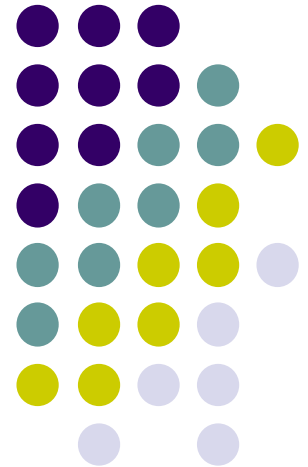


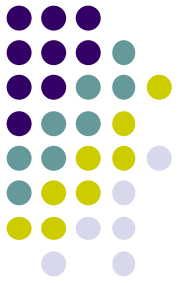
# Brain activity and Sleep

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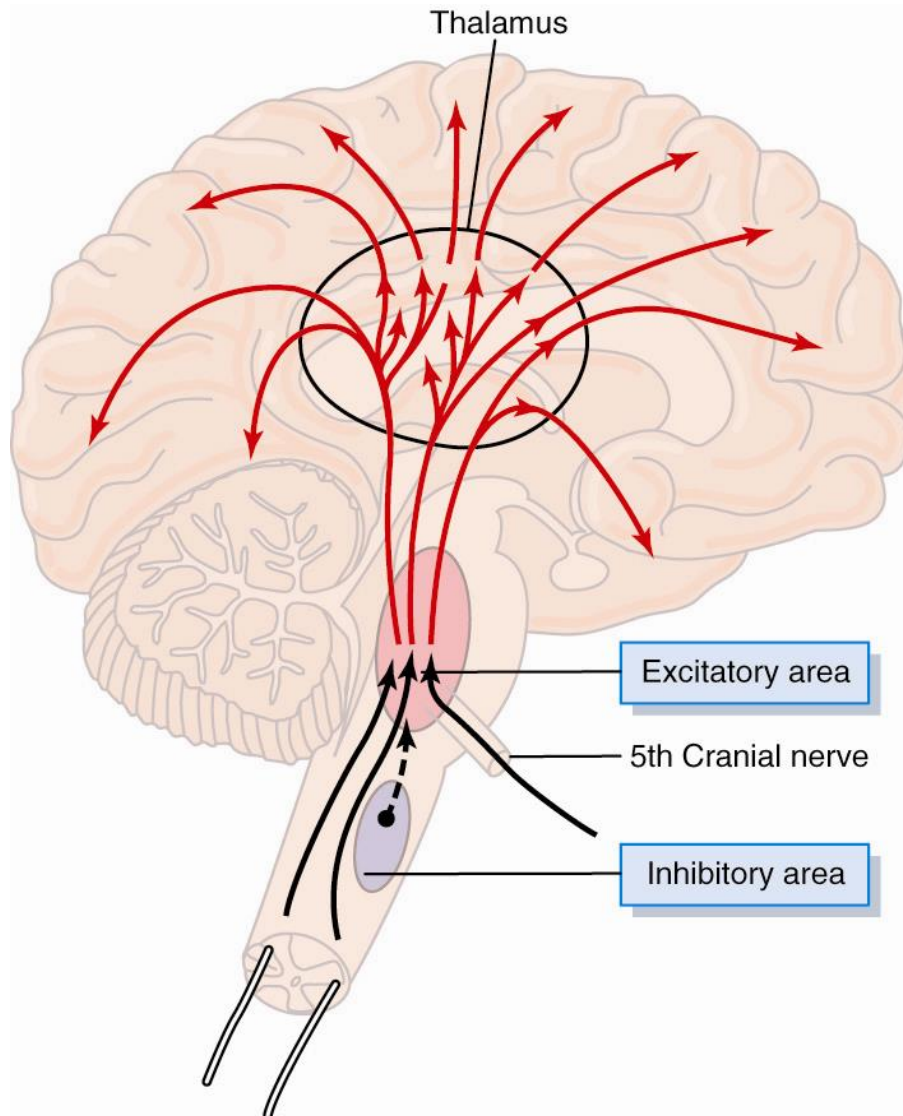
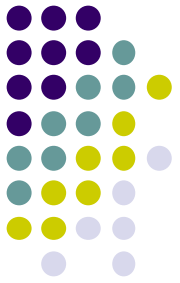
Faisal I. Mohammed, MD, PhD



# Objectives

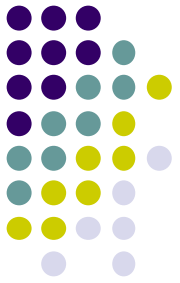


- List types of sleep
- Describe sleep
- Outline the reticular activating system function



## Location of excitatory and inhibitory areas of the brain

# Activating Systems of the Brain



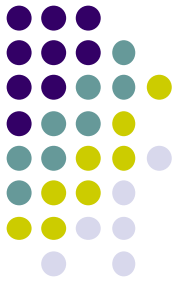
- Cerebrum requires a constant input to remain active.
- Signals from the brainstem activate wide areas of the cortex (background activation) or specific areas to perform discrete tasks.

# Excitatory Signals from the Brainstem



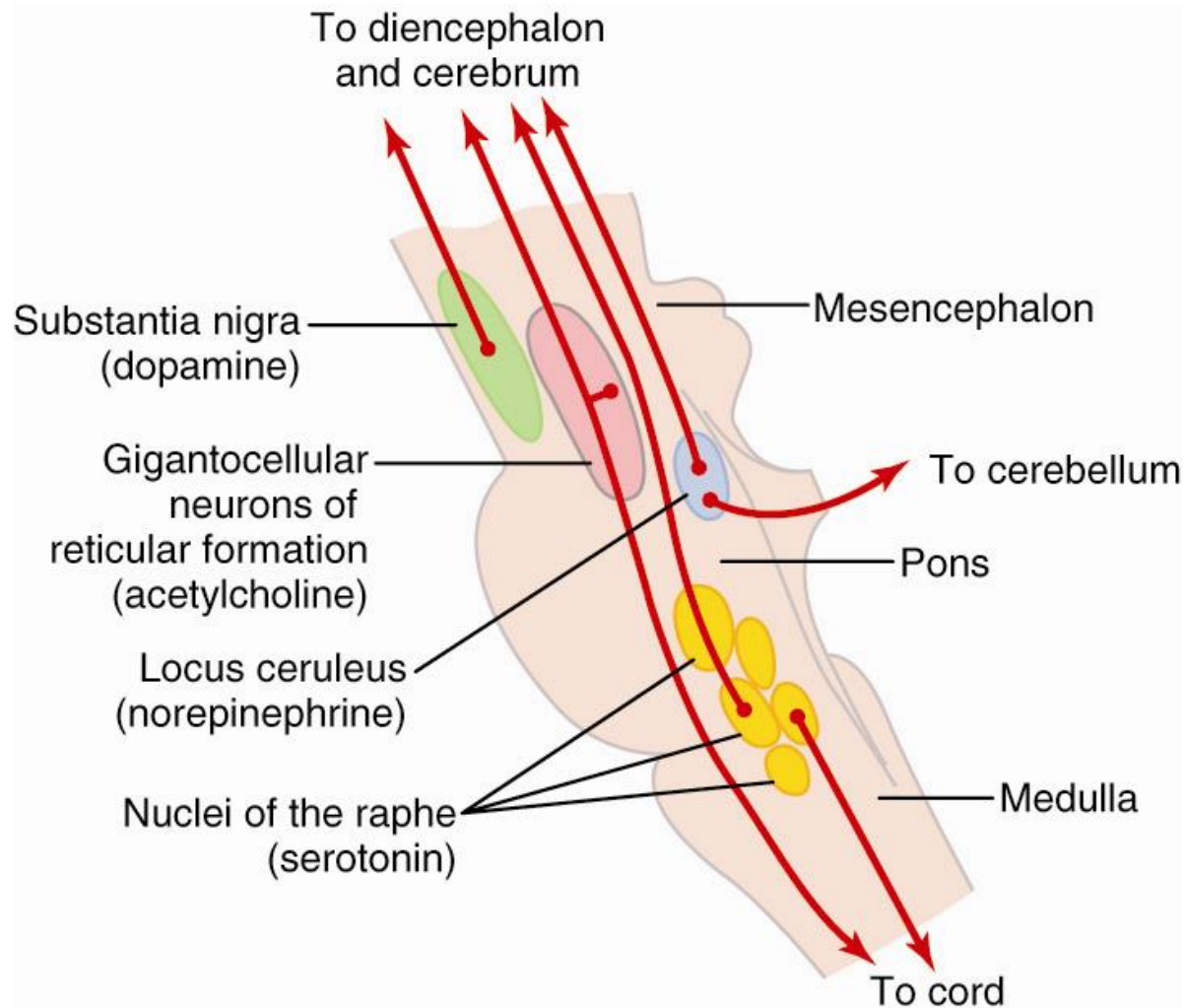
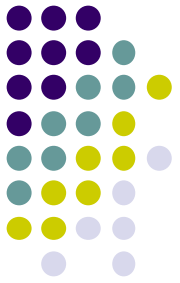
- Bulboreticular facilitory area
  - sends excitatory signals to the antigravity muscles
  - sends excitatory signals to the thalamus and from here they are distributed to widespread areas of the cortex
- Bulboreticular area is excited by signals from the periphery, especially pain signals and also descending signals from the cortex (positive feedback or corticospinal pathway).

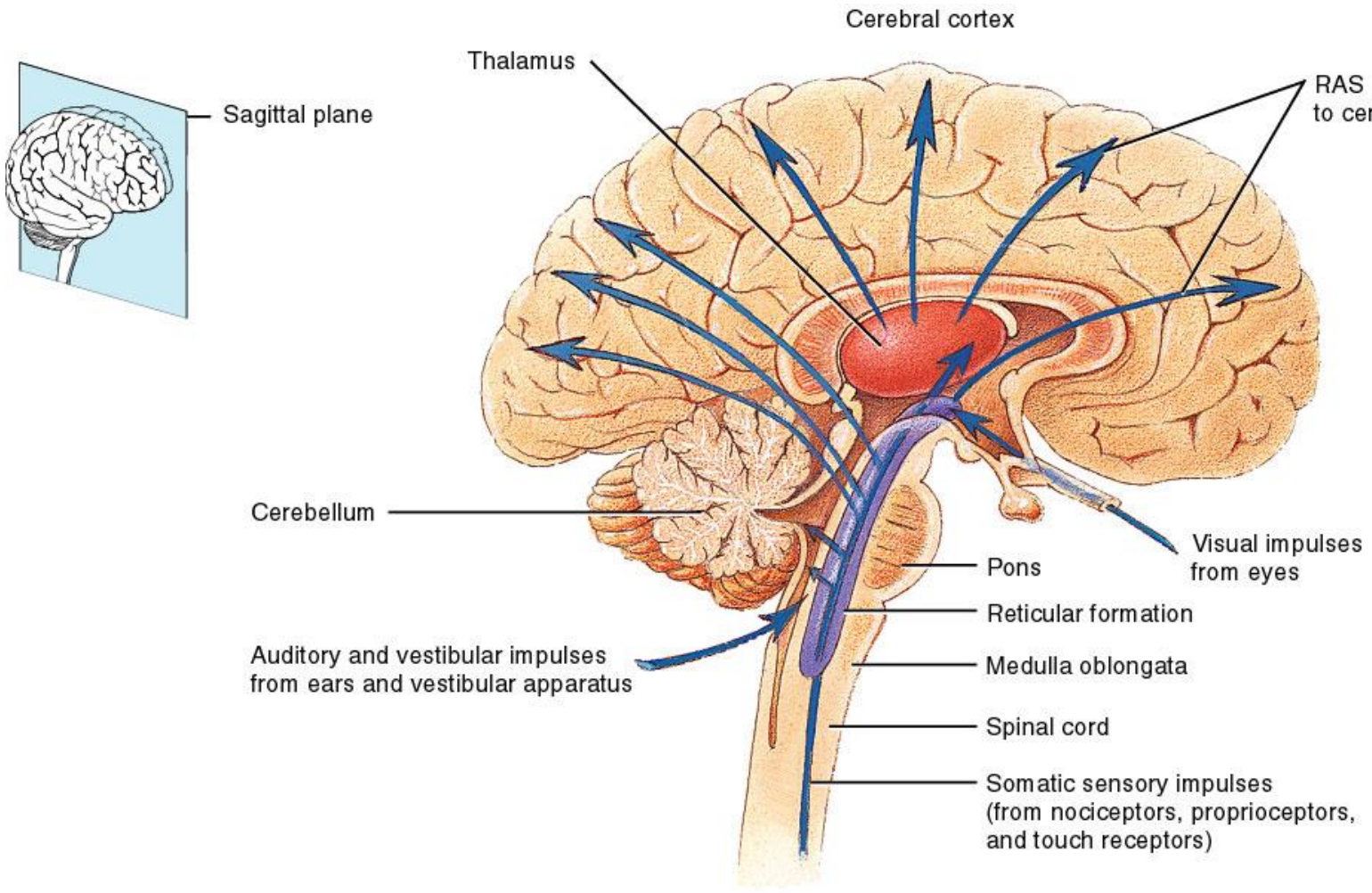
# Inhibitory Signals from the Brainstem



- reticular inhibitory area
  - sends inhibitory signals to the bulboreticular area
  - when the inhibitory area is excited, it will decrease the activity of the excitatory area and decrease the activity of the cortex

# Neurohumoral Control of Brain Activity





Sagittal section through brain and spinal cord

15.10

# Sleep



- unconsciousness from which one can be aroused by sensory stimulus
- different from *coma* from which one cannot be aroused
- two types of sleep:
  - slow wave or deep sleep
  - REM sleep or paradoxical sleep

# Slow Wave Sleep



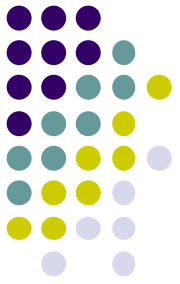
- restful sleep at the beginning of the sleep period
- associated with a decrease in vegetative functions
- usually not associated with dreaming; dreams do occur but they are not remembered

# Rapid Eye Movement (REM) Sleep



- associated with active dreaming
- peripheral muscle tone is inhibited
- associated with an increase in cortical activity and metabolism
- brain waves similar to wakefulness
- begin about 90 minutes after falling asleep and reappear at 90 minute intervals
- last for progressively longer periods of time each time they occur, a few minutes at first, 30 minutes toward the end of the sleep period

# Rapid Eye Movement (REM) Sleep (paradoxical sleep)



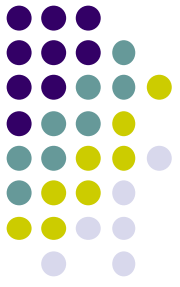
- associated with active dreaming
- peripheral muscle tone is greatly inhibited- difficult to arouse by sensory stimulation
- associated with an increase in cortical activity and metabolism
- Irregular heart rate and respiration
- brain waves similar to wakefulness
- begin about 60-90 minutes after falling asleep and reappear at 60-90 minute intervals
  - last for progressively longer periods of time each time they occur, a few minutes (around 5 min) at first, 30 minutes toward the end of the sleep period

# Why Do We Sleep?

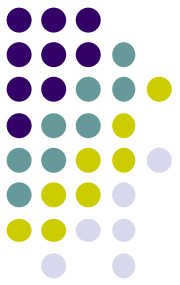


- mechanism is unknown
- probably an active inhibitory process in which the excitatory reticular neurons are inhibited
- stimulation of the *raphe nuclei* causes sleep
  - these nuclei release *serotonin* which is thought to induce sleep
  - blockade of serotonin formation causes prolonged wakefulness in animals, however, blood levels of serotonin are lower during sleep

# Why Do We Sleep?



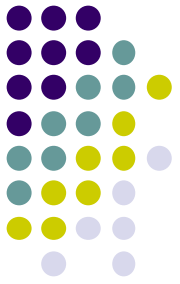
- stimulation of other brain regions can also induce sleep
- nucleus of the solitary tract
  - solitary tract stimulation will not produce sleep if the raphe nuclei are destroyed
  - therefore, solitary tract may be stimulating release of serotonin from the raphe nuclei
- suprachiasmatic area of the rostral hypothalamus, diffuse thalamic nuclei



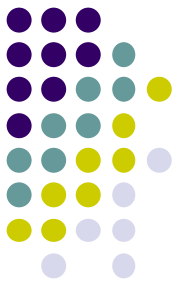
# Why Do We Sleep?

- accumulation of sleep factors
  - muramyl peptide - found in CSF and urine of animals keep awake for prolonged periods, will cause sleep when injected into third ventricle
  - also a peptide isolated from the blood of sleeping animals
  - also substance from brain stem of animals keep awake
- lesions of the raphe nuclei can prevent sleep

# REM Sleep



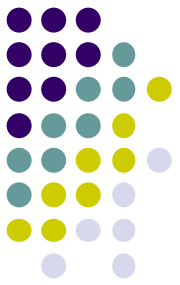
- function of REM sleep is unknown
  - lesions of the *locus ceruleus* prevent REM sleep
  - may be important for neural development
  - testing the cortex to see if it can be brought to activity



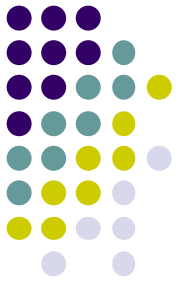
# Sleep Cycle

- no explanation for the sleep - wakefulness cycle
- however, there are many theories
  - sleep cycle may be caused by fatigue of excitatory areas to induce sleep and fatigue of inhibitory areas of the lower brain to awaken.
  - sleep probably is an active process driven by a center below the midpontine level of the brain stem.

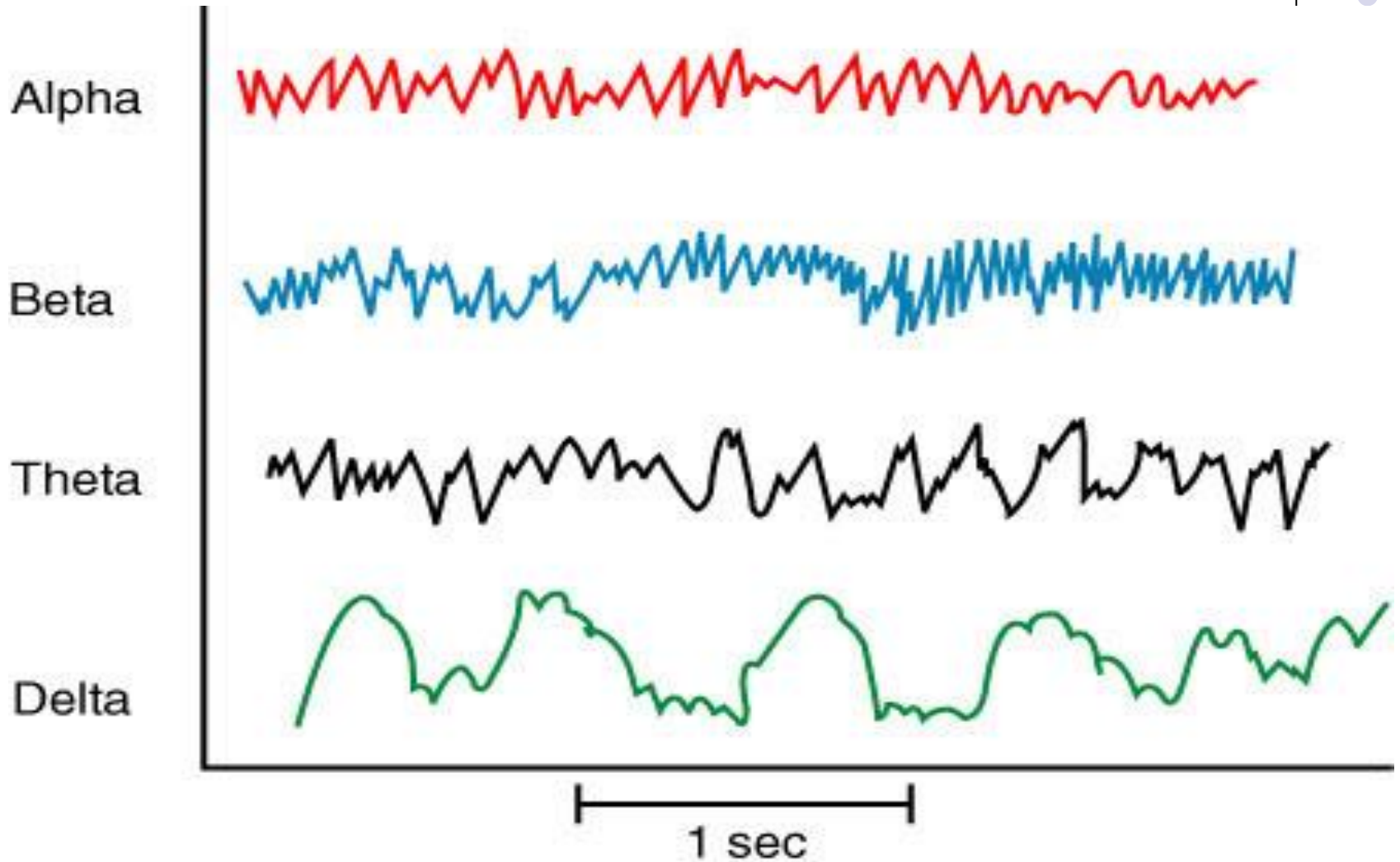
# Physiological Effect of Sleep



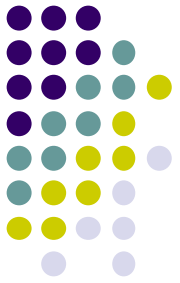
- little on the body itself
  - decrease in sympathetic tone, muscle tone, fall in arterial pressure
- profound effect on the brain
  - lack of sleep can lead to altered mental states
    - paranoia, psychoses
- sleep probably functions to balance the activity of the various areas of the brain, to reset/re-zero/reboot neuronal circuits



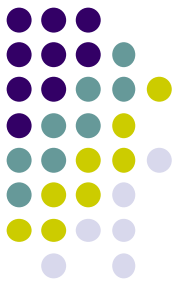
# EEG waves



# Brain Waves



- electrical recordings from the surface of the brain
- characterized as *alpha*, *beta*, *theta* and *delta* depending on the frequency
- each functional state of the brain has a characteristic pattern of brain waves (sleep, wakefulness, epilepsy, psychoses, etc.)



# Alpha and Beta Waves

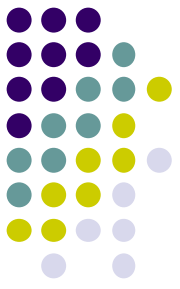
- Alpha waves
  - occur at 8 -13 Hz
  - mostly from occipital cortex but can also be found in frontal and parietal regions as well
  - occur during quiet resting states of cerebration, they disappear when there is a specific mental activity (opening of the eyes, intense mental concentration or stress) or during sleep
  - will not occur without cortical connection to thalamus
- Beta waves
  - occur at 14 - 80 Hz
  - occur during intense mental activity or stress

# Theta and Delta Waves



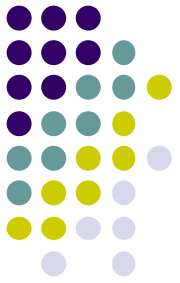
- Theta waves
  - occur at 4 - 7 Hz
  - recorded from parietal and temporal regions in children
  - occur during emotional stress in adults particularly in response to disappointment or frustration
- Delta waves
  - all waves below 3.5 Hz
  - occur during deep sleep thought to be activity of the cortex independent of signals from lower brain areas

# EEG Sleep Patterns



- There are two major types of sleep:
  - Non-rapid eye movement (NREM)
  - Rapid eye movement (REM)
- REM (rapid eye movement):
  - Dreams occur.
  - Low-amplitude, high-frequency oscillations.
  - Similar to wakefulness (beta waves).
- Non-Rem (resting):
  - High-amplitude, low-frequency waves (delta waves).

# Non-REM Sleep



- Alpha, delta, theta activity are present in the EEG record
  - Stages 1 and 2: Alpha waves
  - Stages 3 and 4: delta activity (synchronized)
    - Termed slow-wave sleep (SWS)
- Light, even respiration
- Muscle control is present (toss and turn)
- Dreaming (could but not vivid, rational)
  - Difficult to rouse from stage 4 SWS (resting brain?)

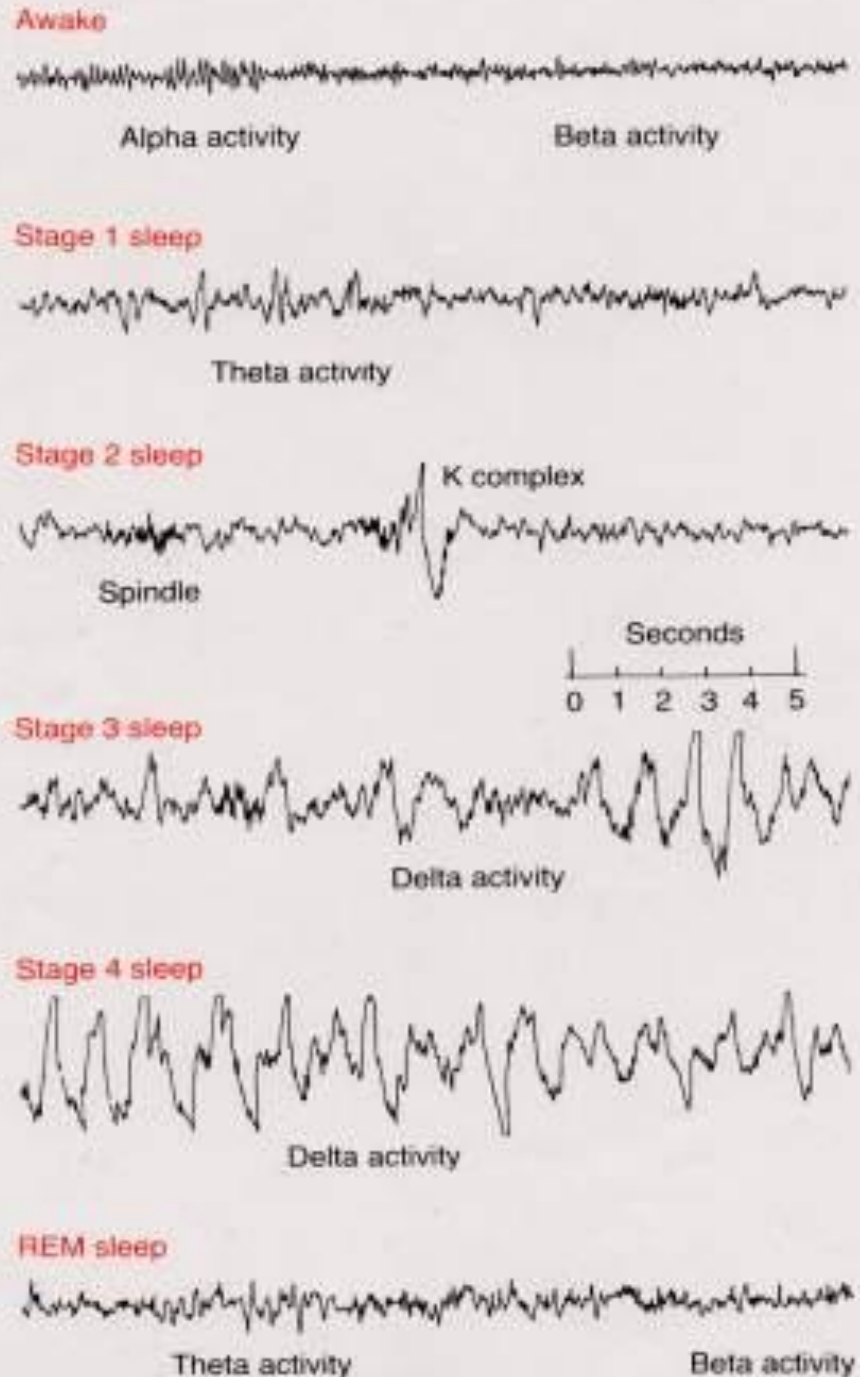
# REM Sleep



- Presence of beta activity (desynchronized EEG pattern)
- Physiological arousal threshold increases
  - Heart-rate quickens
  - Breathing more irregular and rapid
  - Brainwave activity resembles wakefulness
  - Genital arousal
- Pontine-Geniculate-Occipital (PGO) waves?
- Loss of muscle tone (paralysis)
- Vivid, emotional dreams
- May be involved in memory consolidation

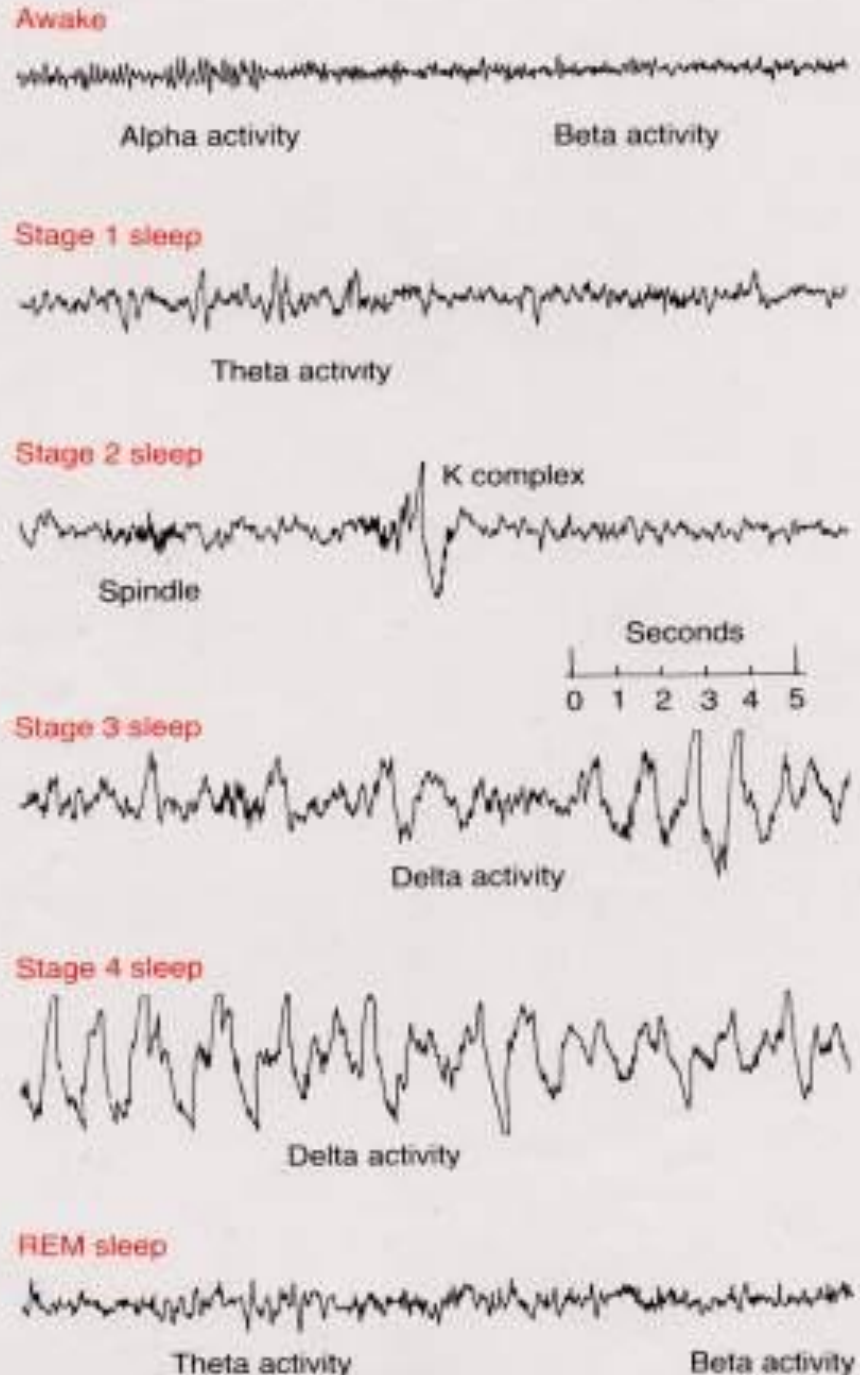
# Types and Stages of Sleep: NREM

- Stage 1 – eyes are closed and relaxation begins; the EEG shows alpha waves; one can be easily aroused
- Stage 2 – EEG pattern is irregular with sleep spindles (high-voltage wave bursts); arousal is more difficult



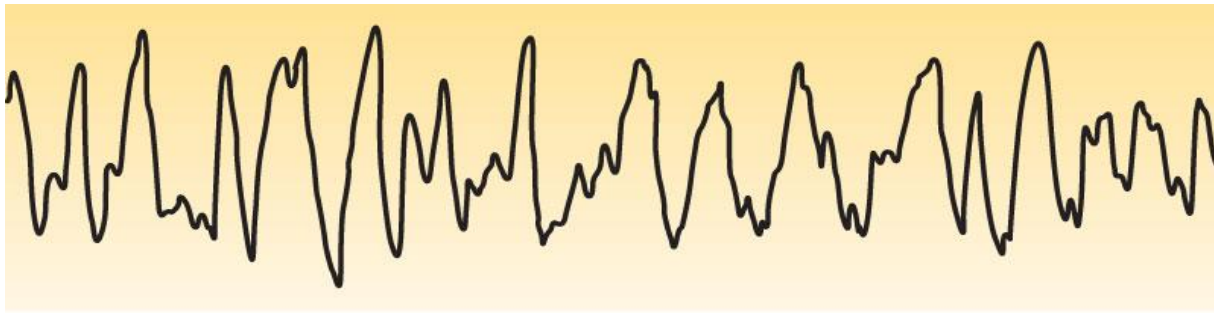
–Stage 3 – sleep deepens; theta and delta waves appear; vital signs decline; dreaming is common

–Stage 4 – EEG pattern is dominated by delta waves; skeletal muscles are relaxed; arousal is difficult

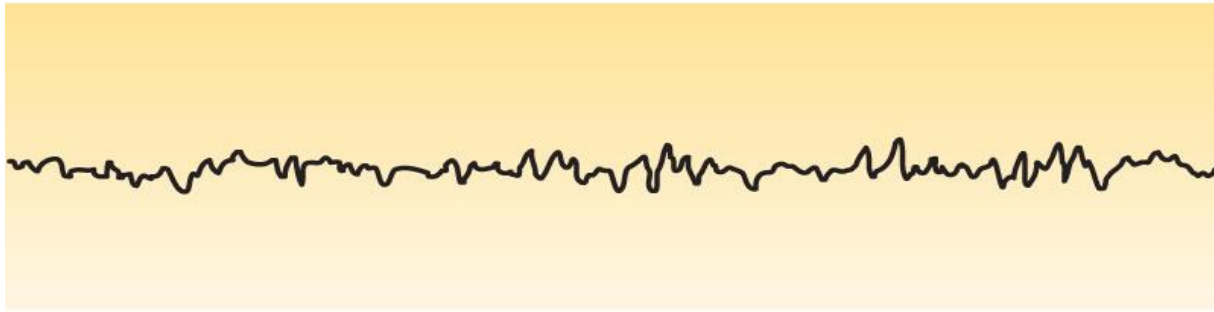




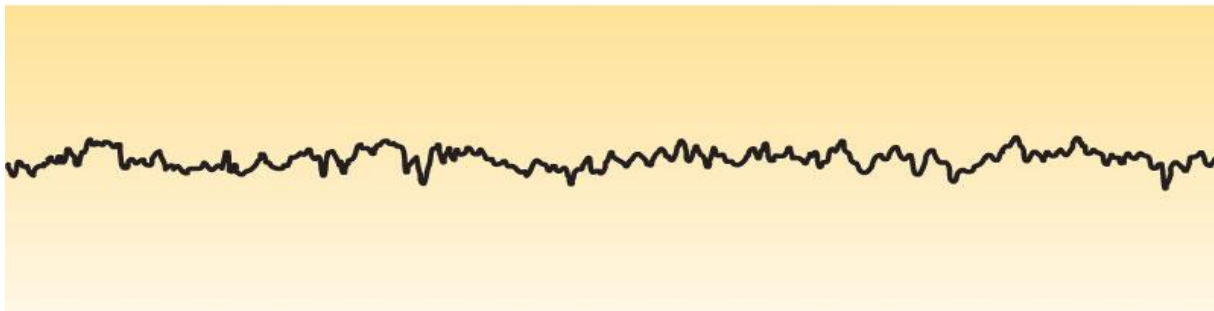
# EEG Patterns During Different Types of Sleep



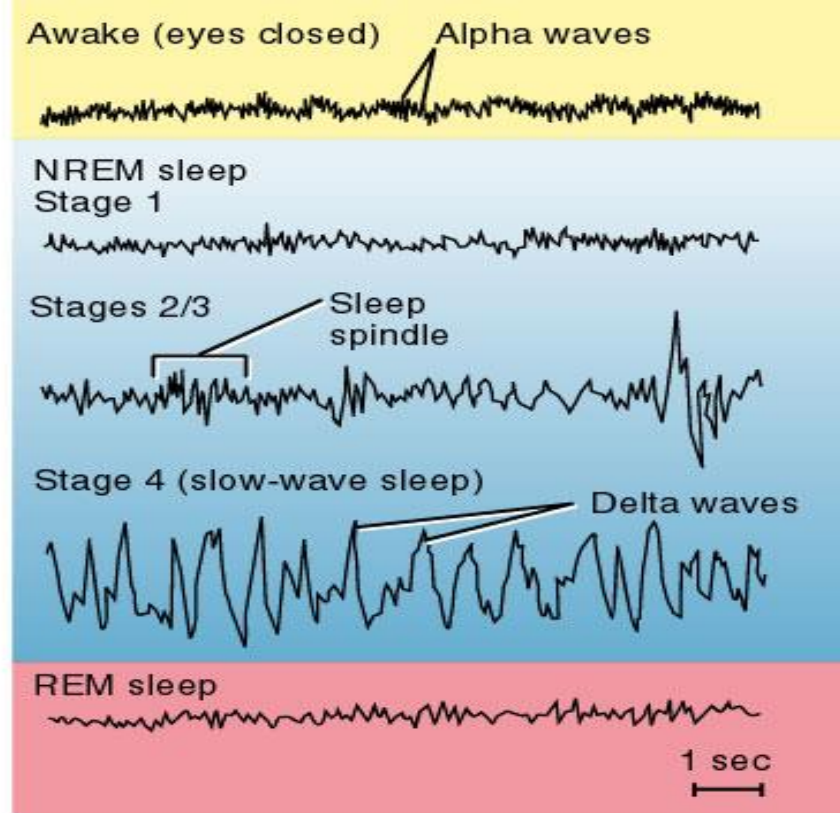
Slow-wave sleep, stage 4



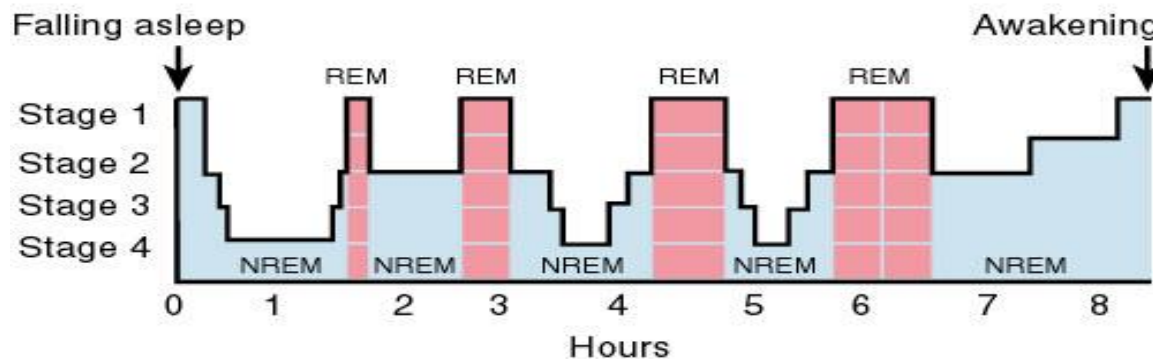
Paradoxical sleep



Awake, eyes open



(a) EEG waves during sleep stages



(b) Pattern of NREM and REM sleep over one sleep period

# Comparison of Slow-Wave and Paradoxical Sleep



CHARACTERISTIC	TYPE OF SLEEP	
	Slow-wave sleep	Paradoxical sleep
<b>EEG</b>	Displays slow waves	Similar to EEG of alert, awake person
<b>Motor Activity</b>	Considerable muscle tone; frequent shifting	Abrupt inhibition of muscle tone; no movement
<b>Heart Rate, Respiratory Rate, Blood Pressure</b>	Minor reductions	Irregular
<b>Dreaming</b>	Rare (mental activity is extension of waking-time thoughts)	Common
<b>Percentage of Sleeping Time</b>	80%	20%
<b>Other Important Characteristics</b>	Has four stages; sleeper must pass through this type of sleep first	Rapid eye movements



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