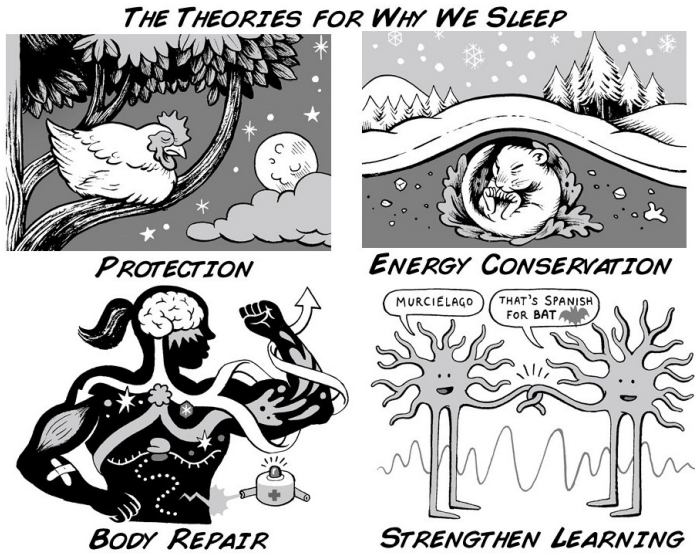
# Biological Rhythms, Sleep, Dreaming (Ch.14) I

- 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)

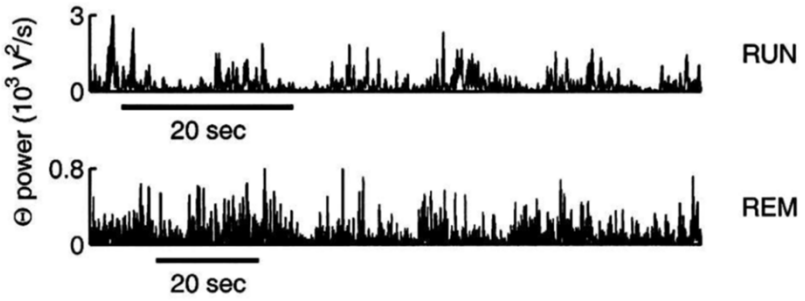
- **Body/Brain Restoration**: Being awake disrupts homeostasis; sleep can be time for body to repair itself
  - **For:** Growth hormones released during sleep
  - Sleep helps recovery from illness
  - Prolonged lack of sleep can be fatal
  - Brain removes more waste products during sleep
  - **Against**: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

# 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

# Support for active role of sleep in memory consolidation

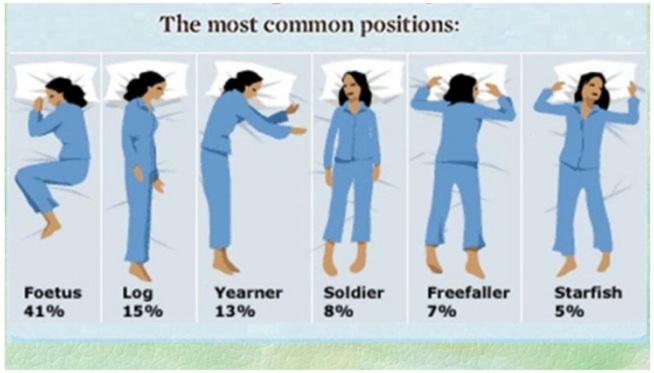
- More REM sleep (dreaming) after new learning
- Increased activity in memory centers during sleep
- Studies in rats suggest that temporal sequences of patterned activity linked to memory traces are reactivated during REM sleep.




- 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

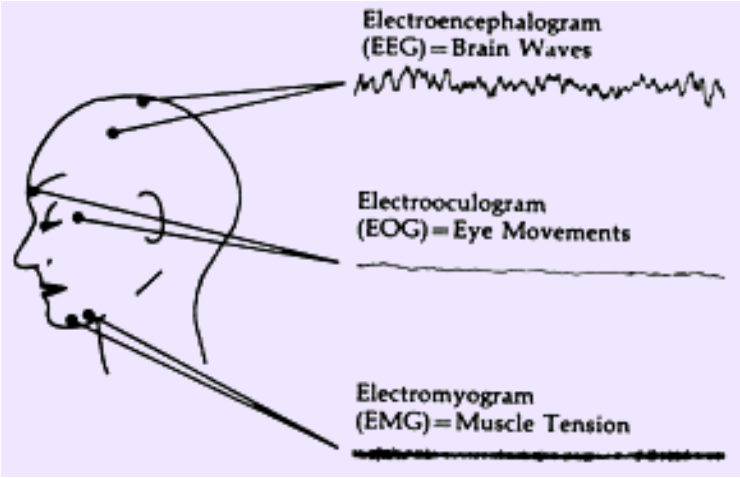
# Defining Sleep

- 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.

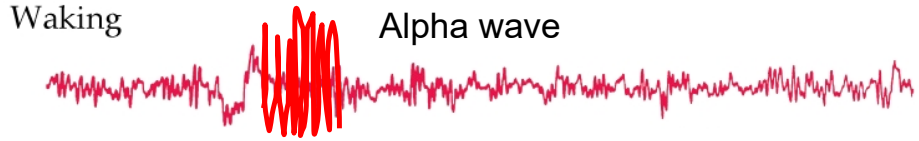
# Measuring Sleep in the Laboratory




- **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.

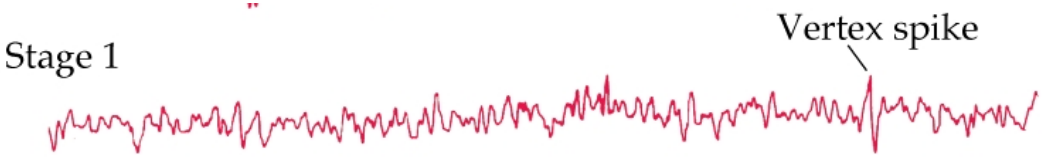
# Stages of Sleep (I)

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




•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)

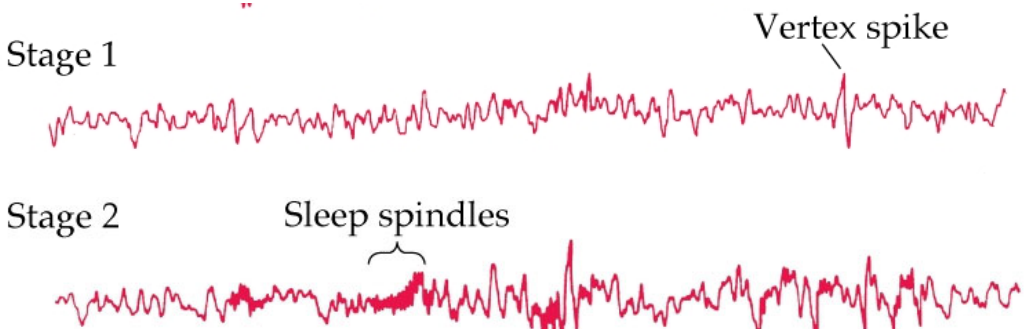



•After a period, alpha waves decrease, EEG becomes smaller and irregular and slower with random bigger spikes.

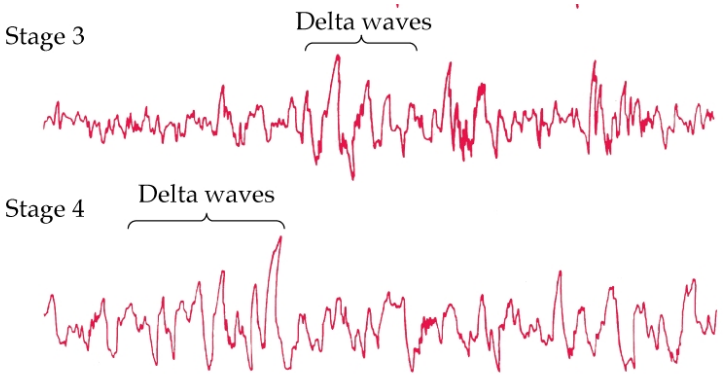
•REMs are absent, but slow rolling eye movements appear.

•The EMG is moderate to low.

# Stages of Sleep (II)




- 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



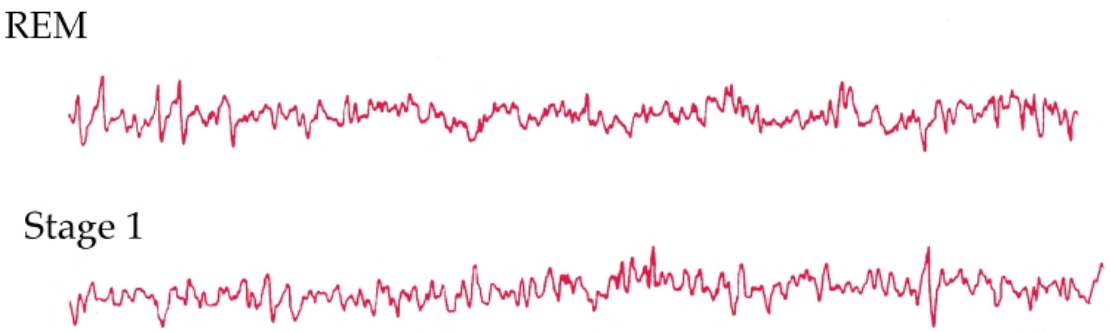

- Stage 3: High amplitude (>75 mV), slow (0.5-2 Hz) waves called "delta waves”
- Stage 3-late (aka Stage 4) defined by delta waves at least 50% of the time

# Stages of Sleep (III)

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

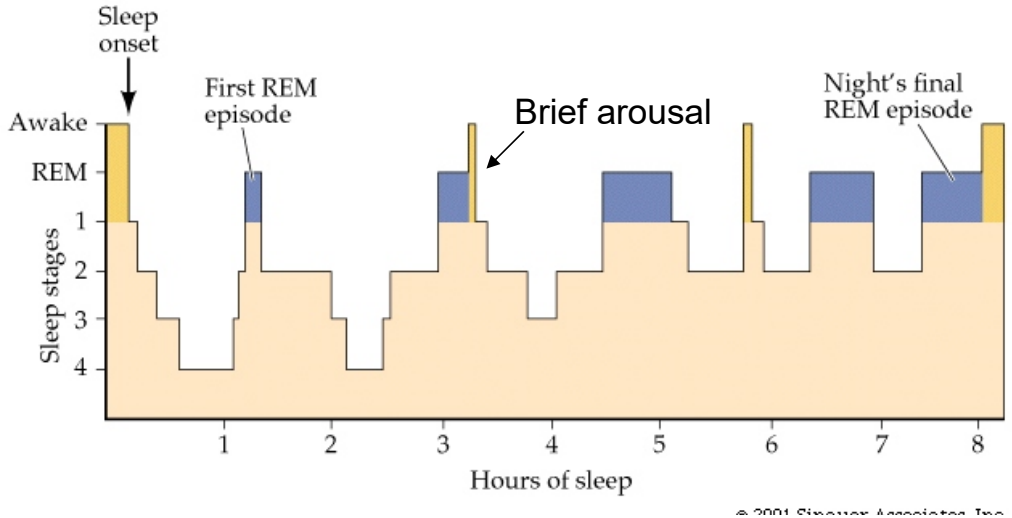
•Then, brain waves start to resemble Stage 1 or Awake stages (low voltage, mixed frequency); however, burst of rapid eye movements appear: EMG is absent but you see occasional twitch

**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



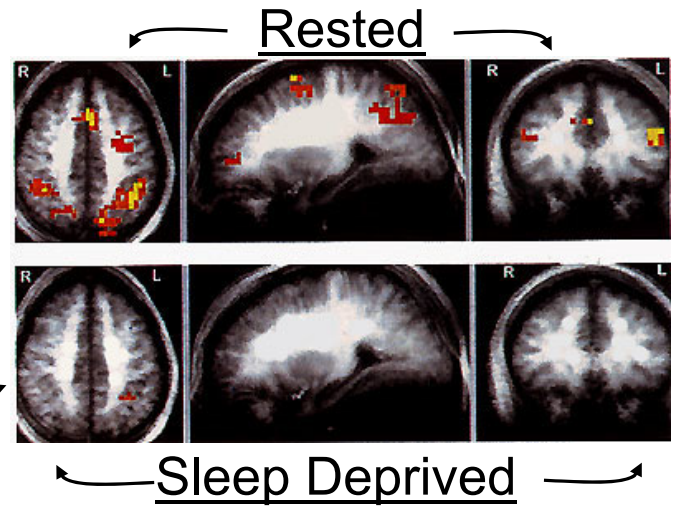

- Over the course of a night's sleep, cycle repeats 4-5 times.
  - ~50% is Stage 2 sleep, 20% REM sleep
  - One cycle typically takes 90-110 minutes
  - Early in sleep period, you see more Stage 3 sleep, but as sleep progresses you see less Stage 3, and longer REM episodes
- **Sleep (in particular REM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

# 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)

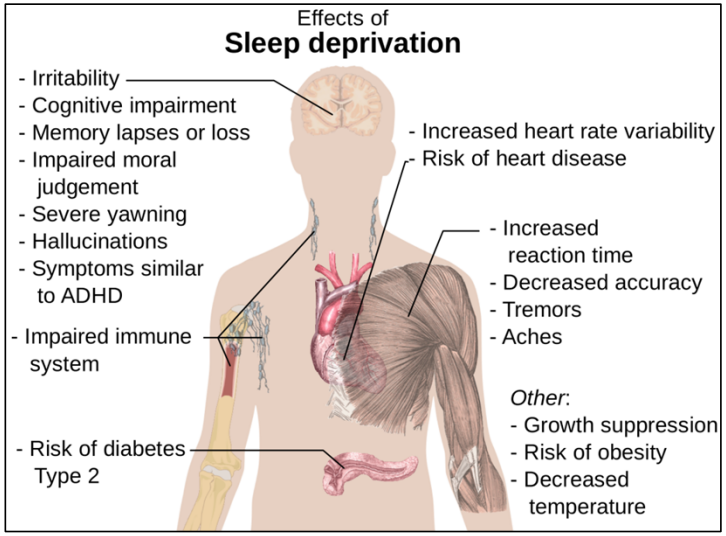
- Great variability in how much sleep humans need, and effects of sleep deprivation
  - Some display hallucinations/paranoia
  - Most show ↑ irritability, ↓ ability to concentrate, no real effect on IQ tests
  - Brain regions activated in rested subjects doing arithmetic problems are not active in sleep-deprived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

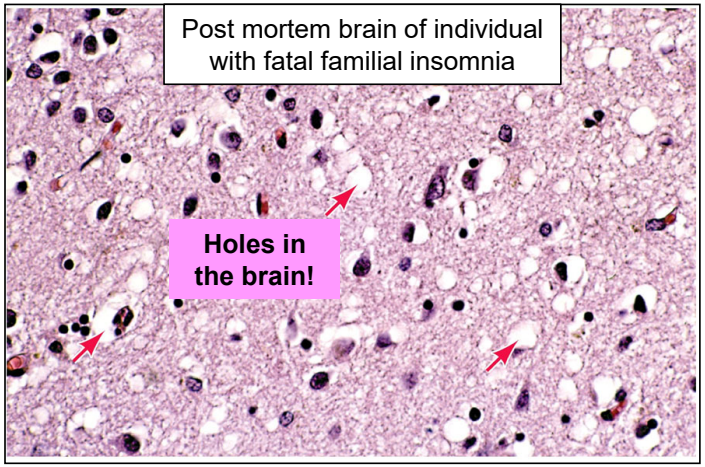



  - More complex cognition mediated by the frontal lobes are most susceptible to sleep deprivation
    - Innovative thinking, planning, selective attention, cognitive flexibility
  - Tasks with high motivation/arousal components are not as affected
  - ALL people show more sleepiness

# 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