What is Sleep?

You spend 1/3 of your life asleep…

Originally thought of as a:

- **passive** state of immobility with
  - cessation of brain activity
  - lack of perception and consciousness

Now we know:

- sleep is composed of **different** states of **brain activity** (sleep stages)
- some perception – wake up faster in response to your own name than the names of others (Oswald, Taylor & Treisman, 1960)
How do we measure sleep?

Polysomnography – gold standard in sleep measurement

- Electroencephalogram (EEG)
  - Records “brainwaves” – sum of electrical activity over an area of cortex

- Electrooculogram (EOG)
  - Records eye movements during sleep

- Electromyogram (EMG)
  - Detects activity in neck muscles during sleep
How do we measure sleep?

- **EEG**
  - Wake
  - Stages 1-4 (NREM)
  - REM Sleep

- **EOG**
  - Wake
  - Stages 1-4 (NREM)
  - REM Sleep

- **EMG**
  - Wake
  - Stages 1-4 (NREM)
  - REM Sleep
Sleep stages across a sleep cycle

REM = Rapid Eye Movements & dreaming

Stages 1 & 2 of NREM = “light” sleep

Stages 3 & 4 of NREM = “deep” Slow Wave Sleep or NREM

Sleep cycle = ~ 90 min
Sleep stages across the night

Deep, Slow-wave Sleep (SWS) is mostly observed at the beginning of the night.

REM sleep is mostly observed at the end of the night (last 2-3 cycles).
Sleep across life

HOW MUCH SLEEP DO YOU REALLY NEED?

- **Newborn to 2 months old**: 12 hrs to 18 hrs
- **3 months to 1 year old**: 14 hrs to 15 hrs
- **1 to 3 years old**: 12 hrs to 14 hrs
- **3 to 5 years old**: 11 hrs to 13 hrs
- **5 to 12 years old**: 10 hrs to 11 hrs
- **12 to 18 years old**: 8.5 hrs to 9.25 hrs
- **Adult (18+)**: 7 hrs to 9 hrs

(National Sleep Foundation; whydon'tyoutrythis.com)
Sleep disorders

- **Insomnia**
  - Inability to fall or stay asleep

- **Sleep Apnea**
  - stop breathing during the night, leads to repeated awakenings
  - most commonly seen in males, overweight, and elderly

- **Narcolepsy**
  - “sleep attacks:” subjects enter directly in REM sleep

- **Sleepwalking, talking, and night terrors** occur mostly in slow-wave sleep
Sleep affects…

- **Cognitive performance**
  - Alertness, attention, reaction time
  - Decision-making
  - Memory

- **Psychological health**
  - Mood
  - Depression, anxiety

- **Physiological health**
  - Growth hormone production
  - Rest and restoration
  - Healing and regeneration of bones, muscles and other tissues
  - Immune function
  - Metabolism

- and much more…. 
Sleep & cognition

- 24 h of sleep deprivation = 0.1 BAC
- ~16-60% of all car accidents due to sleep deprivation
- Sleep debt is **cumulative** – sleeping for only 6 h/night for 2 weeks = same deficits as 24 h sleep deprivation
- Mismatch between perception and performance (people think they’re OK)
- Adding sleep (napping) improves memory
Sleep & cognition

- Sleep is correlated with GPA (Undergrads at UC Berkeley)

(2007 UC Berkeley Office of Student Research)
Sleep in college
Sleep in college

On how many days of the past 7 days did you get enough sleep so that you felt rested when you woke up in the morning?

The 2010 National College Health Assessment by the American College Health Association
Sleep in adolescence

Teens get less & less sleep as they progress through highschool...

2000 National Sleep Foundation report
Class time is typically close to 7:15am so highschoolers wake around 6am

Two schools changed start time from 7:20 to 8:00am

Students got 45 min more sleep on school days

Those extra 45 min of sleep…
- Better grades & SAT scores
- ½ daytime sleepiness
- Fewer doctor visits/late/absent
- Better mood

Data from Owens, Belon & Moss, 2010
Based on preferences for sleep/wake timing and reported alertness across the day

- Genetic component – runs in families

- Associated with the timing of melatonin, cortisol, & BT rhythms

- Changes with age
  - Early -> Late -> Early
What are Circadian Rhythms?
Many aspects of your physiology & behavior have circadian rhythms.

“circa” = about
“dia” = day
Circadian rhythms and behavior

Figure adapted from Froy, 2012 and Glickman, 2013
Some of your body’s circadian rhythms…

- **High alertness**: 10:00
- **Highest testosterone secretion**: 09:00
- **Melatonin secretion stops**: 07:30
- **Sharpest rise in blood pressure**: 06:45
- **Lowest body temperature**: 04:30
- **Deepest sleep**: 02:00
- **Noon**: 12:00
- **Best coordination**: 14:30
- **Fastest reaction time**: 15:30
- **Greatest cardiovascular efficiency and muscle strength**: 17:00
- **18:00**: Highest blood pressure
- **19:00**: Highest body temperature
- **21:00**: Melatonin secretion starts
- **Midnight**: 00:00
The Two-Process Model of Sleep

Homeostatic Sleep Drive

Circadian Alerting Rhythm

9am      day/wake      9pm     night/asleep     9am

Wake

Sleep

alertness
Shifting your clock

Different rates:
Liver in London
Brain in Baltimore
Heart in San Francisco

Figure adapted from Harrison & Gorman, 2015 and Glickman, 2013
Circadian disruption

The circadian system has a slow adjustment rate of ~1 h/day

When your schedule changes….

- Daylight savings
  - ± 1 hr
- Travel across time zones
  - East coast +3 hr
- Shiftwork
  - work at night or on a schedule that changes frequently
Circadian disruption in shiftwork

- The circadian system has a slow adjustment rate of a little more than 1 h/day

- 15 million individuals work outside regular 9-5 shift (U.S. Department of Labor)

- Increased risk of accident & injury (Folkard & Tucker, 2003)

- Myriad physiological & psychological consequences (Evans et al. 2013; Brown et al., 2009; Lawson et al., 2011)

- WHO has cited night shiftwork as a probable carcinogen

- Compromised alertness, performance and health cost ~$200 billion annually (Kerin & Aguirre, 2005)

- Limited practical solutions
What causes the harm?

Three interconnected processes interact in the shiftworker:

- Sleep deprivation
- Circadian misalignment – doing things at the wrong time (jet-lag symptoms, eating, sleeping, concentrating etc)
- Light at night
The visual system

- Two types of photoreceptors for vision:
  - **Cones**: color, daytime and detail vision (5-10%)
  - **Rods**: dim light (90-95%)
    - Both send impulses toward the center of the eye
  - **Ganglion cells** carry visual info to the brain via their axons (optic nerve)
Non-visual responses to light

What about non-image forming responses to light? *Alertness, pupillary light reflex, shifting circadian rhythms, melatonin suppression*

Mediated by rods and cones?

…effects persist even in blind individuals
Melatonin Suppression Action Spectrum

\[ \lambda_{\text{max}} = 464 \text{ nm} \]

\[ R^2 = 0.91 \]

Brainard et al., 2001
## ACTION SPECTRA
for non-image forming functions

<table>
<thead>
<tr>
<th>Peak $\lambda$</th>
<th>Species</th>
<th>Response</th>
<th>Author, Year</th>
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<tr>
<td>459</td>
<td>Human</td>
<td>Melatonin Suppression</td>
<td>Thapan, et al., 2001</td>
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<tr>
<td>479</td>
<td>Mouse</td>
<td>Pupillary Light Reflex</td>
<td>Lucas, et al., 2001</td>
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<tr>
<td>481</td>
<td>Mouse</td>
<td>Circadian Phase-Shifting</td>
<td>Hattar, et al., 2003</td>
</tr>
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Non-image forming functions all have peak sensitivity in 460-480 range (different than rods and cones)
Intrinsically photosensitive Retinal Ganglion Cells (ipRGCs)

- A subset of Retinal Ganglion cells (approx. 2%)
  - Are intrinsically photoreceptive
  - Contain the photopigment melanopsin

- Same neural pathway as vision?
Light & Visual system

[Diagram of the visual system with labels for light, signal, receptors, horizontal cells, bipolar cells, retinal ganglion cells, and other neural structures.]

Visual area of the thalamus
Optic tract
Optic chiasm
Optic nerve
Retina
Visual cortex

www.skidmore.edu/~hfoley/Perc3.htm
www.cs.brown.edu/~deus/courses/optical/Contrast3
Light at night
Increased technology is not only distracting, but light at night:
- **Shifts your clock** (< 20 min of low room light enough)
  - keeping your light on for 1 extra hour = flying 1 hour westward (jet lag!)
- significantly **suppresses melatonin**, your “nighttime” hormone
- increases feelings of **alertness**
Sleep Tips!

• **Make sleep a priority**, and take naps when you can.
• **Keep a consistent schedule.** Establish a bed and wake-time and stick to it, coming as close as you can on the weekends.
• **Avoid light at night.** Keep your room cool, quiet and dark. *Flux*, etc.
• **Get bright light in the morning.**
• **Create a routine.** If you do the same things every night before you go to sleep, you teach your body the signals that it’s time for bed. Try taking a bath or shower (this will leave you extra time in the morning), or reading a book.
  • Avoid caffeine late in the day so you can get to sleep at night.
  • Avoid drinking heavily – while alcohol causes you to fall asleep more quickly and get SWS, you will have disrupted sleep with less REM in the second half.
• Don’t eat, drink, or exercise within a few hours of your bedtime.
• Don’t leave your homework for the last minute.
• Try to avoid the TV, computer and telephone in the hour before you go to bed. Stick to quiet, calm activities.
Thank you!