BioEd℠

THE SCIENCE OF SLEEP AND DAILY RHYTHMS

Sleeping in Space

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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TEAMING WITH BENEFITS

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

Dr. Jeffrey P. Sutton

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

Language arts activity in which students learn from times they have had difficulty sleeping, read about how astronauts sleep in space, and write about unusual places in which they have slept. Many different factors affect the quality of sleep. Astronauts traveling in space experience many disruptions to their normal sleep patterns.

ACTIVITY

SLEEPING IN SPACE

Many factors can impact the quality of sleep, and everyone has difficulty sleeping from time to time. Excitement, anxiety or stress, consumption of stimulants or certain foods close to bedtime, unusual surroundings, noises, travel across time zones, or changes in daily schedules can make sleeping difficult. Insomnia—an ongoing inability to get enough sleep to feel rested during the day—occurs when sleep problems extend beyond a night or two. More than 50% of Americans suffer from occasional bouts of insomnia or other sleep disorders.

Astronauts may experience more disruptions of normal sleep patterns than anyone else. The intense work schedule, unusual surroundings, occasional space motion sickness, cramped work quarters, stress, and excitement of being in space all can make it difficult to sleep. In addition, many visual cues on Earth, including the normal 24-hour cycle of light and darkness that provides time cues to the body's internal clock, are different in space, or absent altogether.

Since lack of sleep can seriously affect performance on physical and mental tasks, it is important to help astronauts overcome sleeping problems. Several days before launching into space, for example, they are exposed to bright lights at specific times, a controlled environment, and programmed meal periods to help reset their bodies' internal clocks to match the schedules followed in space. Research has shown that it is possible to program humans to a day/night cycle similar to the one on Mars (24.65 Earth hours). Research to help astronauts sleep better also can help people on Earth with similar sleep problems.

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.

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

- The potential for accidents and the existence of hazards impose the need for injury prevention.

SCIENCE, HEALTH & MATH SKILLS

- Identifying common elements
- Making extensions to new situations

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

TIME

10 minutes for setup; 30 minutes to conduct activity

MATERIALS

- Copy of student sheet

SETUP & MANAGEMENT

Conduct this activity with the entire class. Students may read the story, "Sleeping in Space," individually, or they may work in teams.

Why Do We Sleep?

Scientists still are trying to answer this question. Some people believe that by slowing metabolism, sleep helps the body recover from activities carried out during waking hours, and that sleep also helps us form memories. Some animals may sleep to save energy during hours when it is too dark or too dangerous to hunt for food.

Effects of Sleeplessness

Sleeplessness diminishes mental and physical performance. Just one sleepless night can impair performance as much as being intoxicated from alcohol. In addition, we are more susceptible to the effects of drugs and alcohol when we're sleepy than when we are well-rested. Sleepiness can build up day after day, creating a sleep "debt" that may be hard to "pay back." Many nights of good sleep may be needed to recover.

Tips for Students

Students can do several things to make sure they are rested and ready to perform well in school.

- Avoid soft drinks or foods with caffeine (e.g., chocolate, some carbonated beverages, coffee, tea), especially close to bedtime. Nicotine (from smoking) and alcohol also interfere with sleep.
- Stick to a regular schedule for going to bed and waking up, and get bright light in the morning to help program your biological clock.
- Do some light exercise in the late afternoon (but not in the evening before going to bed).
- Recognize that most students need at least nine to ten hours of continuous sleep per night, and plan schedules accordingly.
- If you have trouble falling asleep, drink a glass of warm milk, which contains tryptophan, an amino acid that can aid sleep.

PROCEDURE

1. Ask students to remember an occasion when they had difficulty sleeping. Have them share their experiences with the rest of the class, and list the experiences on the board or on an overhead. Scenarios suggested by students might include: the night before an exciting event, such as a birthday party; trying to sleep in the car during a long trip; or being awakened by strange or frightening noises at night.
2. Encourage students to think carefully about the list and to identify common elements among the events. Such elements could include: sleeping in places other than home; sleeping before or after unusual events; sleeping when one's physical state is not normal (sick with an itchy rash, etc.).
3. Mention to students that they will be reading about a situation in which it is very difficult to sleep—being an astronaut in space. Ask, *Do you think astronauts can sleep as well in space as they do at home? What might be different about sleeping in space? How do you think the space station environment affects astronauts' physical and mental performance? How might microgravity—and the feeling of weightlessness experienced while orbiting Earth—affect sleep?*
4. After students have offered their comments, distribute the student sheets.
5. Students may read the essay and complete the writing extensions on their own or in small groups.
6. Allow students to share their work by having them read their paragraphs or by displaying their paragraphs somewhere in class.
7. Conduct a class discussion about the importance of getting enough sleep. Begin by telling students that when you don't get enough sleep, it can be hard to stay alert, especially if you work at night. Ask, *What could happen if someone drives or operates dangerous equipment when he or she is drowsy?* Help students understand the connection between sleep and performance on mental or physical tasks.

Photo by Kris Snibbe/*Harvard News Office*.

Certain wavelengths in the blue portion of the visible spectrum alter melatonin production, thereby affecting the human circadian rhythm. "Blue light" lamps may help to promote a more normal, healthy sleep cycle for astronauts living and working in space. On Earth, blue lighting can be modified for people with sleep disorders and to help shift workers adjust their biological clocks.

EXTENSIONS

- Have students create drawings to accompany and illustrate their paragraphs on sleeping.
- Encourage students to learn more about living and working in space by visiting websites of the National Space Biomedical Research Institute (www.nsbri.org) and NASA (www.nasa.gov); and/or have them investigate research on the relationship between sleep and performance at Harvard University's Healthy Sleep website (http://healthysleep.med.harvard.edu).
- Scientists are using mathematical models to predict alertness levels for astronauts and airplane pilots under a variety of conditions. These predictions can increase safety by enabling astronauts and pilots to know when they are most prone to mistakes caused by sleepiness. Have students think of other ways we use mathematical models to make predictions (weather predictions, stock market predictions, etc.).

ACTIVITY

Sleeping in Space

Read the article, then complete the items beneath it on a separate sheet of paper.

Have you ever slept in a sleeping bag? Maybe when you went camping or slept over at a friend's house? When astronauts sleep on the space shuttle or the International Space Station (ISS), they fasten themselves into special sleeping bags. In space, there is no "up" or "down," and the effects of gravity are minimized. As a result, astronauts feel weightless, and can sleep in any orientation. But they have to attach themselves to a seat or wall inside the crew cabin or sleeping compartment, so they don't float around and bump into something while they sleep.

Astronaut Daniel Tani, NASA ISS Expedition 16 flight engineer, sleeps while floating in his sleeping bag on the space station. It can be difficult to sleep in cramped, unfamiliar quarters.

Generally, astronauts are scheduled for eight hours of sleep each mission day. But like on Earth, they may wake up in the middle of their sleep period, or stay up late to look out the window. The excitement of being in space, motion sickness, and other factors can disrupt an astronaut's sleep pattern. Crewmembers easily can hear each other, so they may need to wear earplugs during their sleep periods.

Astronaut Michael E. Lopez-Alegria, NASA STS-113 mission specialist, is about to take his first of three spacewalks during this mission. *Could you sleep the night before your own spacewalk?*

Sleeping in the shuttle's cockpit is especially difficult because the sun "rises" every 90 minutes while the shuttle orbits Earth. The sunlight and warmth entering the cockpit window are enough to disturb a sleeper who is not wearing a blindfold. When it is time to wake up on the space shuttle, the Mission Control Center in Houston, Texas, plays music to the crew. The ISS crew must use an alarm to wake up.

Astronaut Tracy Caldwell, NASA STS-118 mission specialist, referring to checklists as she operates the shuttle's remote robotic arm. Astronauts' complex tasks require that they get enough sleep to function at their best.

Getting enough sleep is a priority for astronauts in space. Without sufficient sleep, they are more likely to make mistakes and may not perform well during their complex tasks. Researchers with the National Space Biomedical Research Institute are working to improve astronauts' sleep and scheduling of work shifts. For instance, these scientists are learning how specific types of light can increase alertness and performance in space. Their findings also will help people on Earth who have sleep problems.

1. List at least three ways in which sleeping in space is just like sleeping on Earth.

2. List at least three ways in which sleeping in space is different from sleeping on Earth.

3. Write a paragraph about the most unusual place in which you ever have slept. Include answers to the following questions.
   a. Where did you sleep?
   b. How well did you sleep?
   c. How did you feel when you woke up?
   d. Would you like to sleep there every day?

Adapted from "Space Sleep," NASA, http://space flight.nasa.gov/living/spacesleep/index.html. Photos courtesy of NASA, www.nasaimages.org.