Brain activity and Sleep
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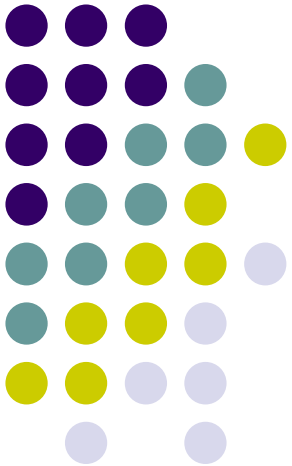
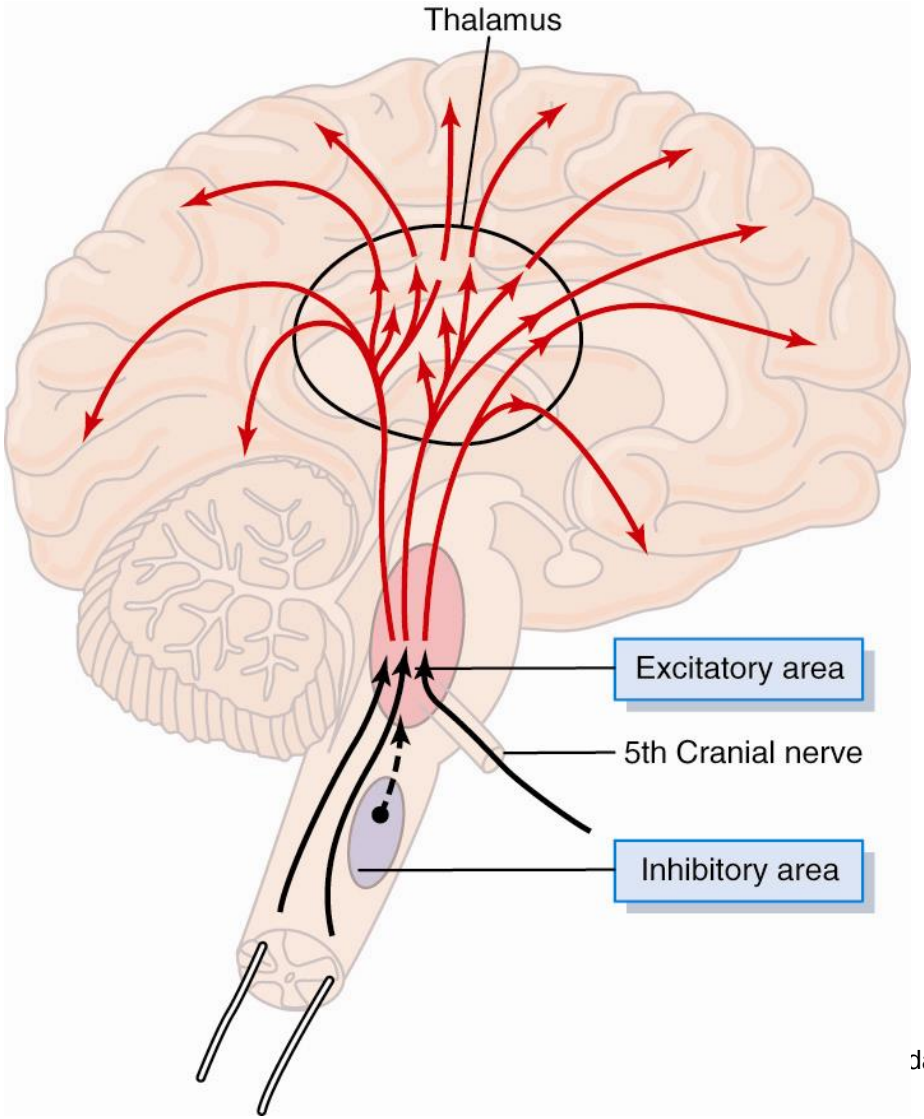


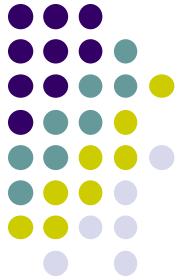
Objectives

- 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

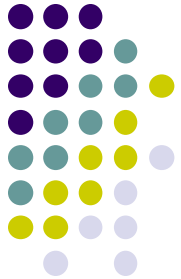


- Cerebrum requires a constant input to remain active.
- Signals from the brainstem activate wide areas of the cortex (background activation) or specific areas to perform discrete tasks.

Excitatory Signals from the Brainstem

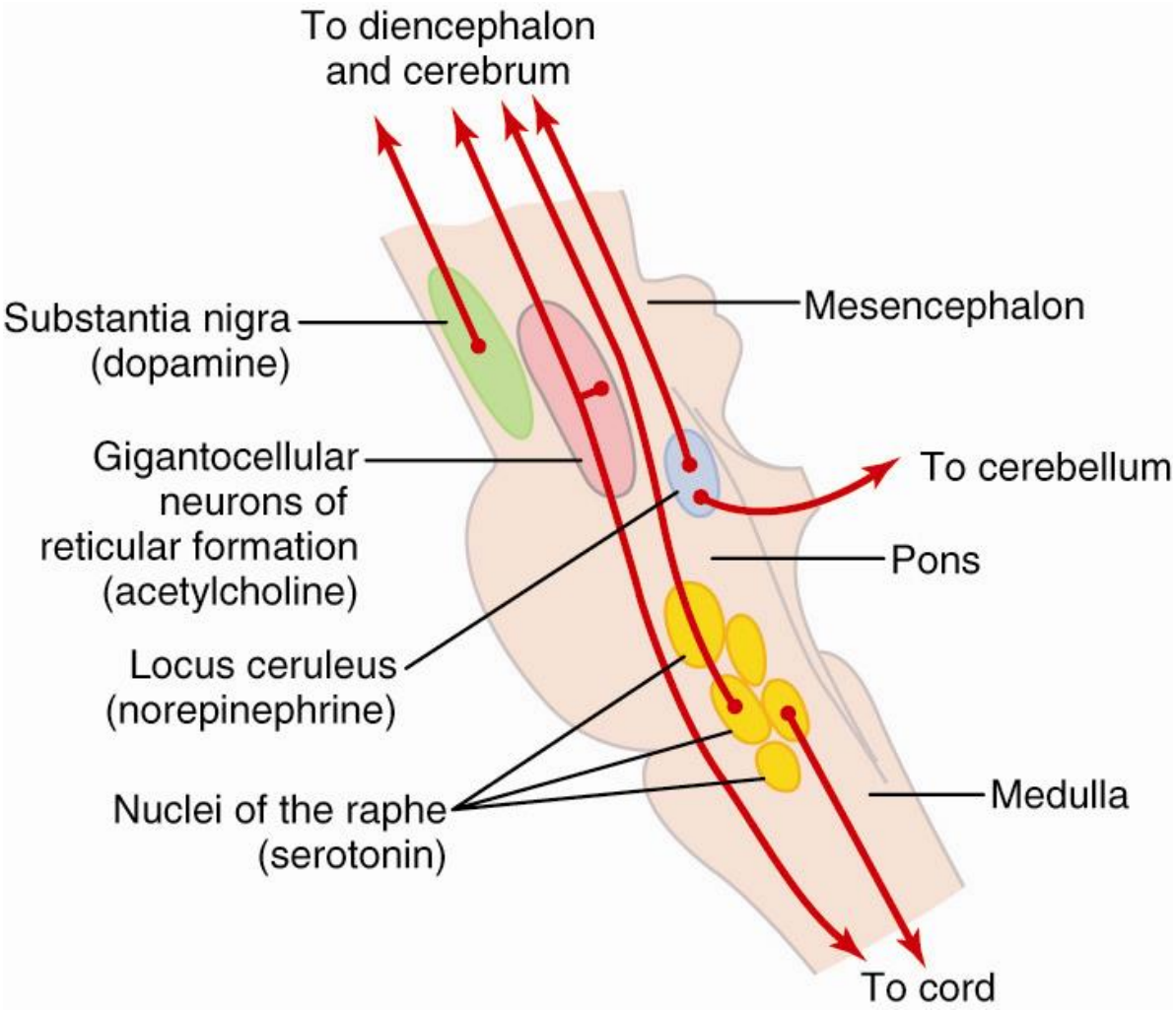
- Bulboreticular facilitory area
  - sends excitatory signals to the antigravity muscles
  - sends excitatory signals to the thalamus and from here they are distributed to widespread areas of the cortex
- Bulboreticular area is excited by signals from the periphery, especially pain signals and also descending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

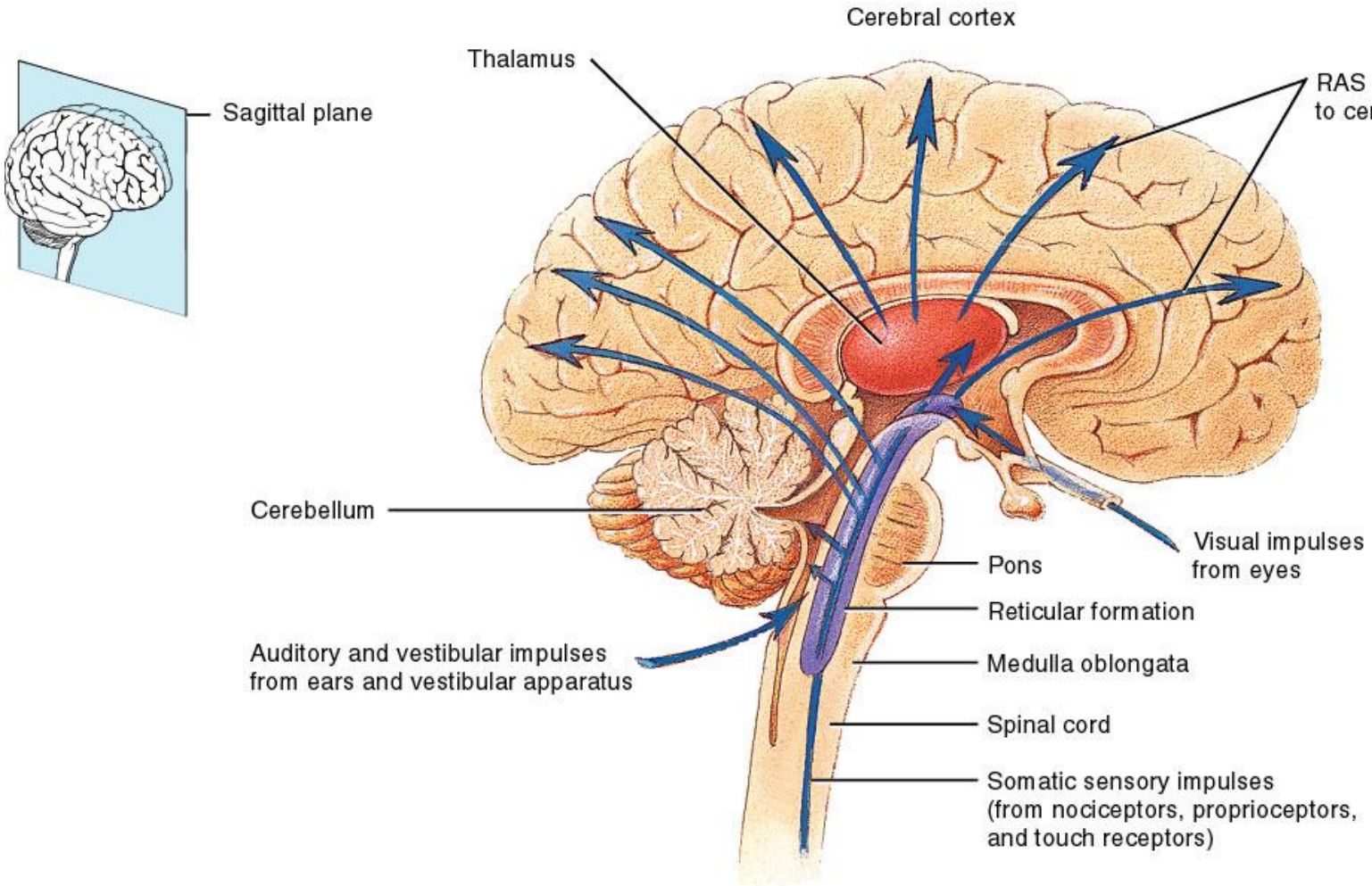
Inhibitory Signals from the Brainstem



- 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

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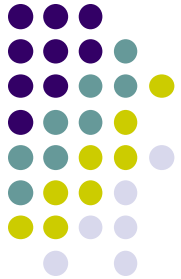
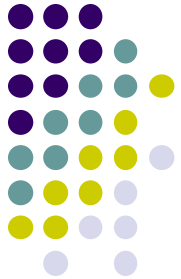
Sleep



- 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

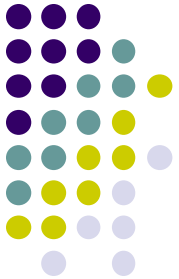


- restful sleep at the beginning of the sleep period
- associated with a decrease in vegetative functions
- usually not associated with dreaming; dreams do occur but they are not remembered

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)

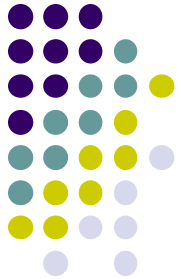


- associated with active dreaming
- peripheral muscle tone is greatly inhibited- difficult to arouse by sensory stimulation
- associated with an increase in cortical activity and metabolism
- Irregular heart rate and respiration
- brain waves similar to wakefulness
- begin about 60-90 minutes after falling 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?

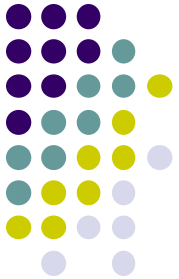
- mechanism is unknown
- probably an active inhibitory process in which the excitatory reticular neurons are inhibited
- stimulation of the *raphe nuclei* causes sleep
  - these nuclei release *serotonin* which is thought to induce sleep
  - blockade of serotonin formation causes prolonged wakefulness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

Why Do We Sleep?



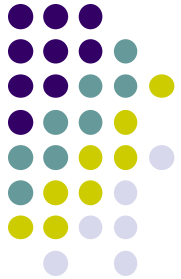
- stimulation of other brain regions can also induce sleep
- nucleus of the solitary tract
  - solitary tract stimulation will not produce sleep if the raphe nuclei are destroyed
  - therefore, solitary tract may be stimulating release of serotonin from the raphe nuclei
- suprachiasmatic area of the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

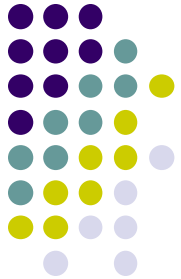


- function of REM sleep is unknown
  - lesions of the *locus ceruleus* prevent REM sleep
  - may be important for neural development
  - testing the cortex to see if it can be brought to activity

Sleep Cycle

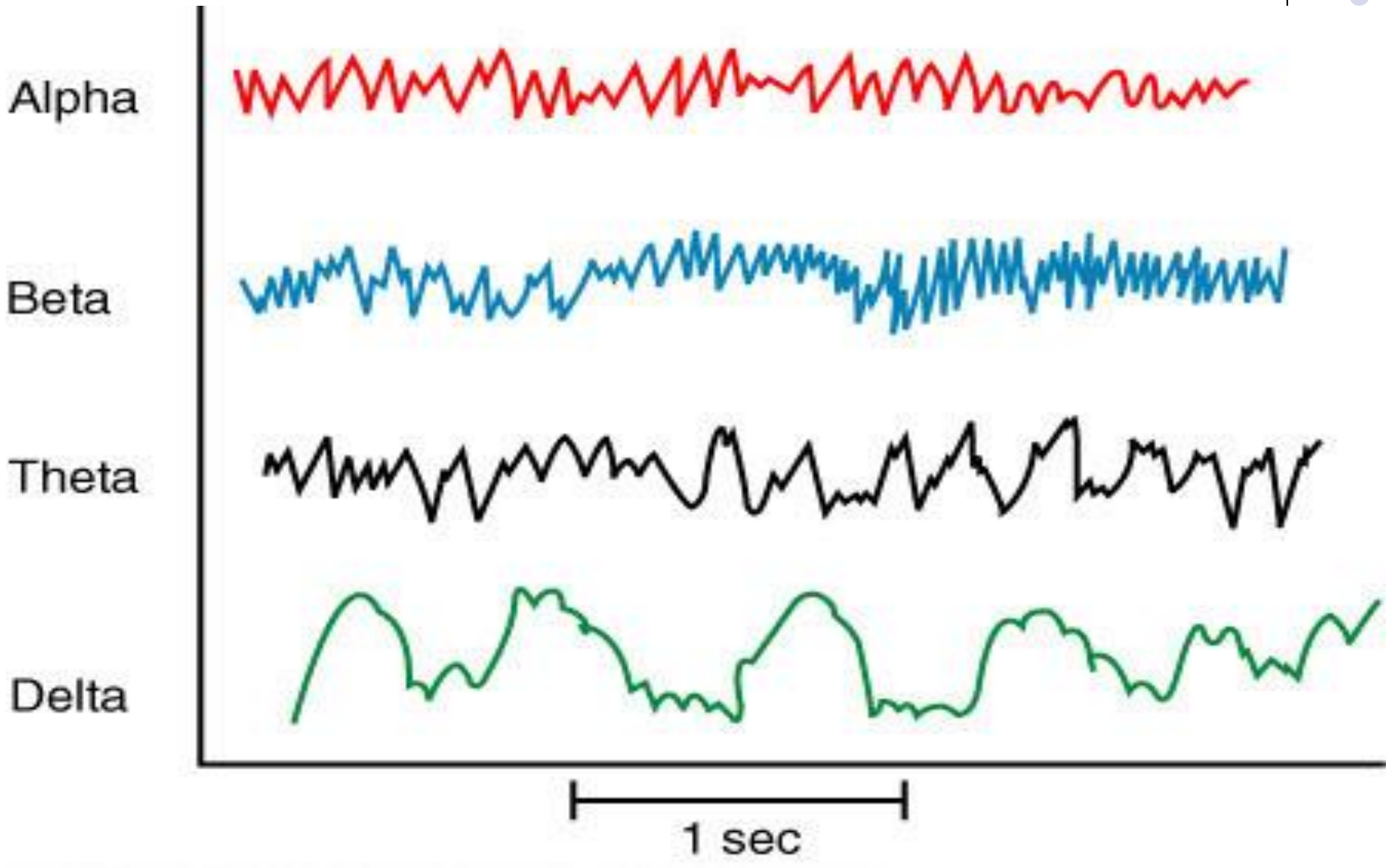
- no explanation for the sleep - wakefulness cycle
- however, there are many theories
  - sleep cycle may be caused by fatigue of excitatory areas to induce sleep and fatigue of inhibitory areas of the lower brain to awaken.
  - sleep probably is an active process driven by a center below the midpontine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

Physiological Effect of Sleep

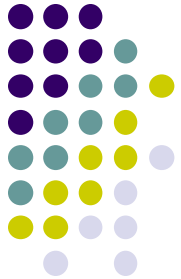


- little on the body itself
  - decrease in sympathetic tone, muscle tone, fall in arterial pressure
- profound effect on the brain
  - lack of sleep can lead to altered mental states
    - paranoia, psychoses
- sleep probably functions to balance the activity of the various areas of the brain, to reset/re-zero/reboot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

EEG waves

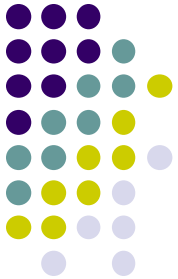


Brain Waves



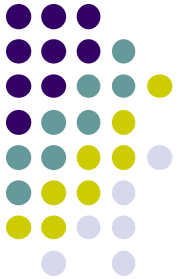
- electrical recordings from the surface of the brain
- characterized as *alpha*, *beta*, *theta* and *delta* depending on the frequency
- each functional state of the brain has a characteristic pattern of brain waves (sleep, wakefulness, epilepsy, psychoses, etc.)

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

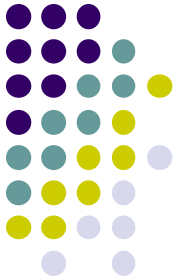


- Theta waves
  - occur at 4 - 7 Hz
  - recorded from parietal and temporal regions in children
  - occur during emotional stress in adults particularly in response to disappointment or frustration
- Delta waves
  - all waves below 3.5 Hz
  - occur during deep sleep thought to be activity of the cortex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



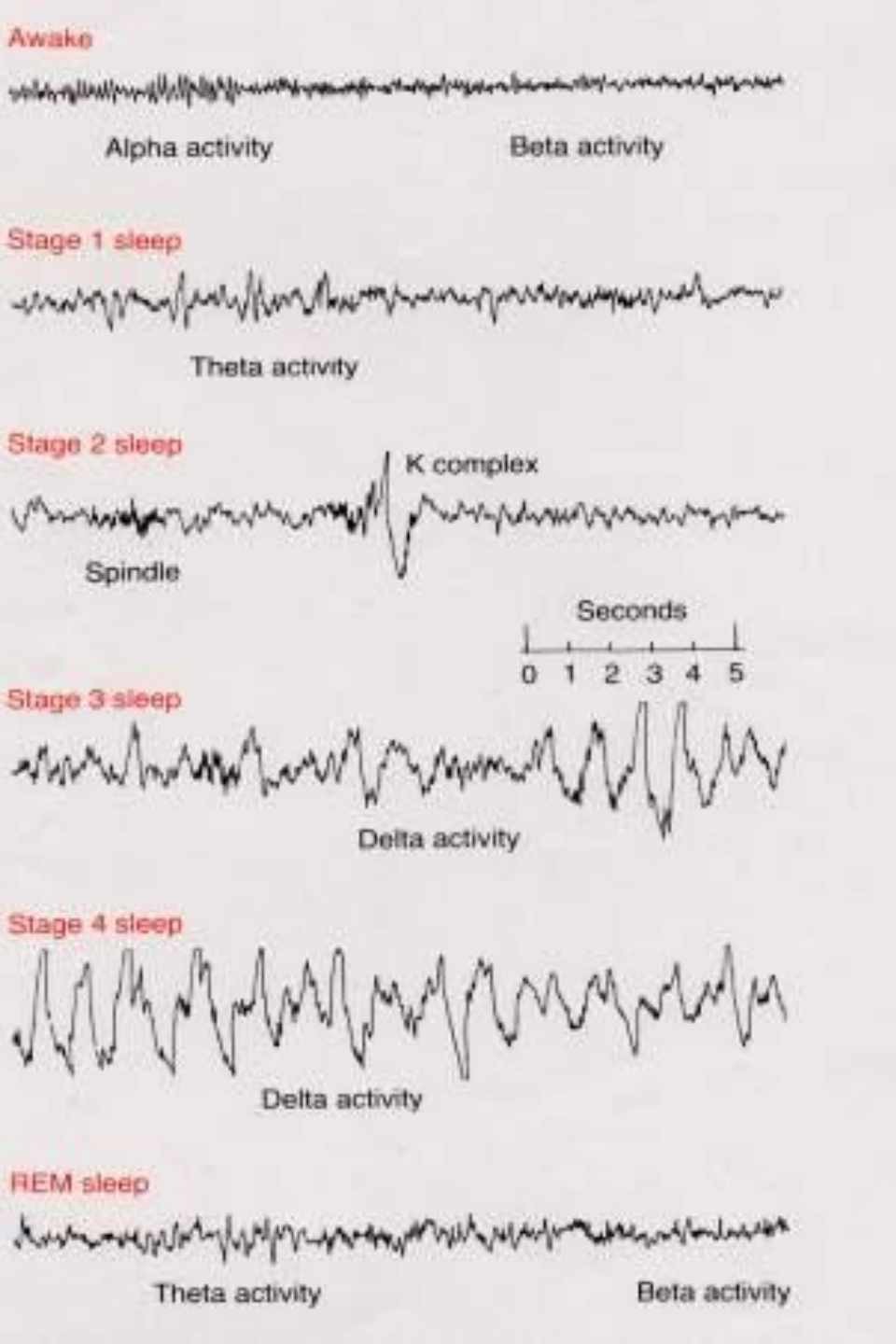
- Alpha, delta, theta activity are present in the EEG record
  - Stages 1 and 2: Alpha waves
  - Stages 3 and 4: delta activity (synchronized)
    - Termed slow-wave sleep (SWS)
- Light, even respiration
- Muscle control is present (toss and turn)
- Dreaming (could but not vivid, rational)
  - Difficult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

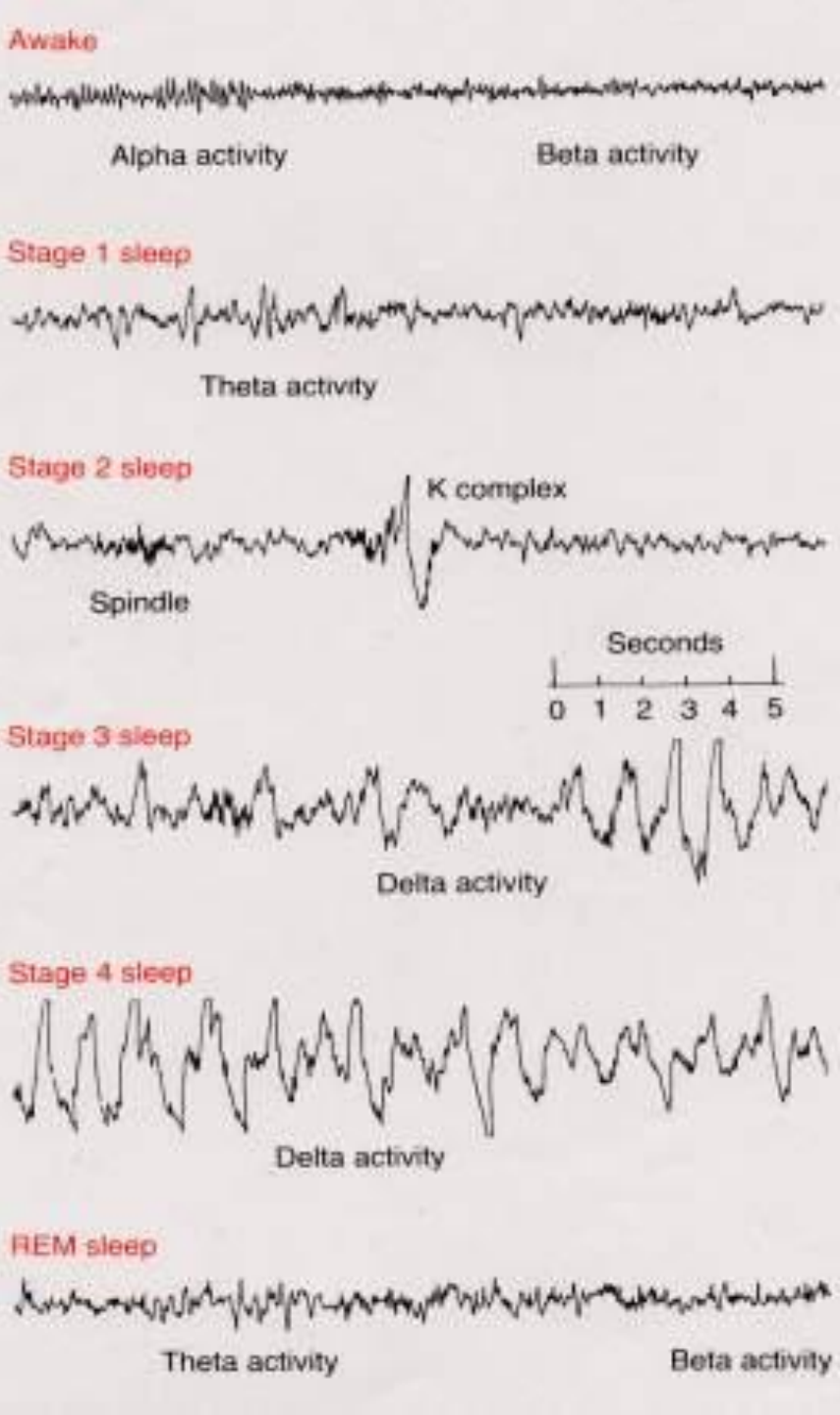
Types and Stages of Sleep: NREM

- 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

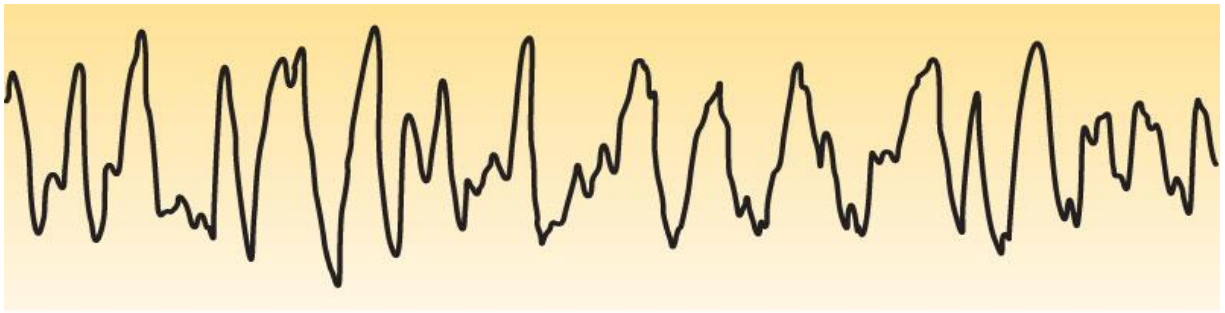


–Stage 3 – sleep deepens; theta and delta waves appear; vital signs decline; dreaming is common

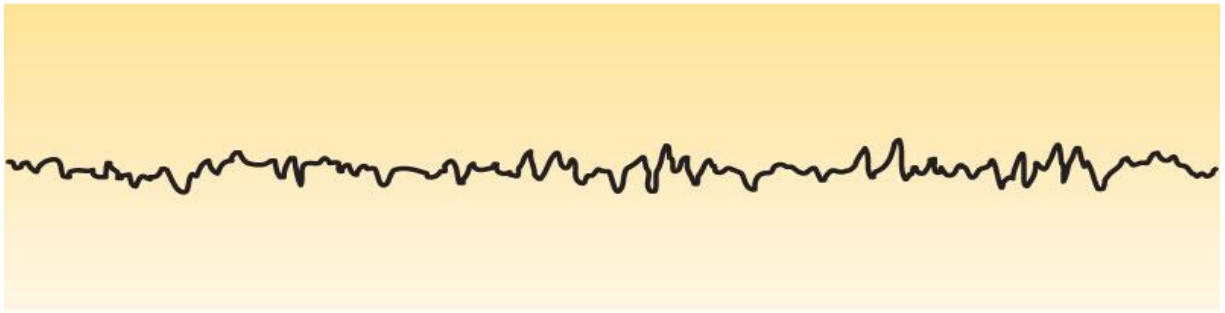
–Stage 4 – EEG pattern is dominated by delta waves; skeletal muscles are relaxed; arousal is difficult



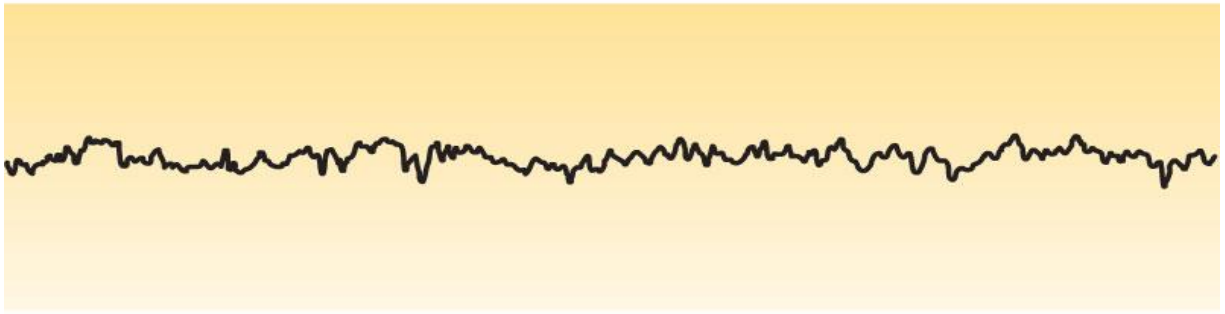
EEG Patterns During Different Types of Sleep



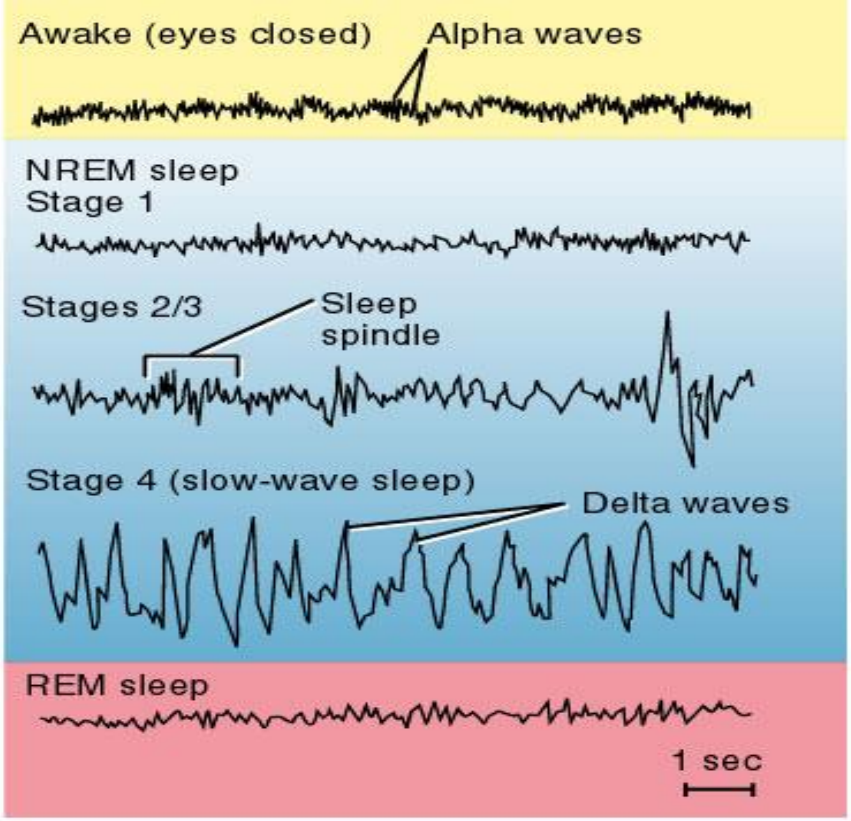
Slow-wave sleep, stage 4



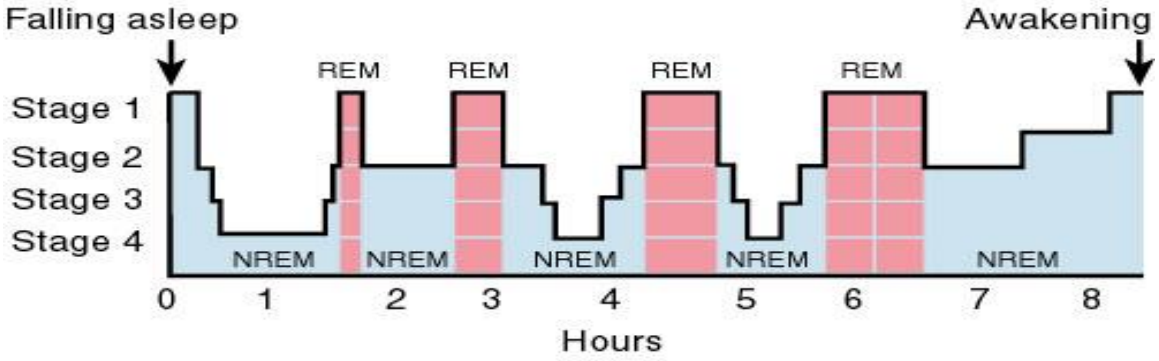
Paradoxical sleep



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