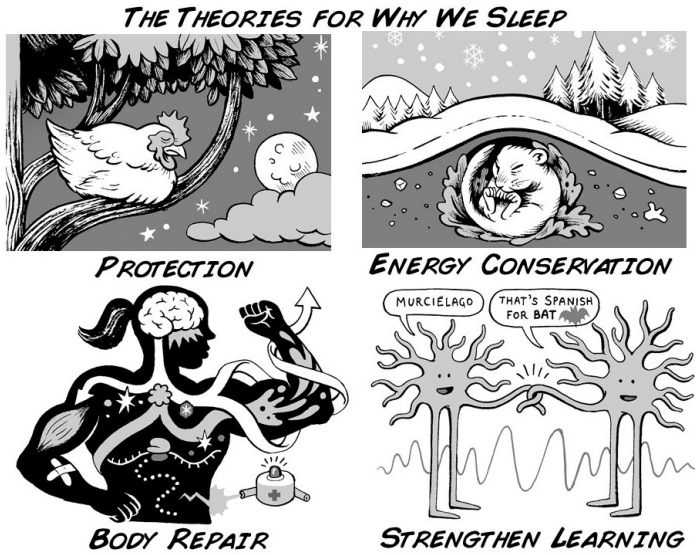
Biological Rhythms, Sleep, Dreaming (Ch.14) I

- Introduction- why we sleep?
- Stages of Sleep
  - Patterns of sleep stages
  - Dreaming
  - Effects of sleep deprivation

- **Note**: there will be no lectures/exam questions on the content in pages 456-462 (Biological Rhythms)
- No Zoom Q & A this week- resumes next week (Feb 14th ❤)

Theories of Sleep (I)

- We spend nearly 1/3 of our lives sleeping, suggesting it serves an important function
- No consensus (all theories may be accurate in some form)
- **Energy Conservation**: we use slightly less energy when we sleep
  - **Evidence for:** smaller animals with higher metabolic rates sleep more
  - **Against:** we still can use a fair amount of energy during sleep (e.g: after a meal) so there is not that much savings
  - Meat eating animals don't show as much of a correlation between mass (metabolic rate) and amount of sleep



Theories of Sleep (II)

- **Body/Brain Restoration**: Being awake disrupts homeostasis; sleep can be time for body to repair itself
  - **For:** Growth hormones released during sleep
  - Sleep helps recovery from illness
  - Prolonged lack of sleep can be fatal
  - Brain removes more waste products during sleep
  - **Against**: Intense metabolic expenditures during day do not reliably increase amount of sleep needed, only decreases time to fall asleep

Sleep = reparitive

certain neurotransmitters promoting sleep released in order to conserve energy to fight infection

Sleep not directly correlate w amt of physical activity

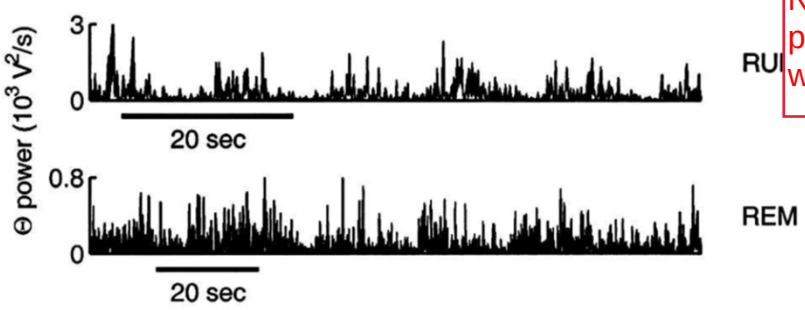
Theories of Sleep (III)

- **Memory Consolidation:** Sleep helps us remember information learned during waking
  - Sleep deprivation can disrupt memory retrieval
  - Humans display better verbal memory retention and motor memories if tested following sleep
  - **Theories**: *Passive* = waking interferes with memory retention, or sleeping slows down memory degradation
  - *Active* = Sleep processes are actively involved in storing memories

Sleep doesn't "shut down" brain

Support for active role of sleep in memory consolidation

- More REM sleep (dreaming) after new learning
- Increased activity in memory centers during sleep
- Studies in rats suggest that temporal sequences of patterned activity linked to memory traces are reactivated during REM sleep.



Neurons fire during REM in the same patterns that they did as when awake rat was exploring + learning

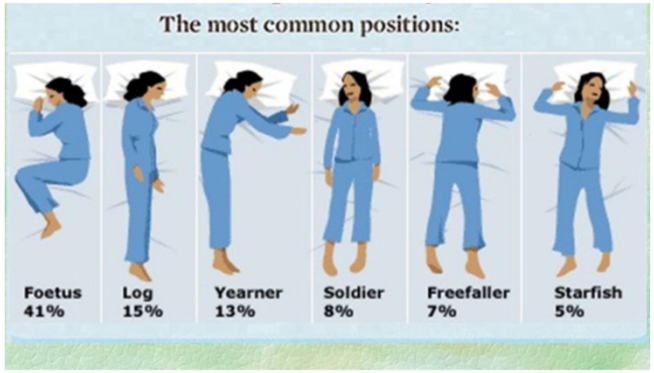
"Rehersal" mechanism

- Continuing debate on the role of ***REM*** sleep and learning (may aid in learning, but may not be necessary for it) and whether it improves consolidation of important memories or diminishes irrelevant ones

not tested on

Defining Sleep

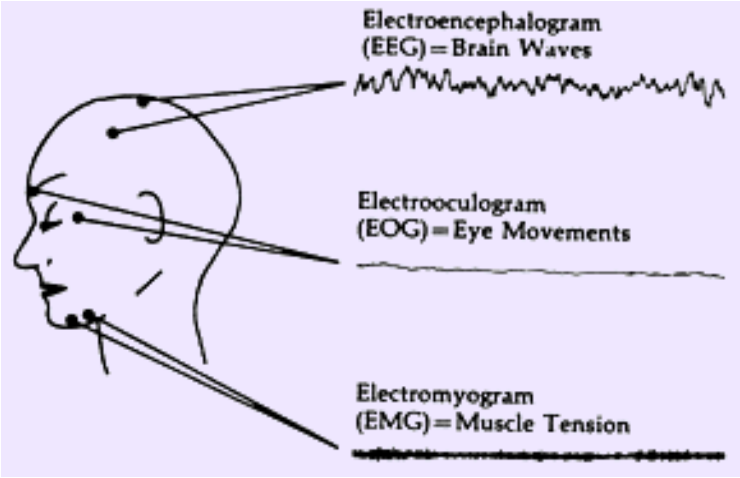
- Sleep can be characterized by 4 phenomenon:



- **Reduced Movement** – walking, talking, and running generally preclude a diagnosis of “Sleep”.
- **Stereotypic Posture** – Usually we are laying down or in a reclined position when we sleep.
- **Reduced Response to Stimulation** – we are not aware of low-intensity sounds or touches that we would normally be aware of when awake.
- **Reversibility** – We know we can awake from sleep, distinguishing it from a coma or death.

diff parts of brain fire at diff rates: the overall electrical activity is messy; if attention is focused, **larger wave**

Measuring Sleep in the Laboratory



- **Electroencephalogram (EEG):** Measures electrical activity of the brain.
- **Electrooculogram (EOG):** Measures eye movements.
  - An electrode placed near the eye will record a change in voltage as the eye moves.
- **Electromyogram (EMG):** Measures electrical activity of the muscles.
  - In humans, sleep researchers usually record from under the chin, as muscle tone in this area is a good reflection of tone in the rest of the body.

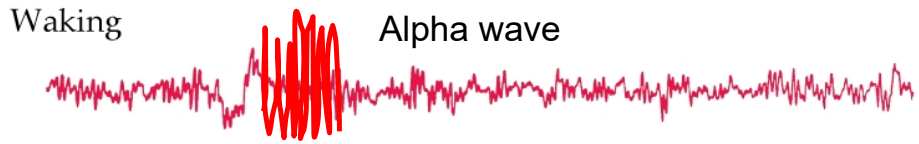
record twitches of eye muscles

muscle tone = indicator of sleep

Stages of Sleep (I)

- Two main classes: Slow-wave sleep (SWS) and Rapid Eye Movement (REM) Sleep

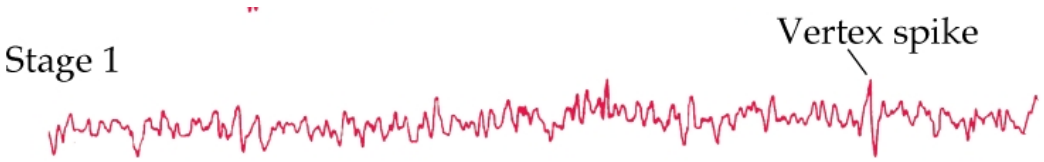
While awake; neurons all scattered, low amplitude, high frequency



•During **awake** period, EEG has fast frequency (15-20 Hz, **beta waves**), low amplitude (10-30 mV)

•When eyes close and relax, (but still awake) EEG now displays higher voltage "**alpha waves**" (9-12 Hz)

Close eyes reduces vis. info; other parts of brain can synchronize more

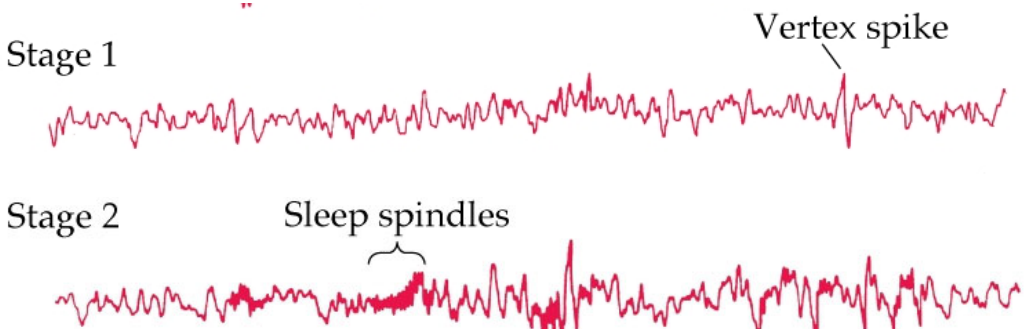


•After a period, alpha waves decrease, EEG becomes smaller and irregular and slower with random bigger spikes.

•REMs are absent, but slow rolling eye movements appear.

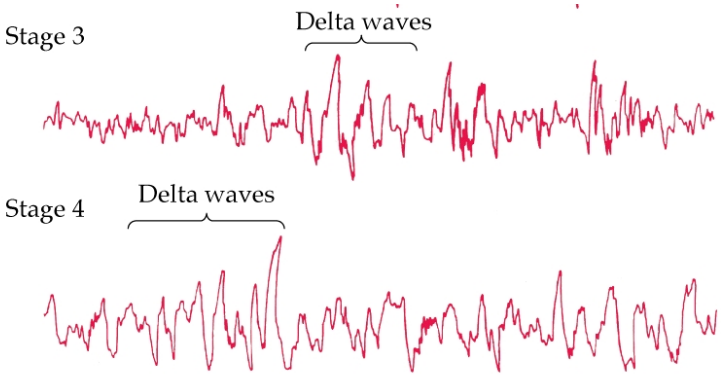
•The EMG is moderate to low.

Stages of Sleep (II)



Muscle spasms falling asleep; spike of synch. activity

- After a few minutes of Stage 1 sleep Stage 2 sets in
- EEG looks similar, but additional 12-14 Hz burst of waves called "sleep spindles" are observed.
- REMs are rare, EMG low to moderate
  - This is the period where you don't think you're asleep, but you're not responsive to environment either



- Stage 3: High amplitude (>75 mV), slow (0.5-2 Hz) waves called "delta waves"
- Stage 3-late (aka Stage 4) defined by delta waves at least 50% of the time

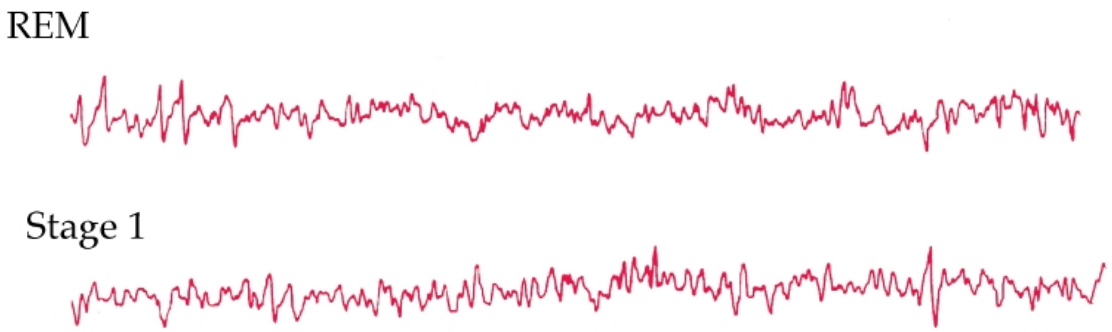
Big delta waves

Stages of Sleep (III)

•These stages cycle 1 to 4, and then back up to stage 2

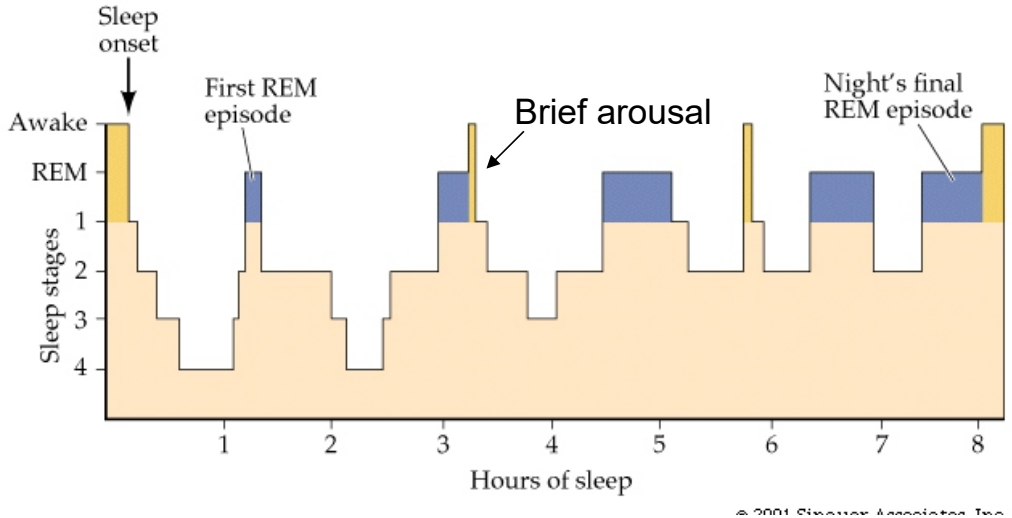
•Then, brain waves start to resemble Stage 1 or Awake stages (low voltage, mixed frequency); however, burst of rapid eye movements appear: EMG is absent but you see occasional twitch

THIS is REM (or paradoxical) sleep



- During REM a number of events occur that are not observed in SWS
  - •Increased and sustained cortical activity
  - •Severely reduced neural responses to sensory stimuli
  - •Vivid Dreams
  - •Complete loss of muscle tone (motor cortex is active, but cannot access musculature)

Sleep Stage Cycles



- Over the course of a night's sleep, cycle repeats 4-5 times.
  - ~50% is Stage 2 sleep, 20% REM sleep
  - One cycle typically takes 90-110 minutes
  - Early in sleep period, you see more Stage 3 sleep, but as sleep progresses you see less Stage 3, and longer REM episodes
- **Sleep (in particular REM sleep) is NOT a state of neural quiescence!**

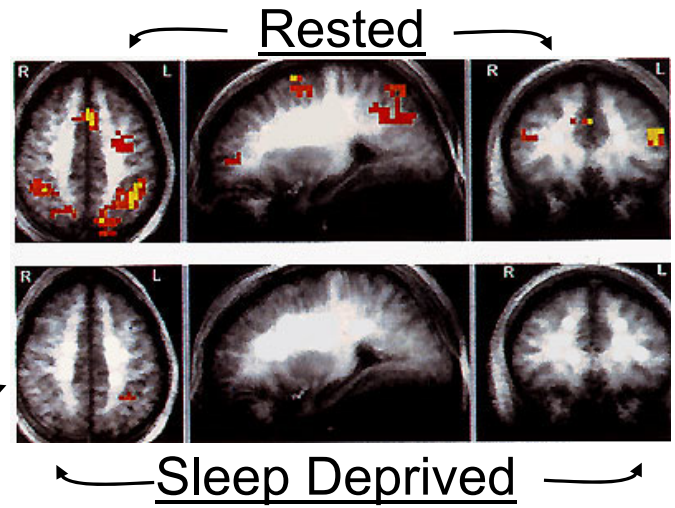
aka not "shut off"

REM Sleep and Dreaming

- ~80% of subjects report dreaming when awakened from REM sleep. Only 10% report dreams from SWS awakenings.
  - Stage 2 awakenings sometimes reveal non-vivid "thinking" dreams
- People who claim not to dream report dreaming when awakened during REM sleep.
- External stimuli can sometimes influence dreams.
  - e.g.: spray water on subject in REM sleep, they dream of water falling on them
- Dreams run on real time: do not last a few seconds usually.
- Sleepwalking/sleep talking do not occur during REM sleep
  - Core muscles tend to be totally relaxed.

Sleep Deprivation (I)

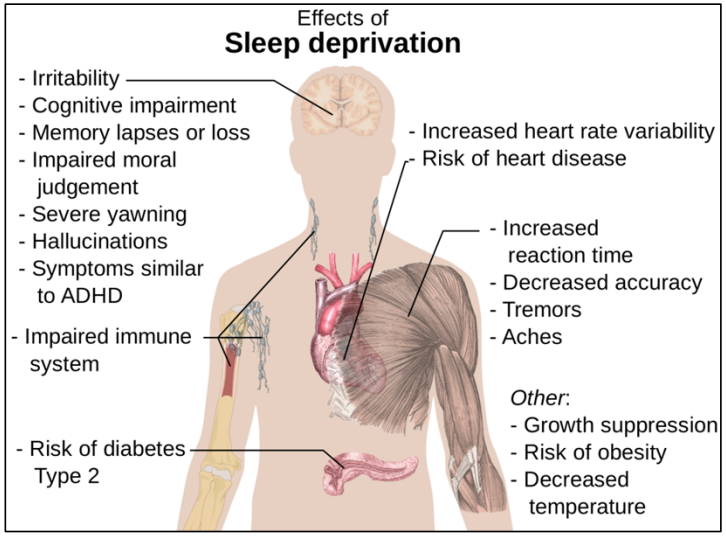
- Great variability in how much sleep humans need, and effects of sleep deprivation
  - Some display hallucinations/paranoia
  - Most show ↑ irritability, ↓ ability to concentrate, no real effect on IQ tests
  - Brain regions activated in rested subjects doing arithmetic problems are not active in sleep-deprived subjects

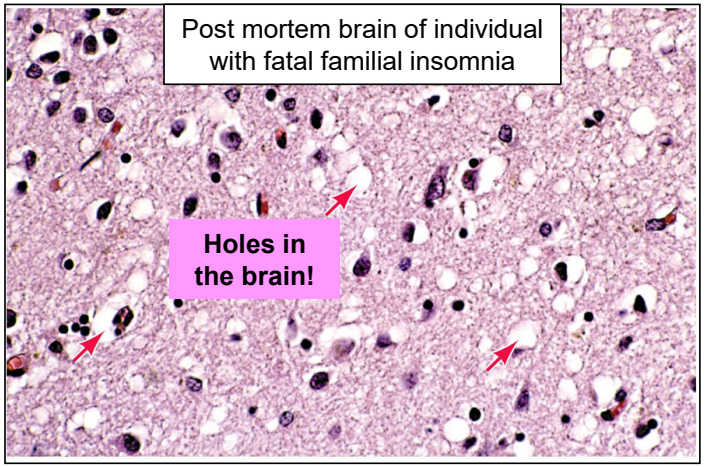


  - More complex cognition mediated by the frontal lobes are most susceptible to sleep deprivation
    - Innovative thinking, planning, selective attention, cognitive flexibility
  - Tasks with high motivation/arousal components are not as affected
  - ALL people show more sleepiness

Sleep Deprivation (II)

- Major health consequences with extreme long-term deprivation
  - — Laboratory animals can die after ~19 days of no sleep
- Humans with ***fatal familial insomnia*** die within 7-24 months of disorder onset (typically in midlife)
  - — Autopsy shows degeneration (i.e.; holes) in the brain (likely causal to sleep problems)
  - — Actual cause of death seems to be due to general disruption of immune function – pathogens that are not normally fatal take their toll on the body





REM-Sleep Deprivation

- Cognitive effects of sleep deprivation seem due to reduced REM sleep
  - Effects can be observed after a few nights of less than normal sleep
  - Waking subjects up from ***only*** REM sleep has similar consequences
  - After repeated REM sleep deprivation, subjects have rebound increases in bouts of REM

- Following sleep deprivation, subjects try to make up sleep loss with more REM sleep
  - After deprivation, sleep time increases for a few days
  - More Stage 3, at the expense of Stage 2
  - REM episodes become more frequent, are longer, and/or more intense, individuals become more "efficient" sleepers