Circadian Rhythms

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What are circadian rhythms?
Circadian rhythms are physical, mental, and behavioral changes that follow a 24-hour cycle. These natural processes respond primarily to light and dark and affect most living things, including animals, plants, and microbes. Chronobiology is the study of circadian rhythms. One example of a light-related circadian rhythm is sleeping at night and being awake during the day. The image to the right shows the circadian rhythm cycle of a typical teen.

What are biological clocks?
Biological clocks are organisms’ natural timing devices, regulating the cycle of circadian rhythms. They’re composed of specific molecules (proteins) that interact with cells throughout the body. Nearly every tissue and organ contains biological clocks. Researchers have identified similar genes in people, fruit flies, mice, plants, fungi, and several other organisms that make the clocks’ molecular components.

What is the master clock?
A master clock in the brain coordinates all the biological clocks in a living thing, keeping the clocks in sync. In vertebrate animals, including humans, the master clock is a group of about 20,000 nerve cells (neurons) that form a structure called the suprachiasmatic nucleus, or SCN. The SCN is in a part of the brain called the hypothalamus and receives direct input from the eyes.

The master clock coordinates biological clocks from received light. Credit: NIGMS

Circadian rhythm cycle of a typical teenager. Credit: NIGMS
**Nobel Prize**

In 2017, researchers Jeffrey C. Hall, Michael Rosbash, and Michael W. Young won the prestigious Nobel Prize for their circadian rhythms research. By studying fruit flies, which have a very similar genetic makeup to humans, they isolated a gene that helps control the body’s clock. The scientists showed that the gene produces a protein that builds up in cells overnight, then breaks down during the day. This process can affect when you sleep, how sharply your brain functions, and more. All three researchers were funded by NIGMS when these major discoveries were made.

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**Does the body make and keep its own circadian rhythms?**

Yes, natural factors in your body produce circadian rhythms. For humans, some of the most important genes in this process are the *Period* and *Cryptochrome* genes. These genes code for proteins that build up in the cell’s nucleus at night and lessen during the day. Studies in fruit flies suggest that these proteins help activate feelings of wakefulness, alertness, and sleepiness. However, signals from the environment also affect circadian rhythms. For instance, exposure to light at a different time of day can reset when the body turns on *Period* and *Cryptochrome* genes.

**How do circadian rhythms affect health?**

Circadian rhythms can influence important functions in our bodies, such as:

- Hormone release
- Eating habits and digestion
- Body temperature

However, most people notice the effect of circadian rhythms on their sleep patterns. The SCN controls the production of melatonin, a hormone that makes you sleepy. It receives information about incoming light from the optic nerves, which relay information from the eyes to the brain. When there is less light—for example, at night—the SCN tells the brain to make more melatonin so you get drowsy.

**What factors can change circadian rhythms?**

Changes in our body and environmental factors can cause our circadian rhythms and the natural light-dark cycle to be out of sync. For example:

- Mutations or changes in certain genes can affect our biological clocks.
- Jet lag or shift work causes changes in the light-dark cycle.
- Light from electronic devices at night can confuse our biological clocks.

These changes can cause sleep disorders, and may lead to other chronic health conditions, such as obesity, diabetes, depression, bipolar disorder, and seasonal affective disorder.
How are circadian rhythms related to jet lag?

When you pass through different time zones, your biological clock will be different from the local time. For example, if you fly east from California to New York, you “lose” 3 hours. When you wake up at 7:00 a.m. on the East Coast, your biological clock is still running on West Coast time, so you feel the way you might at 4:00 a.m. Your biological clock will reset, but it will do so at a different rate. It often takes a few days for your biological clock to align with a new time zone. Adjusting after “gaining” time may be slightly easier than after “losing” time because the brain adjusts differently in the two situations.

How do researchers study circadian rhythms?

Scientists learn about circadian rhythms by studying humans and by using organisms with similar biological clock genes, such as fruit flies and mice. Researchers doing these experiments control the subject’s environment by altering light and dark periods. Then they look for changes in gene activity or other molecular signals. Scientists also study organisms with irregular circadian rhythms to identify which genetic components of biological clocks may be broken.

Understanding what makes biological clocks tick may lead to treatments for jet lag, sleep disorders, obesity, mental health disorders, and other health problems. It can also improve ways for people to adjust to nighttime shift work. Learning more about the genes responsible for circadian rhythms will also help us understand more about the human body.

Learn More

NIGMS Resources

- Biological Clocks (Biomedical Beat blog posts)
- Circadian Rhythms (Pathways)
- Studying Genes (Fact sheet)
- BiblioTech CityHacks: In Search of Sleep (Interactive reading experience for grades 4–6)
- Glossary (Pronunciations and easy-to-understand definitions)

Other Resources

- Brain Basics: Understanding Sleep (NINDS, NIH)
- Circadian Rhythm and Your Health Podcast (NIEHS, NIH)
- Genes Controlling Sleep and Circadian Rhythms (NIH videocast)
- Sleep Disorders (MedlinePlus, NIH)
- Sleep Health (NHLBI, NIH)
- International Space Station Circadian Rhythms Experiment (NASA)
- Sleep Curriculum (The Partnership in Education)