

# PHYSIOLOGY OF SLEEP



## **Prof. Sultan Ayoub Meo**

MBBS, Ph.D (Pak), M Med Ed (Dundee), FRCP (London),  
FRCP (Dublin), FRCP (Glasgow), FRCP (Edinburgh)  
Professor and Consultant, Department of Physiology,  
College of Medicine, King Saud University, Riyadh, KSA



# PHYSIOLOGY OF SLEEP

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## 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

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**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

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## RESTORATION THEORY:

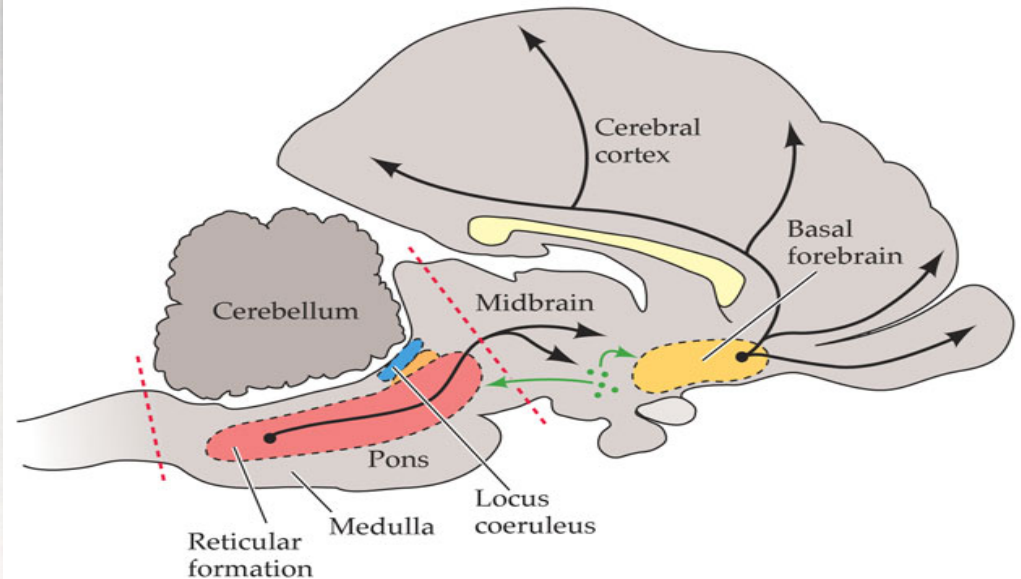
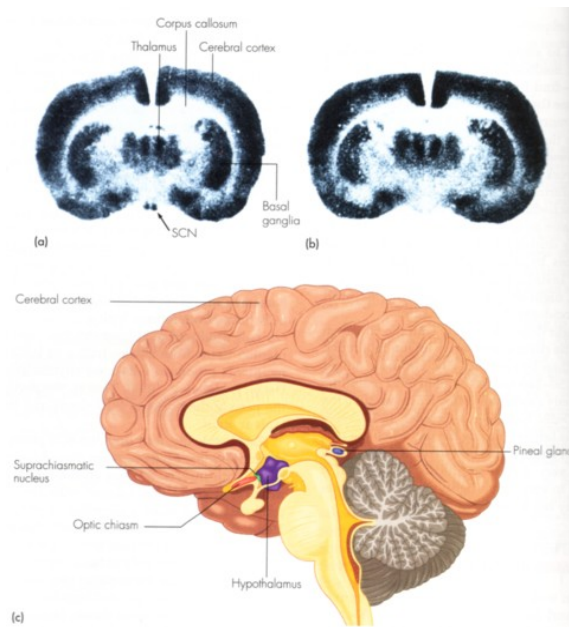
Body wears out during the day and sleep is necessary to bring it back in normal physiological condition.

## PRESERVATION AND PROTECTION THEORY:

Sleep preserve energy and it provide activity

Guyton and Hall, 13<sup>th</sup> Edition 2016; 761-768

# SLEEP CENTERS



BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 14.20 © 2004 Sinauer Associates, Inc.

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

## SLEEP PHYSIOLOGY



# SLEEP: MECHANISM

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**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**

Guyton and Hall, 13<sup>th</sup> Edition 2016; 761-768



# SLEEP: MECHANISM

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- 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.**

Guyton and Hall, 13<sup>th</sup> Edition 2016; 761-768



# SLEEP: MECHANISM

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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

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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

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

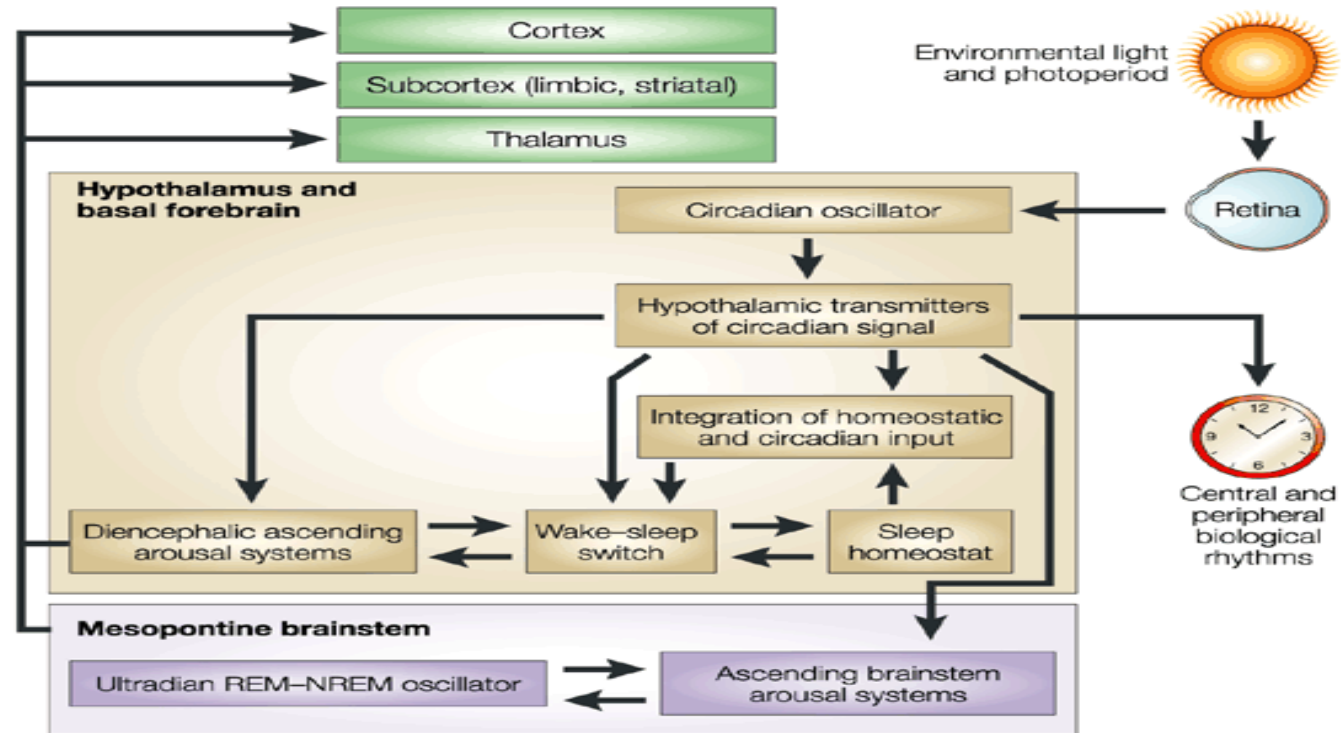
Thalamic part causes arousal that is awakening from deep sleep [sensory input, pain, light].

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

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*New born* = 15 - 20 hours.

*Children* = 10 -15 hours.

*Adults* = 6-9 hours.

*Old age* = 5-6 hours.



# TYPES OF SLEEP

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**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

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## 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

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## *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

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## *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

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**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

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## **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

Guyton and Hall, 13<sup>th</sup> Edition 2016; 761-768



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

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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.

Guyton and Hall, 13<sup>th</sup> Edition 2016; 761-768



# CHARACTERISTICS OF REMS

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- 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

Guyton and Hall, 13<sup>th</sup> Edition 2016; 761-768

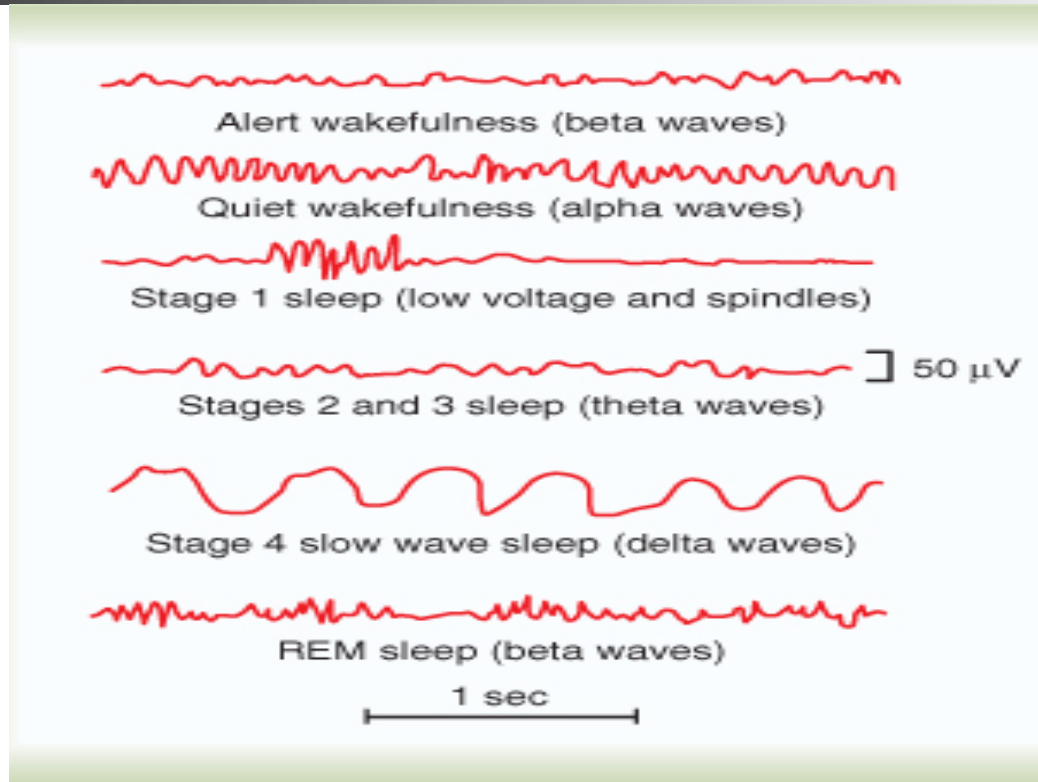
# CHARACTERISTICS OF SWS AND REMS

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

Property	Slow-wave sleep	REM sleep
<b>AUTONOMIC ACTIVITIES</b>		
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
<b>SKELETAL MUSCULAR SYSTEM</b>		
Postural tension	Progressively reduced	Eliminated
Knee jerk reflex	Normal	Suppressed
Phasic twitches	Reduced	Increased
Eye movements	Infrequent, slow, uncoordinated	Rapid, coordinated
<b>COGNITIVE STATE</b>		
	Vague thoughts	Vivid dreams, well organized
<b>HORMONE SECRETION</b>		
Growth hormone secretion	High	Low
<b>NEURAL FIRING RATES</b>		
Cerebral cortex (sustained) activity	Many cells reduced and more phasic	Increased firing rates; tonic
<b>EVENT-RELATED POTENTIALS</b>		
Sensory-evoked	Large	Reduced

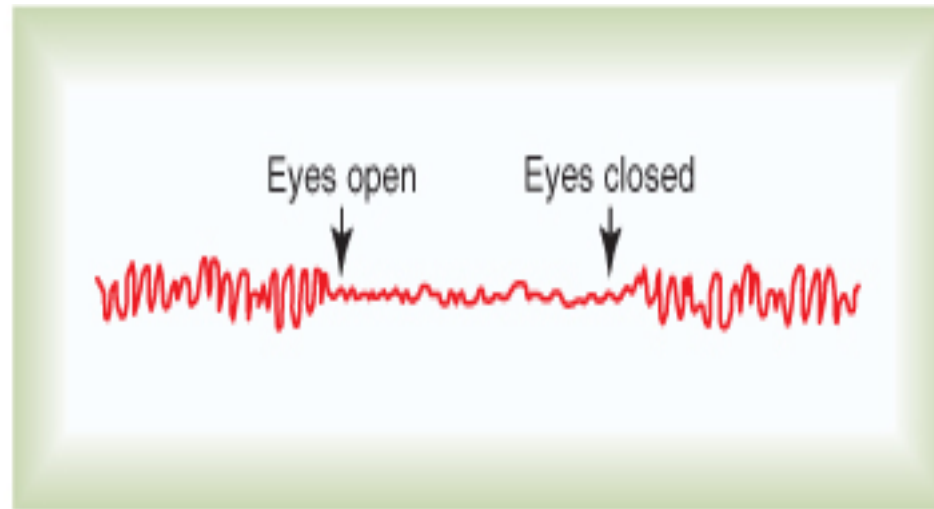
BIOLOGICAL PSYCHOLOGY, Fourth Edition, Table 14.1 © Sinauer Associates, Inc.

# SLEEP AND EEG



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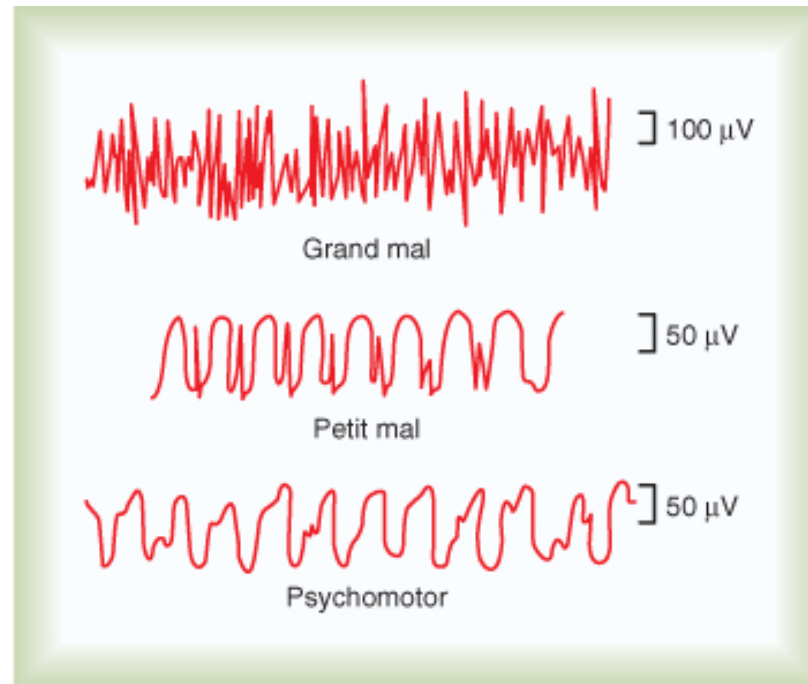
## SLEEP AND EEG



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# SLEEP AND EEG



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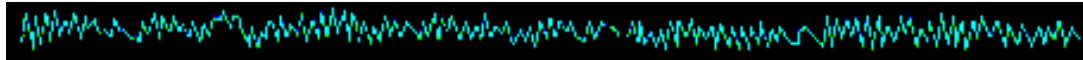
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## EEG WAVES IN WAKKFULNESS

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

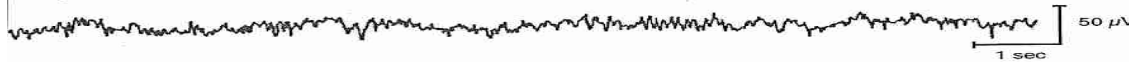


◀ **Beta waves** ▶

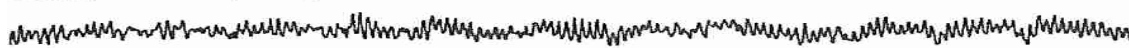
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# SLEEP AND EEG

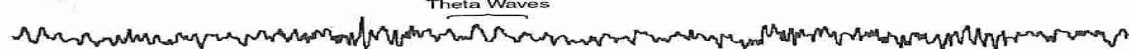
Awake – low voltage – random, fast



Drowsy – 8 to 12 cps – alpha waves



Stage 1 – 3 to 7 cps – theta waves



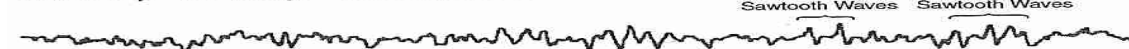
Stage 2 – 12 to 14 cps – sleep spindles and K complexes



Delta Sleep – 1/2 to 2 cps – delta waves  $>75 \mu$ V

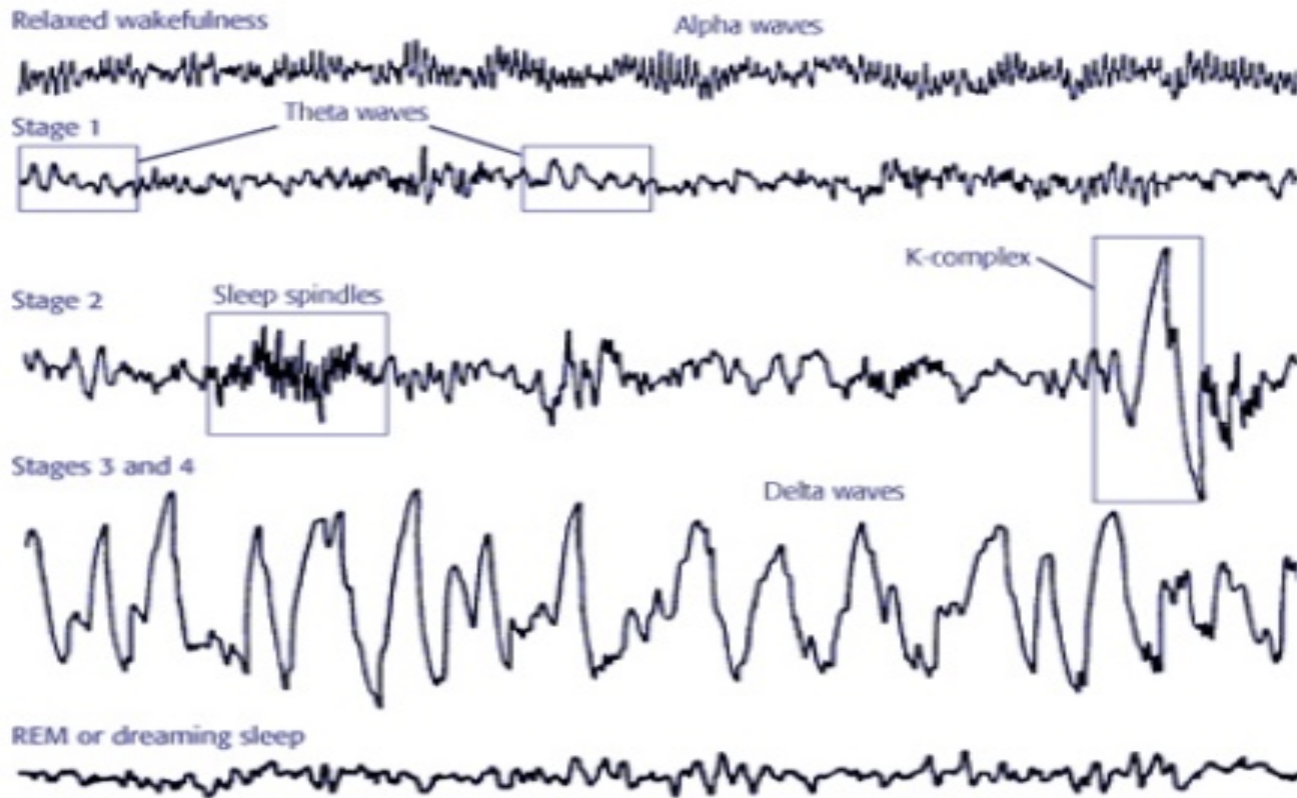


REM Sleep – low voltage – random, fast with sawtooth waves



## SLEEP PHYSIOLOGY

# SLEEP AND EEG



## SLEEP PHYSIOLOGY



## PHYSIOLOGICAL CHANGES IN SLEEP

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**Physiological changes during sleep:**

**CVS:** Pulse Rate, cardiac output, blood pressure, and vasomotor tone 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

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*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

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- 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

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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

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**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**

