The Neuroscience Behind a Good Night’s Sleep

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A Good Night’s Sleep
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What is sleep?

How is sleep regulated?

How can we sleep better?
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What is sleep?
What is sleep?

- Relative immobility
- Higher sensory threshold
- Stereotyped posture
- Reversible
- Homeostatic

Yokogawa et al. (2008) Plos Biology
Electroencephalography (EEG)
Helper T cell Activation and Action

1. Antigen recognition
   - APC (Antigen-presenting cell)
   - MHC-II
   - CD4+
   - Antigen

2. Clonal selection
   - Effector cells
   - Memory T cells

3. Interleukin secretion
   - Neutrophils, Macrophages
   - Killer T cell
   - B cell

Nonspecific Defense
Cellular Immunity
Humoral Immunity
Sleep Deprivation
Sleep Debt
Effects of sleep debt

Psychological
- Lower performance
- Slowed reaction time
- Risk of depression
- Risk of anxiety disorder

Other:
- Overweight or obesity
- High blood pressure
- Risk of heart disease
- Risk of diabetes

Poor immune system function
The Link Between Sleep Quantity and Academic Performance for the College Student

Megan Lowry¹, Kayla Dean², and Keith Manders

Department of Psychology, University of Minnesota, Minneapolis, Minnesota
Sleep inspires insight

Ullrich Wagner¹, Steffen Gais¹, Hilde Haider², Rolf Verleger³ & Jan Born¹

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Practice with Sleep Makes Perfect: Sleep-Dependent Motor Skill Learning

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Sleep quality correlates with perceived attractiveness

Axelsson et al. (2010) BMJ
Sleep quality correlates with perceived attractiveness.

Axelsson et al. (2010) *BMJ*
Local sleep in awake rats

Vladyslav V. Vyazovskiy¹, Umberto Olcese¹,², Erin C. Hanlon¹, Yuval Nir¹, Chiara Cirelli¹ & Giulio Tononi¹
1500 deaths per year
100,000 car crashes per year
Exxon Valdez oil spill
March 24, 1989
$63.2 billion dollars in lost productivity

Kessler et al. (2011) Sleep
A good night’s sleep is about sleep **quality** in addition to sleep quantity
Textbook Hypnogram
Real Hypnogram

Sleep Stage

Wake
REM
Stage 1
Stage 2
Stage 3
Stage 4

Arousal

9pm 10pm 11pm 12am 1am 2am 3am 4am 5am 6am 7am

Time of Day
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![Images of a child sleeping, a brain, and a person using a laptop.]
Two systems in the brain that regulate sleep:

- Circadian
- Homeostatic
Circadian regulation
Homeostatic regulation
How do individual populations of neurons influence sleep/wake states?
Torterolo et al. (2007) *Brain Res*
Optogenetics
Channelrhodopsin-2 (ChR2)

Blue light

Na⁺

K⁺
Halorhodopsin (NpHR)

Yellow light → Cl⁻
What are the effects of sleep fragmentation on memory?
Optogenetic disruption of sleep continuity impairs memory consolidation

Asya Rolls\textsuperscript{a}, Damien Colas\textsuperscript{b}, Antoine Adamantidis\textsuperscript{a}, Matt Carter\textsuperscript{a}, Tope Lanre-Amos\textsuperscript{a}, H. Craig Heller\textsuperscript{b, 1}, and Luis de Lecea\textsuperscript{a, 1}

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Rolls et al. (2011) PNAS
Optogenetic disruption of sleep continuity impairs memory consolidation

Asya Rolls\textsuperscript{a}, Damien Colas\textsuperscript{b}, Antoine Adamantidis\textsuperscript{a}, Matt Carter\textsuperscript{a}, Tope Lanre-Amos\textsuperscript{a}, H. Craig Heller\textsuperscript{b,1}, and Luis de Lecea\textsuperscript{a,1}

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Rolls et al. (2011) PNAS
What are the important downstream targets of Hcrt neurons?
EEG
EMG

Is activity in LC neurons necessary for Hcrt-mediated sleep-to-wake transitions?
Hcrt stimulation with:

No LC modulation

LC inhibition

Wake

Carter et al. (2011) PNAS
Can Hcrt neurons be divided into functional subpopulations?
Hcrt neurons can be divided into functional subpopulations
How does hunger affect sleep?
Visualizing AgRP and CGRP Neurons to Optimize Viral Vector Infection

Alexis Pyle and Zoe Trimmer
Professor Matt Carter
Department of Biology, Williams College, Williamstown, MA.
May 2014

Background

AgRP and CGRP neurons express different peptides, including AgRP in the AgRP neurons and CGRP in the CGRP neurons. These peptides are encoded by different genes that are expressed in different brain regions. The expression of these peptides is modulated by various factors, including diet and stress.

Neurons containing Cre-expressing fluorescent markers when injected with viral constructs

AAV vectors were injected into the brain of mice to express fluorescent markers. The neuronal activity was then monitored using calcium imaging. The results showed that the expression of the fluorescent markers was consistent with the activity of the neurons.

AAV vectors designed for specific experimental purposes

AAV vectors were designed to express different fluorescent markers and to target specific brain regions. The vectors were tested in vitro and in vivo to determine their efficacy in expressing the markers and targeting the neurons.

Expression of GFP and c-Fos in Arcuate Neurons

AAV vectors were designed to express GFP and c-Fos in Arcuate Neurons. The expression of these markers was monitored using immunohistochemistry. The results showed that the expression of GFP and c-Fos was consistent with the activity of the neurons.
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What is sleep?

How is sleep regulated?

How can we sleep better?
Develop a regular night time routine
Avoid before bed:

- Carbohydrates
- Alcohol
- Bright screens
Stress reduces sleep quality

Kerstedt et al. (2012) Sleep Medicine
Postpone stress and worries by writing a to-do list
Use music to control brain activity
By Adding Exercise:

- Time To Fall Asleep
- Deep Sleep and REM Sleep
- Nighttime Awakenings
The **Neuroscience** Behind a Good Night’s Sleep

- **What is sleep?**
- **How is sleep regulated?**
- **How can we sleep better?**
A good night’s sleep is about sleep quality in addition to sleep quantity.
no one looks back on their life and remembers the nights they had plenty of sleep
A good night’s sleep leads to a better day’s wake
Visualizing AgRP and CGRP Neurons to Optimize Viral Vector Infection

Background

Neurons containing Cre express fluorescent markers when injected with viral constructs.

Anna Ryba ’16

Zoe Trutner ’16
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