

THE SCIENCE OF

SLEEP AND

DAILY RHYTHMS



Investigating Sleep

by

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RESOURCES

For online presentations of each activity and downloadable slide sets for classroom use, visit <http://www.bioedonline.org> or <http://www.k8science.org>.

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Printed in the United States of America, Second Edition.

ISBN-13: 978-1-888997-58-3

BioEdSM

Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.
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Senior Editor: James P. Denk, M.A.

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ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of Bobby R. Alford, M.D., Jeffrey P. Sutton, M.D., Ph.D., William A. Thomson, Ph.D., Laurence R. Young, Sc.D., Jeanne L. Becker, Ph.D., and Kathy Major, B.A., as well as the contributions of the following science reviewers: Mary A. Carskadon, Ph.D., Kimberly Chang, Ph.D., Charles A. Czeisler, Ph.D., M.D., David F. Dinges, Ph.D., Hans P.A. Van Dongen, Ph.D., and Kenneth P. Wright, Jr., Ph.D.

We especially thank Siobhan Banks, Ph.D., and Daniel Mollicone, Ph.D., the science reviewers for this revised and updated version of the guide. Preparation of this guide would not have been possible without the invaluable assistance of the following field test teachers: Yolanda Adams, Jeri Alloway, Vivian Ashley, Susan Babac, Henrietta Barrera, Paula Clark, Carol Daniels, Barbara Foreman, Carolyn Hopper, Susan King-Martin, Mary Helen Kirby, Sue Klein, Jacqueline McMahon, Sandra Prill, Carol Reams, Mary Ellen Reid, Sandra Saunders, Angi Signorelli, and Marcia Wutke.

This work was supported by National Space Biomedical Research Institute through NASA NCC 9-58.

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TEAMING WITH BENEFITS

by Jeffrey P. Sutton, M.D., Ph.D., Director, National Space Biomedical Research Institute (NSBRI)

Space is a challenging environment for the human body. With long-duration missions, the physical and psychological stresses and risks to



Dr. Jeffrey P. Sutton

astronauts are significant. Finding answers to these health concerns is at the heart of the National Space Biomedical Research Institute's program. In turn, the Institute's research is helping to enhance medical care on Earth.

The NSBRI, a unique partnership between NASA and the academic and industrial communities, is advancing biomedical research with the goal of ensuring a safe and productive long-term human presence in space. By developing new approaches and countermeasures to prevent, minimize and reverse critical risks to health, the Institute plays an essential, enabling role for NASA. The NSBRI bridges the research, technological and clinical expertise of the biomedical community with the scientific, engineering and operational expertise of NASA.

With nearly 60 science, technology and education projects, the NSBRI engages investigators at leading institutions across the nation to conduct goal-directed, peer-reviewed research in a team approach. Key working relationships have been established with end users, including astronauts and flight surgeons at Johnson Space Center, NASA scientists and engineers, other federal agencies, industry and international partners. The value of these

collaborations and revolutionary research advances that result from them is enormous and unprecedented, with substantial benefits for both the space program and the American people.

Through our strategic plan, the NSBRI takes a leadership role in countermeasure development and space life sciences education. The results-oriented research and development program is integrated and implemented using focused teams, with scientific and management directives that are innovative and dynamic. An active Board of Directors, External Advisory Council, Board of Scientific Counselors, User Panel, Industry Forum and academic Consortium

help guide the Institute in achieving its goals and objectives.

It will become necessary to perform more investigations in the unique environment of space. The vision of using extended exposure to microgravity as a laboratory for discovery and exploration builds upon the legacy of NASA and our quest to push the frontier of human understanding about nature and ourselves.

The NSBRI is maturing in an era of unparalleled scientific and technological advancement and opportunity. We are excited by the challenges confronting us, and by our collective ability to enhance human health and well-being in space, and on Earth.

NSBRI RESEARCH AREAS

CARDIOVASCULAR PROBLEMS

The amount of blood in the body is reduced when astronauts are in microgravity. The heart grows smaller and weaker, which makes astronauts feel dizzy and weak when they return to Earth. Heart failure and diabetes, experienced by many people on Earth, lead to similar problems.

HUMAN FACTORS AND PERFORMANCE

Many factors can impact an astronaut's ability to work well in space or on the lunar surface. NSBRI is studying ways to improve daily living and keep crewmembers healthy, productive and safe during exploration missions. Efforts focus on reducing performance errors, improving nutrition, examining ways to improve sleep and scheduling of work shifts, and studying how specific types of lighting in the craft and habitat can improve alertness and performance.

MUSCLE AND BONE LOSS

When muscles and bones do not have to work against gravity, they weaken and begin to waste away. Special exercises and other strategies to help astronauts' bones and muscles stay strong in space also may help older and bedridden people, who experience similar problems on Earth, as well as people whose work requires intense physical exertion, like firefighters and construction workers.

NEUROBEHAVIORAL AND STRESS FACTORS

To ensure astronaut readiness for space flight, preflight prevention programs are being developed to avoid as many risks as possible to individual and

group behavioral health during flight and post flight. People on Earth can benefit from relevant assessment tests, monitoring and intervention.

RADIATION EFFECTS AND CANCER

Exploration missions will expose astronauts to greater levels and more varied types of radiation. Radiation exposure can lead to many health problems, including acute effects such as nausea, vomiting, fatigue, skin injury and changes to white blood cell counts and the immune system. Longer-term effects include damage to the eyes, gastrointestinal system, lungs and central nervous system, and increased cancer risk. Learning how to keep astronauts safe from radiation may improve cancer treatments for people on Earth.

SENSORIMOTOR AND BALANCE ISSUES

During their first days in space, astronauts can become dizzy and nauseous. Eventually they adjust, but once they return to Earth, they have a hard time walking and standing upright. Finding ways to counteract these effects could benefit millions of Americans with balance disorders.

SMART MEDICAL SYSTEMS AND TECHNOLOGY

Since astronauts on long-duration missions will not be able to return quickly to Earth, new methods of remote medical diagnosis and treatment are necessary. These systems must be small, low-power, noninvasive and versatile. Portable medical care systems that monitor, diagnose and treat major illness and trauma during flight will have immediate benefits to medical care on Earth.

For current, in-depth information on NSBRI's cutting-edge research and innovative technologies, visit www.nsbri.org.

OVERVIEW

Sleeping and waking are governed by the body's "internal clock," which, in turn, is influenced by external cues. Changes in daily routines and schedules sometimes conflict with our internal clocks. Students investigate how changing the time they go to bed impacts their own sleep patterns.



ACTIVITY

INVESTIGATING SLEEP

As students learned earlier, most people go to sleep and wake up at about the same times each day. This sleep/wake cycle is regulated by a group of nerve cells inside the brain, called the suprachiasmatic nuclei, which act as a timer, or "biological clock." These cells receive time cues from the outside environment. For example, special cells in the retina (the part of the eye that has receptors for light) detect sunlight and send messages to the brain in humans and other mammals, saying, "Wake up. It's daytime." In fact, daily exposure to sunlight is an important cue to synchronize the body's sleep cycle.

SCIENCE EDUCATION CONTENT STANDARDS* GRADES 6-12

LIFE SCIENCE

- Behavior is one kind of response an organism can make to an internal or external stimulus.
- Behavioral response is a set of actions determined in part by heredity and in part from experience.

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

- The potential for accidents and the existence of hazards imposes the need for injury prevention.
- Important personal and social decisions are made based on perceptions of benefits and risks.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Observing
- Drawing conclusions

* National Research Council. 1996. National Science Education Standards. Washington, D.C., National Academies Press.

Abrupt changes in one's sleep cycle, such those caused by a new work schedule or travel across time zones, can make it difficult to fall asleep or stay awake, because external cues conflict with messages being sent by the body's internal clock. The brain says, "Sleep," but outside conditions signal, "Be active, it's morning!" Other factors that can affect, or interfere with, the sleep cycle include physical exercise, medicines, meal times and stimulants (such as caffeine in coffee, tea and soft drinks).

This activity allows students to investigate their own internal clocks. For one night, students will go to bed one hour earlier than usual. They will observe and record any impacts that this change has on their abilities to fall asleep, and on their usual wake times the next morning.

TIME

30-60 minutes to conduct initial class discussion; 30-60 minutes to summarize findings the following day

MATERIALS

Each student will need:

- Copies of student sheet

SAFETY

Always follow district and school laboratory safety procedures. It is a good idea for students to wash their hands with soap and water before and after any science activity.

Continued

A Sleep Chemical

Melatonin is a chemical messenger secreted in humans and other mammals during periods of darkness. It is an important aid in synchronizing the circadian biological clock. It also plays a role in triggering some animals' seasonal behaviors, such as coat development and hibernation.

Effects of Daylight Savings Time

In most of the US, people move their clocks ahead one hour—switching to Daylight Savings Time (DST)—in the spring and back one hour in the fall. These changes can cause temporary problems for some people because their sleeping times are changed by one hour. Recently, it has been found that there is an increase in the number of work-related accidents on the day following the switch to DST.



SETUP & MANAGEMENT

Lead a class discussion about the steps and purpose of the activity. Students will carry out their own investigations at home and report back the following day.

PROCEDURE

Day One

1. Remind students of previous activities. Ask, *Did the bean plant leaves move the same way each day? How about the animals you observed? Did their behaviors show a daily pattern? Do you do certain things at about the same time each day?* Have students refer to their sleep journals. Ask, *Do you think a biological clock regulates some of your behaviors?*
2. Explain to students that they will be investigating their own biological clocks. One night, they will go to bed one hour earlier than usual, then observe and record what happens.
3. Mention the observations that students will make: whether it was easy or hard to fall asleep at the earlier time and if they woke at the usual time the next morning. Students also should record how they felt the next day: more/less tired than normal, etc. Explain that results will vary from person to person.
4. Distribute copies of the “Sleep Observations” sheet, on which students will record their data. If possible, have each student enlist the help of a household member to observe and record the actual time the student falls asleep.

Day Two

1. Have students summarize their experiences in short paragraphs. Ask, *Did going to bed earlier make it easier or more difficult than usual to fall asleep? When you went to bed, did you notice noises and other people more or less than you usually would? How did you feel the next morning? Did you wake at your usual time?*
2. Have students share their paragraphs by reading them aloud, or by posting them in the classroom. Initiate a class discussion of the results. Point out that some students may have had difficulty falling asleep because their bodies were used to

a later bedtime. However, students may have woken at their usual times in the morning, even after receiving an extra hour of sleep, due to the programming of their internal clocks. Some students may feel better after receiving the extra sleep.

3. Discuss possible outcomes of going to bed one hour later than usual, instead of earlier. Ask, *How do you think you would feel after getting less sleep than usual? How might a reduction in sleep affect your daily life?* Initiate a class discussion about the normal amount of sleep required by people of different ages (see page 21), and the ways insufficient sleep can impair performance on both mental and physical tasks. For example, lack of sleep, like alcohol intoxication, can make physical reactions slower.

EXTENSIONS

- Have students continue with their earlier bedtimes for several days. Do they eventually become programmed to the earlier times?
- Invite another teacher or a parent who has traveled across several time zones (e.g., across the continental US, to Asia, or to Europe) to talk with the class about how he or she felt physically during the first day or two in the new location. Was it easy to sleep? Was he or she more tired or alert than usual? Did he or she have to readjust to the “normal” schedule after returning home?
- Invite a policeman, fireman or someone else who routinely works a night shift to talk to the class about how he or she has adapted to the stresses of a nocturnal work schedule.

Teens and Sleep

Teenagers’ sleep cycles often get shifted, causing their internally programmed sleep time to begin around midnight. Such shifts may make it difficult for them to get enough sleep.

Light Sensitivity

Rods and cones in the retina of the eye contain light-sensing pigments, which are very sensitive to movement (rods) and color (cones). Recently, scientists discovered a new pigment, called melanopsin, in peripheral cells of the retina. Unlike rod and cone cells, receptors cells with melanopsin detect intensity or changing levels of light. For example, when light becomes brighter in the morning, melanopsin triggers the brain’s master biological clock (suprachiasmatic nuclei) to shift into an active pattern. While rod and cone cells respond best to full spectrum white light, cells containing melanopsin respond most strongly to blue light (446-477 nanometers).

Common Sleep Disorders

Sleep disorders affect up to 70 million people in the US. Insomnia is a common sleep disorder that causes people to have difficulty falling or staying asleep. Apnea is a disorder that makes it difficult for people to breathe while asleep.

