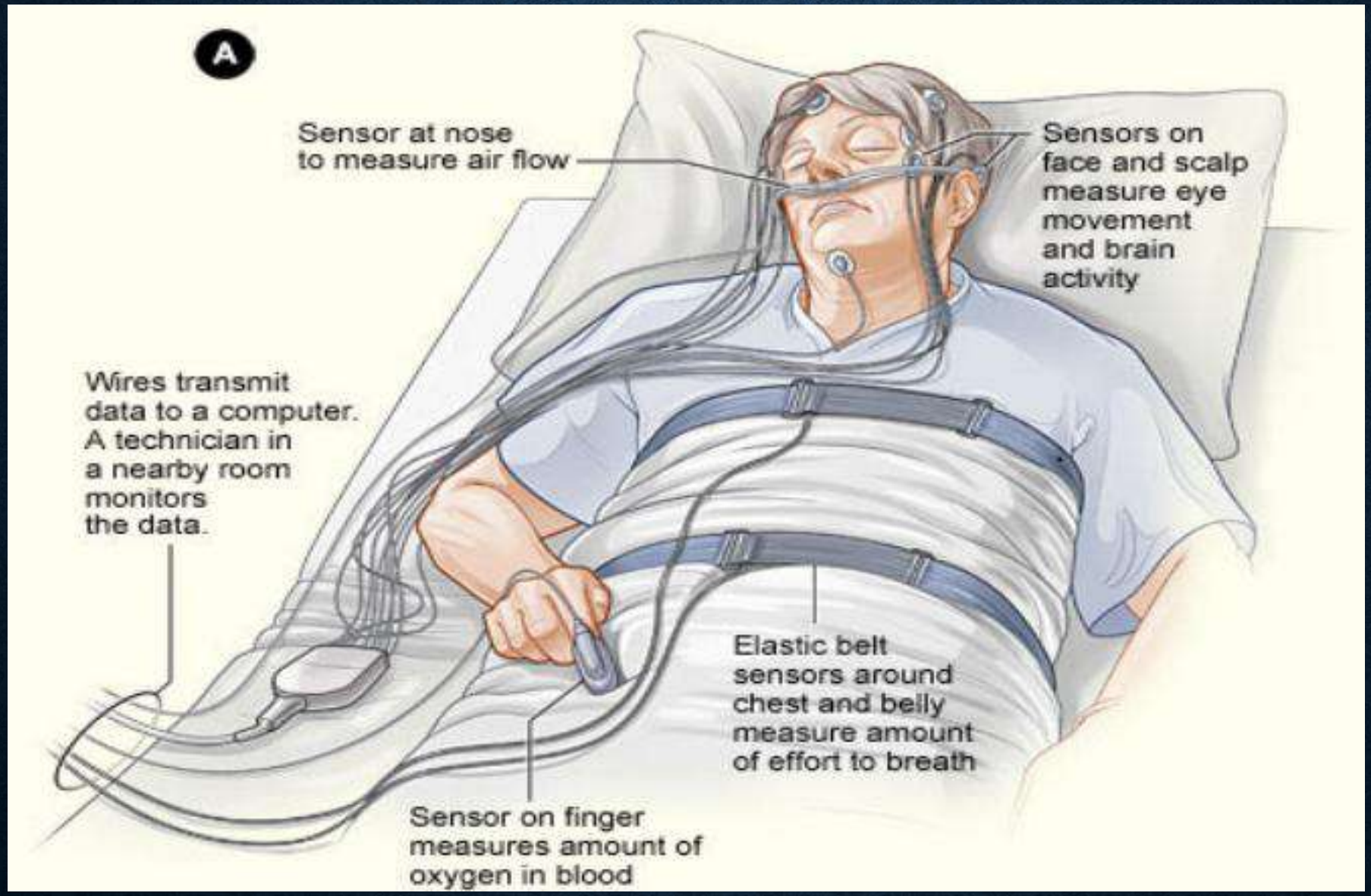
- Sleep stages and other characteristics of sleep are commonly assessed by polysomnography in a specialized sleep laboratory.

- Measurements taken include electroencephalogram (EEG) of brain waves, electrooculography (EOG) of eye movements and electromyography (EMG) of skeletal muscle activity.

- In humans, each sleep cycle lasts from 90 to 110 minutes on average.

THE PROCEDURE

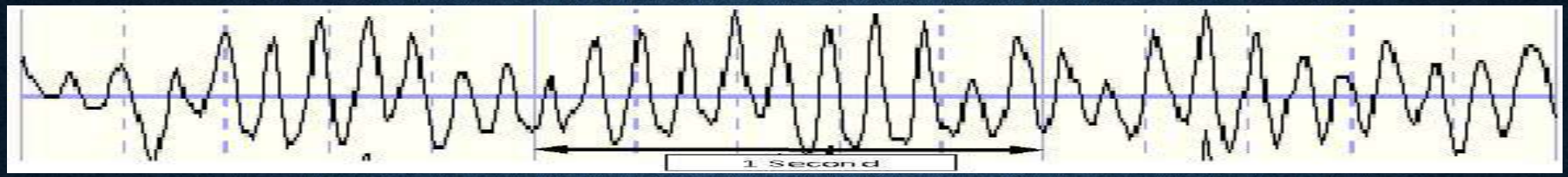
- Patient Arrives
- Head and Body electrodes are applied
- Lights are turned off
- The technician monitors the patient while he is sleeping
- Brain waves , eye movements, heart rate, breathing patterns, blood oxygen levels, body position , limb movements, snoring and any other noise made is recorded.
- The complete procedure may take up to 10 hours


A
Sensor at nose to measure air flow
Sensors on face and scalp measure eye movement and brain activity
Wires transmit data to a computer. A technician in a nearby room monitors the data.
Elastic belt sensors around chest and belly measure amount of effort to breath
Sensor on finger measures amount of oxygen in blood

The Frequency of brain waves ranges from 0.5-500hz and the most clinically relevant waves are

- Alpha waves : 8 - 13hz
- Beta waves : 13 - 35hz
- Theta waves 3.5 - 7.5hz
- Delta waves : 3hz or less

ALPHA WAVES

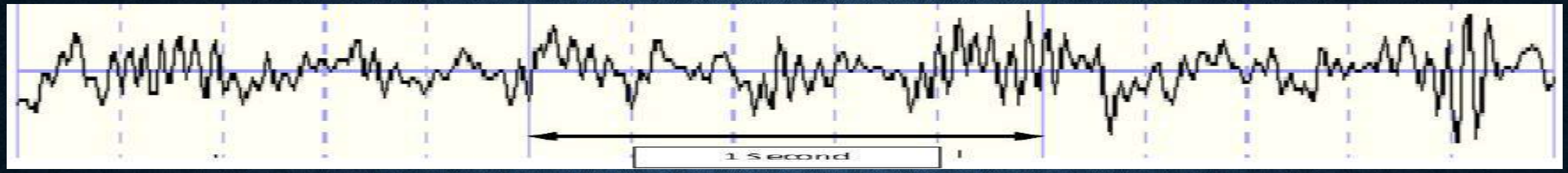


- Frequecy 8 - 13hz
- They are seen in all age groups but are most common in adults
- Most markedly seen in the parieto - occipital area
- Occur rhythmically on both sides of the head but are often slightly higher in amplitude on the **nondominant** side, especially in right-handed individuals
- Occur with closed eyes, relaxation and wondering mind.
- They disappear with attention [e.g - mental arithmetic, opening eyes or any form of sensory stimulation] and during deep sleep.

ABNORMAL OCCURENCES OF ALPHA WAVES

- Frontally prominent & persistent Alpha may indicate hypometabolism (reduced blood flow) & may relate to depression and attention problems
- Alpha that fails to attenuate (diminish) with eye opening may be due to drowsiness or other pathology, including abnormalities in the visual system.
- Decreased Alpha peak frequency may reflect disease or brain injury such as Traumatic Brain Injury, dementia, and age-related cognitive decline.
- Slowed Alpha rhythms may reflect neurological diseases such as dementia, Alzheimer's, head injuries and excessively fast alpha waves can be associated with anxiety and OCD symptoms.

BETA WAVES

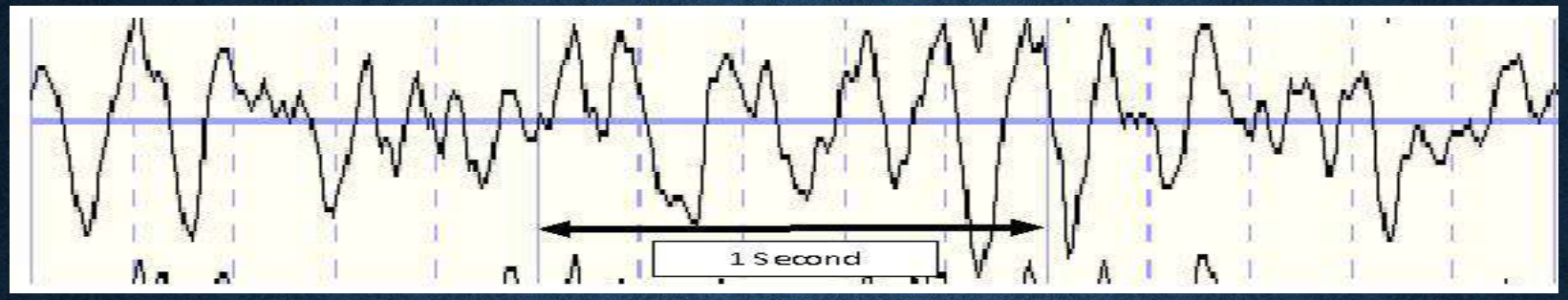


- Frequency 13 - 35hz
- Seen in all age groups
- They are recorded mainly from the parietal and frontal regions during states of concentration
- Beta waves are common in the EEG of most waking adults but may be present in during drowsiness as well
- When the awake person's attention is diverted to something specific, the alpha waves are replaced by asynchronous, higher frequency and lower voltage beta waves.

ABNORMAL OCCURRENCE OF BETA WAVES

- Bi-laterally increased Beta can be due to previous craniotomy (Breech Rhythm).
- Spindling Beta generally reflects increased cortical irritability and is most likely seen in clinical conditions such as…
  - ADHD
  - Epilepsy
  - Psychosis and also during a hallucination
  - Anxiety Disorders
- Excessive Beta activity can relate to symptoms of brain over arousal such as anxiety, obsessiveness, sleep difficulties, hyperactivity, etc and Deficient Beta activity can relate to symptoms of brain under aroused such as difficulty concentrating, problem solving, etc.

THETA WAVES



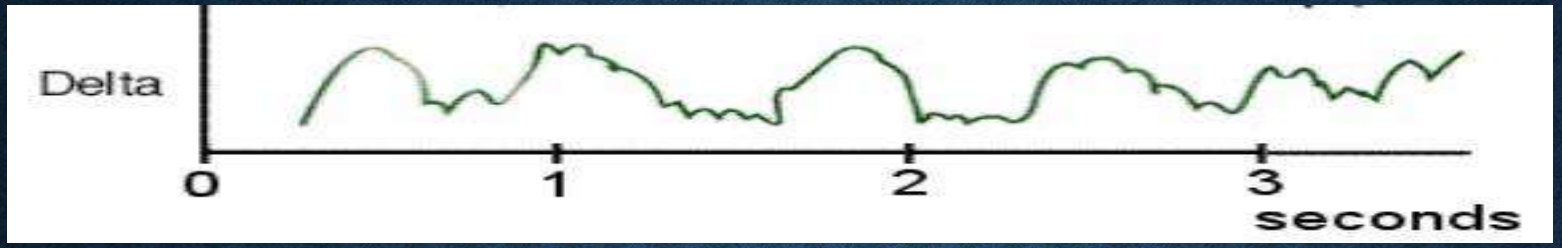
- Theta waves oscillate about 3.5-7.5 times per second (Hz)
- They are normally seen during all stages of sleep and they occur normally in the parietal and temporal regions in children, but they also occur during emotional stress in some adults, particularly during disappointment and frustration.
- Theta waves may occur in some indivisuals who are day dreaming.

ABNORMAL OCCURRENCE OF THETA WAVES

- Excessive Theta activity in the waking EEG of adults is considered abnormal. It can represent reduced metabolism in the cortical grey matter (reduced oxygen uptake).

- Excessive Theta waves are seen in conditions like
  - Learning Disabilities
  - Head injuries or brain lesions
  - ADHD

DELTA WAVES



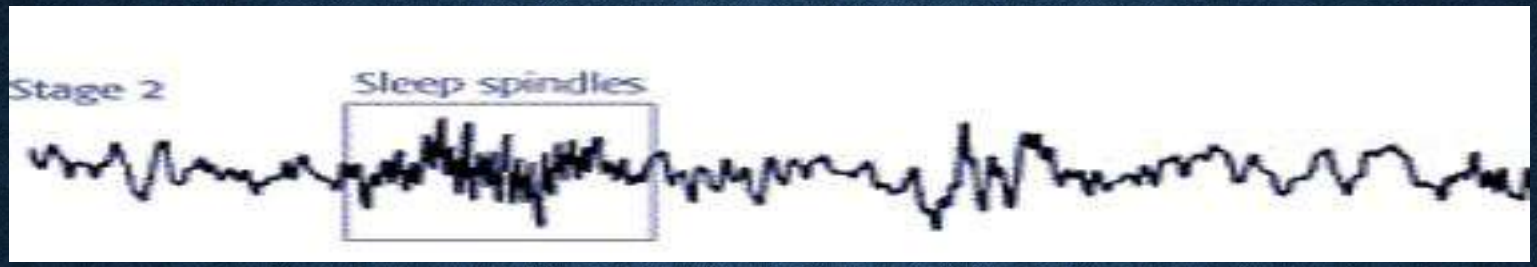
- They are slow waves and have a frequency of less than 3Hz and they often have the largest amplitude amongst all waves
- Delta waves are rarely seen in a healthy waking adult EEG but are prominent and normal during sleep, especially of infants, children and young adults
- Delta waves are common in stage 3 and 4 sleep in adolescents and teenagers
- Delta waves begin to disappear from the sleep records of adults after age 45 and are almost entirely absent in those older than 75
- Delta waves and Theta waves are collectively known as Slow Waves.

ABNORMAL OCCURRENCE OF DELTA WAVES

- Delta waves should generally be absent from the waking EEG records of adults

- Appearance of Delta wave in adults may indicate
  - Head trauma
  - Exposure to Toxins such as heavy metals, pesticides etc
  - Cognitive impairment that might be due to liver disease or a degenerative brain disease like dementia or Alzheimer's disease
  - A focal delta wave may be due to presence of a lesion or tumour that may indicate damage from a stroke.

SLEEP SPINDLES



- Groups of waves that occur during many sleep stages but especially in Stage 2
- Have frequencies in the upper levels of alpha or lower levels of beta [11-16hz]
  - They usually last for a second or less , increase in amplitude initially and then decrease. The waveform resembles a spindle.
- They are usually symmetric and most obvious in the parasaggital regions

TYPES OF SLEEP

- **Alfred Lee Loomis,** an American scientist provided the earliest detailed description of various stages of sleep in the mid - 1930's

- In early 1953, **Eugene Aserinsky** and **Nathaniel Kleitman** identified rapid eye movement.

Types of sleep

Following are the types of sleep depending on the EEG criteria

1 - NREM Sleep

- Stage 1 NREM
- Stage 2 NREM
- Stage 3 NREM

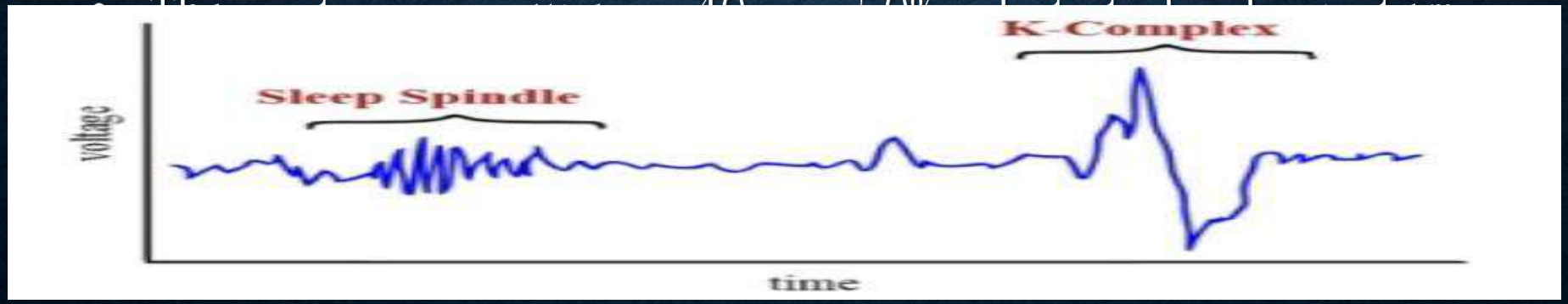
2 - Rapid Eye movement sleep [REM]

STAGE 1 NREM

- **Stage N1** refers to the transition of the brain from alpha waves having a frequency of 8 - 13 Hz (common in the awake state) to theta waves having a frequency of 3.5 - 7.5 Hz.
- This stage is sometimes referred to as somnolence or drowsy sleep in which the muscles are still quite active and the eyes roll around slowly and may open and close from time to time.
- **Dreaming** is relatively rare during this stage, but sudden twitches or **hypnic (hypnagogic) jerks** (sudden short **micro-awakenings** often accompanied by a falling sensation) are quite common and this stage represents 5 % of the total sleep time

STAGE 2 NREM

- Brain waves during this stage are mainly in the theta wave range
- Stage 2 is characterized by 2 distinct phenomenon which are sleep spindles [short bursts of activity ranging 12 - 14 hz lasting about half a second , also known as Sigma Waves and K Complexes, which are short negative high voltage peaks accompanied by a slower positive complex , and then a final negative peak , each complex lasting 1 - 2 minutes.
- This [illegible] 40 - 50% of total sleep time



STAGE 3 NREM

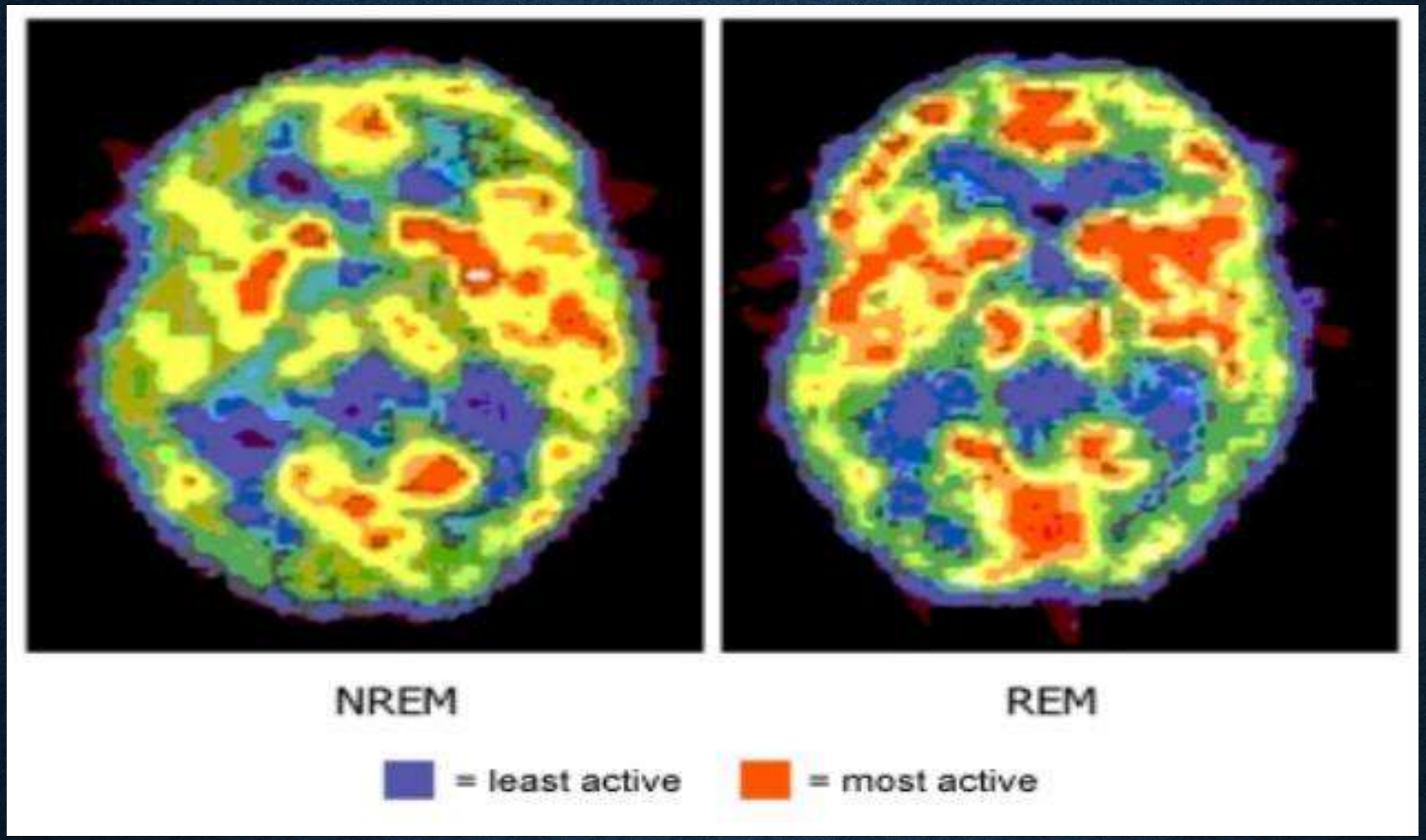
- Stage 3 is also known as deep or delta or slow-wave sleep (SWS)
- During this period the sleeper is even less responsive to the outside environment, essentially cut off from the world and unaware of any sounds or other stimuli and represents around 20% of total sleep time.
- In this stage parasomnias like night terrors, sleep-walking(somnambulism), sleep talking(Somniloquy) and bedwetting (nocturnal enuresis) occur.

REM SLEEP PARADOXICAL SLEEP DESYNCHRONISED SLEEP

- REM sleep accounts for 20 - 25% of total sleep time
- The proportion decreases with age. [a newborn spends about 80% of total sleep time in REM stage]
- REM sleep dominates the latter half of the sleep period, especially the hours before waking, and the REM component of each sleep cycle typically increases as the night goes on.
- The criteria for **REM sleep** include rapid eye movements as well as a rapid low-voltage EEG & 'Saw Tooth' brain waves.
- Most memorable dreaming occurs during this stage.

REM SLEEP

- The person is even more difficult to arouse by sensory stimuli than during deep slow-wave sleep, and yet people usually awaken spontaneously in the morning during an episode of REM sleep.
- The brain is highly active in REM sleep, and overall brain metabolism may be increased as much as 20 per cent.
- The electroencephalogram (EEG) shows a pattern of brain waves similar to those that occur during wakefulness.
- This type of sleep is also called **paradoxical sleep** because it is a paradox that a person can still be asleep despite marked activity in the brain.



The brain areas involved with long-term memory and emotion are highly active during REM sleep

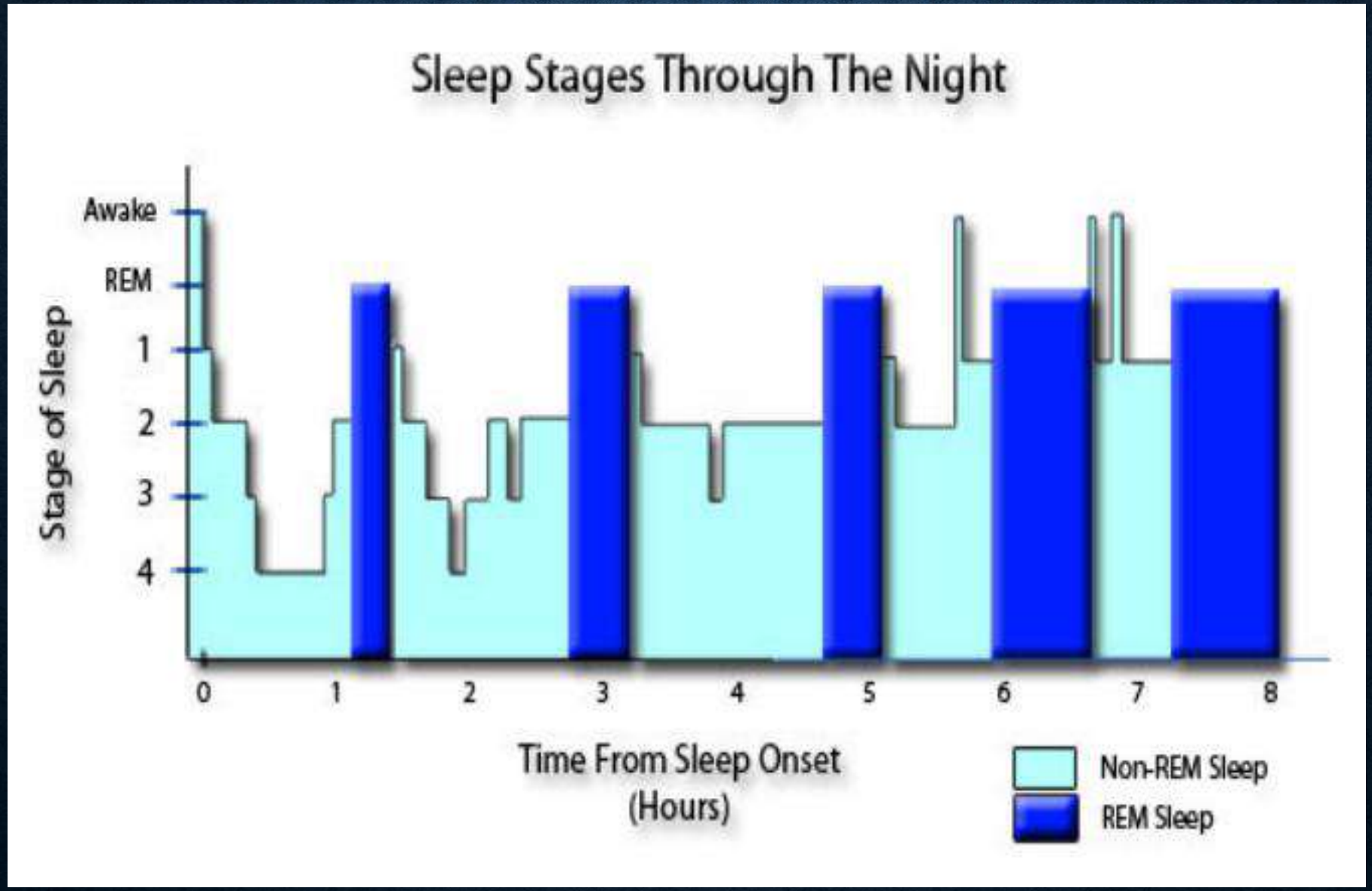
DISTRIBUTION OF SLEEP STAGES

- While NREM occupies about 75 - 80 % of total sleep time, it is interrupted by REM.
- In a typical night of sleep a young adult first enters NREM sleep and passes through stages 1, 2 ,3 and 4.

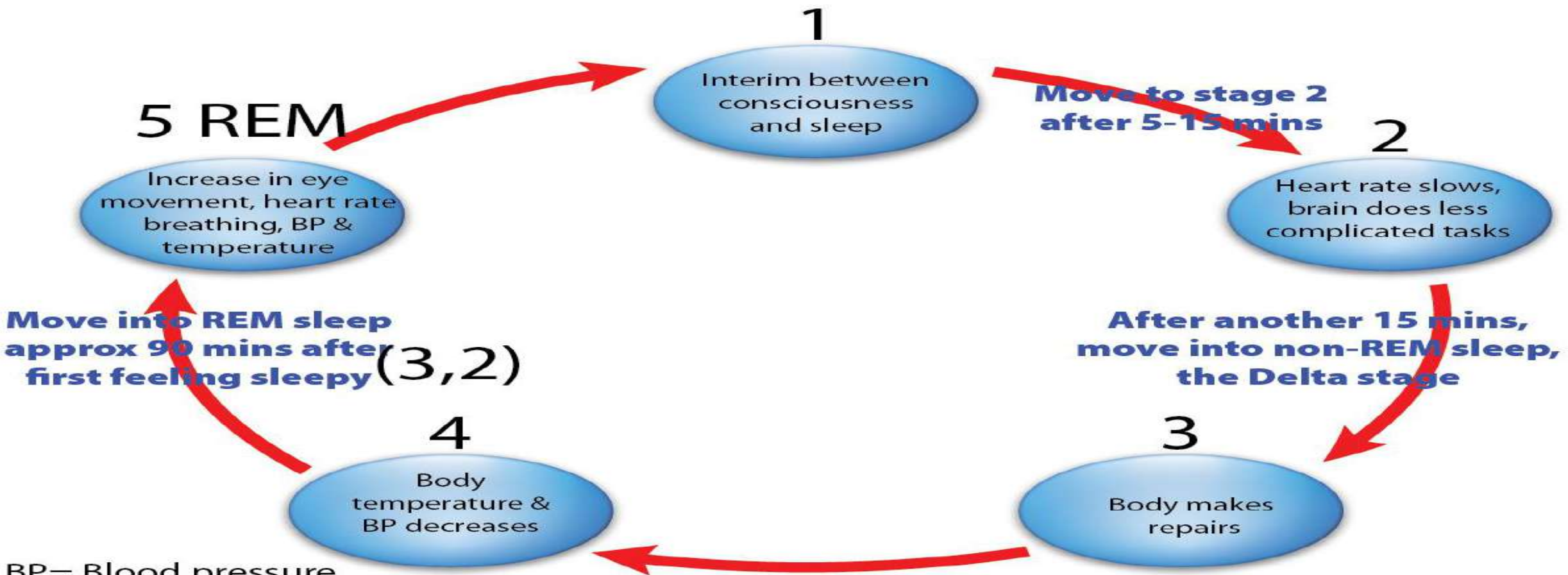
This cycle is repeated at intervals of about 90-110 minutes throughout the 8 hours of a night sleep, Therefore, there are 4-6 sleep cycles per night (and 4-6 REM periods per night).

- As the night goes , there is a progressive decrease in reduction is NREM stage 3 and 4 and a progressive increase in REM sleep.

DISTRIBUTION OF SLEEP STAGES



Sleep wake cycle



BP= Blood pressure

HELP
Health Education Library for People

SLEEP HOURS BY AGE

- Children need more sleep per day in order to develop and function properly.
- Up to 18 hours for newborn babies, with a declining rate as a child ages.
- A newborn baby spends almost 9 hours a day in REM sleep.
- By the age of five or so, only slightly over two hours is spent in REM.
-

SLEEP HOURS BY AGE

New-born	Upto 18 hours
1 - 12 months	14-18 hours
1 - 3 years	12 - 15 hours
3 - 5 years	11 - 13 hours
5 - 12 years	9 - 11 hours
Adolescents	9 - 10 hours
Adults , including elderly	7 - 8 hours
Pregnant women	8[+] hours

PHYSIOLOGY IN SLEEP

NREM SLEEP AUTONOMIC CHANGES

- Characterized by generalized decrease in autonomic activities
- Decrease in autonomic activities causes hypotension and bradycardia
- Decreased generalized metabolic activity

NREM SLEEP HORMONE CHANGES

- Growth Hormone is secreted almost entirely in NREM sleep (due to hypothalamic-pituitary activity)
- GH is secreted in 30 to 60 minutes after the beginning of sleep
- Prolactin is secreted in NREM sleep (at the beginning of sleep)
- Cortisol is secreted in NREM sleep (late at night)

NREM SLEEP BIOCHEMICAL CHANGES

- Increased serotonin activity occurs .

REM SLEEP AUTONOMIC CHANGES

- Increased pulse.
- Increased blood pressure.
- Increased intracranial pressure.
- Increased cerebral flow.
- Increased muscle metabolism.
- In men, penile erections.
- In female, increased vaginal blood flow and clitoral erection.
- These increase in autonomic activities are considered responsible for increased incidence of myocardial infarctions and ischemic CVA

REM SLEEP BIOCHEMICAL CHANGES

- Is associated with increased cholinergic activities.
- Is associated with decreased dopamine, norepinephrine and epinephrine activities.
- REM sleep is enhanced by cholinergic agonists such as nicotine and suppressed by anti-cholinergic medications

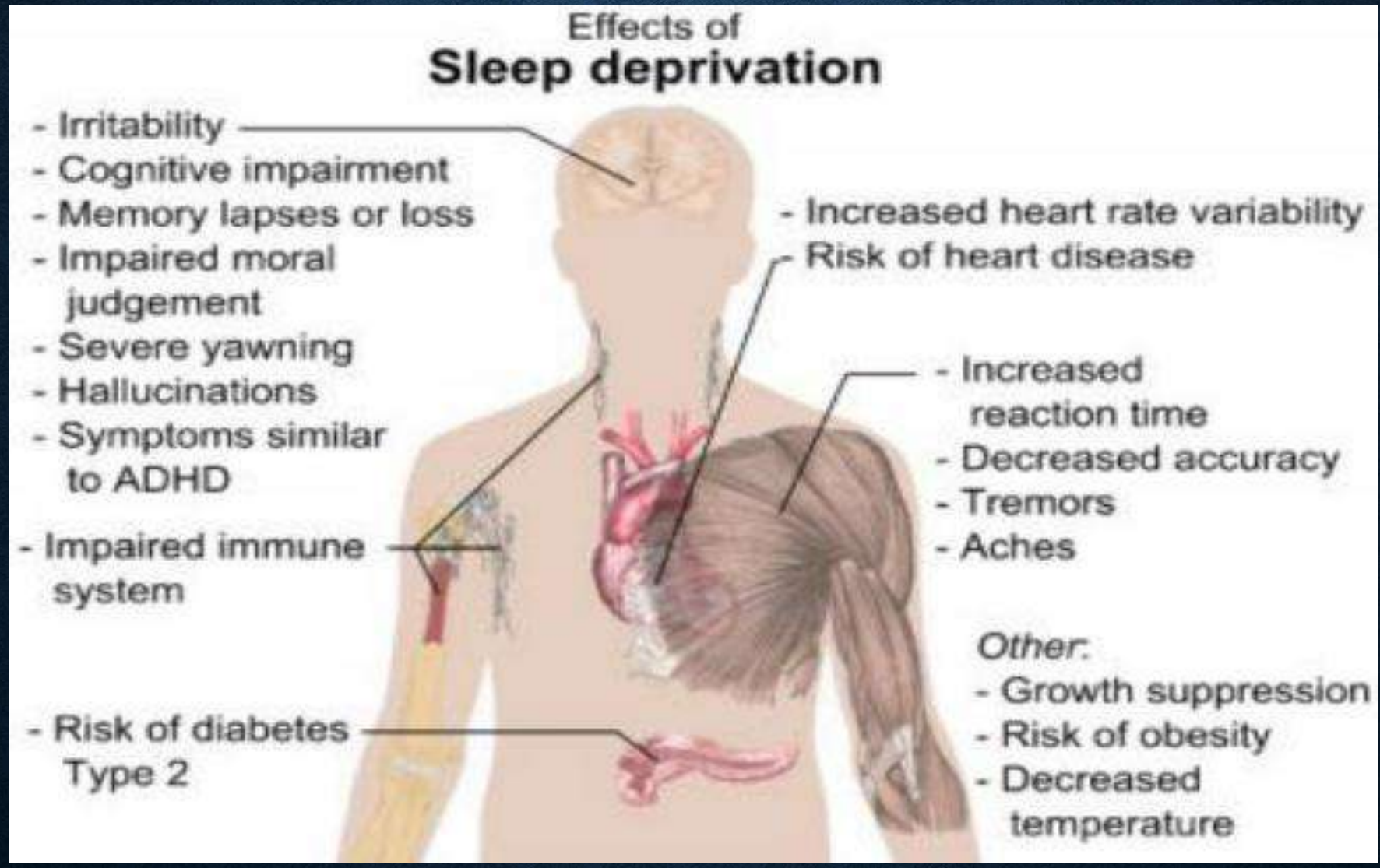
Physiological Process	NREM	REM
Brain activity	Decreases from wakefulness	Increases in motor and sensory areas, while other areas are similar to NREM
Heart rate	Slows from wakefulness	Increases and varies compared to NREM
Blood pressure	Decreases from wakefulness	Increases (up to 30 percent) and varies from NREM
Sympathetic nerve activity	Decreases from wakefulness	Increases significantly from wakefulness
Muscle tone	Similar to wakefulness	Absent
Blood flow to brain	Decreases from wakefulness	Increases from NREM, depending on brain region
Respiration	Decreases from wakefulness	Increases and varies from NREM, but may show brief stoppages; coughing suppressed
Airway resistance	Increases from wakefulness	Increases and varies from wakefulness
Body temperature	Is regulated at lower set point than wakefulness; shivering initiated at lower temperature than during wakefulness	Is not regulated; no shivering or sweating; temperature drifts toward that of the local environment
Sexual arousal	Occurs infrequently	Greater than NREM

SLEEP DEPRIVATION

- Aching muscles
- Confusion, memory lapses or loss
- Hand tremors
- Headaches
- Periorbital puffiness
- Increased blood pressure

SLEEP DEPRIVATION

- Increased stress hormone levels
- Increased risk of diabetes
- Irritability
- Nystagmus
- Obesity
- Temper tantrums in children
- Yawning


Effects of
Sleep deprivation
- Irritability
- Cognitive impairment
- Memory lapses or loss
- Impaired moral judgement
- Severe yawning
- Hallucinations
- Symptoms similar to ADHD
- Impaired immune system
- Risk of diabetes Type 2
- Increased heart rate variability
Risk of heart disease
- Increased reaction time
- Decreased accuracy
- Tremors
- Aches
Other:
- Growth suppression
- Risk of obesity
- Decreased temperature

SLEEP DISORDERS RELATED TO PSYCHIATRIC DISORDERS

MAJOR AFFECTIVE DISORDERS

- Alterations in sleep are the central symptoms in mood disorders.
- Initial insomnia, frequent waking, early morning waking, vivid or disturbed dreams and daytime fatigue are frequently seen in major depressive disorder.
- Episodes of mania may be characterized by marked insomnia, and a decreased need for sleep associated with a much reduced total sleep time.

SLEEP DEPRIVATION

ANXIETY DISORDERS

- Anxiety disorders commonly disrupt the normal sleep pattern leading to insomnia, which may be triggered by an acute stressful event.
- As many as 70% of patients with panic disorders have difficulty with sleep - onset and often report sleep paralysis with hypnagogic hallucinations.

SLEEP DISORDERS RELATED TO PSYCHIATRIC DISORDERS

SCHIZOPHRENIA

- Patients with schizophrenia demonstrate increased nocturnal wakefulness and daytime somnolence

DEMENTIA

- Normal ageing is associated with reduced total sleep time, loss of NREM sleep and fragmentation of nocturnal sleep, and dementia generally causes further increased reduction in total sleep and fragmentation of nocturnal sleep.

SLEEP DISORDERS RELATED TO PSYCHIATRIC DISORDERS

SUBSTANCE USE

ALCOHOL - Acute effects of alcohol lead to reduced sleep latency, increased total sleep time and mild suppression of REM sleep in the first half of the night and there is increased REM sleep in second half which is associated with sleep disruption, intense dreaming and even nightmares

Chronic effects of alcohol abuse sleep disruption and significant insomnia and withdrawal from alcohol is also associated with insomnia.

SLEEP DISORDERS RELATED TO PSYCHIATRIC DISORDERS

SUBSTANCE USE

- Nicotine use tends to cause initial insomnia and may be associated with sleep disruptions and increased REM sleep.
- Cannabis use is associated with hypnotic effects modulated by cannabinoid 1 receptors suppressing REM sleep.
- Opiates cause changes in sleep architecture leading to decrease in sleep efficiency and total sleep time and withdrawal is associated with insomnia and sleep fragmentation.
- Stimulants like amphetamines and cocaine cause reduced REM sleep and daytime sedation and periods of drowsiness and wakefulness.

REFERENCES

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- http://scottsdaleneurofeedback.com/services/qeeg-brain-mapping/eeg-brainwaves.

- http://www.howsleepworks.com.

- Oxford handbook of Psychiatry.

THE END