BioEd℠

THE SCIENCE OF SLEEP AND DAILY RHYTHMS

Teacher's Guide

by

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RESOURCES

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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

All mammals, including humans and many other kinds of animals, need sleep. Most people have regular patterns of sleeping and waking times. Students collect data about their own sleep cycles and use a fraction wheel to examine their data.

ACTIVITY

SLEEP PATTERNS

All mammals—including humans and most vertebrates—sleep. In fact, we spend about one-third of our lives sleeping, but many aspects of sleep still are not understood. Once viewed as a passive shutting-down of most body systems, sleep now is believed to have important functions related to the processing of information by the brain, and the repair and maintenance of body systems. In humans, sleep is known to consist of several stages, each characterized by different levels of brain and muscle activity.

Many people vary their sleep patterns using external alarm clocks to meet school or work schedules. Without an alarm, most individuals sleep about the same number of hours and wake at about the same time each day. This occurs because humans' natural daily wake-up times are governed by an internal "clock," consisting of about 10,000 nerve cells deep inside the brain.

Even without any light or sound cues, most people sleep and wake in roughly 24-hour cycles. And while sleep patterns are stable (they change little, or very slowly), scientists have found that the amount of sleep required to be alert differs considerably from one individual to another. These differences are believed to be inherited as genetic traits.

Sleep patterns also vary by age. For instance, newborns sleep 16–18 hours each day, including several naps. At age one, children average 12–14 hours of sleep daily, including two naps. Twelve-year-olds generally sleep nine or ten hours each day, without naps. Adults sleep six to eight hours per day. The urge to nap in the afternoon is normal for all teenagers and adults, but most people override this urge by remaining active.

Sleep deprived individuals perform less effectively, remember less information, and think less clearly than those who are well rested. In some professions (truck driver, police officer, etc.), sleep deprivation can contribute to accidents. Regardless of the job, a good night's sleep is key to performing at one's best.

TIME

30 minutes to conduct initial class discussion; 3–7 days for students to collect sleep data; 30 minutes to discuss results

Continued

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, HEALTH & MATH SKILLS

- Observing
- Collecting data
- Graphing
- Drawing conclusions
- Learning to identify and practice healthy behaviors

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

A Variety of Sleep Patterns

Courtesy of OAR, NURP, NOAA.

Sleep patterns vary among different animals, but all animals rest between periods of activity. Rabbits, for example, sleep just a few minutes at a time. Dolphins have a unique form of sleep: while one half of the dolphin brain sleeps, the other half remains alert and awake. Other animals, such as cats, are crepuscular, meaning they are active at dawn, but sleepy during the day. Cats typically sleep between 13 and 16 hours per day.

MATERIALS

Each student will need:

- Sheet of heavy white paper
- Sheet of lightly-colored, heavy paper
- Drawing compass
- Protractor
- Markers (different colors)
- Pair of scissors
- Pen or pencil
- Log or journal
- Copy of student sheet

SETUP & MANAGEMENT

Begin the activity with a class discussion. Working individually, students will collect sleep data on themselves and possibly their family members. Next, working in groups of four, they will examine their data and share results.

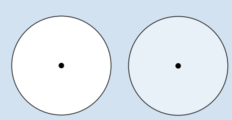
PROCEDURE

Part 1: Sleep Observations

1. Challenge the class to think about all the different things they do during a typical 24-hour period. Let each student suggest one or more activities and create a list on the board.
2. Now ask, *What activities could you leave off this list without affecting your health or how you feel? What activities must stay on the list? Why do you think so?*
3. Explain to students that they will be examining an essential activity on the list: sleep. Then, encourage them to share what they know about sleep. Ask, *When do you usually sleep? How long do you sleep? What makes you wake up?* Tell students that they will be investigating their own sleep patterns to answer the question, "Does my sleep follow a regular pattern?"
4. Have each student create a journal, or "Sleep Log," to record the times that he or she goes to sleep and wakes up each day, for a period of seven days. The Sleep Log should include: bedtime; how the student felt at bedtime; waking time; how the student felt when waking; whether the student used an alarm to wake up; and how the student felt during the day (tired, well rested, etc.). If possible, time the activity so that students are able to compare weeknight and weekend sleep patterns. Students may want to ask other members of their families to participate, and to record those family members' sleep data as well.

Part 2: Looking at Data

1. After students have completed seven days of observations, have them plot their data on the "Sleeping Patterns Graph," (p. 24), and calculate their average number of hours of sleep per night.
2. Have students share and compare their graphs and journals with other members of their groups. Help them to identify similarities, differences, and patterns in their graphs. Ask questions like, *Do most people go to bed and wake up at about the same time each day? Did you feel particularly sleepy on any day? If so, why do you think that is? Do you see anything different about the part of the graph corresponding to that day? Did you notice a difference between days you used an alarm to wake up and days you slept until you woke naturally?*
3. Ask students, *What are some other ways to represent your sleep data?* Mention that fractions can help us to represent and study data. In this case, fractions can be used to illustrate how much of each student's day is spent sleeping.
4. Have the materials managers pick up their supplies. Show students how to make a circle with the compass. Have students make a circle with a 16-cm diameter on each piece of paper, mark the center of each circle with a dot, and then cut out the circles.



5. Tell students they will divide one circle into 24 equal sections. Ask, *Why do you think the circle needs to be divided into 24 sections?* (to represent a 24-hour day). As a class, discuss how to divide

Sleep Phases

Scientists are just beginning to understand why humans sleep, and what happens when we sleep. They know that sleep consists of two different phases. One phase, called non-Rapid Eye Movement (REM) sleep, is characterized by slow brain activity, no eye movement, and very low muscle tone. The second phase of sleep, REM, is characterized by an active brain, bursts of eye movements, and paralyzed muscles (which makes it safe to dream!).

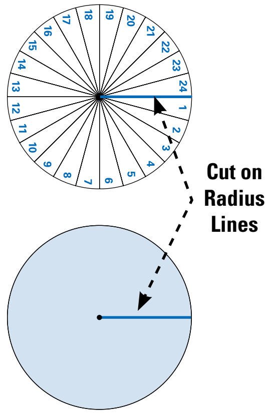
Dreams are prevalent during REM sleep. Scientists have different ideas about the purpose of dreams. Some believe the brain consolidates important (and erases unneeded) information during dreams.

Individual Needs

Some people need more sleep than others—even other members of the same family—and there is quite a bit of variability among individual responses to inadequate sleep.

A Fraction Wheel

Components



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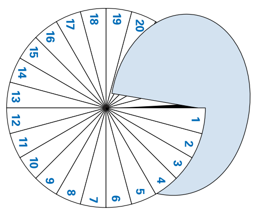


Astronauts and Sleep

Astronauts in space frequently have difficulty sleeping, partly because their internal clocks are not synchronized to the light conditions they experience during a mission, and also because the stresses of space flight and their hectic work schedules affect the quality of sleep. NSBRI and other researchers are seeking ways to address these problems. Results of their work will benefit astronauts and many people on Earth with sleep disorders.

Fraction wheel adapted by M.S. Young from *The Right Ratio of Rest*, NASA CONECT™.

the circle (see "A Fraction Wheel" illustrations, left sidebar). Have students progressively divide the circle into halves, fourths, and eighths; then use the protractor to create three equal sections of 15 degrees within each eighth. Instruct students to number the sections 1-24.

6. Have students draw and cut a radius line (line from the center point to the edge) on both circles.
7. To complete the fraction wheel, have students slip the cut line of one circle into the cut line of the other, so that the circles are joined and one circle slides around the other.
8. Ask students to set their fraction wheels to show the average number of hours of daylight within Earth's light-dark cycle (12 hours), and then write the number as a fraction (12/24). Have students identify fractions equivalent to 12/24, using the segments on their fraction wheels as a guide.
9. Have students move their fraction wheels to the average number of hours they slept per day during the previous week.
10. Remind students that fractions are only one way to represent the parts of a whole, and that fractions also can be written as a decimal or percentage. For example, the entire circle on the fraction wheel represents one day, or 24 hours, and can be written as 24/24, or 1.0 (since 24 divided by 24 is 1.0). Because 24 hours represent the entire circle, they also represent 100% of the hours in a day.
11. Conclude the activity with a class discussion of the guiding question, "Does each person's sleep follow a regular pattern?" Or, have students answer this question with a short essay in their journals. Have them include evidence to support their answers.

Astronaut Jerry Linenger, M.D., Ph.D., STS-81, NASA 4 (Mir), measures his temperature while participating in sleep experiments. He is wearing the Night Headband Monitoring System designed to record head and eyelid movement during sleep. Experiment data is downloaded to a laptop computer.

Photo courtesy of NASA.

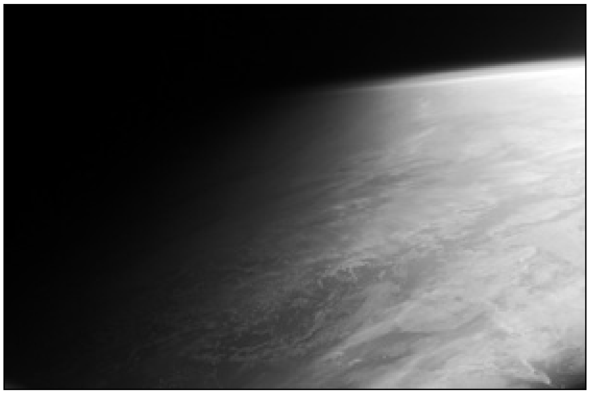
EXTENSIONS

- If students need additional practice converting fractions to decimals and percentages, have them complete an equivalency chart by writing each hour of the 24-hour cycle. For example: Hour (23), fraction (23/24), decimal (0.958), percent (96.8%).
- Have students track other essential activities in their journals, such as eating or exercising.
- Have students investigate the sleeping habits of different kinds of animals: Where do they sleep, and for how long? Do they sleep at night or during the day?
- Discuss how students' sleep patterns change when they do not have to go to school (for example, during summer). Do students stay up later? Do they wake at the same time every day? Do they sleep according to a regular schedule?
- Have students discuss the following questions in their groups. If an astronaut is orbiting Earth, how many times must he or she circle our planet to get the same amount of sleep that you get each night? If the astronaut slept the same percentage of time per day as you do, how much sleep, in minutes, would he or she get per 90 minutes? If the night/day cycle on Mars lasts about 25 hours, how many hours per day would you sleep if you lived on a space station there?

ACTIVITY

Sleeping Patterns Graph

Photo courtesy of NASA.



The Earth at Twilight. As shown in this image taken from the International Space Station, no sudden, sharp boundary marks the passage of day into night on Earth. Instead, the shadow line shows the gradual transition to darkness we experience as twilight. Darkness is just one of the cues that signal our biological clocks when it is time for us to sleep.

1. Color in the square representing your bedtime and the square corresponding to your wake time for each day recorded in your journal. Use a different color to fill in the squares between bedtimes and wake times. Fill in additional squares to represent any naps. Record dates of the week and hours slept. Notice that any given "night" will overlap between two dates.

2. Record the total number of hours slept for each 24-hour period in the table below.

Date	Hours Slept

Dates								
12:00 a.m. Midnight								
1:00 a.m.								
2:00 a.m.								
3:00 a.m.								
4:00 a.m.								
5:00 a.m.								
6:00 a.m.								
7:00 a.m.								
8:00 a.m.								
9:00 a.m.								
10:00 a.m.								
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