Sleep: The role and neurophysiology of sleep

How to Study and Measure Sleep (FIGURE 8.1)

Sleep: Absence of overt behavior, absence of consciousness

→ Measures are “indirect”.

Methods to measure sleep characteristics:

- ElectroMyoGram (EMG): muscle activity (face), legs.
- ElectroEncephaloGram (EEG): brain activity.
- ElectroOculoGram (EOG): eye movements
- Air flow measurements → breathing
- Heart rate…

EEG Measurements of Sleep (FIGURE 8.2)

→ Sleep has different stages characterized by different EEG waveforms (Frequency content)

→ REM sleep = ‘Paradoxical’ sleep *referred to because of its similarities to wakefulness.

Sleep Has Stages

★ Brain rhythms detected using EEG

Sleep stages and rhythms:

→ Stage 1: Drowsiness heavy eyes, θ. Lasts ~10 minutes

→ Stage 2: Sensory disconnection. Sleep spindles and K complexes lasts ~15 minutes

→ Stage 3/ 4: Loss of consciousness . △. Lasts ~60 mins. Also called Slow Wave Sleep.
→ **R.E.M:** Dreaming, loss of muscle tonus. **Rapid Eye Movements (REM),** activity in sexual organs $\theta$ and $\beta$, desynchronized. Lasts $\sim$25 minutes. *Also called ‘Paradoxical’ sleep.*

**EEG and Single Neurons (FIGURE 8.3)**

- During Slow Wave Sleep neurons undergo **Up and Down states** → Periods of activity/silence, *1 period/second.*

  ★ **Down state:**
  - Rest
  ★ **Up state:**
  - Neuron are firing
  - Memory consolidation

**Sleep is a Cycle: Free Running Sleep/Wake Cycle**

→ **Experiment:** Room/Cave without windows, free food, entertainment, no clocks.

→ **Measure:** the amount of time awake/sleeping

→ **Result:** Sleep/wake cycle is **NOT** the same as day/night cycle

**Sleep Has Cycles (FIGURE 8.4)**

- **Sleep is a cycle**
  - Free running Awake/Sleep cycle: $\sim$25 hours.
  - REM/non-REM cycles every 90 minutes. Controlled by internal clock.
  - REM sleep has a refractory period of $\sim$1 hour.

Increase of metabolic activity in **Central Nervous System (CNS),** decrease of activity in **Peripheral Nervous System (PNS).** Sexual organs activity. Dynamic dreams.
Why Do We Sleep? (FIGURE 8.6)

★ Sleep as a *behavior* (adaptive response): all animals have **Slow Wave Sleep**, but only mammals and birds have **REM**.

→ Sleep as a ‘protective behavior’: it is dangerous to move at night…

★ Sleep as a *restorative* process. Resting of the brain (but not related to body activity).

*Evidence:*
- Cortex: Metabolic activity and blood flow decrease by 25% (during **Slow Wave Sleep**).
- Highest activity (when awake) → highest Δ + lowest activity (during **Slow Wave Sleep**).
- Sleep needs vary with development

<table>
<thead>
<tr>
<th>Sleep is a Need (genetic basis)</th>
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<td>- Different species have different sleep needs</td>
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**Sleep Duration in Humans**

- Sleep needs vary among humans (4-10 hours).
- Sleep starts in utero (in the womb).
- Sleep needs vary along life span. Need less and less sleep as we age.

**Deprivation Results**

24 hours sleep deprivation: no ‘rebound’ in sleep duration.

★ Record: 264 hours (11 days), by a 17 yo high school student. ~2 days 'rebound’ only.
**Sleep: Slow Wave Sleep (FIGURE 8.8)**

**Deprivation Studies:**
- No significant physical consequences (*humans*).
- Loss of weight + death (*rats*).
- Not a proportional function of recuperation.
- **SWS** need is not related to physical exercise.
- Brain metabolic activity decreases (by 25%). ∆ occurs in the regions that were the most active in the awake state.
  - Related to mental activity and ‘declarative memory’ consolidation.

**Nap after learning…**
  - Related to body temperature.

Aspirin/ibuprofen ↓ Temp → *prevents* slow wave sleep.

Cytokines (immune system response) ↑ Temp → *increases* slow wave sleep.
  - Dreams: static images.

**Sleep: REM Sleep (FIGURE 8.7)**

**Deprivation Studies:**
- Significant consequences on cognitive performance
- **REM** sleep shows rebound phenomenon after deprivation

**Brain metabolic activity increases:**
- In infants: **REM** = 70% of sleep, developmental role?
- In adults: **REM** = 15% of sleep, learning and memory, consolidation?

**”nap after class” → better memory retention with nap.**

**Sleep Disorders**
➢ **Insomnia**
- Sleep needs are variable (4-8 hours). Depends on genetic and environmental factors *(health, day activity, mood).* ‘Insomnia’ criteria depends on the individual.
- **Insomnia:** problem *falling* asleep. May be due to stress, psychological factors or ‘drug rebounds’ (after benzodiazepines *(valium)* or barbiturates *(anxiolytics)*).
- Quantity of sleep **Vs.** quality of sleep (sleep apnea).

➢ **REM sleep disorders**
- Sleep attack (low arousal, few mins. sleep).
- Cataplexy (high arousal, no loss of consciousness).
- Sleep paralysis (awake atonia): just before/after sleep.
- Hypnagogic hallucinations (awake, dreaming, usually nightmares).
- **REM** without atonia (a.k.a **REM** sleep behavior disorder). Act out dreams.

● **Narcolepsy:** genetic and hormonal (orexin) bases.

**Sleep Disorders (CONT.)**

➢ **SWS Sleep Disorders**
- Sleep walking *(15% children ages 5-12 do it at least once).*
- Eyes open, no arms stretched, state of ‘half consciousness’.
- Usually no “walking”
- Sleep related eating disorder
- Sleep talking (hypnosis, truth serums).
- Night terrors (fear of losing consciousness? no memory for what caused the event).

➔ **Fatal Familial Insomnia:** Damage to thalamus. Insomnia, paranoia, hallucinations, dementia, death, related to ‘mad cow’ disease. *No cure.* Genetic.