

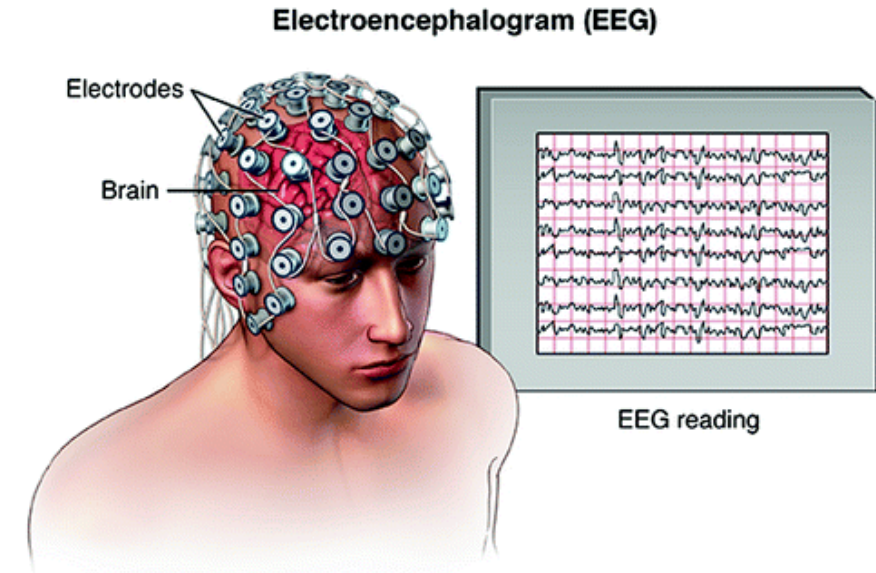
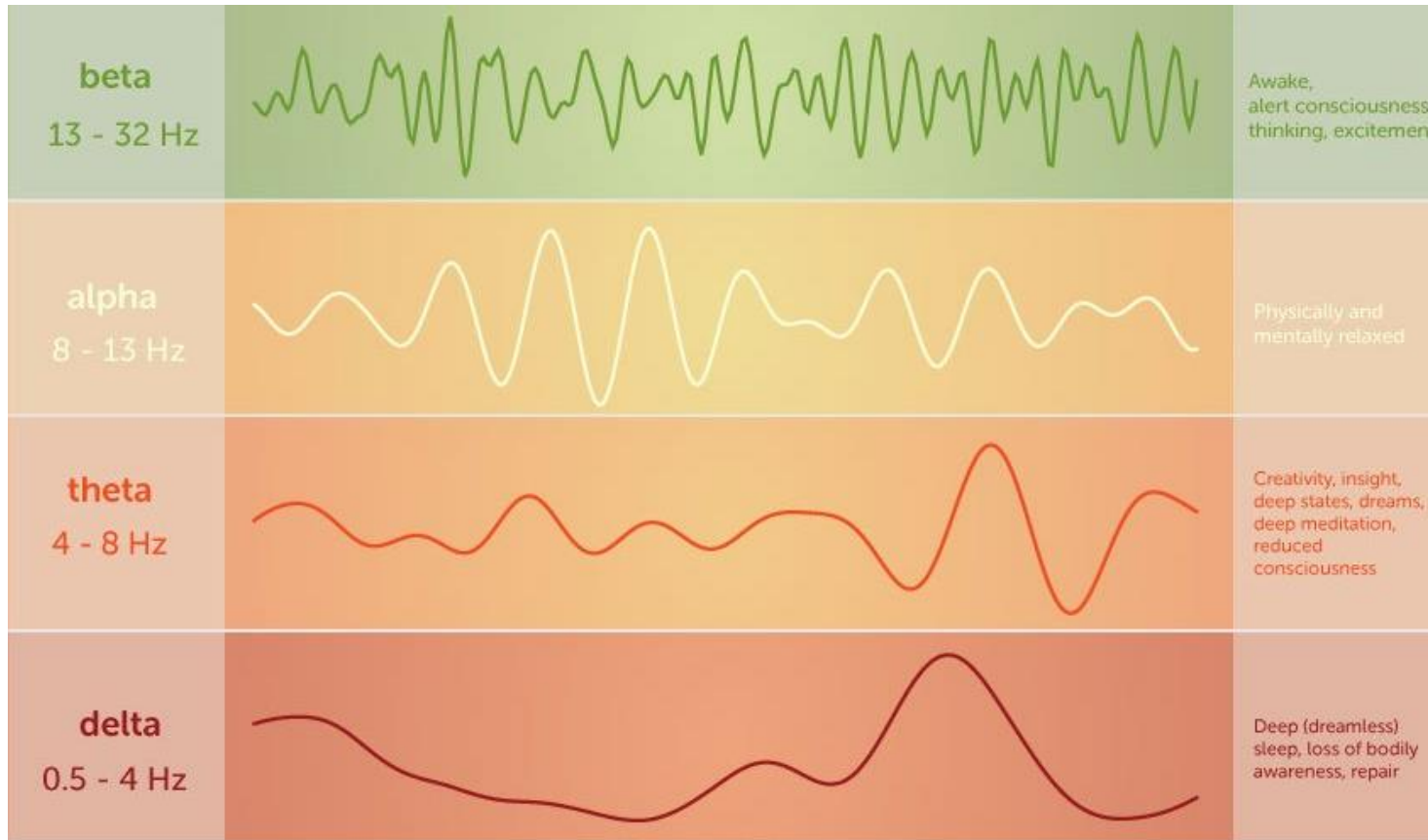
# Round 11: Sleep

02/19/2021

Kristy Snyder Colling, PhD

# Sleep is assessed with EEG

- Electroencephalogram (EEG)
- Records activity from neuronal ensembles - extra cellular current flow

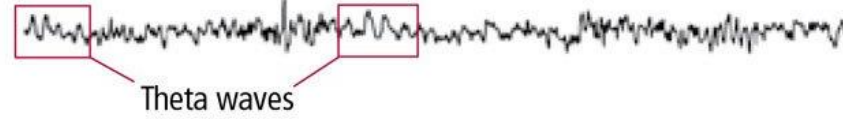


### RELAXED WAKEFULNESS

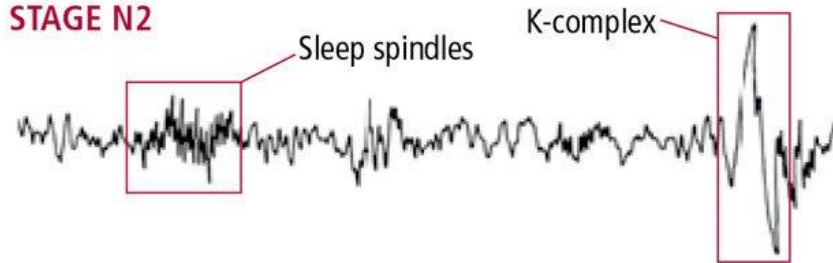
Alpha waves



### STAGE N1



### STAGE N2

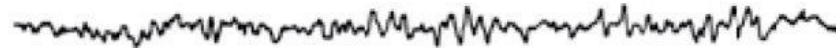


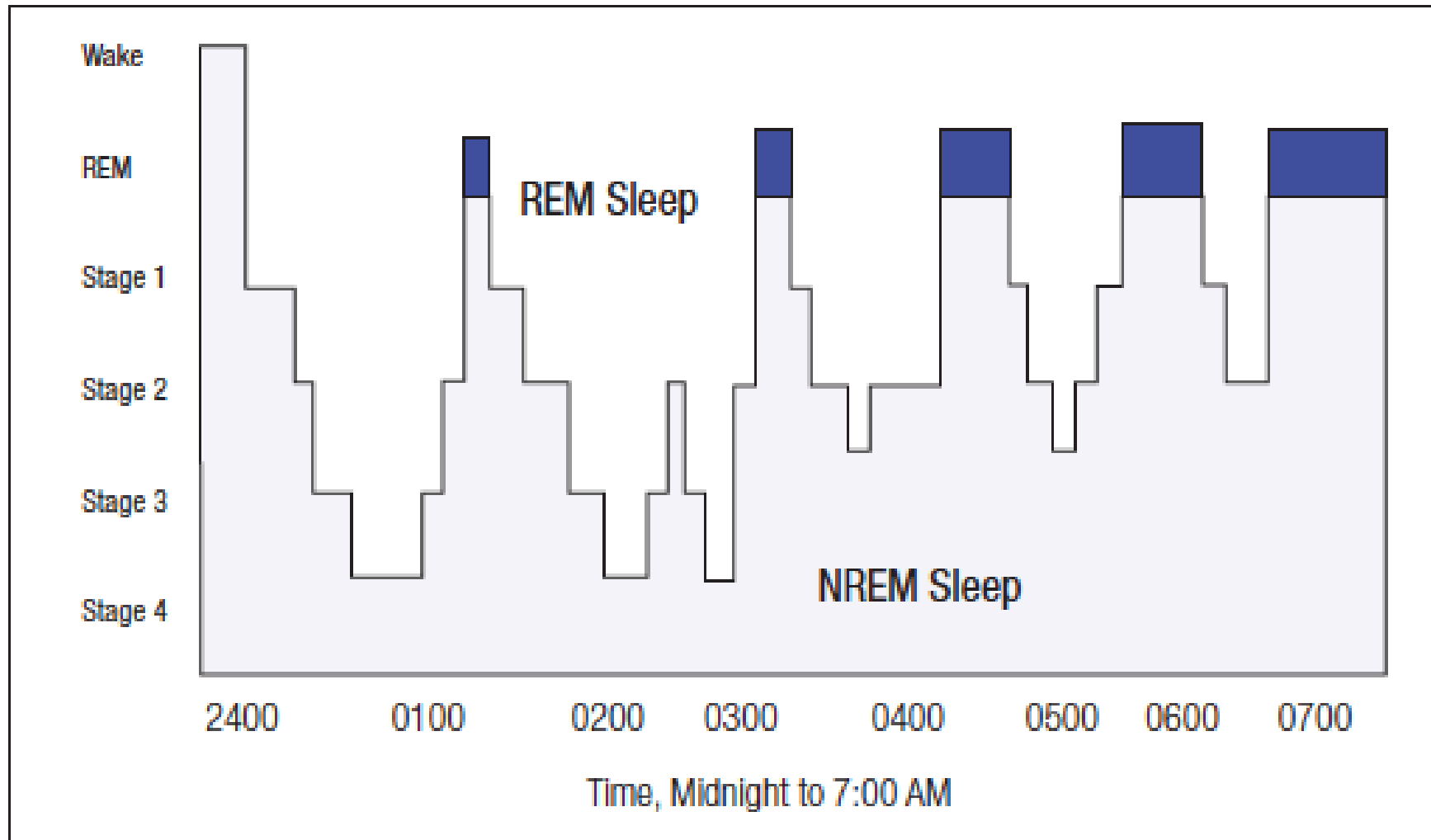
### STAGE N3 or DEEP SLEEP

Delta waves



### REM or DREAMING SLEEP





Major positional adjustments ~20 mins

# Stage 3 & 4: Delta Slow-Wave Sleep

- Influenced by the amount of prior wakefulness
- Correlated to restfulness of sleep
- Age
  - amount of Stage 4 slow wave sleep declines with age and may disappear entirely by 70s
  - Spend more time in lighter stages -> can be roused more easily
  - Less able to reset circadian rhythm – more likely to suffer more intense jetlag
  - Shift from one long sleep to shorter night sleep with a nap in the afternoon



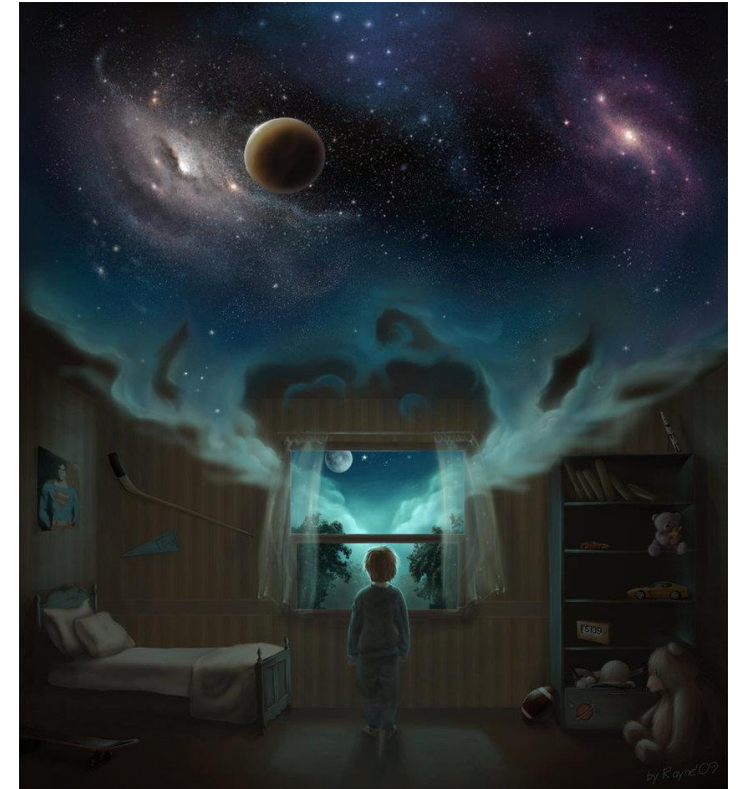
# REM Sleep

- Motor cortex is highly active
- Brain stem [typically] blocks activity paralyzing skeletal muscles
  - excluded are eyes, respiration, and middle ear ossicles
- Pontine-geniculate-occipital (PGO) spikes
  - phasic pacemaker regulating sleep cycle
  - Triggers REM
- Alcohol & Barbiturates suppress REM sleep
- REM changes with age
  - 10 weeks premature – 80 % of sleep
  - 2-4 weeks premature – 60%
  - Full term – 50% (normal 16-hours)
  - 2-year-olds – 30-35%
  - 10 years old – 20-25%



# Dreams

- Occur during REM sleep
- **Theories**
  - Freud
    - Dreams are symbolic
    - Reflect repressed longing/unconscious wishes & urges
    - “Physic safety valve” allowing you to express unacceptable or taboo wishes/urges
  - Carl Jung studied under Freud but thought dreams allowed us to reflect on our waking selves & solve problems
  - **Information-Processing Theory**
    - Help to sort day’s events
    - Way to deal with everyday life by rehearsing stressful situations
    - Memory consolidation - unpack and reshuffle
  - **Activation-Synthesis Theory**
    - REM -> mostly random neural activity that the brain tries to interpret



# Sleep Theories – Why do we sleep?

- **Physiological Necessity**
  - Sleep deprivation – REM rebound
  - The more sleep deprived over long period of time -> more efficient -> spend more time in slow-wave/deep-sleep
- **Developmental** - help develop neural circuitry
  - Amount of REM sleep percentage approximates brain development myelination
  - Pituitary releases human growth hormone
  - Analogous to exercise?
    - Brain oxygen consumption during REM > intense physical or mental exercise while waking
- **Preservation/Evolutionarily beneficial**
  - Conserves energy during the night when dangerous predators are out

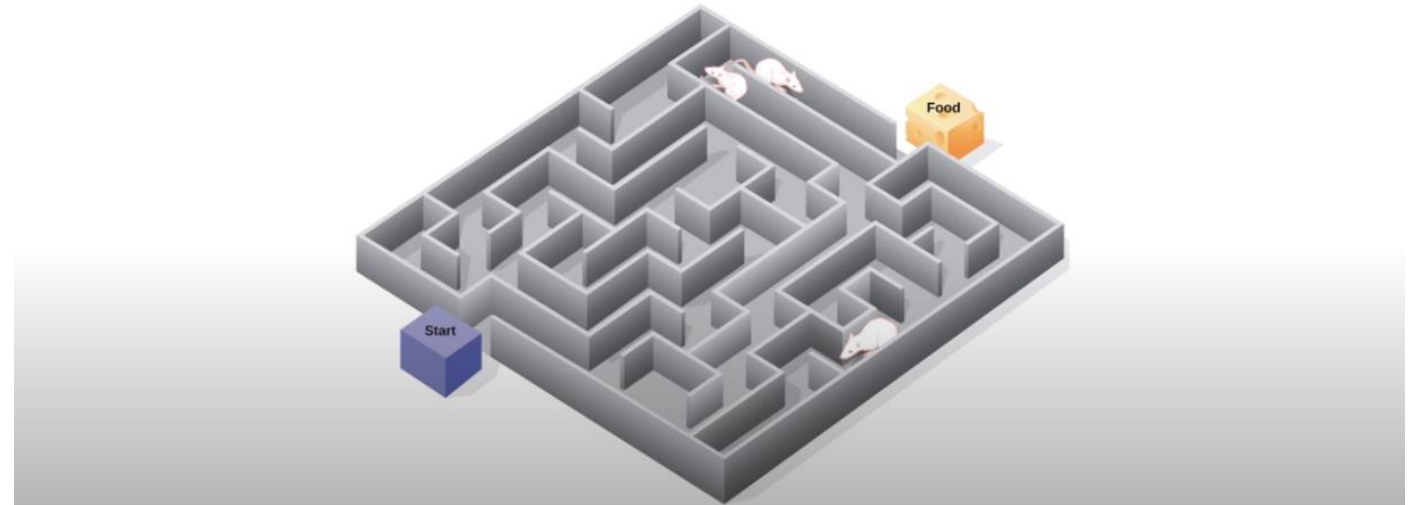


# Sleep Theories – Why do we sleep?

- Recuperation

- Memory consolidation
- Study tip!
- Brain maintenance – removal of debris CSF
- Reduces risk of Alzheimer's
- Many of the substances related to sleep induction also leads to immune responses

**mice navigate the maze and then replay that pattern of electrical activity while sleeping**



# Zeitgebers



- “Time givers”
  - Stimuli that entrain internal circadian rhythm to 24-hour day
    - Sun
    - Clocks
    - Regular work, meal habits
    - Noise or silence
- In the absence of typical light/dark, temperature changes, social cues, and knowledge of time most people will gradually shift to a 25 hour circadian rhythm

# Melatonin

- Superchiasmatic Nucleus (Hypothalamus)

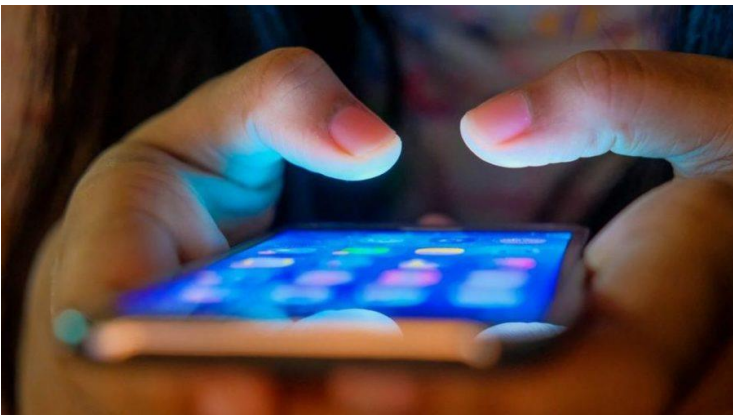
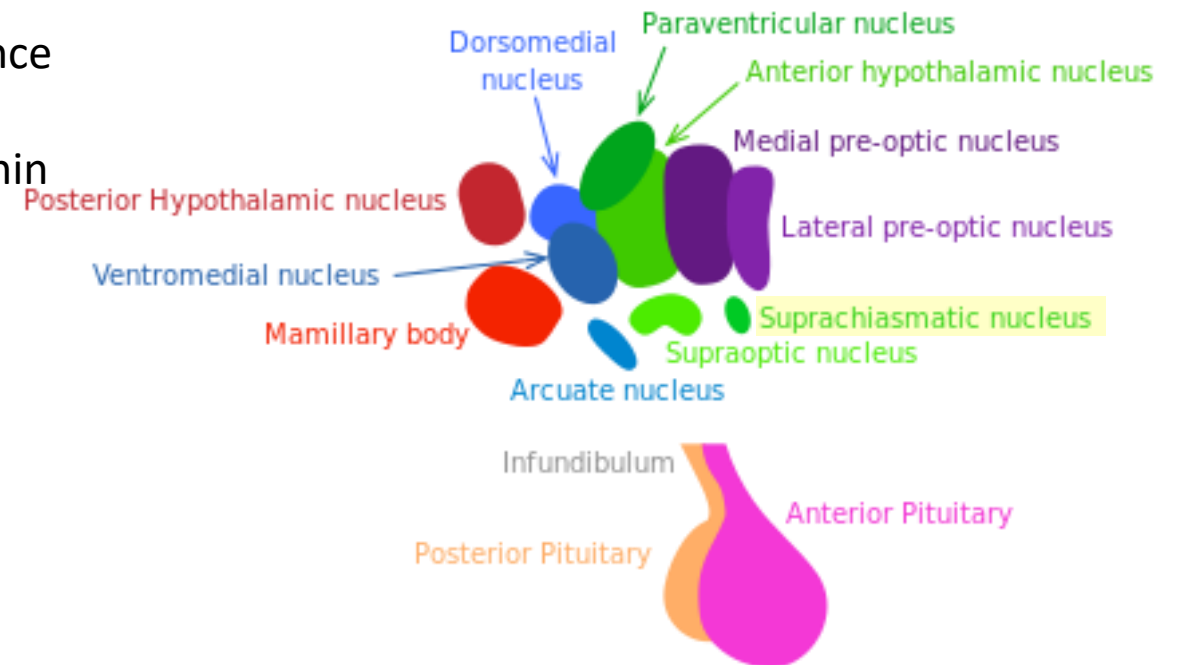
- Circadian rhythm - sleep/wake cycle

- Light hits retina -> optic nerve -> retinohypothalamic tract -> pineal gland -> [darkness] release melatonin

- Seasonal Affective Disorder

- reduced levels of light affect hormone balance

- Blue light wave lengths inhibit release of melatonin



# Adenosine

- Adenosine Triphosphate (ATP) within cells -> transferring energy
- Extracellular levels increase in basal forebrain & cortex during wakefulness, decrease during sleep – homeostatic regulator
- As they bind to receptors, they slow the cell down -> inhibiting arousal.
- Widens blood vessels
  
- Caffeine
  - Blocks adenosine receptors -> cells are not slowed down
  - Cell firing increases
    - triggers the pituitary that “something is happening”
    - Release adrenaline (epinephrine)
      - Pupil dilation
      - Increase heart rate/Blood pressure
  - Constrict blood vessels -> reducing headaches
  - Increases dopamine levels -> affecting mood



# Sleep Disorders

- Sleep loss
  - Memory loss, depression, weight gain, negative mood, decrease in motor function/response time, deficits in cognitive function, reduced immune function, hormonal/metabolic changes
- At least 15% of the population suffer from chronic sleep problems
- Additional 20% suffer occasional sleep problems
- 1/3 of those with sleep complaints have a diagnosed psychopathology, 1/3 have psychological symptoms that do not reach threshold for diagnosis, 1/3 seem to be independent
- Among institutionalized mental patients, 70% seek help for sleep problems
- Sleep disorders are categorized
  - Insomnias - difficulty falling or staying asleep
  - Narcolepsy – excessive daytime sleepiness
  - Sleep-wake rhythm disorders
  - Parasomnia – behavioral dysfunctions associated with sleep (e.g., sleep walking)

# Insomnia

- **Sleep Misperception Syndrome/ Parainsomnia**
  - 10-12% who have subjective reports of insomnia actually sleep normally
  - Fall asleep within 15 minutes and sleep 7 hours
- **Physical events**
  - 30% Nocturnal myoclonus - stereotyped leg movements
  - Restless Leg Syndrome



# Insomnia

- **Psychophysiological Insomnia**

- 15% of insomnia -> Stress/Anticipation of poor sleep leads to poor sleep
- Often sleep better in new environment because sleep anxiety is learned/contextual

- **Less Slow Wave sleep**

- Subjective sleep quality may be related to continuity of slow wave (Stage 3 & 4) Sleep.

- **Body Temperature**

- People with poor sleep have higher internal temperature
  - Problem with autonomic hyperarousal



# Insomnia

- Psychopathology
  - Anxiety
    - difficulty falling asleep
  - Depression
    - early awakenings
    - Less slow wave (Stage 3 & 4) delta wave sleep
    - Enter REM sleep too early
      - 25-35 minutes after sleep onset relative to 80-90 minutes onset of typical sleepers





# Narcolepsy

- Excessive daytime sleepiness despite being well-rested
- Recurrent episodes of rapid-onset, overwhelming sleepiness
  - 3 times a week for 3 months
- Sleeps for about 15 minutes, wakes refreshed
- Dangerous (driving)
  
- May be accompanied by
  - Hallucinations just before going to sleep or waking up
  - Sleep paralysis
    - Aware but unable to move or speak, may hallucinate, lasts a couple of minutes
  - Cataplexy
    - loss of muscle tone following strong emotional stimulus (e.g., laughter)
  
- May be related to decreased Orexin (hypocretin) production in lateral hypothalamus
  - dysregulated sleep-wake cycles
  
- Treatment
  - Daytime stimulants (e.g., amphetamines)



# Parasomnias

- Sleep walking

- Sit up, gets out of bed, walk unsteady at first and then more complex behaviors (e.g., avoiding objects, going to the bathroom, mumbling speaking) eyes are open blank stare. Usually goes back to sleep.
- No memory of episode
- Occurs in slow wave sleep
- Usually occurs in children (17%)
- 4% of adults

- Bedwetting (Enuresis)

- Not related to dreaming
- Occur independently of REM stage, most common occurs in slow wave sleep
- More likely in boys than girls
- 3-6% of general population, 15% for psychologically disturbed children, 30% for institutionalized children
- Weak/immature brain-bladder connection



# Parasomnias

- REM behavior disorder
  - Normal REM paralysis is absent
  - Pts jump out of bed and act out dreams
    - Football player charging an opponent → ran head first into dresser
    - Spy jumping out of a window to avoid explosion → jumped out closed 2<sup>nd</sup> story window
  - May be violent
    - 85% injure self
    - 44% injure sleep partner
  - ~ half have brain stem lesion or other neurological problem
    - Reticular activating system (Raphe nuclei)
  - Treatment
    - Anticonvulsant (e.g., clonazepam, benzodiazepine)



# Sleep Apnea

- Periodic breathing pauses
- Suppression of medullary respiration
  - Diaphragm and related muscles become immobile
  - Last 15-30 seconds
  - Blood oxygen level decreases, carbon dioxide increases -> stimulates respiration center
  - Lungs do not fill with air because throat has collapsed
- May be related to sudden infant death syndrome (SIDs)
- 30% of people over 65
- Treatment
  - Positive airway pressure (C-PAP)
  - Weight loss



# Sleep Terror Disorder

- Periods of inconsolable terror with screaming last about 1-2 minutes
- Inconsolable, sweating, racing heart rate, breathing fast
- No memory of event – as opposed to nightmares, which are remembered
- Occurs during slow wave delta sleep, within 30 minutes of falling asleep
- Most common in children
  - ~30%
  - 3-7 years old
- Triggered by emotional stress, fever, lack of sleep
- May be treated with benzodiazepine – suppress slow wave sleep
  - Treat insomniacs by lowering body temperature
  - Are habit forming



# TBI & Sleep Disorders

- Sleep disorders occur in 30-70% of TBI patients
- Most common complaint Insomnia, fatigue/sleepiness
- Most common accompany
  - contact injuries -> focal damage
  - acceleration/deceleration -> generalized brain damage
- Hypersomnia
  - Damage to reticular activating formation, posterior hypothalamus, area surrounding third ventricle
- Narcolepsy
  - Following TBI there are low levels of Hypocretin, resolve after ~ 6 months
- Circadian Rhythm Dysfunction
  - Damage to base of skull affecting suprachiasmatic nucleus and/or output tracts
- Parasomnias

# ADHD & Sleep Disorders

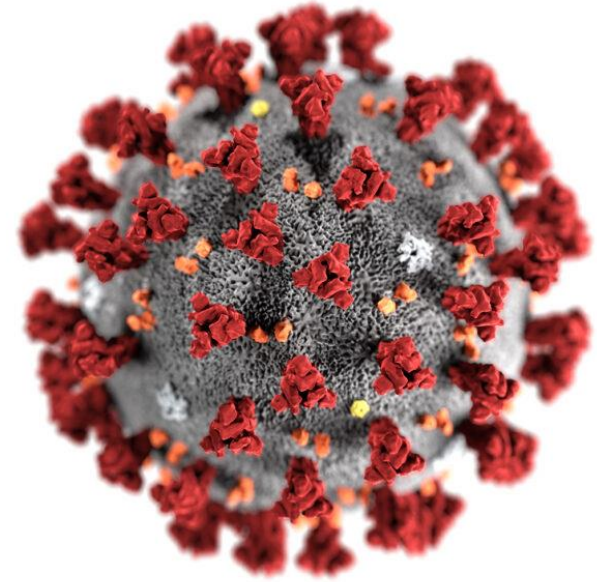
- Reduced sleep (6 hours for 2 weeks) leads to inattention, declined sustained attention & working memory, and reduced behavioral regulation
- Thus, Sleep restriction can induce ADHD symptoms in “typical” children
- Children with ADHD have high instances of comorbid sleep disturbances
  - Insomnia, sleep-disordered breathing, increased nocturnal motor activity (e.g., restless leg syndrome), parasomnia, delayed sleep-wake disorder
  - Spend more time in Sleep stage 1 (shallow sleep), less quality sleep, excessive daytime sleepiness
- Many children have shifted chronotype “night owl” as opposed to “early bird”
  - Delayed melatonin production
  - Shifting school start times and allowing children to get more sleep helped reduced symptoms

# NFB in Relieving Sleep Symptoms

- Barry Sterman & the SMR (Sensory Motor Rhythm)
  - 1968 Operant conditioning experiments in cats
  - 12-15 Hz pattern produced over motor strip when alert & motionless
  - Training this frequency increased resistance to seizure
- Joel Lubar (1976,1984) found that training this rhythm helped reduce ADHD symptoms
  - ADHD patients have been shown to have reduced 12-15 HZ during sleep
- Training this rhythm also leads to
  - increased sleep spindles density during sleep (may help protect against waking from external stimuli)
  - decreased sleep latency
  - increased total sleep time
  - Improved attention after training



# COVID & Sleep



- Anxiety-induced Insomnia
- COVID recovery -> Myalgic Encephalomyelitis/Chronic Fatigue Syndrome
  - ~50% of COVID survivors report lasting symptoms >3 months from initial recovery
    - Fatigue & muscle weakness (63%)
    - Sleep difficulties (26%)
  - Of those, 10% report lasting chronic fatigue
    - excessive tiredness & cognitive dysfunction after exertion that interferes with their ability to perform daily activities
  - Chronic low-grade inflammation, specifically neuroinflammation
    - Activates the body's "Fatigue nucleus" -> tells the body to rest and recuperate in sickness
      - Raphe nucleus of reticular activating network
    - Impaired energy production
    - Oxidative stress
    - Impaired cerebral perfusion

# Sleep in other Animals

- Nonhuman primates resembles that of humans
- Rodents, smaller mammals, birds
  - 2 stages that are similar to human Stage 4 & REM
  - 15-20% of sleep for most placental mammals
  - Only mammal with no REM: Spiny anteater – egg-laying monotreme
- Amphibians & Reptiles
  - no neocortex so EEG can't recognize sleep stages



# Good Sleep Hygiene

- Manage your Zeitgebers by limiting activities at given times before bed
  - 8 hours before bed – Coffee
  - 5 hours – other caffeinated beverages
  - 4 hours – exercise
  - 3 hours – alcohol & heavy meals
  - 2 hours – work & serious conversations
  - 1 hour – Digital devices
  - Bed – lights out
- Create a ritual that tells your body its time for sleep
  - Cool temperature (below 68)
  - Bath/shower
  - Calming – reduce the stress of the day, help turn mind off
- Other tips
  - Go to bed & wake up at the same time everyday
  - Clean clutter out of bedroom

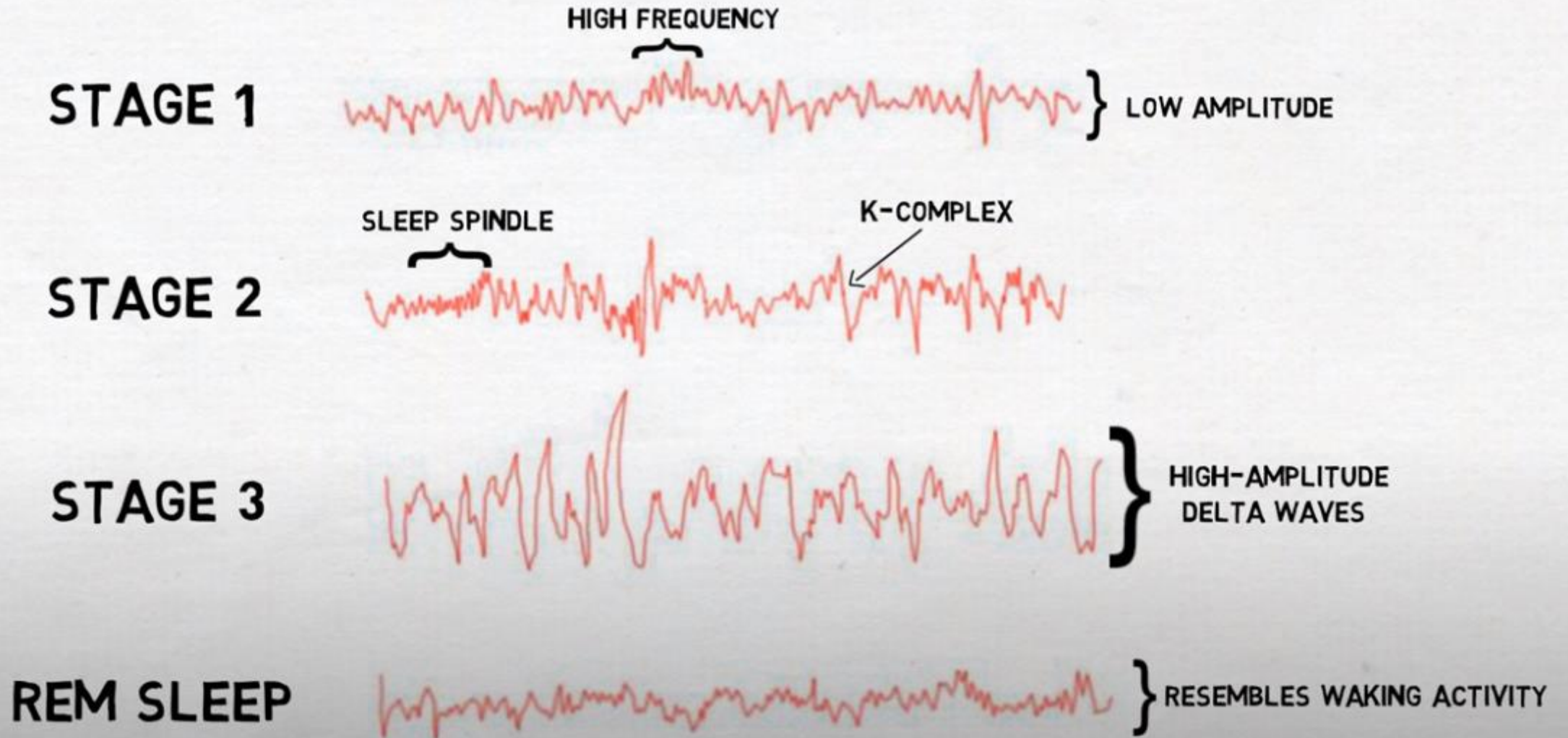




Mood disorder

Circadian rhythm disorder

# SLEEP STAGES



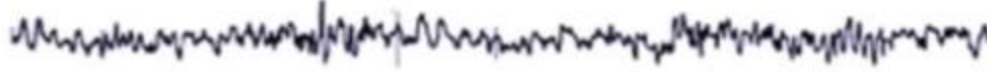
# Stages of Sleep

alpha waves



Awake

theta waves



Stage N1

spindle

K-complex



Teeth grinding

Stage N2

delta waves



Stage N3

Sleep walking bed  
wetting

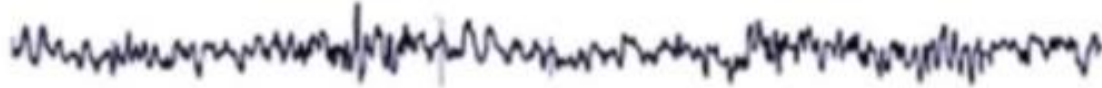
# Stages of Sleep

**alpha waves**



Awake

**theta waves**



Stage N1

**spindle**

**K-complex**

Teeth grinding



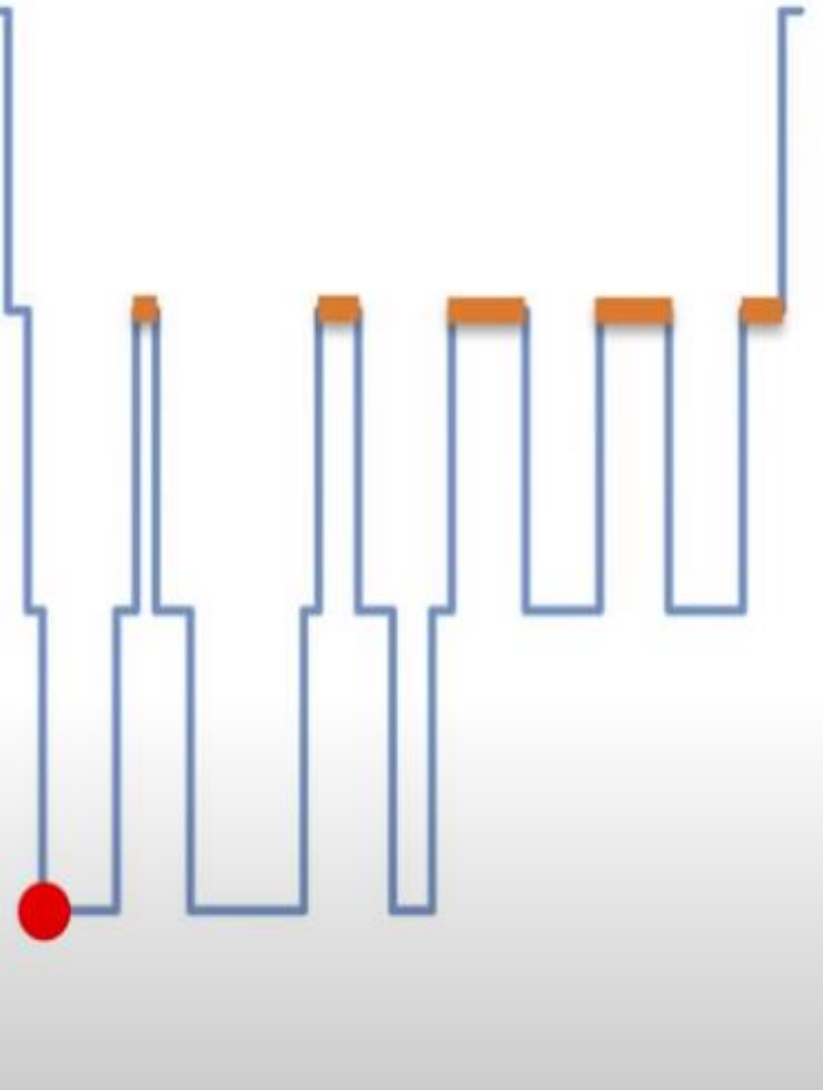
Stage N2

**delta waves**

Sleep walking  
bed wetting

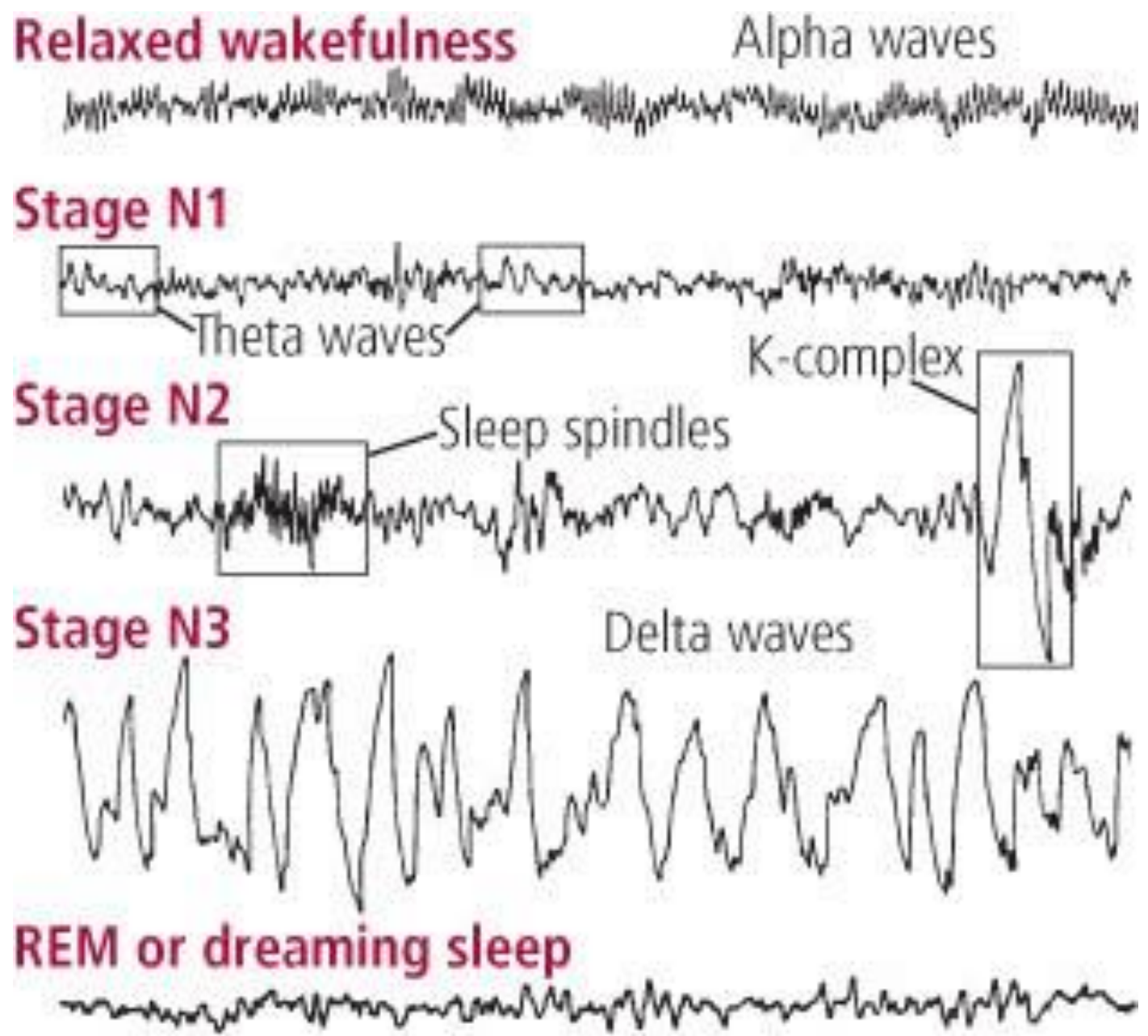
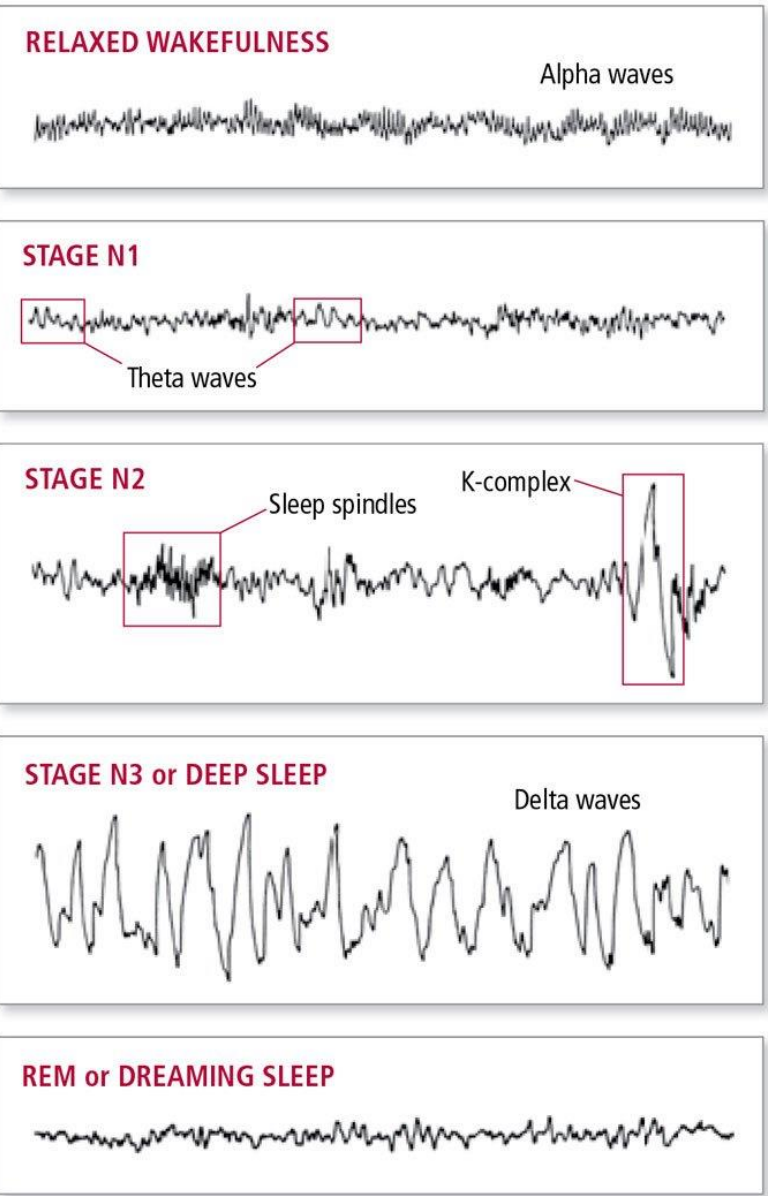


Stage N3





**Figure 1: EEG brain wave patterns during sleep**



Brain waves change dramatically during the different stages of sleep.



**CYCLE REPEATS 4-5 TIMES PER NIGHT (ON AVERAGE)**  
**EACH CYCLE LASTS AROUND 90-110 MINUTES**