

PHYSIOLOGY OF SLEEP



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PHYSIOLOGY OF SLEEP

Lecture Objectives:

Explain the difference between sleep and coma

Define NREM (non-rapid eye movement, SWS)

REM (rapid eye movement) sleep .

Describe how NREM and REM sleep are distributed

Describe the behavioral and autonomic features associated with NREM and REM sleep .

Describe Physiology of Sleep and EEG

Describe the theories about the neural basis of sleep



SLEEP: INTRODUCTION

Sleep: This is the state of unconsciousness from which a subject can be aroused by appropriate sensory or other stimuli.

Sleep may also be defined as a normal, periodic, inhibition of the Reticular Activating System (RAS).

Awake: This is the state of readiness / alertness and ability to react consciously to any stimuli.

Coma: This is the state of unconsciousness from which a person cannot be aroused by any external stimuli.



SLEEP: THEORIES

RESTORATION THEORY:

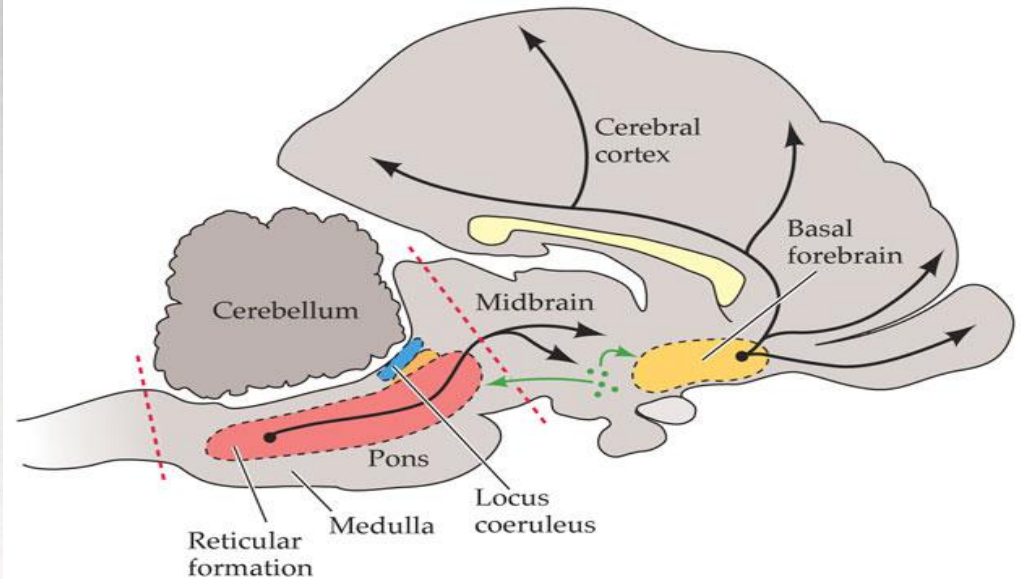
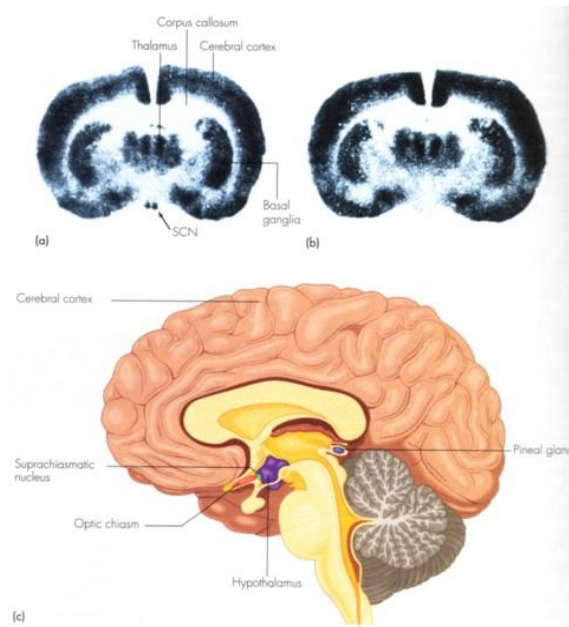
Body wears out during the day and sleep is necessary to bring it back in normal physiological condition.

PRESERVATION AND PROTECTION THEORY:

Sleep preserve energy and it provide activity

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SLEEP CENTERS



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Normal sleep is under control of the reticular activating system in the upper brain stem and diencephalon

SLEEP PHYSIOLOGY



SLEEP: MECHANISM

SLEEP IS CAUSED BY AN ACTIVE INHIBITORY PROCESS

EARLY THEORY OF SLEEP:

The excitatory areas of the upper brain stem, the *reticular activating system*, simply **became fatigue** during the day activities, waking day and became inactive as a result.

CURRENT THEORY:

Sleep is caused by an **active inhibitory process**

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SLEEP: MECHANISM

- Stimulation of some specific areas of the brain can produce sleep
- **Raphe nuclei** in the Medulla Oblongata: Fibers from these raphe neurons secrete **serotonin**.
- Drugs that **blocks the formation of serotonin** administered to an animal, the **animal cannot sleep** for the next several days. **Serotonin is associated with the production of sleep.**

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SLEEP: MECHANISM

Sleep is promoted by a complex set of neural and chemical mechanisms:

- **Daily rhythm of sleep and arousal** suprachiasmatic nucleus of the hypothalamus
- pineal gland's secretion of melatonin (**Increased melatonin make sleepy**)
- **Slow-wave sleep:** Raphe nuclei of the medulla and pons, the secretion of **serotonin associated with initiation of sleep**
- **REM sleep:** Neurons of the pons



SLEEP: MECHANISM

Consists of two parts:

Mesencephalic part: Composed of area of **grey matter of mid brain and pons** when this area is stimulated, nerve impulses going to **thalamus and disperse to the cerebral cortex**. This greatly effects the cortical activity. Mesencephalic part causes consciousness.



SLEEP: MECHANISM

Thalamic part: Consists of gray matter in the thalamus. When the thalamic part is stimulated, it develop activity in the cerebral cortex.

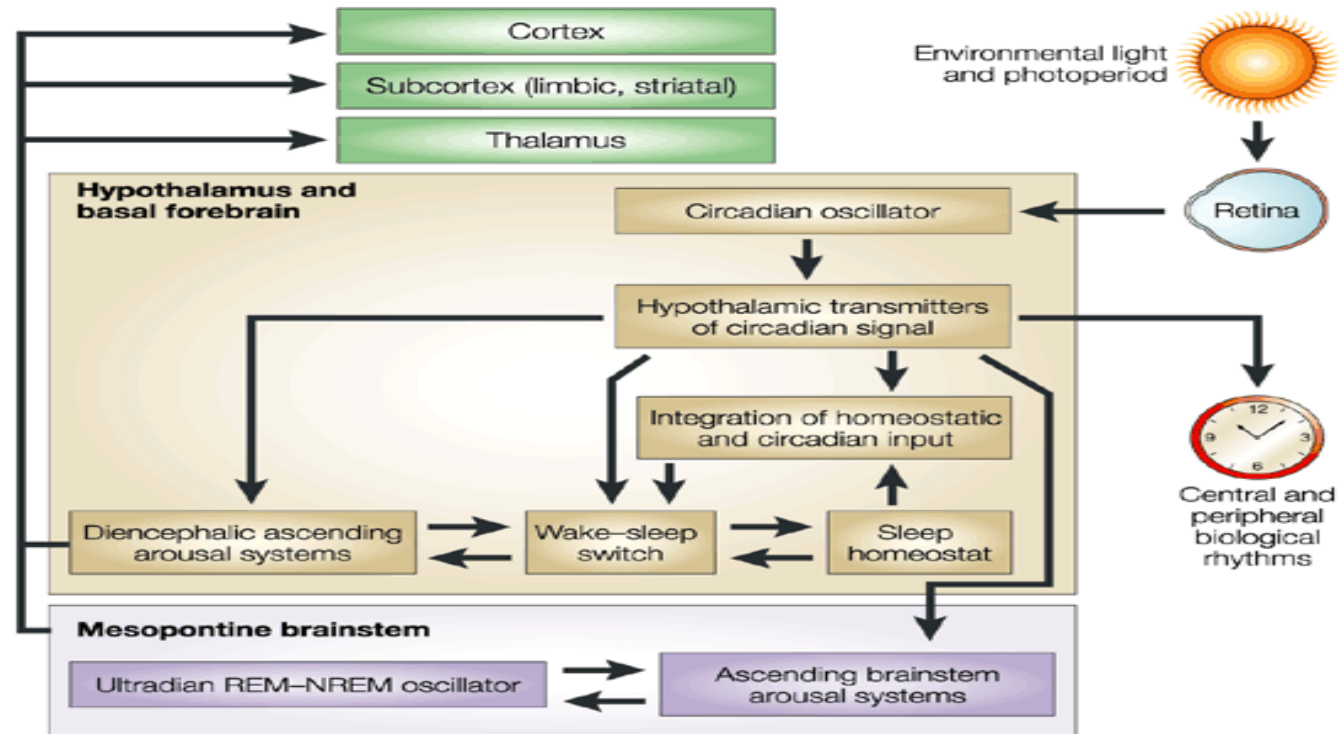
Thalamic part causes arousal that is awakening from deep sleep [sensory input, pain, light].

The RAS and cerebral cortex continue to activate each other through a feedback system.

The RAS also has a feedback system with the spinal cord.

SLEEP: MECHANISM

b Sleep-wake control systems



Nature Reviews | Neuroscience

SLEEP PHYSIOLOGY



NORMAL SLEEP DURATION

New born = 15 - 20 hours.

Children = 10 -15 hours.

Adults = 6-9 hours.

Old age = 5-6 hours.



TYPES OF SLEEP

There are two types of sleep:

1. Non Rapid Eye Movement Sleep

[Slow Wave Sleep- Dreamless]

2. Rapid eye movement sleep [Dreamful].

Both types alternate with each other.



Slow-wave: Non Rapid Eye Movement Sleep

1. Slow-wave (non rapid eye movement sleep)

This stage of sleep consists of four stages.

Stage 1: This is an initial stage between awakening and sleep.

It normally lasts from 1-7 minutes.

the person feels relaxed with eye closed.

If awakened, the person will frequently say that he has not been sleeping.

E.E.G. findings: Alpha waves diminish and Theta waves appear on EEG.



Slow-wave: Non Rapid Eye Movement Sleep

Stage 2:

This is the first stage of true sleep.

The person experiences only light sleep.

It is a little harder to awake the person.

Fragment of dream may be experienced.

Eyes may slowly roll from side to side.

E.EG-findings: Shows sleep spindles (sudden, sharply, pointed waves 12-14-Hz (cycles/sec)).



Slow-wave: Non Rapid Eye Movement Sleep

Stage 3:

This is the period of moderately deep sleep.

The person is very relaxed.

Body temperature begin to fall.

B.P decreases.

Difficult to awaken the person.

This stage occurs about 20-25 minutes after falling asleep.

E.E.G.findings: Shows mixture of sleep spindles and delta waves.



Slow-wave: Non Rapid Eye Movement Sleep

Stage 4: Deep sleep starts

Person become fully relaxed.

Respond slowly if awakened.

E.E.G.findings: Dominated by Delta Waves.

Note: Most sleep during each night is of a slow wave

Lasts for 80=90 minutes.

Dreams / night mare even occur.

The difference is that the **dreams in slow wave sleep are not remembered** but in **REM, dreams can be remembered.**



RAPID EYE MOVEMENT SLEEP / PARADOXICAL SLEEP/ DREAMFUL / DESYNCHRONIZED SLEEP

Possible Cause of REM Sleep:

It is not understood why slow-wave sleep is broken periodically by REM sleep.

Drugs that mimic the action of acetylcholine increase the occurrence of REM sleep.

It has been postulated that the **large acetylcholine secreting neurons in the upper brain stem reticular formation might, through their extensive efferent fibers, activate brain.**

This mechanism theoretically could cause the excess activity that occurs in certain brain regions in REM sleep

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RAPID EYE MOVEMENT SLEEP / PARADOXICAL SLEEP/ DREAMFUL / DESYNCHRONIZED SLEEP

In normal sleep bouts of REM sleep lasting for 5-30 minutes usually appear on the average after every 90 minutes.

The first such period occurring 80-100 minutes after the person falls a sleep.

When the person is in extreme sleep, the duration of each bout of REM is very short. It may even be absent.

- As the person becomes more rested through the night, the durations of the REM bouts increase.

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CHARACTERISTICS OF REMS

- Active form of sleep associated with dreaming
- Difficult to arouse by sensory stimuli.
- Muscle tone through out the body is depressed.
- Heart rate and respiration become irregular which is characteristic of a dream state.
- Brain is highly active in REM sleep and brain metabolism may be increased by 20%.
- *EEG.:* Pattern shows brain wave of wakefulness, REM sleep is a type of sleep in which the brain is quite active.
- Brain is quite active

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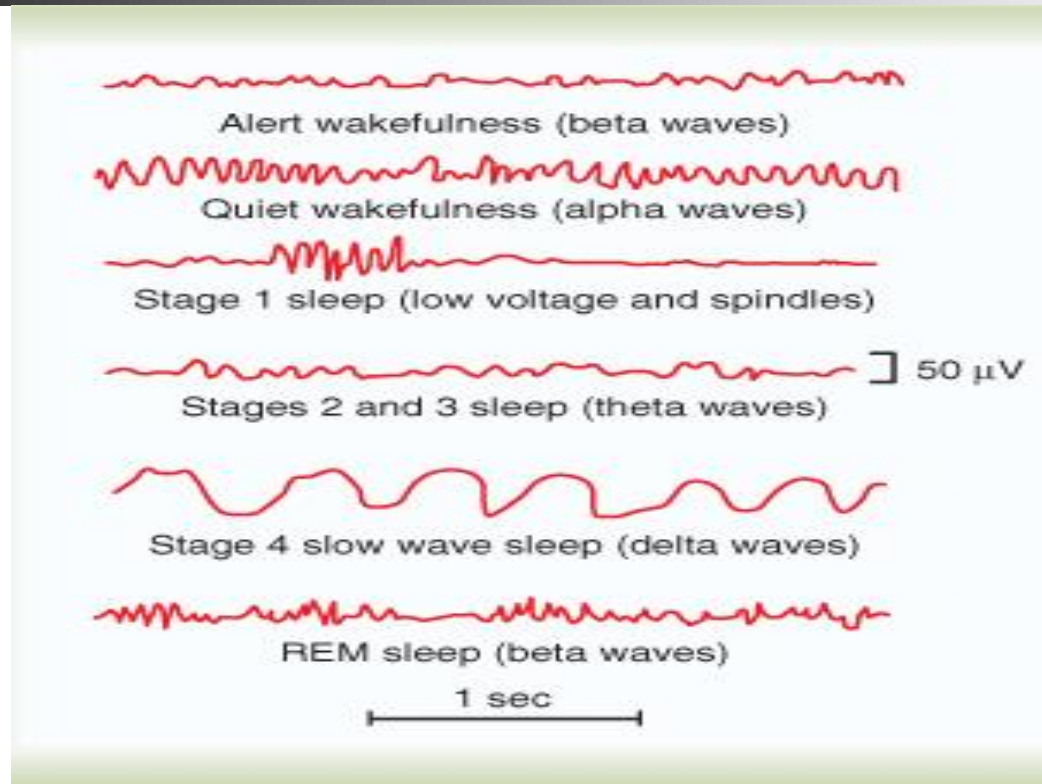
CHARACTERISTICS OF SWS AND REMS

TABLE 14.1 *Properties of Slow-Wave and REM Sleep*

Property	Slow-wave sleep	REM sleep
AUTONOMIC ACTIVITIES		
Heart rate	Slow decline	Variable with high bursts
Respiration	Slow decline	Variable with high bursts
Thermoregulation	Maintained	Impaired
Brain temperature	Decreased	Increased
Cerebral blood flow	Reduced	High
SKELETAL MUSCULAR SYSTEM		
Postural tension	Progressively reduced	Eliminated
Knee jerk reflex	Normal	Suppressed
Phasic twitches	Reduced	Increased
Eye movements	Infrequent, slow, uncoordinated	Rapid, coordinated
COGNITIVE STATE		
	Vague thoughts	Vivid dreams, well organized
HORMONE SECRETION		
Growth hormone secretion	High	Low
NEURAL FIRING RATES		
Cerebral cortex (sustained) activity	Many cells reduced and more phasic	Increased firing rates; tonic
EVENT-RELATED POTENTIALS		
Sensory-evoked	Large	Reduced

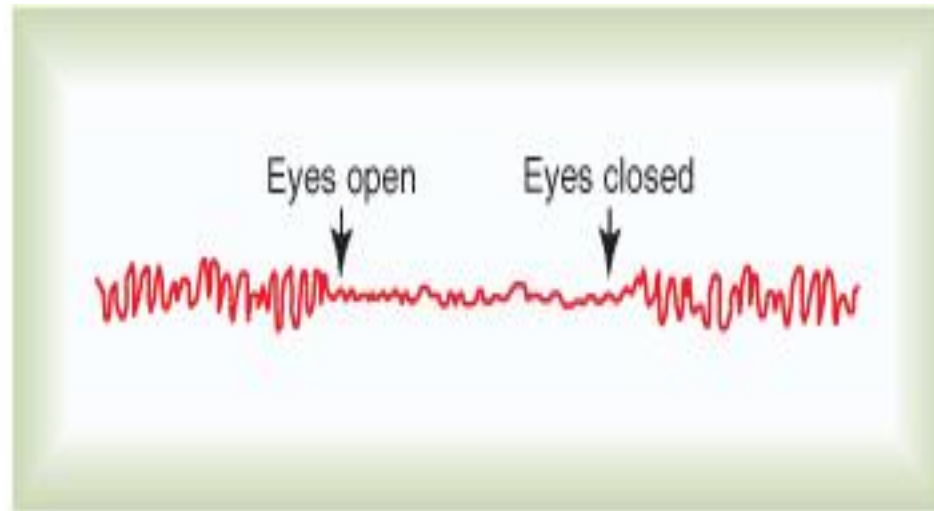
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SLEEP AND EEG



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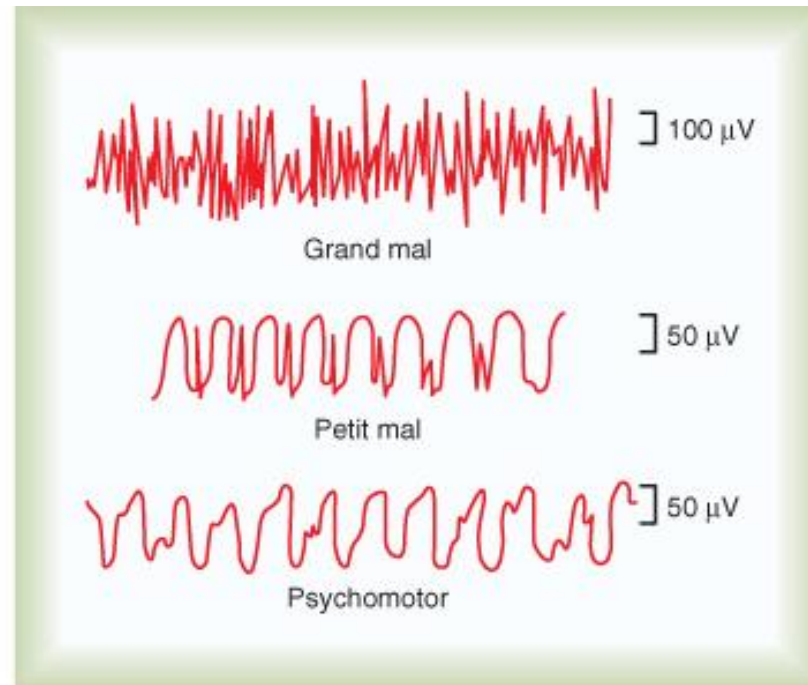
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EEG WAVES IN WAKKFULNESS

Awake, but non-attentive - large, regular alpha waves

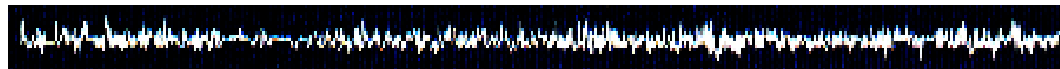
Awake, nonattentive 1 second



◀ **Alpha waves** ▶

Awake and attentive - low amplitude, fast, irregular beta waves

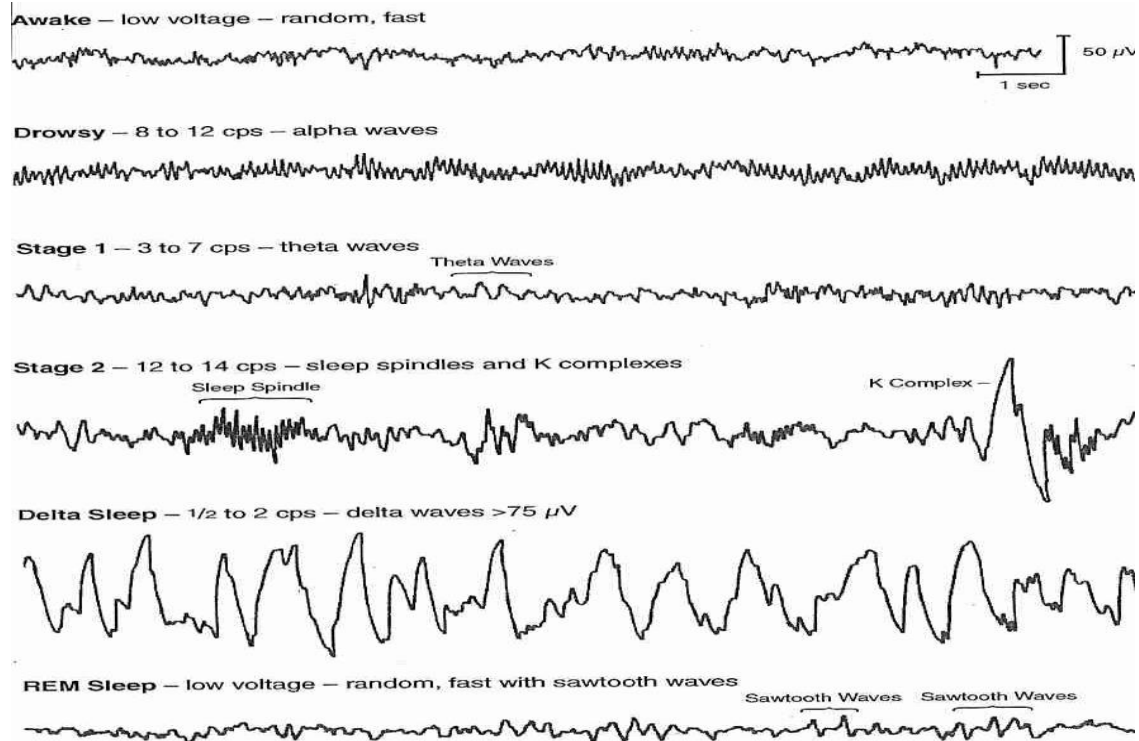
Awake, attentive 1 second



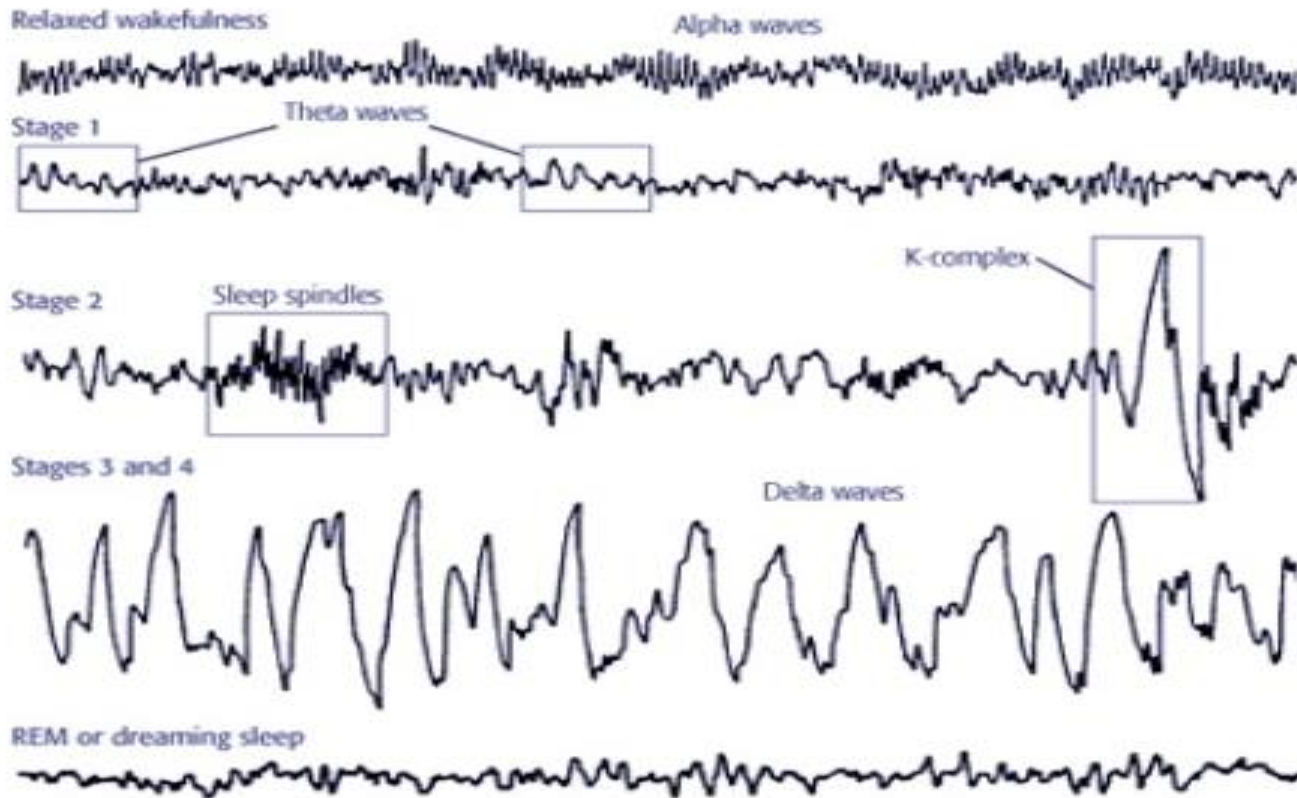
◀ **Beta waves** ▶

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SLEEP AND EEG



SLEEP AND EEG



SLEEP PHYSIOLOGY



PHYSIOLOGICAL CHANGES IN SLEEP

Physiological changes during sleep:

CVS: Pulse Rate, cardiac output, blood pressure, and vasomotortone are decreased but the blood volume is increased.

Respiration: Tidal volume and rate of respiration is decreased. BMR is decreased 10-15%.

Urine volume: Urine volume is decreased.

Secretions: Salivary / lacrimal secretions are reduced, gastric/sweet secretions are increased.

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PHYSIOLOGICAL CHANGES DURING SLEEP

Muscles: Relaxed.

Superficial reflexes are unchanged except plantar reflex.

Deep reflexes are reduced.

Effects produced by awakening after 60-100 hours:

Equilibrium disturbed.

Neuromuscular junction fatigue.

Threshold for pain is lowered.

Some cells shrink.

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FUNCTIONS OF SLEEP

- Neural maturation
- Facilitation of learning, memory
- Cognition
- Clearance of metabolic waste products generated by neural activity in the awake brain
- Conservation of metabolic energy.
- Restore natural balances among the neuronal centers.

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NEURONAL ACTIVITY

TABLE 14.2 *Neural Activity of Neurotransmitter Systems during Sleep and Arousal*

Neurotransmitter	Site of cell bodies	Activity during		
		Wakefulness	SWS	REM
Serotonin	Raphe nuclei	High	Low	Very low
Norepinephrine	Locus coeruleus	High	Low	Very low
Acetylcholine	Brainstem	High	Low	High



SLEEP DISORDERS

Insomnia: Inability to sleep

Somnolence: Extreme sleepiness

Disorder of slow wave sleep:

Sleep talking / sleep walking [common in children]

Night tremors: Are seen in III, IV stage of slow wave sleep [common in children].

Disorder of REM sleep:

Nightmare = Frightening dream.

Sleep Paralysis = Subject awake but unable to speak or move.

Sleeping Sickness.



SLEEP DISORDERS

Somnambulism –Walking during sleep

Nightmares: Frightening dreams, awake from REM

Night terrors - Sudden arousal from sleep and intense fear accompanied by physiological reactions (e.g., rapid heart rate, perspiration) that occur during slow-wave sleep

Narcolepsy - Excessive sleepiness may occur while talking, sitting, decreased ability to regulate sleep

Sleep apnea - failure to breathe when asleep

THANK YOU

