"Sleep is the golden chain that ties health and our bodies together."

Thomas Dekker

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Diego Rivera
First, then, this much is clear, that waking and sleep appertain to the same part of an animal, inasmuch as they are opposites, and sleep is evidently a privation of waking.

Aristotle

Sleep dwell upon thine eyes, peace in thy breast! Would I were sleep and peace, so sweet to rest.

Shakespeare

Think in the morning. Act in the noon. Eat in the evening. Sleep in the night.

William Blake
“We are always hearing people talk about ‘loss of sleep’ as a calamity. They better call it loss of time, vitality and opportunities.”

— Thomas Edison

“Sleep is a criminal waste of time and a heritage from our cave days.”

Photos: Henry Ford Museum
Margaret Thatcher

“Sleep is for wimps!”
Bill Clinton

"Every important mistake I've made in my life, I've made because I was too tired."
Sleep deprived bees cannot communicate the direction of the food source when they are sleep deprived.

Sleep deprivation impairs precision of waggle dance signaling in honey bees

Barrett A. Klein, Arno Klein, Margaret K. Wray, Ulrich G. Mueller, and Thomas D. Seeley
Sleep deprivation has been indicated as a cause in 7.8 percent of all the Air Force's Class A mishaps (Luna, 2003). Disasters such as Chernobyl, Three Mile Island, Davis-Besse, and Rancho Seco all occurred in the early morning (2:00 a.m. to 4:00 a.m.), a time when sleep deprivation effects are especially powerful, and all involved errors made by people working in groups (Harrison & Horne, 2000). Furthermore, sleep loss was specifically cited as a factor that contributed to the collective human error and poor judgment related to the Space Shuttle Challenger disaster (Presidential Commission on Space Shuttle Challenger Accident, 1986).
One Silicon Valley startup that encouraged its employees to think about work 24/7 found they missed market signals, tanked deals and became too irritable to build crucial working relationships.
What happens when we don't sleep?

1. Cognitive & behavioral changes
2. ↓↓ ability to concentrate
3. ↓↓ short-term memory
4. Paranoia & hallucinations

The world's record for the longest sleep deprivation period is 11 days!

http://www.online-clockalarm.com/facts/the-worlds-record-for-the-longest-sleep-deprivation-period-is-11-days
No Sleep $\rightarrow$ Cognitive Impairment

17-19 Hours $\rightarrow$ 0.05 BAC

28 Hours $\rightarrow$ 0.1 BAC

Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication

Occup Environ Med 2000;57:649–655

A M Williamson, Anne-Marie Feyer
New way to think about sleep
Sleep is important; our bodies demand it.
What regulates sleep?
Sleep wake cycle is regulated by the circadian system.

Light & Melatonin are the two most influential external cues that synchronize the circadian rhythm.
Superchiasmatic Nucleus in the brain is the “master clock” used to coordinate and synchronize most of the body clocks in the periphery.
melatonin
If the sleep wake cycle is disrupted it can cause metabolic dysregulation.

- Metabolic disruption
- Weight gain, obesity
- Impaired immunity
- Cognitive malfunction

Shift work
Jet lag
Sleep disorders
Poor sleep hygiene
“All-nighters”
Cyanobacteria is a photoautotrophic organism that has a self-sustained circadian rhythm. Sleep wake cycle is regulated by the circadian system.
Our metabolic clocks are based on the diurnal rhythm – it is in our genes.
Watch brain ticking

Day in the life of a cell 0-24 hours

Genes in cells cycle on and off every 24 hours
Every cell has its own clock!

Data from: David Welsh; Video: J. Takahashi (2013) https://www.youtube.com/watch?v=ocqn3wYTCRM#

SKIN CELLS

Video recorded for 42 days!
One week of insufficient sleep alters gene expression in human blood cells.

Intensifies the effects of subsequent total sleep loss on gene expression

Effects of insufficient sleep on circadian rhythmicity and expression amplitude of the human blood transcriptome


Insufficient sleep and circadian rhythm disruption are associated with negative health outcomes, but the mechanisms involved remain largely unexplored. We show (pp. E1132–E1141) that one wk of insufficient sleep alters gene expression in human blood cells, reduces the amplitude of circadian rhythms in gene expression, and intensifies the effects of subsequent acute total sleep loss on gene expression. The affected genes are involved in chromatin remodeling, regulation of gene expression, and immune and stress responses. The data imply molecular mechanisms mediating the effects of sleep loss on health and highlight the interrelationships between sleep homeostasis, circadian rhythmicity, and metabolism.

Immune and stress response
Shift workers are more prone to developing metabolic disorders

- 40% more likely to have cardiovascular disease
- Higher incidence of Diabetes Type II
- Higher risk of cancer — melatonin disruption

The Health Survey for England (2013);
Davis S, Mirick DK. Cancer Causes Control. 2006 May; 17(4):539-45.
Adapted from: Nature Neuroscience Reviews
Disruption of the Circadian Clock in Mice Increases Intestinal Permeability and Promotes Alcohol-Induced Hepatic Pathology and Inflammation

SCN is not the only clock in the body.

Intestinal activity and its ability to absorb nutrients are dependent on the time of day.

Food can be a zeitgeber for the gut.
Time of eating has a huge effect on the liver and insulin efficacy

Cellular response to INSULIN is dependent on the circadian cycle.

Glucose uptake in muscle is dependent on the circadian rhythm. 

Insulin-sensitivity is dependent on the peripheral clock in muscle cells.

Beta cells release INSULIN

Insulin stimulates the liver to remove glucose from the blood and stores it as glycogen.

Tissues take up glucose from blood.

Lowers glucose levels in blood.

Figure adapted from Kaidanovich-Beilin, O. et al. 2012.
**Glucagon** stimulates the conversion of stored glycogen in the liver into glucose.

*Figure adapted from Kaidanovich-Beilin, O. et al. 2012*
When you eat sugar determines how your body will respond.

EATING SUGAR AT NIGHT → HIGHER BLOOD SUGAR
Insulin activates insulin receptors in the brain → affects feeding behaviors, reward, body metabolism, normal emotion & cognitive behaviors.

Insulin receptors are found throughout the brain – cortex, midbrain and hypothalamus.
Diabetes is a risk factor for dementia. The risk of developing Alzheimer's disease is increased by 50 percent in people with diabetes.

Craft, S. Nat. Rev. Neurol. 8, 360–362 (2012);
Circadian rhythm disruption → Metabolic dysfunction → Insulin resistance → Alzheimer’s Disease

The circadian clock has a profound effect on the physiology and behavior of organisms.
A Single Night of Partial Sleep Deprivation Induces Insulin Resistance in Multiple Metabolic Pathways in Healthy Subjects

Esther Donga, Marieke van Dijk, J. Gert van Dijk, Nienke R. Biermasz, Gert-Jan Lammers, Klaas W. van Kralingen, Eleonara P. M. Corssmit, and Johannes A. Romijn

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Average Number of Hours of Sleep per Night

- 1960: 8+ hours
- 1995: 7 hours
- 2004: 6 hours

Are you getting enough sleep?

Imagine the benefits that would await you if you got one more hour of sleep?