Beyond the Pillow

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What is sleep?
Cortical Definition of Sleep

Electrophysiology used to characterize sleep

- In animals with a developed neocortex
  - The neocortex covers the parts of the brain where the neuronal loci of sleep generators and regulators are located
  - Appears as telltale patterns of brain activity
The Neocortex
Electroencephalography (EEG)

- Records signals from the neocortex
- Detects voltage
Types of Sleep

- REM and non-REM
- REM and awake
  - REM/PS (paradoxical sleep)
Drawbacks

- Can only record surface
- Unable to distinguish between REM/PS and awake
- Neocortex not found in invertebrates
Behavioral Definition of Sleep

Irene Tobler of the University of Zurich

1. Reduced mobility
2. Site preference
3. Specific posture
4. Rapid reversibility
5. Increased arousal threshold
6. Homeostatic control

This definition of sleep can be applied to ALL animals!
Drawbacks

● Unable to quantify sleep
  ○ Need to wake the animal
Working towards a Subcortical Definition of Sleep

Using electrophysiological and behavioral criteria, researchers have

1. Pinpointed the location of:
   Brain nuclei, circuits, and neurotransmitters involved in sleep-wake regulation

2. Identified centers of state-switching in the brainstem and hypothalamus
Brainstem/Hindbrain contain regions critical to:

- Sleep induction
- Arousal
  - Locus coeruleus
  - Parabrachial nucleus
- Muscle-tone control

Would only define sleep for vertebrates, NOT invertebrates
Brainstem/Hindbrain
“With the development of whole-brain imaging methods allowing the comparison of two distinct vertebrate sleep models... we should soon be able to define sleep for all vertebrates based on the dynamics of conserved networks in deeper brain regions.”
Why do we sleep?

● Sleep strengthens
  ○ Cognitive functions
  ○ Memory processing
  ○ Learning
  ○ Physical health
  ○ Mental health

● Deprivation impairs
  ○ Motor tasks
  ○ Cognitive tasks
Working towards a Synaptic and Functional Definition of Sleep

- Sleep is important for synaptic remodeling for ALL animals
- Sleep can be compared to a neurodevelopmental state, a state preserved from simple circuits to neocortical complex networks
- On a synaptic level, sleep can be defined as:

  “A specific type of Plastic state likely conserves across circuits, developmental stages and evolution.”
Sleep Deprivation

- Pressure to sleep builds up during day until we feel sleepy in the evening
- Deprival of sleep → Lead to “Sleep Drunk” or “Cerebral Exhaustion”
- Sleep Drunk
  - Waking up & remaining in confused state for certain period of time before going back to sleep or fully waking up
  - Typically happen during REM sleep
- Cerebral Exhaustion
  - Brain demands sleep
REM (Rapid Eye Movement) Sleep

- Also known as Paradoxical Sleep (PS)
- Characterized by low voltage, choppy, swiftly changing brain waves
- Occurs at intervals of about 90-120 minutes during night
- Brain can go through several changes such as
  - Rapid eye movements
  - Fast & irregular breathing
  - Dreaming movements
- Brain is active
Non- Rem Sleep

- Characterized by slowly rising & falling waves of large amplitude
- The deeper the sleep, the slower & larger the brain waves
3 Stages of Non-Rem Sleep

- **Stage 1** → Occurs in beginning of sleep; Slow eye movements (Relaxed wakefulness)
- **Stage 2** → No eye movements; Dreaming is rare
- **Stage 3** → Deep sleep → Memory consolidation
Sleep Stages

Stage 1
Theta Waves

Stage 2
Light Sleep

Stage 3 & 4
Delta Waves

REM Sleep
## NREM versus REM

<table>
<thead>
<tr>
<th>NREM</th>
<th>REM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow eye movement</td>
<td>Rapid Eye movement</td>
</tr>
<tr>
<td>Restful sleep</td>
<td>NOT restful</td>
</tr>
<tr>
<td>Decreased metabolism</td>
<td>Increased metabolism</td>
</tr>
<tr>
<td>Vital signs LOW</td>
<td>Vital signs Irregular</td>
</tr>
<tr>
<td>Muscle tone maintained</td>
<td>Muscle tone depressed</td>
</tr>
<tr>
<td>NO vivid dreams</td>
<td>Dreams occur</td>
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</tbody>
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Microsleep

- Brief episodes of sleep lasting from a second to 30 seconds
  - Temporary loses consciousness
  - External stimuli aren’t perceived
- Can occur during tedious or long tasks
  - Driving long distances
  - Attending long meetings
Characteristics of Microsleep

- Drowsiness → Droopy eyes → Eyelids close → Heads nods up & down repetitively → Consciousness lapses suddenly

- Tend to believe they’re alert without recalling unconsciousness
Microsleep: Experiment

- Tracking moving target on computer monitor with joystick for 50 minutes
- Participants had 79 microsleep episodes per hr (1-6 seconds each)
Experiment - Could brain still monitor what was going on during sleep?

Had people listen to spoken words in French & push button with their hand to indicate if word was object or animal as volunteers fall asleep.
Brain activity was measured using EEG
Divided sleep into 3 stages:

1. REM → Prepared finger movement during word task as if they were awake
2. Light NREM → Showed motor preparation whether words were novel or presented before
3. Deep NREM → No brain activity involved with button pushing
Conclusion - Could brain still monitor what was going on?

- When we sleep → Lose consciousness of self & outside world
- Continue to hear & process words during light non-REM sleep
  - Doesn’t lose all responsiveness
- Brain is assumed to block out external stimuli through gating mechanism at thalamus but certain stimuli could filter through & trigger awakening
Dreaming

- Quality of attention goes from concentrated to diffused → Approach sleep
Dreaming: The spectrum

- **Upper spectrum**
  - Ignore emotion as we pursue mental object by reasoning or analysis

- **Down the spectrum**
  - Daydreams are often emotional
  - Dreaming encounter most saturated emotions a mind can generate

- A steady shift from mind dominated by action to one dominated by passion mental experience
  - Mental doing to mental being
Intentionality & Experience

Intentionality

- Quality of aboutness
- Sometimes called “the mark of the mental”
- Belongs to upper spectrum & disappears gradually as we descend

Experience

- Dominates mind at the bottom spectrum
- The states that allow the reproduction of emotions depend on physical properties of particular objects
Software Simulations

Digital computer only resembles upper spectrum

Drawback:

- Can’t reproduce emotions
- No resemblance of lower part of the spectrum
Dreaming is a hallucination

- Different self in dreaming state from our waking self
- Difficult to grasp
- Start losing sense of them when we wake up
It's strange: I sleep about 18 hours a day, but I still can't remember any of my dreams...