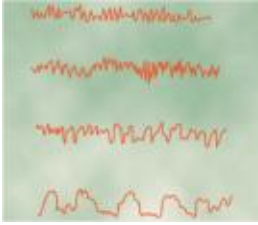
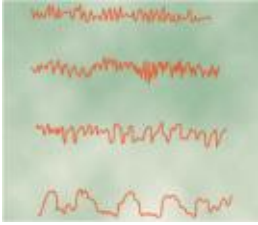


Neurophysiology Of Sleep

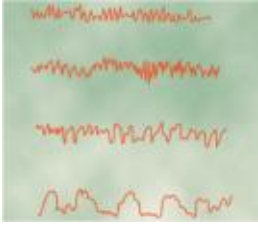
Dr Farida Ahmad

physiology

Learning Objectives



- Define sleep. Is it a different of brain activity or just “Rest of neurons”?
- Discuss the rapidly moving eyes of a sleeping person.
- Describe the effect of sleep on HR, BP, RR.
- Discuss sleep walking?
- Describe the sleep patterns of elderly.
- Describe the effect of depression on sleep and how then sleeping pills work?
- Describe the **neurophysiology of sleep**

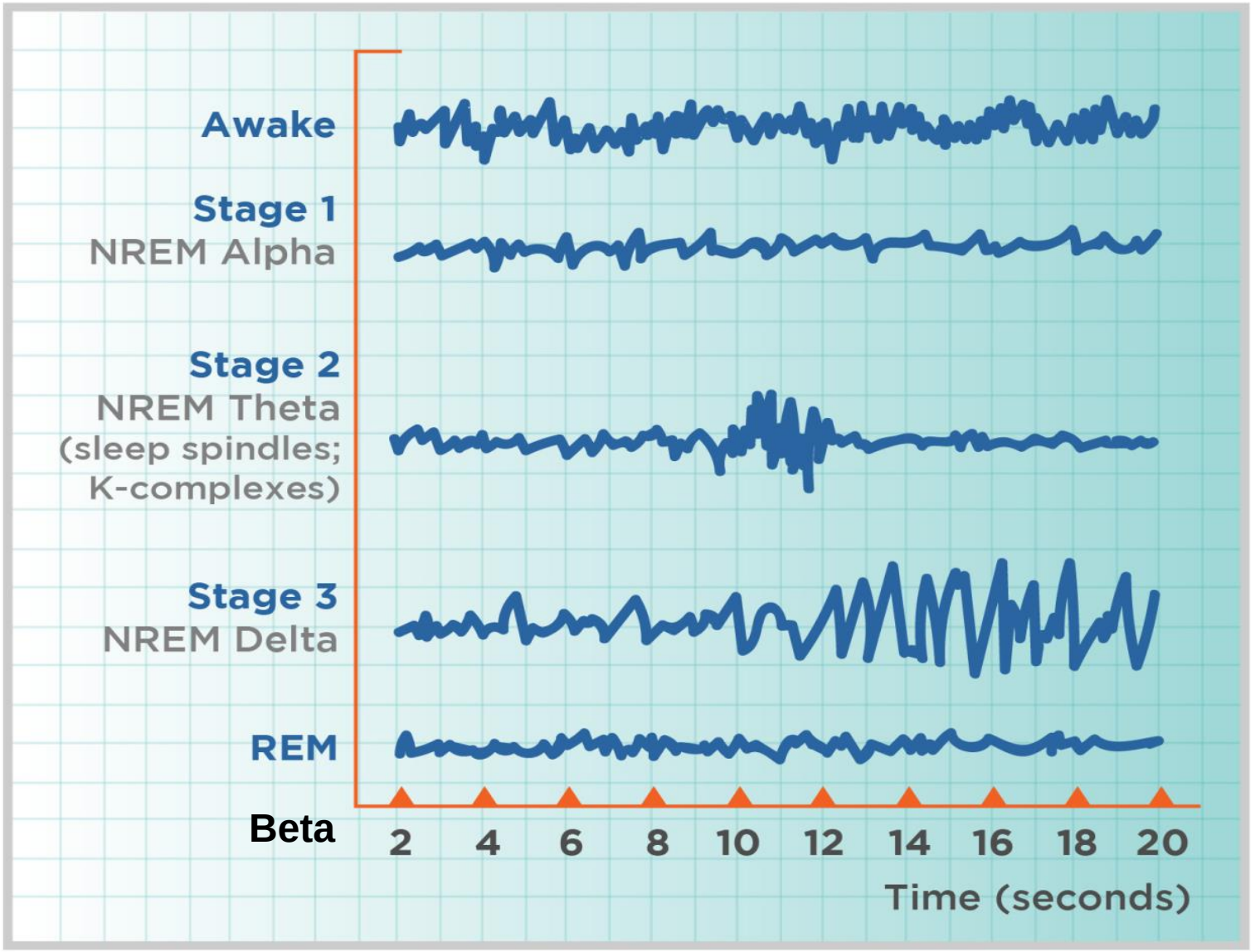


Definition

- A state of temporary unconsciousness or altered consciousness from which the person can be aroused by sensory or other stimuli

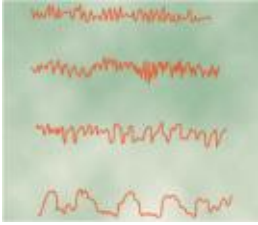
- Many stages of sleep → from very light to very deep sleep

EEG RECORDINGS DURING SLEEP



Stages of Sleep

Stage 1	Lightest stage of sleep (theta)	Transition from wakefulness to sleep Last 1-7 minutes Lose responsiveness to stimuli **Drifting thoughts & images**
Stage 2	"Real Sleep" (theta)	**Gradual decrease in: heart rate, respiration, body temperature, & muscle tension** Difficult to be awakened
Stage 3	Transition Stage (delta)	30-45 Minutes after drifting off to sleep
		Decrease in: Heart rate, respiration, temperature, & muscle tension Difficult to be from which to be awakened
Stage 4	"Slow wave sleep" (delta)	Deepest Stage of sleep Most difficult from which to be awakened May **sleepwalk, sleep talk, snack, night terror**
REM	Rapid Eye Movement (beta)	**Eyes move rapidly** back & forth behind closed lids Physiologically **body is very aroused** **Voluntary muscles are paralyzed** (if a nightmare, will NOT act out because) Pass though 5-6 times a night (15-45 min each time; 30-90 min between each period)



Types of Sleep

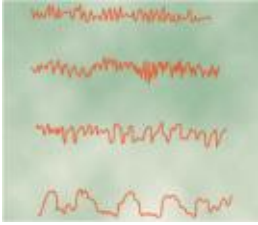
1. **Slow Wave Sleep (80%)**

Brain waves are **strong** and **low frequency,** comprises **most** of the sleep, **deep**, **restful** during first hour of sleep, **dreamless sleep**

2. **Rapid Eye Movement (REM) Sleep**

Eyes undergo rapid movements

20% to **25%** of sleep and recurs every 90 min associated with **vivid dreaming**



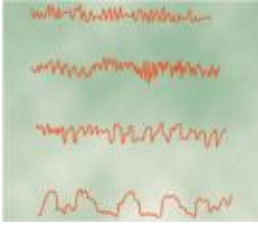
Slow Wave Sleep (NREM)

NREM (slow wave sleep) → 80 %

Characteristics

1. Deep restful
2. 4 stages
3. EEG: High amplitude slow waves
4. Dreamless sleep
5. Decrease vegetative functions
   B.P, R.R, B.M.R, Peripheral Vascular Tone

Slow Wave Sleep

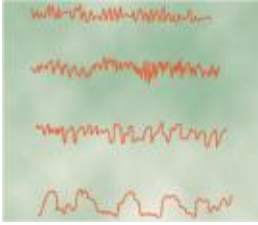


Deep slow wave sleep after being awake for more than 24 hour

- **Restful sleep**
- **↓ in vascular tone**, **B.P**, **Respiratory rate**, **BMR**
- **Dreamless mostly** but dreams and nightmares sometimes occur

Dreams are **not remembered** because consolidation of dreams in memory does not occur

REM Sleep



Paradoxical / desynchronized Sleep

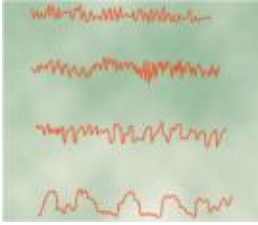
- Bouts of REM sleep last **5 to 30 min every 90** min
- When very sleepy REM sleep is short / absent

Characteristics of REM sleep

1) **Active** form of sleep associated with **dreaming** and active **bodily movements**

2) Person is more **difficult to arouse** by sensory stimuli

Characteristics of REM Sleep

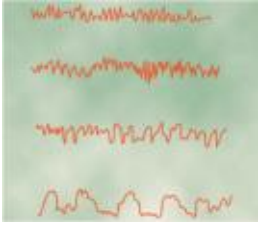


3) **Muscle tone** throughout body is depressed

4)**Heart rate** and **respiratory rate** become irregular

5) **Irregular muscle movements** occur

6) **Highly active brain**, brain metabolism rises by 20%, EEG pattern mimics wakefulness, paradox of active brain and still asleep

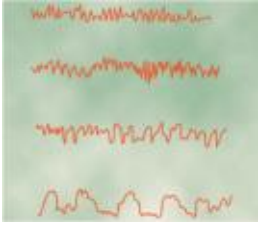


Characteristics of REM….

7) **Eye movements**, loss of muscle tone, **pupillary constriction** and **penile erection**

8) Use of **benzodiazepines** and increasing **age** decrease the duration of REM sleep

9) Possible cause is **large acetylcholine neurons** in brainstem → activate brain



REM SLEEP

Desynchronized

→ 5 – 30 min

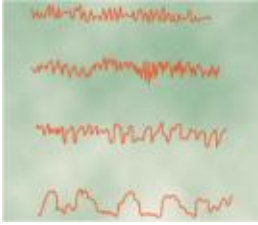
→ Every 90 min

→ Duration decrease with deep sleep

Characteristics:

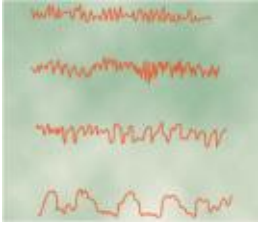
1. Active dreaming
2. Difficult to arouse (morning)
3. Decrease muscle tone
4. H.R, R.R irregular
5. Few irregular muscles movements (eyes)
6. Active brain
7. EEG: Rapid, low voltage

Comparison of Types of sleep



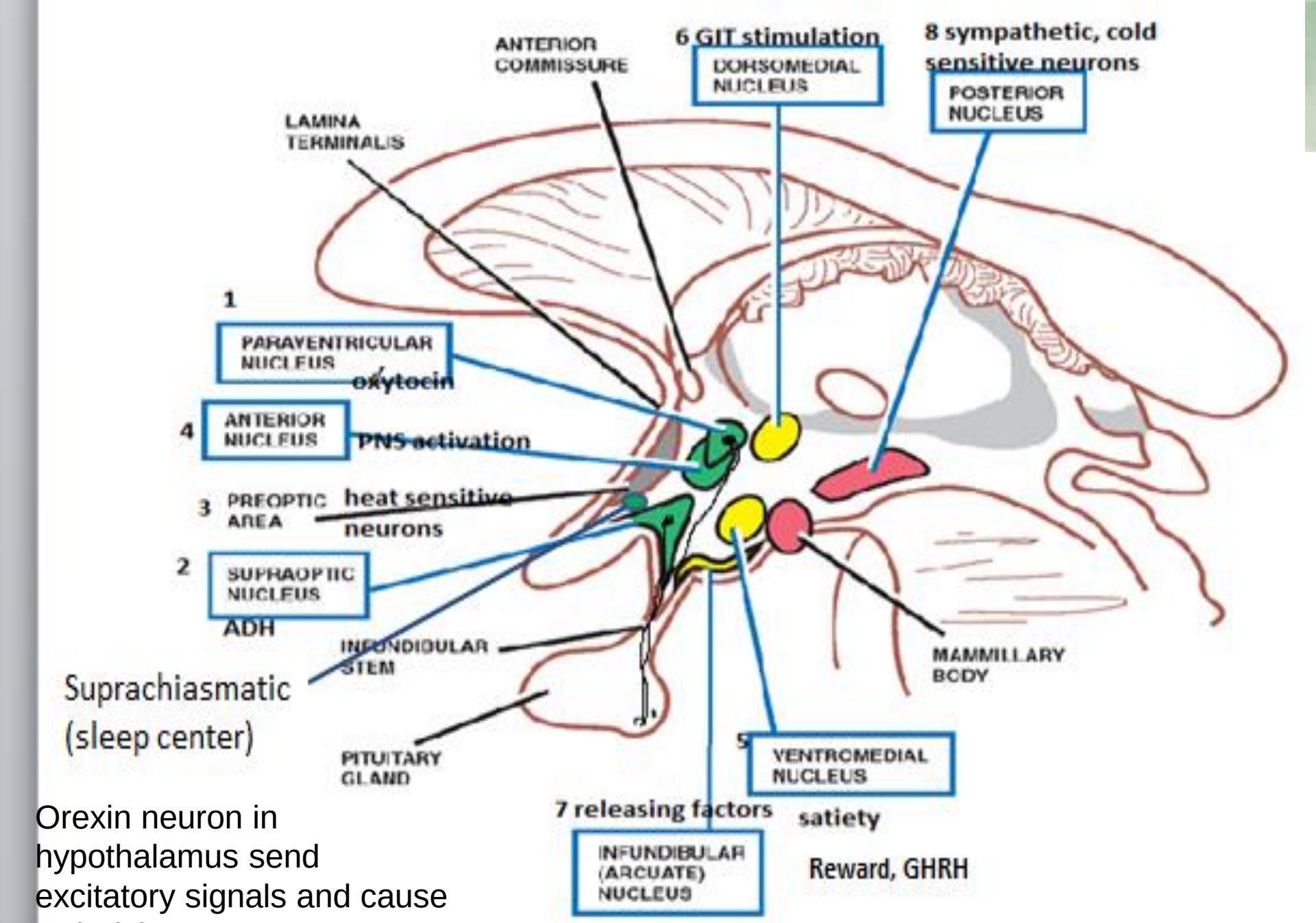
Characteristics	Slow Wave Sleep	REM Sleep
EEG	**slow waves**	Similar to **EEG of alert , awake person**
Motor activity	Considerable muscle tone; frequent shifting	Abrupt inhibition of muscle tone; body movements
HR,RR, B.P	**Minor reductions**	**Irregular**
Dreaming	**Rare**	**common**
Arousal	Sleeper easily awakened	Sleeper hard to arouse but apt to wake up spontaneously
% of sleeping time	**80%**	**20%**
Others	**Has 4 stages,** sleeper must pass through this first	**Rapid eye movements**

Basic Theories

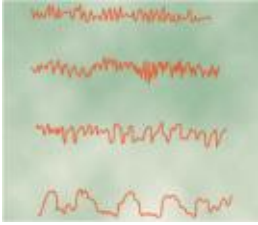


- **Active Inhibitory Process** → sleep is caused by an active mechanism that inhibits other parts of brain

- **Passive Theory of Sleep** an earlier theory → fatigue and inactivity of reticular activating system during day



Orexin neuron in hypothalamus send excitatory signals and cause wakefulness

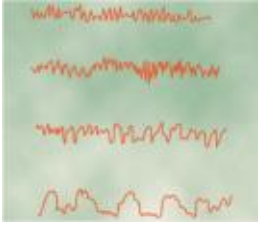


Neuronal Centres for Sleep
Active Inhibitory Process

1. **Raphe nuclei** in lower pons and medulla send inhibitory signals upwards and downwards to reticular activating system(**Serotonin inhibitory**)
2. **Diencephalon –** sleep centers

   a) suprachiasmal area of hypothalamus send inhibitory signals to RAS b) an area in diffuse nuclei of thalamus

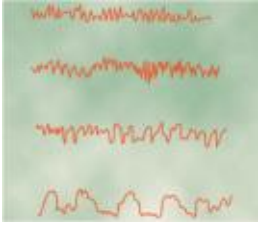
3. Muramyl peptide
4. **Nucleus of Tractus Solitarius** - site for termination in medulla and pons of vagus and glossopharyngeal nerves



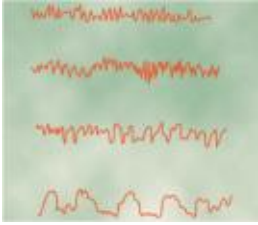
Serotonin role in sleep

- Serotonin does not therefore stimulate the brain; it instead balances out the excessive excitatory effects of other neurotransmitters(orexin producing neurons in hypothalamus = excites many parts of brain)

Lesions In Sleep Centres cause Wakefulness



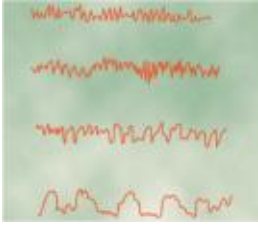
- Lesions in **Raphe Nuclei**
- Bilateral lesions in medial rostral **suprachiasmal** area in anterior hypothalamus
- Both lesions lead to **intense wakefulness**



Neurotransmitters

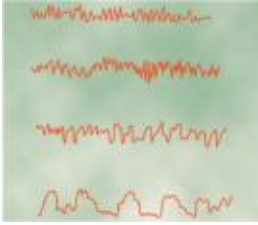
1. **Serotonin**
2. **Muramyl peptide**

   (CSF and urine in animals kept awake)
3. **Nonapeptide** (blood of sleeping animals)
4. **Sleep Factors** in brainstem/CSF



- The neuropsychological processes modulated by serotonin can include having a role in attention, perception, reward, anger, aggression, memory, motor skills, and appetite.
- Serotonin is considered to be a natural mood stabiliser and when functioning normally, it is believed to help people with feeling happy, calm, focused, and emotionally stable.

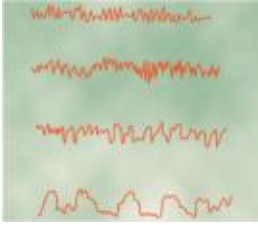
Circadian Rhythm - Sleep-Wake Cycles



24 hour cycle of sleep and waking is called **Circadian Rhythm** (regulated by pineal gland)

Due to cyclical interplay of different neural systems

- Arousal system
- sleep centre



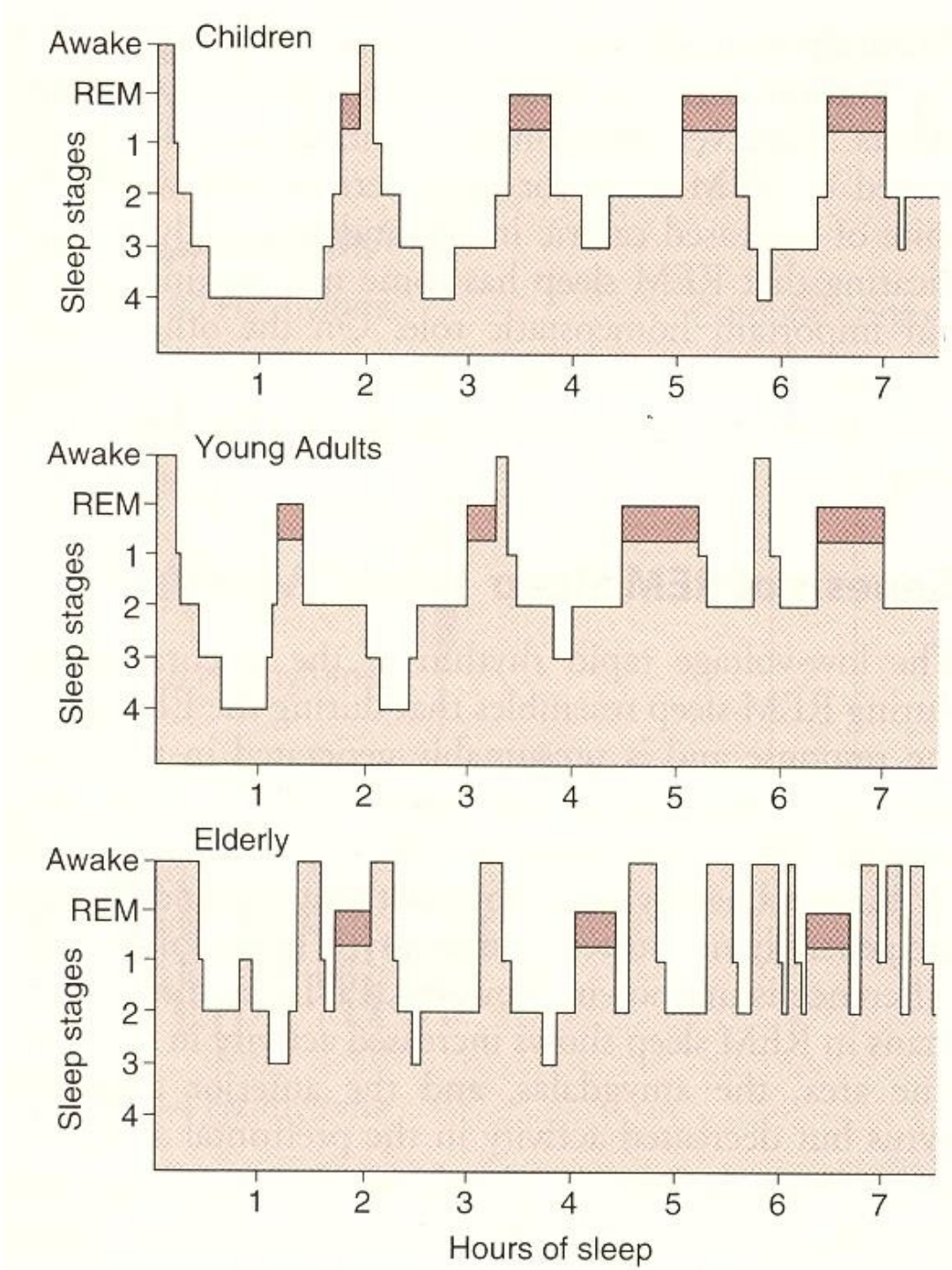
Orexin Neurons

- Are important in arousal and wakefulness
- Also called Hypocretin in hypothalamus
- Most active during waking and stop firing during sleep
- Loss of orexin neurons or receptor → Narcolepsy and such patients might have Cataplexy

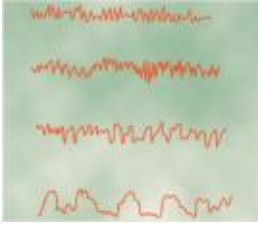
Sleep Cycle at various ages

REM is indicated by darker areas

Sleep Hypnogram

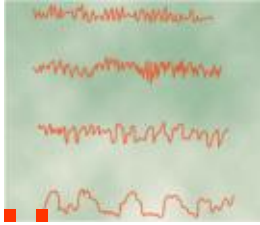


Physiologic Functions of Sleep



- Not clear
- Catch up or rebound sleep
- Sleep deprivation over a few days degrade cognitive and physical performance, overall productivity and health

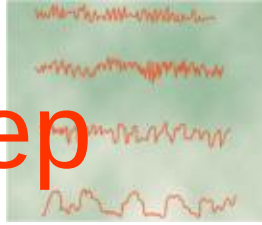
Physiologic Functions of Sleep..



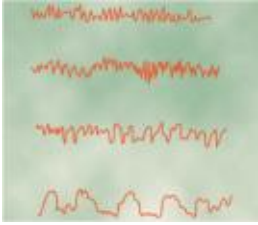
1) Neural Maturation
2) Facilitation of Learning or Memory
3) Cognition
4) Conservation of metabolic energy

Restores Natural balances among neuronal centres

Physiological Changes During Sleep



1. **Eyes** → pupils constricted, upward divergence
2. **Heart Rate**→ falls
3. **Lungs** → RR falls
4. **GIT** → gastric secretions and motility decreased
5. **Kidneys** → urine formation decreased
6. **Muscles** → decrease in muscle tone



Changes ..

7. **BMR** → falls

8. **B.P**→ falls by 10 to 20 mmHg

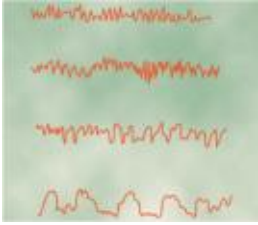
9**. Blood Volume** → hemodilution and blood volume is increased

10**. Increased Hormones** - Growth hormone and adrenocortical hormones (cortisol)

11**. Sphincters** → tonic contraction of vesicle and anal sphincters

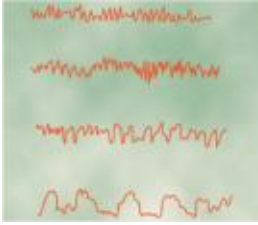
Fall in sympathetic activity and increase in parasympathetic activity

Variations with Age and Sleep Deprivation



- ↓ with age especially REM and stage 4 Sleep

- Deprivation leads to irritability, loss of concentration, restlessness, slurred speech, auditory and visual hallucinations and psychotic behaviour



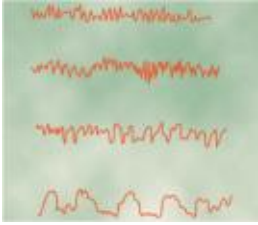
Sleep Disorders

- Insomnia is the general term for inability to sleep

- 2 types of Sleep disorders

    1. Slow Wave Sleep Disorders
    2. REM Sleep Disorders

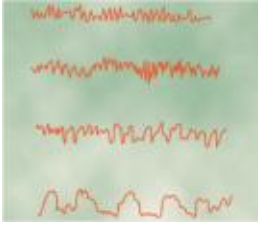
Slow Wave Sleep Disorders



1) **Sleep Walking and Sleep Talking–** common in normal children (light sleep) but uncommon in adults

2) **Night Terrors** → sudden arousal from deep slow wave sleep stage 3 & 4 seen in both children and adults (wakes up in agitation or fear, violent behaviour)

REM Sleep Disorders



1. **Nightmares** → frightening dreams

2. Sleep Paralysis → inability to move any muscle while falling asleep

3. Narcolepsy → excessive day time sleep, inherited disorder, falls asleep during bathing, eating, driving (short duration)

4. Cataplexy → brief sudden loss of skeletal muscle tone following an emotional stimulus → Collapse


Thank
you!!