Sleep, Dreaming and Circadian Rhythms
People typically sleep about 8 hours per day, and spend 16 hours awake. Most people sleep over 175,000 hours in their lifetime.

The vast amount of time spent sleeping suggests that sleep has a significant biological function.

- recuperation
- adaptation
Three Physiological Measures of Sleep

Electroencephalogram (EEG)
Reveals gross electrical activity of the brain “brainwaves”

Electrooculogram (EOG)
Records eye movements seen during rapid eye movement (REM) sleep

Electromyogram (EMG)
Detects loss of activity in neck muscles during some sleep stages
Four Stages of Sleep EEG

Awake: low-voltage, high-frequency (fast) waves

Pre-sleep: intermittent alpha waves, bursts of low-frequency (8-12Hz) waves

Sleep: voltage increases and frequency decreases (slows) with progression through stages 1-4
- Stage 1: theta waves
- Stage 2: spindles and K complexes
- Stage 3: occasional delta waves (large and slow, 1-2Hz)
- Stage 4: predominantly delta waves
Course of Sleep and REM Sleep

A sleeper progresses from stage 1 to stage 4 sleep and then back through stages 3, 2, to (emergent) stage 1, then repeats the cycle.

Emergent stage 1 differs from initial stage 1 (and all other stages):
• rapid eye movement (REM) sleep – dreams
• loss of body core muscle tone (cerebral activity increases to awake levels)

Sleepers progress through sleep stages in 90-minute cycles, where the durations of emergent stage 1 periods lengthen and stages 3-4 shorten as the night progresses.
80% of awakenings from REM sleep yield reports of story-like dreams. Only 7% of awakenings from non-REM sleep lead to dream recall.

External stimuli may be incorporated into dreams.

Dreams run in “real” time.

Everyone dreams.

Interpretation?
• troubled subconscious
• activation-synthesis theory
Why Do We Sleep?

There are two kinds of theories for sleep: recuperation and adaptation.

- **Recuperation:** Sleep is needed to restore homeostatic balance lost during the day.
- **Adaptation:** Sleep is the result of an internal timing mechanism, evolved to conserve energy and to protect us from the dangers of the night.

Comparative analysis:

- All mammals and birds sleep; not a special human function
- There is no clear relationship between species’ daily activity levels and sleep times.

<table>
<thead>
<tr>
<th>Mammalian Species</th>
<th>Hours of Sleep per Day</th>
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<tbody>
<tr>
<td>Giant sloth</td>
<td>20</td>
</tr>
<tr>
<td>Opossum, brown bat</td>
<td>19</td>
</tr>
<tr>
<td>Giant armadillo</td>
<td>18</td>
</tr>
<tr>
<td>Owl monkey, nine-banded armadillo</td>
<td>17</td>
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<tr>
<td>Arctic ground squirrel</td>
<td>16</td>
</tr>
<tr>
<td>Tree shrew</td>
<td>15</td>
</tr>
<tr>
<td>Cat, golden hamster</td>
<td>14</td>
</tr>
<tr>
<td>Mouse, rat, gray wolf, ground squirrel</td>
<td>13</td>
</tr>
<tr>
<td>Arctic fox, chinchilla, gorilla, raccoon</td>
<td>12</td>
</tr>
<tr>
<td>Mountain beaver</td>
<td>11</td>
</tr>
<tr>
<td>Jaguar, vervet monkey, hedgehog</td>
<td>10</td>
</tr>
<tr>
<td>Rhesus monkey, chimpanzee, baboon, red fox</td>
<td>9</td>
</tr>
<tr>
<td>Human, rabbit, guinea pig, pig</td>
<td>8</td>
</tr>
<tr>
<td>Gray seal, gray hyrax, Brazilian tapir</td>
<td>6</td>
</tr>
<tr>
<td>Tree hyrax, rock hyrax</td>
<td>5</td>
</tr>
<tr>
<td>Cow, goat, elephant, donkey, sheep</td>
<td>3</td>
</tr>
<tr>
<td>Roe deer, horse</td>
<td>2</td>
</tr>
</tbody>
</table>
Effects of Sleep Deprivation

Recuperation theories predict that long periods of wakefulness will result in behavioral and physiological disturbances, and much of the missed sleep will be regained.

In support of theory:
• bad mood, reduced cognitive abilities (creative thinking) and sleepiness
• reduced immune function, increased blood pressure, and lower body temperature

Inconsistent with the theory:
• unimpaired logical and critical thinking
• retained physical strength and motor performance
• recovery sleep is relatively short

If REM-sleep alone is deprived then the effects are minimal, indicating that deep sleep is responsible for most benefits of sleep. REM-sleep may improve memory-storage (inconclusive), or prepare an organism for wakefulness where immediate activity may be required upon waking (default theory).
The world in which we live cycles from light to dark and back again once every 24 hours.

Circadian rhythms: “lasting about a day”

Virtually all physiological, biochemical, and behavioral processes show some circadian rhythmicity.

zeitgebers: environmental cues that entrain circadian cycles
Free-running circadian rhythms
If zeitgebers are removed, then rhythms are governed by internal circadian clock (runs a little slow)

Jet lag
Zeitgebers are accelerated (flying east) or decelerated (flying west). Remedies: pre-shift sleep cycle, melatonin, light exposure

Shift work
Zeitgebers are unchanged, but the sleep–wake cycle must be altered. Remedies: pre-shift cycle, later shifts
Suprachiasmatic nucleus (SCN) located in hypothalamus = sleep-wake circadian clock
• Lesions do not reduce sleep time, but they abolish its periodicity.
• Exhibits electrical, metabolic, and biochemical activity that can be entrained by the light–dark cycle
• Transplant SCN, transplant sleep–wake cycle

Inputs to the SCN come from special retinal ganglion cells that are themselves photosensitive (2%; not activated by rods or cones). Roughly 10% of blind people lack these cells, and thus have free-running sleep-wake cycles.
Sleep-Wake Areas

There are four areas of the brain known to be directly involved in producing or reducing sleep: two in the hypothalamus; and two in the reticular formation.

- anterior hypothalamus (VLPO) – sleep
- posterior hypothalamus – wakeful
- rostral reticular formation – wakeful
- caudal reticular REM nuclei – sleep
Human sleep is believed to be regulated by two basic neural processes:
- the homeostatic process (sleep need), whose magnitude depends on the amount of prior sleep and wakefulness;
- the circadian process (sleep urge), which is governed by the SCN clock.

The sleep/wake cycle is thought to be governed by a flip-flop neural circuit involving mutual inhibition between sleep promoting regions (anterior hypothalamus; VLPO) and arousal systems (rostral reticular formation).
Most drugs that influence sleep fall into three different categories:

- **hypnotic** (increase sleep time);
- **antihypnotic** (reduce sleep time); and
- **chronobiotic** (alter circadian rhythm).

**Hypnotic** drugs (benzodiazepines; Valium, Librium) enhance the effect of the inhibitory neurotransmitter GABA in the brain

- **Mode:** depress wakeful centers
- **Complications:** tolerance, addiction, cessation leads to insomnia

**Antihypnotic** drugs (stimulants, tricyclic antidepressants) increase the activity of catecholamine transmitters by enhancing release and/or blocking reuptake

- **Mode:** activate sympathetic (f/flight NS)
- **Complications:** lost appetite, addiction

**Chronobiotic** drugs increase the level of melatonin in the brain

**Mode:** levels of melatonin, synthesized naturally by the pineal gland, follow circadian rhythms set by SCN, and are high at night and low during the day. Thus, melatonin taken at night/morning can prolong sleep.

Drugs that Affect Sleep
Many sleep disorders fall into one of two complementary categories:

• **insomnia** (disorders of sleep initiation and maintenance); and
• **hypersomnia** (disorders of excessive daytime sleep or sleepiness)

Approximately 30% of respondents report sleep-related problems; far fewer truly have a problem.

**Insomnia:**
• Iatrogenic: physician-related (pills)
• Sleep apnea: obstructive; central
• Limb movement before (restless legs) or during sleep (periodic)

**Hypersomnia:**
Narcolepsy: daytime “sleep attacks”, cataplexy (loss of muscle tone), hypnagogic hallucinations (daydreams)
Symptoms suggest REM intruding into wakefulness; may be due to genetic deficiency in orexin synthesis in the posterior hypothalamus (wake center)
How Much Sleep Do We Need?

The optimal duration and cycle of sleep is unknown

- There are no consistent differences in any measures of health and behavior between short (<6 hours) and long sleepers (>8 hours)
- Evidence suggests that napping throughout the day (a polyphasic sleep cycle) provides greater recuperation than a monophasic pattern. Indeed, a schedule of 15 minutes of sleep every 4 hours (total of 1.5 hours sleep/day) produces no ill effects
- Fewer deaths occur for people sleeping 5-7 hours/night than the presumed ideal of 8 hours/night
- Find what works for you!

Archives of General Psychiatry, 2002