Sleep, Sleep Disorders, and Biological Rhythms

NIH Curriculum Supplement Series

Grades 9-12

National Institutes of Health

National Heart, Lung, and Blood Institute

Department of Health and Human Services

BSCS

Sleep, Sleep Disorders, and Biological Rhythms

under a contract from the
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National Heart, Lung, and Blood Institute

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Foreword

This curriculum supplement, from *The NIH Curriculum Supplement Series*, brings cutting-edge medical science and basic research discoveries from the laboratories of the National Institutes of Health (NIH) into classrooms. As the largest medical research institution in the United States, NIH plays a vital role in the health of all Americans and seeks to foster interest in research, science, and medicine-related careers for future generations. The NIH Office of Science Education (OSE) is dedicated to promoting science education and scientific literacy.

We designed this curriculum supplement to complement existing life science curricula at both the state and local levels and to be consistent with *National Science Education Standards*.[1] It was developed and tested by a team composed of teachers from across the country, scientists, medical experts, other professionals with relevant subject-area expertise from institutes and medical schools across the country, representatives from the NIH National Heart, Lung, and Blood Institute (NHLBI), and curriculum-design experts from Biological Sciences Curriculum Study (BSCS), SAIC, and Edge Interactive. The authors incorporated real scientific data and actual case studies into classroom activities. A three-year development process included geographically dispersed field tests by teachers and students.

The structure of this module enables teachers to effectively facilitate learning and stimulate student interest by applying scientific concepts to real-life scenarios. Design elements include a conceptual flow of lessons based on BSCS's 5E Instructional Model of Learning, multisubject integration emphasizing cutting-edge science content, and built-in assessment tools. Activities promote active and collaborative learning and are inquiry-based to help students develop problem-solving strategies and critical thinking.

This curriculum supplement comes with a complete set of materials for both teachers and students including printed materials, extensive background and resource information, and a Web site with interactive activities. This supplement is distributed at no cost to teachers across the United States. All materials may be copied for classroom use but may not be sold. We welcome feedback from our users. For a complete list of curriculum supplements, updates, availability, and ordering information, or to submit feedback, please visit our Web site at *http://science.education.nih.gov* or write to

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We appreciate the valuable contributions of the talented staff at BSCS, SAIC, and Edge Interactive. We are also grateful to the NIH scientists, advisors, and all other participating professionals for their work and dedication. Finally, we thank the teachers and students who participated in focus groups and field tests to ensure that these supplements are both engaging and effective. I hope you find our series a valuable addition to your classroom and wish you a productive school year.

Bruce A. Fuchs, Ph.D.
Director
Office of Science Education
National Institutes of Health

1 In 1996, the National Academy of Sciences released the *National Science Education Standards*, which outlines what all citizens should understand about science by the time they graduate from high school. The *Standards* encourages teachers to select major science concepts that empower students to use information to solve problems rather than stressing memorization of unrelated information.

About the National Institutes of Health

Founded in 1887, the National Institutes of Health (NIH) today is the federal focal point for medical research in the United States. Composed of separate institutes and centers, NIH is one of eight health agencies of the Public Health Service within the U.S. Department of Health and Human Services. The NIH mission is to uncover new knowledge about the prevention, detection, diagnosis, and treatment of disease and disability, from the rarest genetic disorder to the common cold. It does this through

- *Research.* Enhancing research outcomes across the medical research continuum by supporting research in NIH's own intramural laboratories as well as the research of nonfederal scientists working in universities, medical schools, hospitals, and research institutions throughout the country and abroad; communicating scientific results; promoting the efficient transfer of new drugs and other technologies; and providing effective research leadership and administration.
- *Research Training and Career Development Program*. Supporting research training and outreach designed to ensure a continuing supply of well-trained scientists.
- *Research Facilities Program*. Modernizing and improving intramural and extramural research facilities to ensure that the nation's scientists have adequate facilities in which to conduct their work.

Science education efforts by NIH and its institutes and centers are critical in ensuring the continued supply of well-trained basic research and clinical investigators, as well as the myriad professionals in the many allied disciplines who support the research enterprise. These efforts also help educate people about the scientific results so that they can make informed decisions about their own health as well as the health of the public.

This curriculum supplement is one such science education effort, done through the partnership of the NIH National Heart, Lung, and Blood Institute, the NIH Office of Science Education, and Biological Sciences Curriculum Study (BSCS).

About the National Heart, Lung, and Blood Institute

The National Heart, Lung, and Blood Institute (NHLBI) is one of 27 institutes and centers that compose the National Institutes of Health (NIH), the principal biomedical research agency of the federal government.

In 1948, the National Heart Institute was established through the National Heart Act, with a mission to support research and training in the prevention, diagnosis, and treatment of cardiovascular diseases. Twenty-four years later, Congress mandated that the Institute expand and coordinate its activities in an accelerated attack against heart, blood vessel, lung, and blood diseases. The renamed National Heart, Lung, and Blood Institute expanded its scientific areas of interest and intensified its efforts related to research and education. Over the years, these areas have grown to include high blood pressure, cholesterol, asthma, heart attack, obesity, blood disorders, nutrition, sleep, and sleep disorders.

The Institute plans, conducts, and supports a coordinated program of basic research, clinical investigations and trials, observational studies, and demonstration and education projects related to the causes, prevention, diagnosis, and treatment of heart, blood vessel, lung, and blood diseases and sleep disorders.

The translation and dissemination of research to health professionals, the public, and patients is also an important mission of NHLBI. In addition, the Institute establishes partnerships with a variety of voluntary organizations, professional associations, and international, national, and local government agencies in order to improve public health.

The National Center on Sleep Disorders Research (NCSDR) was established within the NHLBI specifically to coordinate and support NIH research, training, health-information dissemination, and other activities with respect to sleep and sleep disorders, including biological and circadian rhythms research, basic understanding of sleep, and chronobiological and other sleep-related research. The NCSDR also coordinates its activities with other federal agencies, including the other components of NIH and other public and nonprofit entities. In addition to identifying and supporting key research in sleep and sleep disorders, education programs for students, teachers, parents, and physicians are an important component of the NCSDR's mandate.

Introduction to *Sleep, Sleep Disorders, and Biological Rhythms*

Sleep is an essential life process. It is as important to our well-being as the food we eat, the water we drink, and the air we breathe. Unfortunately, it is easy to take sleep for granted. Busy people sometimes regard sleep as a waste of time. They take time away from sleep to tend to affairs of the day. Sleep deprivation is a common feature of our society, affecting children and adults alike. As a nation, we are increasingly a sleep-deprived people, and we pay a price for it.

Lack of sleep reduces our alertness, impairs our judgment, and affects our moods. Impairments to alertness and judgment due to sleep deprivation not only lead to a loss of productivity at school or work, but also contribute to increased accident rates. It is especially important that young people preparing to drive recognize the dangers of drowsy driving. To be credible, such educational messages must be based on science.

What Are the Objectives of the Module?

Sleep, Sleep Disorders, and Biological Rhythms has four objectives. The first is to help students understand the importance of sleep to our health and to understand the consequences of poor sleep or lack of sleep. By focusing on the biology of sleep, the module seeks to help students understand why good sleep hygiene is important to their lives.

The second objective is to use sleep as a way of understanding important scientific concepts. Lessons in this module help students sharpen their skills in observation, critical thinking, experimental design, and data analysis. They also make connections to other disciplines such as English, mathematics, and social science.

The third objective is to convey to students the purpose of scientific research. Ongoing research affects how we understand the world around us and gives us the foundation for improving our choices about our personal health and the health of our community. In this module, students experience how science provides evidence that can be used to understand and treat human disease. Because the mission of the National Heart, Lung, and Blood Institute includes helping the public understand the importance of sleep to their health, the Institute believes that education is an important venue for accomplishing this mission. The lessons in this module encourage students to think about the relationships among knowledge, choice, behavior, and human health in this way:

Knowledge (what is known and not known) + Choice = Power

Power + Behavior = Enhanced Human Health

The final objective of this module is to encourage students to think in terms of these relationships now and as they grow older.

Why Teach the Module?

High school biology classes offer an ideal setting to integrate many areas of student interest. In this module, students participate in activities that integrate inquiry science, human health, mathematics, and science-technology-society relationships. The real-life context of the module's classroom lessons is engaging for students, and the knowledge gained can be applied immediately to students' lives.

"I overheard a student say, 'Boy, did I learn a lot—and it was fun! I learned about EEGs, EMGs, and it was painless.'" – Field-Test Teacher

"I like the way it involves a lot of group work. The sleep diary was my favorite part because it told me something about how I sleep. This whole unit was interesting." – Field-Test Student

What's in It for the Teacher?

Sleep, Sleep Disorders, and Biological Rhythms meets many of the criteria by which teachers and their programs are assessed.

- The module is **standards based** and meets science content, teaching, and assessment standards as expressed in the *National Science Education Standards*. It pays particular attention to the standards that describe what students should know and be able to do with respect to **scientific inquiry**.
- As described on page 1, it is an **integrated** module, drawing most heavily from the subjects of science, social science, mathematics, and health.
- The module has a Web-based **technology component** on which there is an interactive database and simulations.
- Finally, the module includes built-in **assessment tools**, which are noted in each of the lessons with an assessment icon.

In addition, the module provides a means for **professional development**. Teachers can engage in new and different teaching practices, like those described in this module, without completely overhauling their entire program. In *Designing Professional Development for Teachers of Science and Mathematics*, Susan Loucks-Horsley et al.[19] write that supplemental programs such as this one "offer a window through which teachers get a glimpse of what new teaching strategies look like in action." By experiencing a short-term unit, teachers can "change how they think about teaching and embrace new approaches that stimulate students to problem solve, reason, investigate, and construct their own meaning for the content." Using a supplemental unit can encourage reflection and discussion and stimulate teachers to improve their practices by focusing on student learning through inquiry.

The following table correlates topics often included in the biology curriculum with the major concepts presented in this module. This information is presented to help teachers make decisions about incorporating this material into the curriculum.

Correlation of *Sleep, Sleep Disorders, and Biological Rhythms* to High School Biology

Topic	Pre-lesson	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Organisms maintain a dynamic equilibrium.	✔	✔	✔	✔	✔	
Organisms respond to their environment through their behavior.		✔	✔		✔	✔
Living systems share many features reflecting their common ancestry.				✔		
Science and technology influence, and are influenced by, society.						✔
The nature of science is to propose questions, gather evidence, and answer questions based on that evidence.	✔	✔	✔	✔	✔	✔

Implementing the Module

The six lessons in this module are designed to be taught in sequence for one to two weeks in high school biology. The following pages offer general suggestions about using these materials in the classroom; you will find specific suggestions in the procedures provided for each lesson.

What Are the Goals of the Module?

Sleep, Sleep Disorders, and Biological Rhythms is designed to help students develop these major goals associated with scientific literacy:

- to understand a set of basic scientific principles related to the nature and function of sleep and its effects on human health;
- to experience the process of scientific inquiry and develop an enhanced understanding of the nature and methods of science; and
- to recognize the role of science in society and the relationship between basic science and human health.

What Are the Science Concepts and How Are They Connected?

We designed the lessons in this module to move students from what they already know, or think they know, about sleep toward an understanding of the scientific bases of sleep and its importance. Students begin learning about sleep by investigating their own sleep habits and collecting data that reflect the rhythmic nature of sleepiness (*Sleep Diary*). Students then explore biological aspects of sleep, how sleep is related to health and well-being (*What Is Sleep?*), and how scientists define the active, dynamic nature of sleep (*Houston, We Have a Problem*). An investigation of environmental influences (*Do You Have Rhythm?*) allows students to consider their own sleep patterns in the context of internal and external cues. *Evaluating Sleep Disorders* gives students a chance to use information they've learned from the previous lessons in the context of diagnosing and treating various sleep disorders. The final lesson, *Sleepiness and Driving: What You Don't Know Can Kill You*, examines the impact of sleep loss on society, focusing on drowsy driving, an issue of interest and major importance to teenagers. The following two tables illustrate the science content and conceptual flow of the classroom lessons.

Science Content and the Lessons

Lesson	Science Content
Pre-lesson	Biological rhythms
Lesson 1	Biology of sleep; relationship to health
Lesson 2	Dynamic nature of sleep; sleep states
Lesson 3	Biological clocks
Lesson 4	Sleep hygiene and sleep disorders
Lesson 5	Sleep loss and consequences

Conceptual Flow of the Lessons

Lesson	Learning Focus	Major Concept
Pre-lesson Activity *Sleep Diary*	Engage*	Sleep/wake cycles vary among individuals, and daily sleepiness occurs in a rhythmic pattern.
Lesson 1 *What Is Sleep?*	Engage	Sleep is an essential, biologically motivated behavior. Adequate amounts of sleep are necessary for normal motor and cognitive function. Sleep is required for survival, and the drive to sleep is intense.
Lesson 2 *Houston, We Have a Problem*	Explore	Sleep is divided into two major states: NREM and REM. Bodily systems function in characteristic ways during wakefulness, NREM sleep, and REM sleep. Evaluating these bodily functions provides a means of determining an individual's state of wakefulness or sleep.
Lesson 3 *Do You Have Rhythm?*	Explore/Explain	Humans, and many other animals, have an internal biological clock. This clock operates on a cycle of just over 24 hours. Environmental cues, especially light, serve to reset the clock, keeping it in time with the day/night cycles. The clock directs the rhythmic secretion of hormones, such as melatonin, that influence our sleep cycle. If the biological clock gets out of phase with the environment, various types of sleep problems can result.
Lesson 4 *Evaluating Sleep Disorders*	Elaborate	Many factors affect the quality and quantity of sleep. Poor sleep hygiene and/or biological factors can lead to a variety of sleep disorders such as insomnia, narcolepsy, apnea, and restless legs syndrome. Treatments exist for most sleep disorders.
Lesson 5 *Sleepiness and Driving: What You Don't Know Can Kill You*	Evaluate	Sleep loss has a number of negative impacts on society, including loss of productivity, increased accident rates, increased vehicle crashes, and medical consequences.

*See How Does the 5E Instructional Model Promote Active, Collaborative, Inquiry-Based Learning?, on page 7.

NSES

How Does the Module Correlate to the *National Science Education Standards?*

Sleep, Sleep Disorders, and Biological Rhythms supports you in your efforts to provide science education in the spirit of the National Research Council's 1996 *National Science Education Standards (NSES)*. The content of the module is explicitly standards based: each time a lesson addresses a standard, an icon appears in the margin to identify the applicable standard. The following chart lists the specific content standards that this module addresses.

Content Standards: Grades 9–12

Standard A: As a result of activities in grades 9–12, all students should develop	**Correlation to *Sleep, Sleep Disorders, and Biological Rhythms***
Abilities necessary to do scientific inquiry	
• Identify questions and concepts that guide scientific investigations.	Pre-lesson, Lessons 1, 3
• Design and conduct a scientific investigation.	Pre-lesson, Lessons 1, 3
• Use technology and mathematics to improve investigations and communications.	Pre-lesson, Lessons 1, 2, 3
• Formulate and revise scientific explanations and models using logic and evidence.	Lessons 1, 3, 4
• Recognize and analyze alternative explanations and models.	Lessons 1, 2, 3, 4
• Communicate and defend a scientific argument.	All lessons
Understandings about scientific inquiry	
• Scientists usually inquire about how physical, living, or designed systems function.	All lessons
• Scientists conduct investigations for a wide variety of reasons, such as to discover new aspects of the natural world, to explain observed phenomenon, or to test conclusions of prior investigations or predictions of current theories.	Lessons 1, 2, 3, 4
• Scientists rely on technology to enhance gathering and manipulating data.	Lessons 1, 2, 3,
• Mathematics is essential in all aspects of scientific inquiry.	Pre-lesson, Lessons 1, 3
• Scientific explanations must adhere to criteria.	Lessons 1, 2, 3, 4
• Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists.	Pre-lesson, Lessons 1, 5
Standard C: As a result of their activities in grades 9–12, all students should develop understanding of	**Correlation to *Sleep, Sleep Disorders, and Biological Rhythms***
The cell	
• Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.	Lesson 3

The behavior of organisms	
• Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with an organism's own species and others, as well as environmental changes. These responses are either innate or learned.	All lessons
Standard F: As a result of their activities in grades 9–12, all students should develop understanding of	**Correlation to *Sleep, Sleep Disorders, and Biological Rhythms***
Personal and community health	
• Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices.	All lessons
• An individual's mood and behavior may be modified by substances. The modification may be beneficial or detrimental depending on the motives, type of substance, duration of use, pattern of use, level of influence, and short- and long-term effects. Students should understand that drugs can result in physical dependence and can increase the risk of injury, accidents, and death.	Pre-lesson, Lessons 1, 4, 5
Standard G: As a result of activities in grades 9–12, all students should develop understanding of	**Correlation to *Sleep, Sleep Disorders, and Biological Rhythms***
Science as a human endeavor	
• Individuals and teams have contributed and will continue to contribute to the scientific enterprise.	Lessons 3, 5
• Scientists have ethical traditions that value peer review, truthful reporting about methods and investigations, and making public the results of work.	Lessons 1, 3, 5
• Scientists are influenced by societal, cultural, and personal beliefs. Science is a part of society.	Lesson 5
The nature of scientific knowledge	
• Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism.	All lessons
• Scientific explanations must meet certain criteria such as consistency and accuracy.	Lessons 1, 2, 3, 4
• All scientific knowledge is subject to change as new evidence becomes available.	Lessons 1, 3, 4

Teaching Standards

The suggested teaching strategies in all the lessons support you as you work to meet the teaching standards outlined in the *National Science Education Standards*. The module helps you plan an inquiry-based science program by providing short-term objectives for students. It also includes planning tools such as the Conceptual Flow of the Lessons chart and the Suggested Timeline for teaching the module. You can use this module to update your curriculum in response to your students' interest in this topic. The focus on active, collaborative, and inquiry-based learning in the lessons helps you support the development of student understanding and nurture a community of science learners.

The structure of the lessons in this module enables you to guide and facilitate learning. All the activities encourage and support student inquiry, promote discourse among students, and challenge students to accept and share responsibility for their learning. The use of the 5E Instructional Model, combined with active, collaborative learning, allows you to respond effectively to the diversity of student backgrounds and learning styles. The module is fully annotated, with suggestions for how you can encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

Assessment Standards

You can engage in ongoing assessment of your teaching and of student learning by using the variety of assessment components embedded within the module's structure. The assessment tasks are authentic: they are similar in form to tasks in which students will engage in their lives outside the classroom or in which scientists participate. Annotations guide you to these opportunities for assessment and provide answers to questions that can help you analyze student feedback.

How Does the 5E Instructional Model Promote Active, Collaborative, Inquiry-Based Learning?

Because learning does not occur through a process of passive absorption, the lessons in this module promote active learning: students are involved in more than listening and reading. They are developing skills, analyzing and evaluating evidence, experiencing and discussing, and talking to their peers about their own understanding. Students work collaboratively with others to solve problems and plan investigations. Many students find that they learn better when they work with others in a collaborative environment than they do when they work alone in a competitive environment. When all this active, collaborative learning is directed toward inquiry science, students succeed in making their own discoveries. They ask questions, observe, analyze, explain, draw conclusions, and ask new questions. These inquiry experiences include both those that involve students in direct experimentation and those in which students develop explanations through critical and logical thinking.

This view of students as active thinkers who construct their own understanding out of interactions with phenomena, the environment, and other individuals is based on the theory of constructivism. A constructivist view of learning recognizes that students need time to

- express their current thinking;
- interact with objects, organisms, substances, and equipment to develop a range of experiences on which to base their thinking;
- reflect on their thinking by writing and expressing themselves and comparing what they think with what others think; and
- make connections between their learning experiences and the real world.

This module provides a built-in structure for creating a constructivist classroom: the 5E Instructional Model. This model sequences the learning experiences so that students can construct their understanding of a concept over time. The model takes students through five phases of learning that are easily described using five words that begin with the letter "E": Engage, Explore, Explain, Elaborate, and Evaluate. The following paragraphs illustrate how the 5Es are implemented across the lessons in this module.

Engage

Students come to learning situations with prior knowledge. This knowledge may or may not be congruent with the concepts presented in this module. Engage lessons provide the opportunity for you to find out what students already know or think they know about the topic and concepts to be developed.

The two Engage lessons in this module, Pre-lesson, *Sleep Diary*, and Lesson 1, *What Is Sleep?,* are designed to

- pique students' curiosity and generate interest;
- determine students' current understanding about sleep;
- invite students to raise their own questions about sleep, specifically their own sleep and the effects of sleep on human health;
- encourage students to compare their ideas with those of others; and
- enable you to assess what students do or do not understand about the stated outcomes of the lesson.

Explore

In the Explore phase of the module, Lesson 2, *Houston, We Have a Problem,* and Lesson 3, *Do You Have Rhythm?,* students investigate the major stages of sleep and the physiological changes that occur during sleep as compared to wakefulness. This phase requires students to make observations, evaluate and interpret data, and draw conclusions. Students

- interact with materials and ideas through classroom demonstrations and simulations;
- consider different ways to solve a problem or answer a question;
- acquire a common set of experiences with their classmates so they can compare results and ideas;
- observe, describe, record, compare, and share their ideas and experiences; and
- express their developing understanding of sleep by using graphs, analyzing simulations, and answering questions.

Explain

The Explain lesson provides opportunities for students to connect their previous experiences and to begin making conceptual sense of the main ideas of the module. This phase also allows for the introduction of formal language, scientific terms, and content information that might make students' previous experiences easier to describe and explain.

In the Explain lesson in this module, Lesson 3, *Do You Have Rhythm?*, students

- explain concepts and ideas about their own circadian rhythm (the graph of their sleepiness) in their own words;
- listen to and compare others' explanations of their results with their own;
- become involved in student-to-student discourse in which they explain their thinking to others and debate their ideas;
- revise their ideas;
- record their ideas and current understanding;
- use labels, terminology, and formal language; and
- compare their current thinking with what they previously thought.

Elaborate

In Elaborate lessons, students apply or extend the concepts to new situations and relate their previous experiences to new ones.

In the Elaborate lesson in this module, Lesson 4, *Evaluating Sleep Disorders*, students make conceptual connections between new and former experiences. They draw upon their knowledge about sleep to evaluate data and diagnose fictitious individuals who are experiencing sleep problems. In this lesson, students

- connect ideas, solve problems, and apply their understanding in a new situation;
- use scientific terms and descriptions;
- draw reasonable conclusions from evidence and data;
- add depth to their understanding of concepts and processes; and
- communicate their understanding to others.

Evaluate

The Evaluate lesson is the final stage of the instructional model, but it only provides a "snapshot" of what the students understand and how far they have come from where they began. In reality, the evaluation of students' conceptual understanding and ability to use skills begins with the Engage lesson and continues throughout each stage of the model. However, combined with the students' written work and performance of tasks throughout the module, the Evaluate lesson can serve as a summative assessment of what students know and can do.

The Evaluate lesson in this module, Lesson 5, *Sleepiness and Driving: What You Don't Know Can Kill You,* provides an opportunity for students to

- demonstrate what they understand about sleep and how well they can apply their knowledge to solve a problem;
- share their current thinking with others;
- assess their own progress by comparing their current understanding with their prior knowledge; and
- ask questions that take them deeper into a concept.

To review the relationship of the 5E Instructional Model to the concepts presented in the module, see the chart Conceptual Flow of the Lessons, on page 4.

When you use the 5E Instructional Model, you engage in practices that are nontraditional. In response, students also participate in their learning in ways that are different from those seen in a traditional classroom. The charts on pages 10 and 11, What the Teacher Does and What the Students Do, outline these differences.

How Does the Module Support Ongoing Assessment?

Because teachers will use this module in many ways and at a variety of points in their curriculum, the most appropriate mechanism for assessing student learning occurs informally throughout the lessons, rather than something that happens more formally just once at the end of the module. Accordingly, specific assessment components are integrated into the lessons. These "embedded" assessment opportunities include one or more of the following strategies:

- performance-based activities (for example, developing graphs or participating in a discussion of health effects or social policies);
- oral presentations to the class (for example, presenting experimental results); and
- written assignments (for example, answering questions or writing about demonstrations).

These strategies allow you to assess a variety of aspects of the learning process, such as students' prior knowledge and current understanding, problem-solving and critical-thinking skills, level of understanding, communication skills, and ability to synthesize ideas and apply their understanding to a new situation.

An assessment icon and an annotation that describes the aspect of learning that you can assess appear in the margin beside the step in which each embedded assessment occurs.

How Can Controversial Topics Be Handled in the Classroom?

Teachers sometimes feel that the discussion of values is inappropriate in the science classroom or that it detracts from the learning of "real" science. The lessons in this module, however, are based upon the conviction that there is much to be gained by involving students in analyzing issues of science, technology, and society. Society expects all citizens to participate in the democratic process, and our educational system must provide opportunities for students to learn to deal with contentious issues with civility, objectivity, and fairness. Likewise, students need to learn that science intersects with life in many ways.

In this module, students have a variety of opportunities to discuss, interpret, and evaluate basic science and health issues, some in the light of values and ethics. As students encounter issues about which they feel strongly, some discussions might become controversial. How much controversy develops will depend on many factors, such as how similar the students are with respect to socioeconomic status, perspectives, value systems, and religious preferences. In addition, the

What the Teacher Does

Stage	That is *consistent* with the 5E Instructional Model	That is *inconsistent* with the 5E Instructional Model
Engage	• Piques students' curiosity and generates interest • Determines students' current understanding (prior knowledge) of a concept or idea • Invites students to express what they think • Invites students to raise their own questions	• Introduces vocabulary • Explains concepts • Provides definitions and answers • Provides closure • Discourages students' ideas and questions
Explore	• Encourages student-to-student interaction • Observes and listens to the students as they interact • Asks probing questions to help students make sense of their experiences • Provides time for students to puzzle through problems	• Provides answers • Proceeds too rapidly for students to make sense of their experiences • Provides closure • Tells students that they are wrong • Gives information and facts that solve the problem • Leads students step-by-step to a solution
Explain	• Encourages students to use their common experiences and data from the Engage and Explore lessons to develop explanations • Asks questions that help students express understanding and explanations • Requests justification (evidence) for students' explanations • Provides time for students to compare their ideas with those of others and perhaps to revise their thinking • Introduces terminology and alternative explanations after students express their ideas	• Neglects to solicit students' explanations • Ignores data and information students gathered from previous lessons • Dismisses students' ideas • Accepts explanations that are not supported by evidence • Introduces unrelated concepts or skills
Elaborate	• Focuses students' attention on conceptual connections between new and former experiences • Encourages students to use what they have learned to explain a new event or idea • Reinforces students' use of scientific terms and descriptions previously introduced • Asks questions that help students draw reasonable conclusions from evidence and data	• Neglects to help students connect new and former experiences • Provides definitive answers • Tells students that they are wrong • Leads students step-by-step to a solution
Evaluate	• Observes and records as students demonstrate their understanding of concept(s) and performance of skills • Provides time for students to compare their ideas with those of others and perhaps to revise their thinking • Interviews students as a means of assessing their developing understanding • Encourages students to assess their own progress	• Tests vocabulary words, terms, and isolated facts • Introduces new ideas or concepts • Creates ambiguity • Promotes open-ended discussion unrelated to the concept or skill

What the Students Do

Stage	That is *consistent* with the 5E Instructional Model	That is *inconsistent* with the 5E Instructional Model
Engage	• Become interested in and curious about the concept/topic • Express current understanding of a concept or idea • Raise questions such as, What do I already know about this? What do I want to know about this? How could I find out?	• Ask for the "right" answer • Offer the "right" answer • Insist on answers or explanations • Seek closure
Explore	• "Mess around" with materials and ideas • Conduct investigations in which they observe, describe, and record data • Try different ways to solve a problem or answer a question • Acquire a common set of experiences so they can compare results and ideas • Compare their ideas with those of others	• Let others do the thinking and exploring (passive involvement) • Work quietly with little or no interaction with others (only appropriate when exploring ideas or feelings) • Stop with one solution • Demand or seek closure
Explain	• Explain concepts and ideas in their own words • Base their explanations on evidence acquired during previous investigations • Record their ideas and current understanding • Reflect on and perhaps revise their ideas • Express their ideas using appropriate scientific language • Compare their ideas with what scientists know and understand	• Propose explanations from "thin air" with no relationship to previous experiences • Bring up irrelevant experiences and examples • Accept explanations without justification • Ignore or dismiss other plausible explanations • Propose explanations without evidence to support their ideas
Elaborate	• Make conceptual connections between new and former experiences • Use what they have learned to explain a new object, event, organism, or idea • Use scientific terms and descriptions • Draw reasonable conclusions from evidence and data • Communicate their understanding to others • Demonstrate what they understand about the concept(s) and how well they can implement a skill	• Ignore previous information or evidence • Draw conclusions from "thin air" • Use terminology inappropriately and without understanding
Evaluate	• Compare their current thinking with that of others and perhaps revise their ideas • Assess their own progress by comparing their current understanding with their prior knowledge • Ask new questions that take them deeper into a concept or topic area	• Disregard evidence or previously accepted explanations in drawing conclusions • Offer only yes-or-no answers or memorized definitions or explanations as answers • Fail to express satisfactory explanations in their own words • Introduce new, irrelevant topics

language and attitude of the teacher factor into the flow of ideas and the quality of exchange among the students.

The following guidelines may help you facilitate discussions that balance factual information with feelings.

- Remain neutral. Neutrality may be the single most important characteristic of a successful discussion facilitator.
- Encourage students to discover as much information about the issue as possible.
- Keep the discussion relevant and moving forward by questioning or posing appropriate problems or hypothetical situations. Encourage everyone to contribute, but do not force reluctant students into the discussion.
- Emphasize that everyone must be open to hearing and considering diverse views.
- Use unbiased questioning to help the students critically examine all views presented.
- Allow for the discussion of all feelings and opinions.
- Avoid seeking consensus on all issues. The multifaceted issues that the students discuss result in the presentation of divergent views, and students should learn that this is acceptable.
- Acknowledge all contributions in the same evenhanded manner. If a student seems to be saying something for its shock value, see whether other students recognize the inappropriate comment and invite them to respond.
- Create a sense of freedom in the classroom. Remind students, however, that freedom implies the responsibility to exercise that freedom in ways that generate positive results for all.
- Insist upon a nonhostile environment in the classroom. Remind students to respond to ideas instead of to the individuals presenting those ideas.
- Respect silence. Reflective discussions often are slow. If you break the silence, students may allow you to dominate the discussion.
- At the end of the discussion, ask the students to summarize the points that they and their classmates have made. Respect students regardless of their opinion about any controversial issue.

Using the Student Lessons

The heart of this module is a set of classroom lessons. These lessons are the vehicles that we hope will convey important concepts related to sleep and its physiological functions, and biological rhythms, as well as sleep disorders and the effects of sleep deprivation. To review the concepts in detail, refer to the chart Conceptual Flow of the Lessons, found on page 4.

Format of the Lessons

As you scan the lessons, you will find that each contains several major features.

At a Glance gives you a convenient summary of the lesson.

- The **Overview** provides a short summary of student activities.
- The **Major Concepts** section states the central idea(s) that the lesson is designed to convey.
- **Objectives** lists specific understandings or abilities students should have after completing the lesson.
- **Teacher Background** specifies which sections of the Information about Sleep (pages 19–37) relate directly to the student lesson. This reading material provides you with the science content that underlies the key concepts covered in the lesson. The information provided is *not* intended to form the basis of lectures to students. Instead, it enhances your understanding of the content so that you can more accurately facilitate class discussions, answer student questions, and provide additional examples.

  In Advance provides instructions for collecting and preparing the materials required to complete the activities in the lesson.

- **Web-Based Activities** tells you which of the lesson's activities use the World Wide Web site as the basis for instruction.
- **Photocopies** lists the paper copies or transparencies that need to be made from masters, which follow the student lesson.
- **Materials** lists all the materials other than photocopies needed for each of the activities in the lesson.
- **Preparation** outlines the things you need to do to be ready to teach each of the activities in the lesson.

Procedure outlines the steps in each activity in the lesson. It provides implementation suggestions and answers to questions.

Within the procedures, annotations provide additional commentary.

- **Assessment** provides you with strategies for assessing student progress throughout the module, and is identified by an assessment icon (see page 14).
- **Icons** identify specific annotations:

NSES identifies teaching strategies that address specific science content standards as defined by the *National Science Education Standards*.

WWW identifies when to use the World Wide Web site as part of the teaching strategies. Instructions in the **Procedure** section tell you how to access the Web site. Additional information about using the Web site can be found in Using the Web Site (see page 15). A print-based alternative to Web activities is provided in case a computer with Internet access is not available.

identifies a print-based alternative to a Web-based activity to be used when computers are not available.

identifies when assessment is embedded in the module's structure. An annotation suggests strategies for assessment.

The **Lesson Organizer** provides a brief summary of the lesson. It outlines procedural steps for each activity and includes icons that denote where in each activity masters, transparencies, and the Web site are used. The lesson organizer is intended to be a memory aid for you to use only after you become familiar with the detailed procedures for the activities. It can be a handy resource during lesson preparation as well as during classroom instruction.

The **Masters** to be photocopied are found at the end of each lesson.

Timeline for the Module

The Suggested Timeline (below) outlines the optimal plan for completing the lessons in this module. The plan assumes you will teach the lessons on consecutive days. If your class requires more time for completing the procedures, discussing issues raised in this module, or completing activities on the Web site, adjust your timeline accordingly.

Suggested Timeline

Timeline	Activity
3 weeks ahead	Reserve computers Check performance of Web site
10 days ahead	**Pre-lesson** Activity: *Sleep Diary*
7 days ahead	Make photocopies Make transparencies Gather materials
Day 1 Monday	**Lesson 1** Activity 1: *What Do You Know (or Think You Know) about Sleep?*
Day 2 Tuesday	**Lesson 1** Activity 2: *Sleep Diary*
Day 3 Wednesday	**Lesson 2** Activity 1: *Houston, We Have a Problem*
Day 4 Thursday	**Lesson 3** Activity 1: *Michel Siffre Story* Activity 2: *Sleepiness Scale, Introduction to Rhythms*
Day 5 Friday	**Lesson 4** Activity 1: *Snoring—Believe It or Not!* Activity 2: *Diagnosis Unknown*
Day 6 Monday	**Lesson 5** Activity 1: *Sleepiness and Driving—What You Don't Know Can Kill You*

Using the Web Site

The
W
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of the module, engage student inter
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lessons.

Hardware/Software Requirements

The W
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Links to download the Macr
QuickT

Getting the Most Out of the Web Site

Minimum Hardware/Software Requirements for Using the Web Site

CPU/Processor (PC Intel, Mac)	Pentium 333 MHz, Power PC or faster
Operating system (DOS/Windows, Mac OS)	Windows 95/98/2000 or Mac OS 7
System memory (RAM)	64 MB or more
Screen display	800 x 600, 16 bit (65K colors)
Browser	Microsoft Internet Explorer 5.5 or Netscape Communicator 4.75 and higher
Browser settings	JavaScript enabled
Free hard drive space	10 MB
Connection speed	56 kbps
Plug-ins	Macromedia Flash Player (version 6 and higher) and QuickTime Player (version 5 and higher)
Audio	Sound card with speakers

- motivate students by helping them enjoy learning and want to learn more because it enlivens content that they otherwise might find uninteresting;
- offer unique instructional capabilities that allow students to explore topics in greater depth and in ways that are closer to actual field experience than print-based resources can offer;
- provide you with support for experimenting with new instructional approaches that allow students to work independently or in small teams and that give you increased credibility among today's technology-literate students; and
- increase your productivity by helping you with assessment, record keeping, and classroom planning and management.

The ideal use of the Web site requires one computer for each student team. However, if you have only one computer available, you can still use the Web site (for example, by using a suitable device for projecting the screen image, or by rotating student teams through the computer station to access the Web resources). If you do not have the facilities for using the Web site with your students, you can use the print-based alternative provided for those lessons.

Collaborative Groups

Many of the activities in the lessons are designed to be completed by teams of students working together. Although individual students working alone can complete these activities, this strategy will not stimulate the types of student-student interactions that are one of the goals of active, collaborative, inquiry-based learning. Therefore, we recommend that you organize collaborative teams of two to four students each, depending on the number of computers available. Students in groups larger than this will have difficulty organizing the student-computer interactions equitably, which can lead to one or two students' assuming the primary responsibility for the computer-based work. Although this type of arrangement can be efficient, it means that some students do not get the opportunity to experience the in-depth discovery and analysis that the Web site was designed to stimulate.

We recommend that that you keep your students in the same collaborative teams for all the activities in the lessons. This will allow each team to develop a shared experience with the Web site and with the ideas and issues that the activities present. A shared experience will also enhance your students' perceptions of the lessons as a conceptual whole.

If your student-to-computer ratio is greater than four students to one computer, then you will need to change the way you teach the module from the instructions in the lessons. For example, if you have only one computer available, you may want students to complete the Web-based work across an extended time period. You can do this in several ways. The most practical way is to use your computer as a center along with several other centers at which students complete other activities. In this approach, students rotate through the computer center, eventually completing the Web-based work you have assigned.

A second way to structure the lessons if you only have one computer available is to use a projection system to display the computer monitor onto a screen for the whole class to view. Giving selected students the opportunity to manipulate the Web activities in response to suggestions from the class can give students some of the same type of autonomy in their learning that they would gain from working in small teams.

Web Activities for Students with Disabilities

The Office of Science Education (OSE) is committed to providing access to the Curriculum Supplement Series for individuals with disabilities, including members of the public and federal employees. To meet this commitment, we will comply with the requirements of Section 508 of the Rehabilitation Act. Section 508 requires that individuals with disabilities who are members of the public seeking these materials will have access to and use of information and data that are comparable to those provided to members of the public who are not individuals with disabilities. The online versions of this series have been prepared to comply with Section 508.

If you use assistive technology (such as a Braille reader or a screen reader) and the format of any material on our Web sites interferes with your ability to access the information, please use the following points of contact for assistance. To enable us to respond in a manner most helpful to you, please indicate the nature of your accessibility problem, the format in which you would prefer to receive the material, the Web address of the requested material, and your contact information.

Contact us at

Curriculum Supplement Series
Office of Science Education
National Institutes of Health
6705 Rockledge Drive, Suite 700 MSC 7984
Bethesda, MD 20892-7984
ose@science.education.nih.gov

***Sleep, Sleep Disorders, and Biological Rhythms* 508-Compliant Web Activities**

Lesson, activity	For students with hearing impairment	For students with sight impairment
Lesson 1, Activity 2: *Sleep Diary*	No special considerations are required.	Students must proceed through a three-page form in the Enter Sleep Data section. The form has been set up so that a student using a screen reader can access the form. If using a screen magnifier, be aware that the Enter Sleep Data form has long selection fields that may extend beyond the range of the magnifier. Also, an alert pops up if a field is left blank. This alert may be beyond the current range of the screen magnifier. Supervision is recommended.
Lesson 2, *Houston, We Have a Problem*	Students may click on the closed-captioning icon (below) to view the captioning for the activity's introduction.  The icon is located in the top left corner of the animation after it begins playing. The text appears below the animation.	Using a screen reader, students will listen to a short introduction to the activity and then hear instructions on how to proceed. To complete the activity, students use alternate text descriptions to evaluate physiologic data and determine whether the three astronauts are asleep or awake. The astronauts can be evaluated in any order. **Note:** Students using a screen magnifier may prefer the original version of the activity. After the introduction, students can press a button to proceed to the original version of the activity.
Lesson 3, Activity 2: *Sleepiness Scale, Introduction to Rhythms*	No special considerations are required.	The tabular report data entered in "Lesson 1—What Is Sleep?" have been designed to be accessible with a screen reader. No adjustment to the procedure is necessary.

Information about Sleep

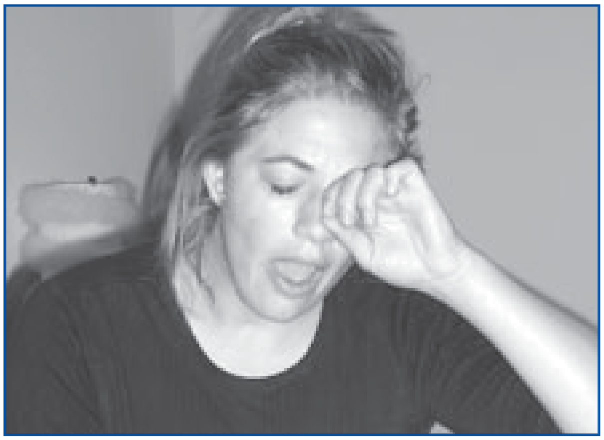


Figure 1. Problem sleepiness can have serious consequences.

1 Introduction

Sleep is a behavioral state that is a natural part of every individual's life. We spend about one-third of our lives asleep. Nonetheless, people generally know little about the importance of this essential activity. Sleep is not just something to fill time when a person is inactive. Sleep is a required activity, not an option. Even though the precise functions of sleep remain a mystery, sleep is important for normal motor and cognitive function. We all recognize and feel the need to sleep. After sleeping, we recognize changes that have occurred, as we feel rested and more alert. Sleep actually appears to be required for survival. Rats deprived of sleep will die within two to three weeks, a time frame similar to death due to starvation.[32]

It is not normal for a person to be sleepy at times when he or she expects to be awake. Problem sleepiness may be associated with difficulty concentrating, memory lapses, loss of energy, fatigue, lethargy, and emotional instability. The prevalence of problem sleepiness is high and has serious consequences, such as drowsy driving or workplace accidents and errors. Lifestyle factors and undiagnosed or untreated sleep disorders can cause problem sleepiness. Lifestyle factors include not getting enough sleep, having an irregular sleep schedule, and using alcohol or certain medications. Of the more than 70 known sleep disorders, the most common are **obstructive sleep apnea**, **insomnia**, **narcolepsy**, and **restless legs syndrome**. Large numbers of individuals suffering from these sleep disorders are unaware of—and have not been diagnosed or treated for—their disorder.[35]

Problem sleepiness may be associated with difficulty concentrating, memory lapses, loss of energy, fatigue, lethargy, and emotional instability.

Problem sleepiness can be deadly. Approximately 100,000 automobile crashes each year result from drivers who were "asleep at the wheel." In a survey of drivers in New York State, approximately 25 percent reported they had fallen asleep at the wheel at some time.[28] Crashes in which the driver falls asleep are especially common among young male drivers. One large study found that in over 50 percent of fall-asleep crashes, the driver was 25 years old or younger.[29] In addition to the high risk of automobile crashes, problem sleepiness can cause difficulties with learning, memory, thinking, and feelings, which may lead to poor school and work performance and difficulty with relationships. Furthermore, problem sleepiness leads to errors and accidents in the workplace.

Very few textbooks for high school students provide any scientific information about changes that occur in the body during sleep and how those changes affect our ability to move and think. Of course, we've heard that a good night's sleep will help us perform better on a test the next day, but is this based on scientific fact, or is it just a continuing myth? The lack of information in textbooks may be due to the fact that sleep research is only recently gaining recognition. A great deal remains to be learned through scientific studies, including an answer to the key question, What is the function of sleep? Although its function remains unclear, research is providing a great deal of information about what happens in the brain and body during sleep and how the body regulates sleep.

2 Misconceptions about Sleep

Students may have misconceptions about what causes us to sleep, what occurs during sleep, how our body responds to a lack of sleep, and what function(s) sleep fulfills. The materials in this curriculum supplement, *Sleep, Sleep Disorders, and Biological Rhythms,* should help correct the following misconceptions.

Misconception 1: Sleep is time for the body in general and the brain specifically to shut down for rest.

Sleep is an active process involving specific cues for its regulation. Although there are some modest decreases in metabolic rate, there is no evidence that any major organ or regulatory system in the body shuts down during sleep.[32] Some brain activity, including **delta waves**, increases dramatically. Also, the **endocrine system** increases secretion of certain hormones during sleep, such as growth hormone and prolactin. In **REM sleep**, many parts of the brain are as active as at any time when awake.

Misconception 2: Getting just one hour less sleep per night than needed will not have any effect on daytime functioning.

When daily sleep time is less than an individual needs, a "sleep debt" develops. Even relatively modest daily reductions in sleep time (for example, one hour) can accumulate across days to cause a sleep debt. If the debt becomes too great, it can lead to problem sleepiness. Although the individual may not realize his or her sleepiness, the sleep debt can have powerful effects on daytime performance, thinking, and mood.

The biological clock that times and controls a person's sleep/wake cycle will attempt to function according to a normal day/night schedule even when that person tries to change it.

Misconception 3: The body adjusts quickly to different sleep schedules.

The **biological clock** that times and controls a person's sleep/wake cycle will attempt to function according to a normal day/night schedule even when that person tries to change it. Those who work night shifts naturally feel sleepy when nighttime comes. A similar feeling that occurs during travel is known as jet lag. (See Major Concepts, section 3.5, on pages 26–30.) This conflict, set up by trying to be active during the brain's biological nighttime, leads to a decrease in cognitive and motor skills. The biological clock can be reset, but only by appropriately timed cues and even then, by one to two hours per day at best.[12] Problems resulting from a mismatch of this type may be reduced by behaviors such as sleeping in a dark, quiet room, getting exposure to bright light at the right time, and altering eating and exercise patterns. Because humans function best when they sleep at night and act in the daytime, the task for a person who must be active at night is to retrain the biological clock (by light cues).

Misconception 4: People need less sleep as they grow older.

Older people don't need less sleep, but they often ***get*** less sleep. That's because the ability to sleep for long periods of time and to get into the deep, restful stages of sleep decreases with age. Many older people have more fragile sleep and are more easily disturbed by light, noise, and pain than when younger. They are also more likely to have medical conditions that contribute to sleep problems.

Misconception 5: A "good night's sleep" can cure problems with excessive daytime sleepiness. Excessive daytime sleepiness can be associated with a sleep disorder or other medical condition. Sleep disorders, including sleep apnea (that is, absence of breathing during sleep), insomnia, and narcolepsy, may require behavioral, pharmacological, or even surgical intervention to relieve the symptoms.[22, 24] Extra sleep may not eliminate daytime sleepiness that may be due to such disorders.

3 Major Concepts Related to the Biology of Sleep

Research is providing a scientific foundation for understanding sleep's physiology, rhythms, and implications for our health. Although much remains to be learned, this research is clarifying a number of important issues relating to sleep.

3.1 Sleep is a dynamic process. Sleep is not a passive event, but rather an active process involving characteristic physiological changes in the organs of the body. Scientists study sleep by measuring the electrical changes in the brain using **electroencephalograms (EEGs)**. Typically, electrodes are placed on the scalp in a symmetrical pattern. The electrodes measure very small voltages that scientists think are caused by synchronized activity in very large numbers of synapses (nerve connections) in the brain's outer layers (cerebral cortex). EEG data are represented by curves that are classified according to their frequencies. The wavy lines of the EEG are called brain waves. An **electrooculogram (EOG)** uses electrodes on the skin near the eye to measure changes in voltage as the eye rotates in its socket. Scientists also measure the electrical activity associated with active muscles by using **electromyograms (EMGs)**. In this technique, electrodes are placed on the skin overlaying a muscle. In humans, the electrodes are placed under the chin because muscles in this area demonstrate very dramatic changes during the various stages of sleep.

In practice, EEGs, EOGs, and EMGs are recorded simultaneously on continuously moving chart paper or digitized by a computer and displayed on a high-resolution monitor. This allows the relationships among the three measurements to be seen immediately. The patterns of activity in these three systems provide the basis for classifying the different types of sleep.

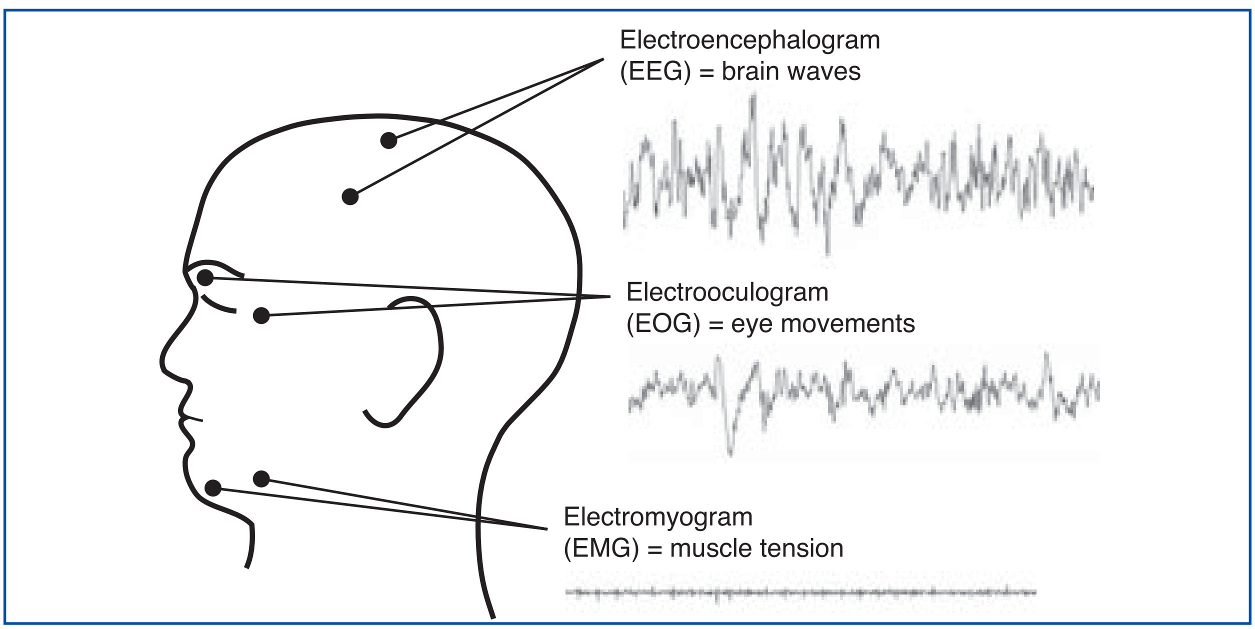


Figure 2. Placement of electrodes to determine EEG, EOG, and EMG.

Studying these events has led to the identification of two basic stages, or states, of sleep: **n**on–**r**apid **e**ye **m**ovement (**NREM**) and **r**apid **e**ye **m**ovement (**REM**). [15, 38]

Sleep is a highly organized sequence of events that follows a regular, cyclic program each night. Thus, the EEG, EMG, and EOG patterns change in predictable ways several times during a single sleep period. NREM sleep is divided into four stages according to the **amplitude** and **frequency** of brain wave activity. In general, the EEG pattern of NREM sleep is slower, often more regular, and usually of higher voltage than that of wakefulness. As sleep gets deeper, the brain waves get slower and have greater amplitude. NREM Stage 1 is very light sleep; NREM Stage 2 has special brain waves called **sleep spindles** and **K complexes**; NREM Stages 3 and 4 show increasingly more high-voltage slow waves. In NREM Stage 4, it is extremely hard to be awakened by external stimuli. The muscle activity of NREM sleep is low, but the muscles retain their ability to function. Eye movements normally do not occur during NREM sleep, except for very slow eye movements, usually at the beginning. The body's general physiology during these stages is fairly similar to the wake state. **In this module, we will emphasize NREM sleep in general and not its individual substages.**

The EEG recorded during REM sleep shows very fast and desynchronized activity that is more random than that recorded during NREM sleep. It actually looks similar to the EEG (low voltage with a faster mix of frequencies) from when we are awake. REM sleep is characterized by bursts of rapid eye movements. The eyes are not constantly moving, but they dart back and forth or up and down. They also stop for a while and then jerk back and forth again. Always, and just like waking eye movements, both eyes move together in the same direction. Some scientists believe that the eye movements of REM sleep relate to the visual images of dreams, but why they exist and what function they serve, if any, remain unknown. Additionally, while muscle tone is normal in NREM sleep, we are almost completely paralyzed in REM sleep. Although the muscles that move our bodies go limp, other important muscles continue to function in REM sleep. These include the heart, diaphragm, eye muscles, and smooth muscles such as those of the intestines and blood vessels. The paralysis of muscles in the arms and legs and under the chin show electrical silence in REM sleep. On an EMG, the recording produces a flat line. Small twitches can break through this paralysis and look like tiny blips on the flat line.

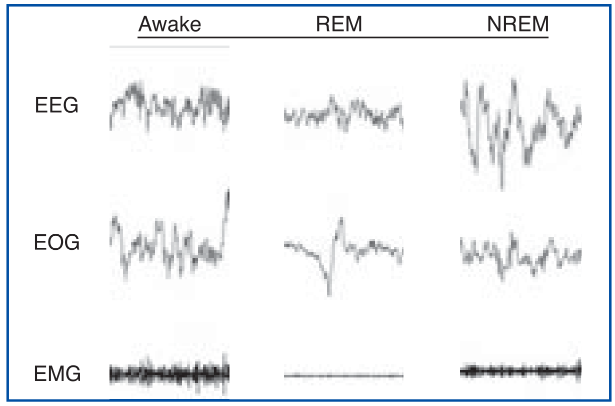


Figure 3. *Characteristic EEG, EOG, and EMG patterns for wakefulness, REM sleep, and NREM sleep. Each of the nine patterns was made over a period of about three seconds.*

Sleep is a cyclical process. During sleep, people experience repeated cycles of NREM and REM sleep, beginning with an NREM phase. This cycle lasts approximately 90 to 110 minutes and is repeated four to six times per night. As the night progresses, however, the amount of deep NREM sleep decreases and the amount of REM sleep increases. Figure 3 graphically depicts the pattern of cycling we experience. The term **ultradian rhythm** (that is, rhythm occurring within a period of less than 24 hours) is used to describe this cycling through sleep stages.

The chart in Figure 4 is called a **hypnogram**. Hypnograms were developed to summarize the voluminous chart recordings of electrical activities (EEG, EOG, and EMG) collected during a night's sleep. Hypnograms provide a simple way to display information originally collected on many feet of chart paper or stored as a large file on a computer.

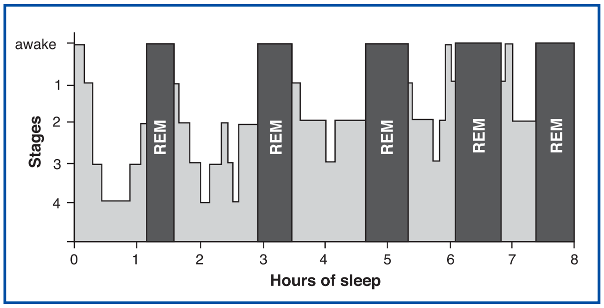


Figure 4. A typical hypnogram from a young, healthy adult. Light-gray areas represent non–rapid eye movement (NREM) sleep.

We can make several observations about the hypnogram in Figure 4. First, the periods of NREM and REM sleep alternate during the night. Second, the deepest stages of NREM sleep occur in the first part of the night. Third, the episodes of REM sleep are longer as the night progresses. This hypnogram also indicates two periods during the night when the individual awakened (at about six and seven hours into the night).

It is useful to distinguish between sleep and the state induced during general **anesthesia** or seen in people who are in a coma. While these latter individuals are often said to be "asleep," their conditions are not readily reversible (that is, they cannot be awakened by a strong stimulus), and they do not exhibit the same brain wave patterns characteristic of true sleep.

3.2 Physiological changes during sleep. Table 1 summarizes some basic physiological changes that occur in NREM and REM sleep.

Table 1. Comparison of Physiological Changes During NREM and REM Sleep

Physiological Process	During NREM	During REM
brain activity	decreases from wakefulness	increases in motor and sensory areas, while other areas are similar to NREM
heart rate	slows from wakefulness	increases and varies compared with NREM
blood pressure	decreases from wakefulness	increases (up to 30 percent) and varies from NREM
blood flow to brain	does not change from wakefulness in most regions	increases by 50 to 200 percent from NREM, depending on brain region
respiration	decreases from wakefulness	increases and varies from NREM, but may show brief stoppages (apnea); coughing suppressed
airway resistance	increases from wakefulness	increases and varies from wakefulness
body temperature	is regulated at lower set point than wakefulness; shivering initiated at lower temperature than during wakefulness	is not regulated; no shivering or sweating; temperature drifts toward that of the local environment
sexual arousal	occurs infrequently	increases from NREM (in both males and females)

The functions of many organ systems are also linked to the sleep cycle, as follows:

- *Endocrine system*. Most hormone secretion is controlled by the circadian clock or in response to physical events. Sleep is one of the events that modify the timing of secretion for certain hormones. Many hormones are secreted into the blood during sleep. For example, scientists believe that the release of growth hormone is related in part to repair processes that occur during sleep. **Follicle stimulating hormone** and **luteinizing hormone**, which are involved in maturational and reproductive processes, are among the hormones released during sleep. In fact, the sleep-dependent release of luteinizing hormone is thought to be the event that initiates puberty. Other hormones, such as thyroid-stimulating hormone, are released prior to sleep.
- *Renal system*. Kidney filtration, plasma flow, and the excretion of sodium, chloride, potassium, and calcium all are reduced during both NREM and REM sleep. These changes cause urine to be more concentrated during sleep.
- *Alimentary activity*. In a person with normal digestive function, gastric acid secretion is reduced during sleep. In those with an active ulcer, gastric acid secretion is actually increased. In addition, swallowing occurs less frequently.

3.3 Sleep and the brain. Sleep is actively generated in specific brain regions. These sites have been identified through studies involving electrical stimulation, damage to specific brain regions, or other techniques that identify sleep-inducing sites. The basal forebrain, including the **hypothalamus**, is an important region for controlling NREM sleep and may be the region keeping track of how long we have been awake and how large our sleep debt is. The brainstem region known as the **pons** is critical for initiating REM sleep. As depicted in Figure 5, during REM sleep, the pons sends signals to the visual nuclei of the thalamus and to the cerebral cortex (this region is responsible for most of our thought processes). The pons also sends signals to the spinal cord, causing the temporary paralysis that is characteristic of REM sleep. Other brain sites are also important in the sleep process. For example, the thalamus generates many of the brain rhythms in NREM sleep that we see as EEG patterns.

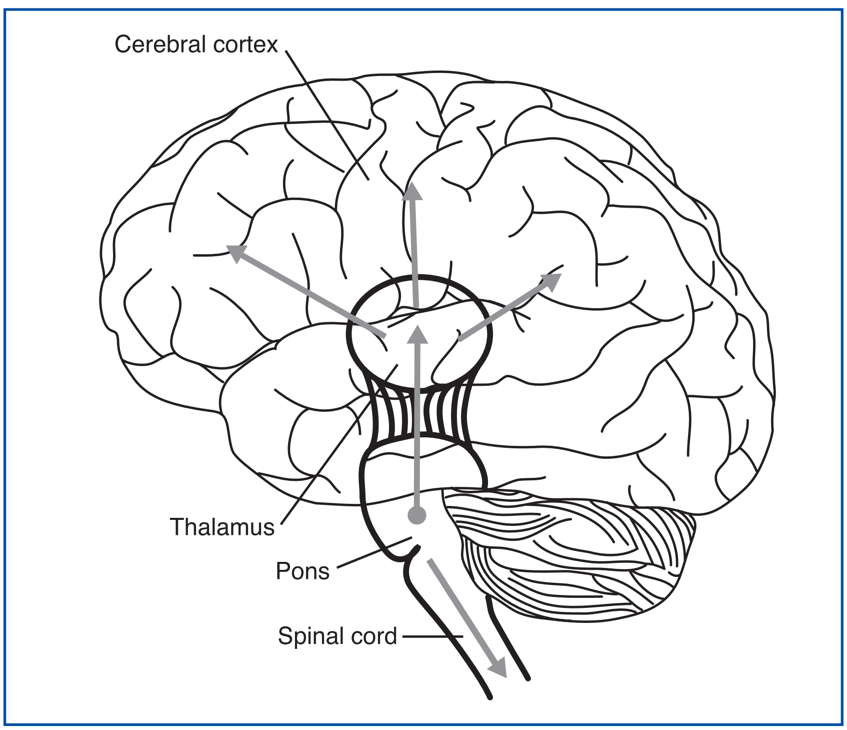


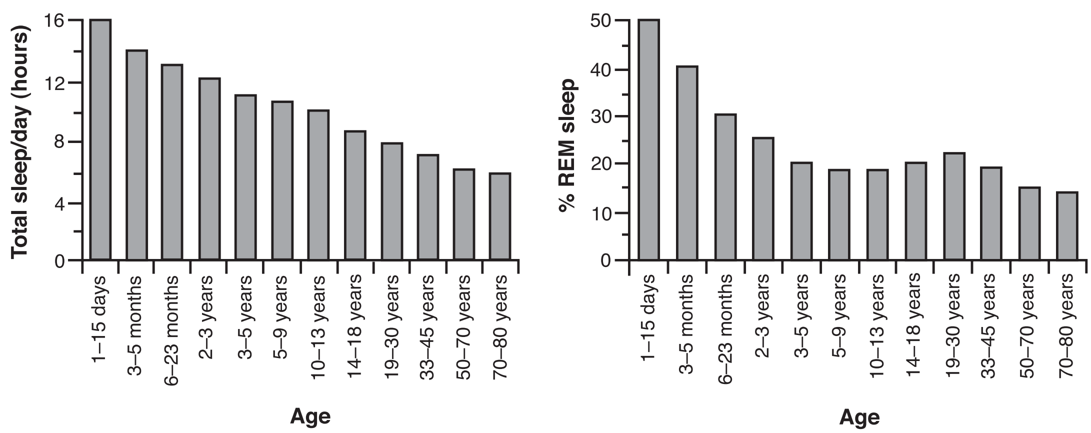
Figure 5. *Pathways of brain activity during REM sleep.*

*3.4 **Sleep patterns.*** Sleep patterns change during an individual's life. In fact, age affects sleep more than any other natural factor. Newborns sleep an average of 16 to 18 hours per day. By the time a child is three to five years old, total sleep time averages 10 to 12 hours, and then it further decreases to 7 to 8 hours per night by adulthood. One of the most prominent age-related changes in sleep is a reduction in the time spent in the deepest stages of NREM (Stages 3 and 4) from childhood through adulthood. In fact, this change is prominent during adolescence, when about 40 percent of this activity is lost and replaced by Stage 2 NREM sleep. In addition to these changes, the percentage of time spent in REM sleep also changes during development. Newborns may spend about 50 percent of their total sleep time in REM sleep. In fact, unlike older children and adults, infants fall asleep directly into REM sleep. Infant sleep cycles generally last only 50 to 60 minutes. By two years of age, REM sleep accounts for 20 to 25 percent of total sleep time, which remains relatively constant throughout the remainder of life.[15] Young children have a high arousal threshold, which means they can sleep through loud noises, especially in the early part of the night. For example, one study showed that 10-year-olds were undisturbed by a noise as loud as the sound of a jet airplane taking off nearby.

Although most humans maintain REM sleep throughout life, brain disorders like Alzheimer's and Parkinson's are characterized by decreasing amounts of REM sleep as the diseases progress. Also, elderly individuals exhibit more variation in the duration and quality of sleep than do younger adults. Elderly people may also exhibit increased sleep fragmentation (arousals from sleep that occur as either short or more extended awakenings). Figure 6 depicts these developmental changes in sleep patterns.

Teenagers, on average, require about nine or more hours of sleep per night to be as alert as possible when awake.

Several issues are important to consider. First, individual sleep needs vary. For instance, eight hours of sleep per night appears to be optimal for most adults, although some may need more or less. Teenagers, on average, require about nine or more hours of sleep per night to be as alert as possible when awake. If sleep needs are not met, a



Data from Roffwarg, H.P., J.N. Muzic, and W.C. Dement. 1966. Ontogenetic development of the human sleep-dream cycle. *Science,* 152: 604–619.

Figure 6. *Average sleep need (left graph) and percentage of REM sleep (right graph) at different ages.*

progressive sleep debt occurs and eventually the body requires that the debt be paid. It does not appear that we are able to adapt to getting less sleep than our bodies require. Not getting enough sleep, while still allowing us to function in a seemingly normal manner, does impair motor and cognitive functions. Caffeine and other stimulants cannot substitute for sleep, but they do help to counteract some of the effects of sleep deprivation.

*3.5 **Biological clock.*** An internal biological clock regulates the timing for sleep in humans. The activity of this clock makes us sleepy at night and awake during the day. Our clock cycles with an approximately 24-hour period and is called a **circadian** clock (from the Latin roots *circa* = about and *diem* = day). In humans, this clock is located in the **suprachiasmatic nucleus (SCN)** of the hypothalamus in the brain (see Figure 7). [21] The SCN is actually a very small structure consisting of a pair of pinhead-size regions, each containing only about 10,000 neurons out of the brain's estimated 100 billion neurons.

Biological clocks are genetically programmed physiological systems that allow organisms to live in harmony with natural rhythms, such as day/night cycles and the changing of seasons. The most important function of a biological clock is to regulate overt biological rhythms like the sleep/wake cycle. The biological clock is also involved in controlling seasonal reproductive cycles in some animals through its ability to track information about the changing lengths of daylight and darkness during a year.

Biological rhythms are of two general types. **Exogenous rhythms** are directly produced by an external influence, such as an environmental cue. They are not generated internally by the organism itself, and if the environmental cues are removed, the rhythm ceases. **Endogenous rhythms**, by contrast, are driven by an internal, self-sustaining bio-

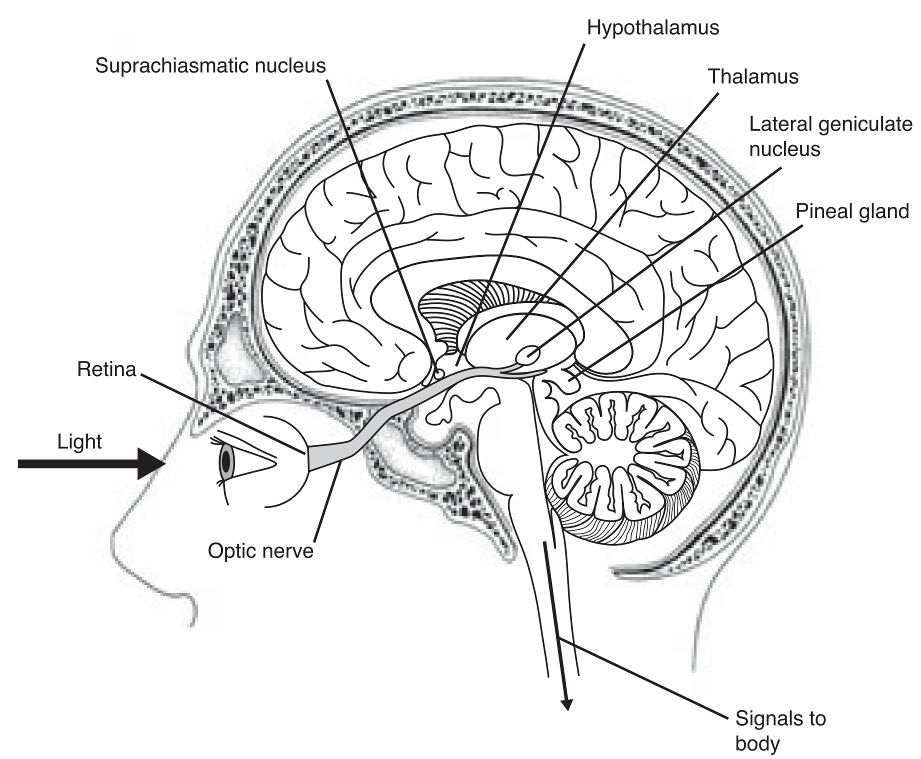


***Figure 7.** The biological clock is located within the suprachiasmatic nucleus in the brain.*

logical clock rather than by anything external to the organism. Biological rhythms, such as **oscillations** in core body temperature, are endogenous. They are maintained even if environmental cues are removed.

Because the circadian clock in most humans has a natural day length of just over 24 hours, the clock must be entrained, or reset, to match the day length of the environmental photoperiod (that is, the light/dark, or day/night, cycle).

Because the circadian clock in most humans has a natural day length of just over 24 hours, the clock must be **entrained**, or reset, to match the day length of the environmental **photoperiod** (that is, the light/dark, or day/night, cycle). The cue that synchronizes the internal biological clock to the

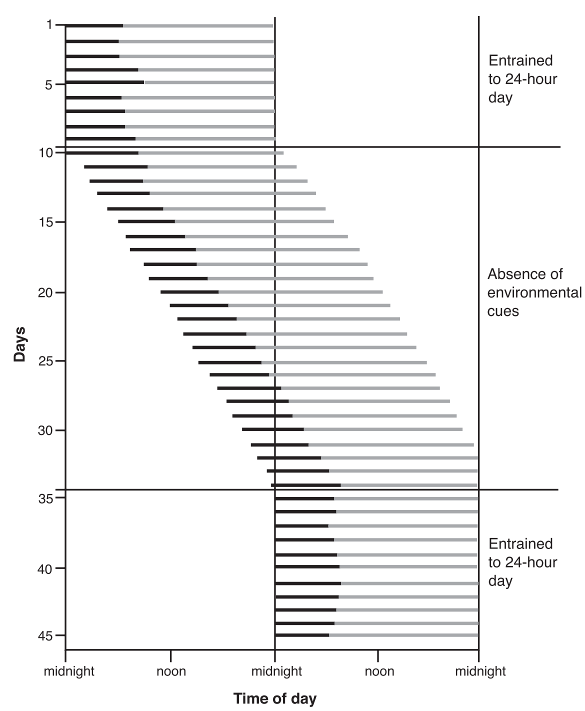


Figure 8. Entrainment of the biological clock. Black bars, asleep; gray bars, awake.

environmental cycle is light. **Photoreceptors** in the retina transmit light-dependent signals to the SCN. Interestingly, our usual visual system receptors, the rods and cones, are apparently not required for this photoreception.[9] Special types of retinal ganglion cells are photoreceptive, project directly to the SCN, and appear to have all the properties required to provide the light signals for synchronizing the biological clock.[3] At the SCN, the signal interacts with several genes that serve as "pacemakers."

Endogenous sleep rhythms can be depicted graphically. Figure 8 shows a day-by-day representation of one individual's sleep/wake cycle. The black lines indicate periods of sleep, and the gray lines indicate periods of wakefulness. The upper portion of the figure (days 1 through 9) represents this individual's normal sleep/wake cycle. Under these conditions, the individual is exposed to regularly timed exposure to alternating daylight and darkness, which has entrained this person's sleep/wake cycling to a period of 24 hours.

Contrast this upper portion of the figure with the middle portion (days 10 through 34). In the middle portion, this individual has been isolated from normal environmental cues like daylight, darkness, temperature variation, and noise variation. There are two important points to be derived from this portion of the figure. First, this individual's sleep/wake cycle continues to oscillate in the absence of external cues, stressing that this rhythm is endogenous, or built in. Second, in the absence of external cues to entrain circadian rhythms, this individual's clock cycles with its own natural, built-in rhythm that is just over 24 hours long. Consequently, without environmental cues, the individual goes to bed about one hour later each night. After 24 days, the individual is once again going to bed at midnight. The lower portion of Figure 8 depicts the change in the sleep/wake cycle after the individual is once again entrained to a 24-hour day containing the proper environmental cues.

Another interesting rhythm that is controlled by the biological clock is the cycle of body temperature, which is lowest in the biological night and rises in the biological daytime. This fluctuation persists even in the absence of sleep. Activity during the day and sleep during the night reinforce this cycle of changes in body temperature, as seen in Figure 9.

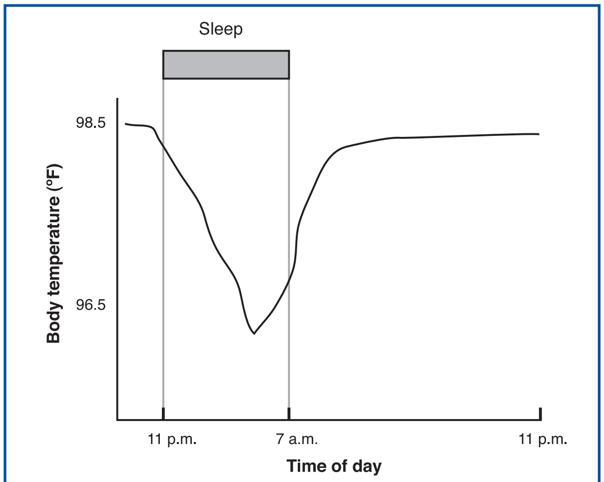


Figure 9. Body temperature in relation to the sleep cycle.

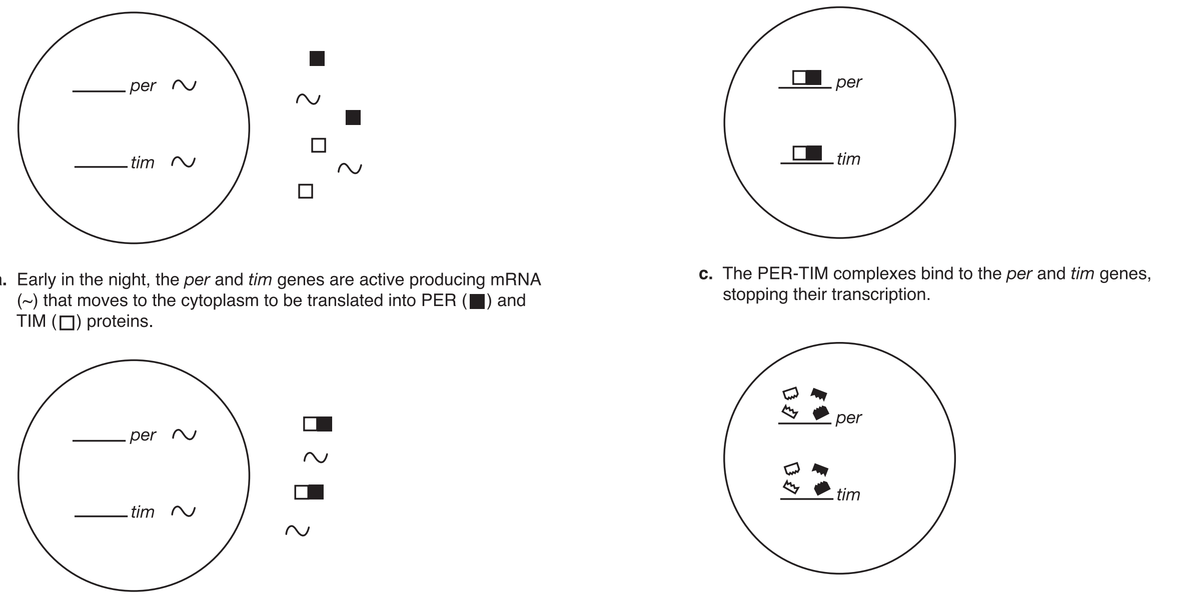
The release of **melatonin**, a hormone produced by the pineal gland, is controlled by the circadian clock in the SCN. Its levels rise during the night and decline at dawn in both **nocturnal** and **diurnal** species. Melatonin has been called the hormone of darkness because of this pattern. The SCN controls the timing of melatonin release; melatonin then feeds back on the SCN to regulate its activity. In mammals, for example, most of the brain receptors for melatonin are located in the SCN. Research has demonstrated that administering melatonin can produce shifts in circadian rhythms in a number of species including rats, sheep, lizards, birds, and humans. These effects are most clearly evident when melatonin is given in the absence of light input. Thus, for example, giving melatonin to blind people can help set their biological clocks. Melatonin is available as an over-the-counter nutritional supplement. Although claims are made that the supplement promotes sleep, the evidence for this is inconclusive. Potential side effects of long-term administration of melatonin remain unknown, and its unsupervised use by the general public is discouraged.

In addition to synchronizing these daily rhythms, biological clocks can affect rhythms that are longer than 24 hours, especially seasonal rhythms. Some vertebrates have reproductive systems that are sensitive to day length. These animals can sense changes in day length by the amount of melatonin secreted. The short days and long nights of winter turn off the reproductive systems of hamsters, while in sheep the opposite occurs. The high levels of melatonin that inhibit reproduction in hamsters stimulate the reproductive systems of sheep, so they breed in winter and give birth in the spring.

Biological clocks exist in a wide range of organisms, from **cyanobacteria** (blue-green algae) to humans. Clocks enable organisms to adapt to their surroundings. Although scientists currently believe that clocks arose through independent evolution and may use different clock proteins, they all share several regulatory characteristics. In particular, they are maintained by a biochemical process known as a negative feedback loop.

Much of what is known about clock regulation has come from studying the fruit fly *Drosophila melanogaster*, from which biological clock genes were first cloned. Two genes called *period (per)* and *timeless (tim)* were found to cycle with a 24-hour, or circadian, rhythm.[8, 12] The genes are active early in the night and produce mRNA that is then translated into the proteins PER and TIM. These proteins begin to accumulate in the **cytoplasm.** After the proteins have reached high enough levels, PER protein binds to TIM protein, forming a complex that enters the cell's nucleus. In the nucleus, the PER-TIM complexes bind to the *per* and *tim* genes to suppress further transcription. This creates what is called a negative feedback loop. After a while, the PER and TIM proteins degrade, and transcription from the *per* and *tim* genes begins again.

This description of *Drosophila's* clock is a simplified one. Other genes have been identified that produce proteins involved with regulating the circadian clock. For example, the proteins CLOCK, CYCLE, and VRILLE are transcription factors that regulate expression of the *per* and *tim* genes. Other



a. Early in the night, the *per* and *tim* genes are active producing mRNA (~) that moves to the cytoplasm to be translated into PER (■) and TIM (□) proteins.

b. The PER and TIM proteins bind to each other to form a complex (□■) that enters the nucleus.

c. The PER-TIM complexes bind to the *per* and *tim* genes, stopping their transcription.

d. Eventually, the PER-TIM complexes break down and the *per* and *tim* genes become active again.

Figure 10. In the fruit fly, the biological clock is largely controlled by two genes called per *and* tim*, whose expression cycles with an approximately 24-hour period. This cycling of gene expression is controlled by a process called a negative feedback loop.*

proteins, like the enzymes DOUBLE-TIME and SHAGGY, can alter the periodicity of the clock through chemical modification (phosphorylation) of PER and TIM. Mutations have been identified in clock genes that speed up, slow down, or eliminate the periodicity of the circadian clock in flies. Interestingly, similar genes and proteins have been identified in mammals, and studies indicate that the mammalian clock is regulated in much the same way as that of the fly.[8, 10, 11, 33] Developmental changes in the circadian clock occur from infancy to childhood to adolescence, and further changes occur as adults age. Very little is known about specific genes and mediators responsible for the normal development of the circadian clock.

Jet lag results from the inability of our circadian clock to make an immediate adjustment to the changes in light cues that come from a rapid change in time zone.

One negative consequence of our circadian cycle afflicts travelers who rapidly cross multiple time zones. Jet lag produces a number of unwanted effects including excessive sleepiness, poor sleep, loss of concentration, poor motor control, slowed reflexes, nausea, and irritability. Jet lag results from the inability of our circadian clock to make an immediate adjustment to the changes in light cues that an individual experiences when rapidly crossing time zones. After such travel, the body is in conflict. The biological clock carries the rhythm entrained by the original time zone, even though the clock is out of step with the cues in the new time zone. This conflict between external and internal clocks and signals is called **desynchronization**, and it affects more than just the sleep/wake cycle. All the rhythms are out of sync, and they take a number of days to re-entrain to the new time zone. Eastward travel generally causes more severe jet lag than westward travel, because traveling east requires that we shorten our day and adjust to time cues occurring earlier than our clock is used to. In general, the human circadian clock appears better able to adjust to a longer day than a shorter day. For example, it is easier for most people to adjust to the end of daylight savings time in the fall when we have one 25-hour day than to the start of daylight savings time in the spring, when we have a 23-hour day. Similarly, traveling from the West Coast of the United States to the East Coast produces a loss of three hours —a 21-hour day. Thus, travelers may find it difficult to sleep because of the three-hour difference between external cues and their internal clock. Likewise, travelers may find it difficult to awaken in the morning. We may try to go to sleep and wake up at our usual local times of, say, 11 p.m. and 7 a.m., but to our brain's biological clock, the times are 8 p.m. and 4 a.m. Other circadian rhythm problems include

- *Monday morning blues*. By staying up and sleeping in an hour or more later than usual on the weekends, we provide our biological clock different cues that push it toward a later nighttime phase. By keeping a late sleep schedule both weekend nights, our internal clock becomes two hours or more behind our usual weekday schedule. When the alarm rings at 6:30 a.m. on Monday, our body's internal clock is now set for 4:30 a.m. or earlier.
- *Seasonal affective disorder (SAD)*. A change of seasons in autumn brings on both a loss of daylight savings time (fall back one hour) and a shortening of the daytime. As winter progresses, the day length becomes even shorter. During this season of short days and long nights, some individuals develop symptoms similar to jet lag but more severe. These symptoms include decreased appetite, loss of concentration and focus, lack of energy, feelings of depression and despair, and excessive sleepiness. Too little bright light reaching the biological clock in the SCN appears to bring on this recognized form of depression in susceptible individuals. Consequently, treatment often involves using light therapy.
- *Shift work*. Unlike some animals, humans are active during daylight hours. This pattern is called diurnal activity. Animals that are awake and active at night (for example, hamsters) have what is known as nocturnal activity. For humans and other diurnally active animals, light signals the time to awake, and sleep occurs during the dark. Modern society, however, requires that services and businesses be available 24 hours a day, so some individuals must work the night shift. These individuals no longer have synchrony between their internal clocks and external daylight and darkness signals, and they may experience mental and physical difficulties similar to jet lag and SAD.

3.6 Homeostasis and sleep. The relationship of circadian rhythms to sleep is relatively well understood. Continuing studies in genetics and molecular biology promise further advances in our knowledge of how the circadian clock works and how a succession of behavioral states adapt to changes in light/dark cycles. In addition to the circadian component, there is a fundamental regulatory process involved in programming sleep. Consider that the longer an individual remains awake, the stronger the desire and need to sleep become. This pressure to sleep defines the **homeostatic** component of sleep. The precise mechanism underlying the pressure that causes us to feel a need to sleep remains a mystery. What science does know is that the action of nerve-signaling molecules called **neurotransmitters** and of nerve cells (neurons) located in the brainstem and at the base of the brain determines whether we are asleep or awake. Additionally, there is recent evidence that the molecule adenosine (composed of the base adenine linked to the five-carbon sugar ribose) is an important sleepiness factor: it appears to "keep track" of lost sleep and may induce sleep. Interestingly, caffeine binds to and blocks the same cell receptors that recognize adenosine.[21, 30] This suggests that caffeine disrupts sleep by binding to adenosine receptors and preventing adenosine from delivering its fatigue signal. The homeostatic regulation of sleep helps

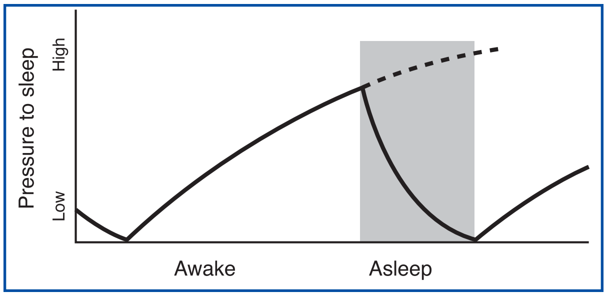


Figure 11. Homeostatic regulation of sleep: the pressure to sleep grows stronger across the day as one stays awake and then dissipates when one sleeps at night (shaded area). Sleep pressure increases (dashed line) as one stays awake longer into the normal sleeping hours.

reinforce the circadian cycle. We usually sleep once daily because the homeostatic pressure to sleep is hard to resist after about 16 hours, and then while we sleep, our closed eyes block the light signals to the biological clock. See Figure 11.

*3.7. **Dreams.*** An intriguing occurrence during sleep is dreaming. Although reports of dreaming are most frequent and vivid when an individual is aroused from REM sleep, dreams do occur at sleep onset and during NREM sleep as well.[23] During an average night's sleep, about two hours are spent dreaming, mostly during REM sleep. Although some dreams are memorable because of their extraordinary or bizarre nature, other dreams reflect realistic experiences. Despite this realism, REM dreams are usually novel experiences, like a work of fiction, instead of a replay of actual events. Pre-sleep stimuli do not seem to affect dream content. In fact, the source of the content of any given dream is unknown. REM sleep and dreams are associated with each other, but they are not synonymous. While REM sleep is turned on and off by the pons (see section *3.3 Sleep and the brain*, page 24), two areas in the cerebral hemispheres (areas far from the pons that control higher mental functions) regulate dreaming.

REM sleep and dreaming can be dissociated from one another, as seen after the administration of certain drugs or in cases of brain damage either to the pons (loss of REM sleep but not of dreaming) or to the frontal areas (no dreaming but REM sleep cycle unaffected). Consequently, REM sleep appears to be just one of the triggers for dreaming. Using scanning techniques that assess brain activity, scientists have determined which areas of the brain are active during REM sleep dreaming.[4, 14] These areas are illustrated in Figure 12. Brain regions that are inactive during dreaming include those that regulate intelligence, conscious thought, and higher-order reasoning. Higher-order

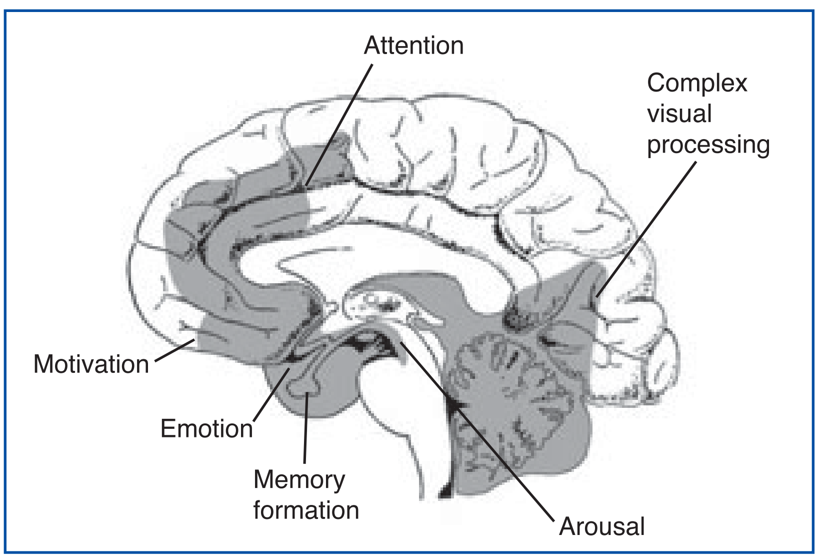


Figure 12. Areas of the brain active during REM sleep dreaming.

reasoning is that part of brain function responsible for processing experiences into memory and regulating vision while we are awake. The significance of dreaming to one's health and the meaning of dreams remain mysteries.

Scientists still do not fully understand the functions of sleep.

3.8 Functions of sleep. Animal studies have demonstrated that sleep is essential for survival. Consider studies that have been performed with laboratory rats. While these animals will normally live for two to three years, rats deprived of REM sleep survive an average of only five months. Rats deprived of all sleep survive only about three weeks.[32] In humans, extreme sleep deprivation can cause an apparent state of paranoia and hallucinations in otherwise healthy individuals. However, despite identifying several physiological changes that occur in the brain and body during sleep, scientists still do not fully understand the functions of sleep. Many hypotheses have been advanced to explain the role of this necessary and natural behavior.[32] The following examples highlight several of these theories:

Hypothesis: Restoration and recovery of body systems. This theory recognizes the need of an organism to replenish its energy stores and generally repair itself after a period of energy consumption and breakdown (wakefulness). The brain remains active during sleep, and the low metabolic rate characteristic of sleep is thought to be conducive to biosynthetic reactions. There is little, if any, evidence that more repair occurs during sleep than during rest or relaxed wakefulness. In fact, whole-body protein synthesis decreases during sleep, which is consistent with sleep being a period of overnight fasting.

Hypothesis: Energy conservation. This theory states that we sleep to conserve energy and is based on the fact that the metabolic rate is lower during sleep. The theory predicts that total sleep time and NREM sleep time will be proportional to the amount of energy expended during wakefulness. Support for this theory is derived from several lines of evidence. For example, NREM and REM sleep states are found only in **endothermic** animals (that is, those that expend energy to maintain body temperature). Species with greater total sleep times generally have higher core body temperatures and higher metabolic rates. Consider also that NREM sleep time and total sleep time decrease in humans, with age, as do body and brain metabolism. In addition, infectious diseases tend to make us feel sleepy. This may be because molecules called **cytokines**, which regulate the function of the immune system, are powerful sleep inducers. It may be that sleep allows the body to conserve energy and other resources, which the immune system may then use to fight the infection.

Hypothesis: Memory consolidation. The idea here is that sleeping reinforces learning and memory, while at the same time, helping us to forget or to clear stores of unneeded memories. During the course of a day we are inundated with experiences, some of which should be remembered while others need not be. Perhaps sleep aids in rearranging all of the experiences and thoughts from the day so that those that are important are stored and those that are not are discarded. A recent study of songbirds suggests that sleep may play an important role in learning.[7] Young birds listened to the songs of adult birds and began to practice and refine their own songs. The scientists were able to monitor the firing of individual brain cells involved with singing. They found that if sleeping birds listened to a recording of their own song, their neurons would later fire in a pattern nearly identical to that of song production though no sound was produced. The researchers speculate that the birds dream of singing; they relay and rehearse their songs and strengthen the nerve patterns required for song production. Sleep appears to be important for human learning as well. People who get plenty of deep NREM sleep in the first half of the night and REM sleep in the second half improve their ability to perform spatial tasks. This suggests that the full night's sleep plays a role in learning—not just one kind of sleep or the other.

Hypothesis: Protection from predation. Inactivity during sleep may minimize exposure to predators. At the same time, however, sleep decreases sensitivity to external stimuli and may, as a consequence, increase vulnerability to predation.

Hypothesis: Brain development. This proposed function of sleep is related to REM sleep, which occurs for prolonged periods during fetal and infant development. This sleep state may be involved in the formation of brain synapses.

Hypothesis: Discharge of emotions. Perhaps dreaming during REM sleep provides a safe discharge of emotions. As protection to ourselves and to a bed partner, the muscular paralysis that occurs during REM sleep does not allow us to act out what we are dreaming. Additionally, activity in brain regions that control emotions, decision making, and social interactions is reduced during sleep. Perhaps this provides relief from the stresses that occur during wakefulness and helps maintain optimal performance when awake.

Unfortunately, each of these hypotheses suffers from flaws. Most fail because they cannot offer a mechanism for why sleep is more valuable than simply resting while remaining awake. In others, the shortcomings are more subtle.

3.9 Evolution of sleep. Sleep is **ubiquitous** among mammals, birds, and reptiles, although sleep patterns, habits, postures, and places of sleep vary greatly. Consider the following:

- *Sleep patterns.* Mammals generally alternate between NREM and REM sleep states in a cyclic fashion as described earlier, although the length of the sleep cycle and the percentage of time spent in NREM and REM states vary with the animal. Birds also have NREM/REM cycles, although each phase is very short (NREM sleep is about two and one-half minutes; REM sleep is about nine seconds). Additionally, birds do not lose muscle tone during REM sleep, a good thing for animals that sleep while standing or perching. Most scientific studies have failed to demonstrate REM sleep in reptiles. These findings have led some scientists to suggest that REM sleep may be a later evolutionary development related to warm-blooded animals.
- *Sleep habits.* Some mammals, such as humans, sleep primarily at night, while other mammals, such as rats, sleep primarily during the day. Furthermore, most (but not all) small mammals tend to sleep more than large ones (see Table 2 for examples). In some cases, animals have developed ways to sleep and concurrently satisfy critical life functions. These animals engage in **unihemispheric sleep**, in which one side of the brain sleeps while the other side is awake. This phenomenon is observed most notably in birds (like those that make long, transoceanic flights) and aquatic mammals (like dolphins and porpoises). Unihemispheric sleep allows aquatic mammals to sleep and continue to swim and surface to breathe. It allows animals to keep track of other group members and watch for predators. In fact, there is recent scientific evidence that mallard ducks can increase their use of unihemispheric sleep as the risk of predation increases.[31]
- *Sleep postures.* A wide variety of postures are seen: from sleeping curled up (dogs, cats, and many other animals), to standing (horses, birds), swimming (aquatic mammals, ducks), hanging upside down (bats), straddling a tree branch (leopard), and lying down (humans).
- *Sleep places.* Again, there is great variety, especially for mammals: burrows (rabbits), open spaces (lions), under water (hippopotami), nests (gorillas), and the comfort of one's own bed (humans).

Sleep may also occur among lower life forms, such as fish and invertebrates, but it is hard to know because EEG patterns are not comparable to those of vertebrates. Consequently, investigating sleep in species other than mammals and birds has relied on the identification of specific behavioral characteristics of sleep: a quiet state, a typical species-specific sleep posture, an elevated arousal threshold (or reduced responsiveness to external stimuli), rapid waking due to moderately intense stimulation (that is, sleep is rapidly reversible),

Table 2. Representative Total Sleep Requirements for Various Species

Species	Average Total Sleep Time (hours/day)
brown bat	19.9
python	18.0
owl monkey	17.0
human infant	16.0
tiger	15.8
squirrel	14.9
golden hamster	14.3
lion	13.5
gerbil	13.1
rat	12.6
cat	12.1
mouse	12.1
rabbit	11.4
jaguar	10.8
duck	10.8
dog	10.6
bottle-nosed dolphin	10.4
baboon	10.3
chimpanzee	9.7
guinea pig	9.4
human adolescent	9.0
human adult	8.0
pig	7.8
gray seal	6.2
goat	5.3
cow	3.9
sheep	3.8
elephant	3.5
donkey	3.1
horse	2.9
giraffe	1.9

Sources: References 1, 5, 16, and 36.

and a regulated response to sleep deprivation. Recent research demonstrates that even the fruit fly *Drosophila melanogaster* responds similarly to mammals when exposed to chemical agents that alter sleep patterns.[13, 34]

Comparative studies have explored the evolution of sleep. Although REM sleep is thought to have evolved from NREM sleep, recent studies suggest that NREM and REM sleep may have diverged from a common precursor sleep state.

3.10 Sleep loss and wakefulness. About 30 to 40 percent of adults indicate some degree of sleep loss within any given year, and about 10 to 15 percent indicate that their sleep loss is chronic or severe.[20] In addition, millions of Americans experience problems sleeping because of undiagnosed sleep disorders or sleep deprivation. Adolescents and shift workers are at very high risk of problem sleepiness due to sleep deprivation and the desynchronized timing of sleep and wakefulness, respectively.

As outlined in section *3.5 Biological clock*, sleep and wakefulness are linked in part to the activity of the circadian clock. Recent studies show that individual preferences for morning and evening activity may have a biological basis.[37] In addition, studies show that adolescents experience a delay in the circadian timing system that results in a tendency for them to stay up later and sleep in later.[6] Loss of sleep creates an overwhelming and uncontrollable need to sleep and affects virtually all physiological functions. Sleep loss causes problems with memory and attention, complex thought, motor responses to stimuli, performance in school or on the job, and controlling emotions. Sleep loss may also alter **thermoregulation** and increase the risk for various physical and mental disorders.

Many adolescents are chronically sleep-deprived and hence at high risk of drowsy-driving crashes.

Sleep loss affects personal safety on the road. The National Highway Traffic Safety Administration has estimated that approximately 100,000 motor vehicle crashes each year result from a driver's drowsiness or fatigue while at the wheel.[28] Driving at night or in the early to mid afternoon increases the risk of a crash because those are times that our biological clocks make us sleepy. Drowsy driving impairs a driver's reaction time, vigilance, and ability to make sound judgments. Many adolescents are chronically sleep-deprived and hence at high risk of drowsy-driving crashes. In one large study of fall-asleep crashes, over 50 percent occurred with a driver 25 years old or younger.

4 Sleep Disorders

Problems with sleep can be due to lifestyle choices and can result in problem sleepiness—that is, feeling sleepy at inappropriate times. Environmental noise, temperature changes, changes in sleeping surroundings, and other factors may affect our ability to get sufficient restful sleep. Short-term problem sleepiness may be corrected by getting additional sleep to overcome the sleep deficit. In other cases, problem sleepiness may indicate a sleep disorder requiring medical intervention. Alcohol abuse can cause or exacerbate sleep disorders by disrupting the sequence and duration of sleep states. Alcohol does not promote good sleep, and consuming alcohol in the evening can also exacerbate sleep apnea problems.

Problem sleepiness is feeling sleepy at inappropriate times.

More than 70 sleep disorders have been described, the most common of which are

- ***Insomnia***, the most prevalent sleep disorder, is characterized by an inability to fall asleep and/or by waking up during the night and having difficulty going back to sleep. Primary insomnia is more common in women than men and tends to increase with age. Short-term or transient insomnia may be caused by emotional or physical discomfort, stress, environmental noise, extreme temperatures, or jet lag, or may be the side effect of medication. Secondary insomnia may result from a combination of physical or mental disorders, undiagnosed or uncontrolled sleep disorders (that is, sleep apnea, restless legs syndrome, narcolepsy, and circadian rhythm disorders), and effects of prescription or nonprescription medications. Treatment will differ for primary and secondary causes of insomnia. Treatment may include behavioral aspects, such as following a specific nighttime routine, improving sleep environment, reducing caffeine and alcohol intake, or reducing afternoon napping. Pharmacological treatments may alleviate symptoms in specific cases. Some individuals try to overcome the problem of insomnia by drinking alcoholic beverages. Alcohol inhibits REM sleep and the deeper, restorative stages of sleep, and therefore does not promote good, restful sleep. [22, 23]

Obstructive sleep apnea is a potentially life-threatening disorder in which breathing is interrupted during sleep.

- ***Obstructive sleep apnea*** (OSA) is a potentially life-threatening disorder in which breathing is interrupted during sleep. An estimated 12 million Americans have OSA. This condition may be associated with bony or soft tissue that limits airway dimensions and is made worse in the presence of excess fatty tissue. Repetitive episodes of no effective breath, very shallow breaths, or adequate breaths but with high airway resistance can occur 20 to 30 times per hour or more. These episodes cause temporary drops in blood oxygen and increases in carbon dioxide levels, which lead to frequent partial arousals from sleep. Limitations in upper-airway dimensions are typically associated with chronic loud snoring. The frequent arousals result in ineffective sleep and account for the chronic sleep deprivation and the resultant excessive daytime sleepiness that is a major hallmark of this condition. Additional effects include morning headaches, high blood pressure, heart attacks, heart-rhythm disorders, stroke, and decreased life expectancy. OSA also occurs in children and is generally related to enlarged tonsils or adenoids. It occurs equally often in boys and girls and is most common in preschool-age children. Because many of the factors contributing to OSA appear to have significant genetic influences (such as bony dimensions of upper airways), genetic risk factors are likely important in the occurrence of OSA. Treatment for adult OSA can include behavioral therapy (losing weight, changing sleeping positions, and avoiding alcohol, tobacco, and sleeping pills), use of mechanical devices (continuous positive airway pressure to force air through the nasal passages, or dental appliances that reposition the lower jaw and tongue), and surgery to increase the size of the airway.[27]

- ***Restless legs syndrome*** **(RLS)** is a neurologic movement disorder that is often associated with a sleep complaint. People with RLS have unpleasant leg sensations and an almost irresistible urge to move the legs. Symptoms are worse during inactivity and often interfere with sleep. RLS sufferers report experiencing creeping, crawling, pulling, or tingling sensations in the legs (or sometimes the arms) that are relieved by moving or rubbing them. Sitting still for long periods becomes difficult; symptoms are usually worse in the evening and night and less severe in the morning. Periodic leg movements, which often coexist with restless legs syndrome, are characterized by repetitive, stereotyped limb movements during sleep. Periodic limb movement disorder can be detected by monitoring patients during sleep. Some people with mild cases of RLS can be treated by exercise, leg massages, and eliminating alcohol and caffeine from the diet. Others require pharmacological treatment, and it may take some time to determine the right medication or combination of medications for the individual. Estimates suggest that RLS may affect between 10 and 15 percent of the population.[17, 26]

- ***Narcolepsy*** is a chronic sleep disorder that usually becomes evident during adolescence or young adulthood and can affect both men and women.[2] In the United States, it affects as many as 250,000 people, although fewer than half are diagnosed. The main characteristic of narcolepsy is excessive and overwhelming daytime sleepiness (even after adequate nighttime sleep). A person with narcolepsy is likely to become drowsy or to fall asleep at inappropriate times and places. Daytime sleep attacks may occur with or without warning and may be irresistible. In addition, nighttime sleep may also be fragmented. Three other classic symptoms, which may not occur in all people with narcolepsy, are **cataplexy** (sudden muscle weakness often triggered by emotions such as anger, surprise, laughter, and exhilaration), **sleep paralysis** (temporary inability to talk or move when falling asleep or waking up), and **hypnagogic hallucinations** (dreamlike experiences that occur while dozing or falling asleep). People with narcolepsy have difficulty staying awake, and in extreme conditions, narcoleptic episodes can occur during periods of activity. Narcolepsy is not the same as simply becoming tired or dozing in front of the TV after a day's work.

Sleep walking, sleep talking, and sleep terrors are more common in children than adults. Children generally have no memory of such events, usually do not require treatment, and usually outgrow the disorder.

REM sleep in people with narcolepsy frequently occurs at sleep onset instead of after a period of NREM sleep. Consequently, researchers believe that the symptoms of narcolepsy result from a malfunction in some aspect of REM sleep initiation. Some scientists believe that the immune system causes narcolepsy by attacking the nervous system (that is, an autoimmune response). In this view, exposure to an unknown environmental factor results in an immune response against nerve cells in the brain circuits that control arousal and muscle tone. The discovery of a narcolepsy gene in dogs indicates that genetic risk factors for narcolepsy may also be pertinent in humans.[18] Studies of narcoleptic dogs suggest that altered receptors for a specific neurotransmitter in the hypothalamus can cause cataplexy and the other symptoms of narcolepsy. Many individuals with narcolepsy appear to have a deficiency of this hypothalamic transmitter. There is no definitive cure for narcolepsy, but several treatment options alleviate various symptoms. Treatment is individualized depending on the severity of the symptoms, and it may take weeks or months for the optimal regimen to be worked out. Treatment is primarily by medications, but lifestyle changes are also important.

- ***Parasomnias*** are sleep disorders that involve a range of behaviors that occur during sleep.[38] These include sleepwalking, sleep talking, **enuresis** (bed-wetting), and sleep terrors, which are NREM disorders that occur early in the night. Many of the parasomnias (including sleepwalking, sleep talking, and sleep terrors) are more common in children. Children generally have no memory of such events, usually do not require treatment, and usually outgrow the disorder. Enuresis may respond to drug treatment, and like other parasomnias in children, generally resolves as the child becomes older.

REM sleep behavior disorder is a parasomnia that occurs later in the night than NREM disorders. It differs from the parasomnias discussed previously because it usually affects middle-aged or elderly individuals. Frequently, sufferers will also have a neurological disorder. The temporary muscle paralysis that normally occurs during REM sleep does not occur in this disorder. Because the muscles are not paralyzed, individuals may act out potentially violent behaviors during sleep and cause injuries to themselves or their bed partners.

Glossary

amplitude: Magnitude, greatness of size.

anesthesia: Complete or partial loss of sensation, usually caused by artificially produced unconsciousness.

biological clock: A collection of cells that regulates an overt biological rhythm, such as the sleep/wake cycle, or some other aspect of biological timing, including reproductive cycles or hibernation.

cataplexy: Sudden muscle weakness associated with narcolepsy. It is often triggered by emotions such as anger, surprise, laughter, and exhilaration.

cerebral cortex: The brain's outer layer of gray tissue that is responsible for higher nervous function.

circadian: Exhibiting a periodicity of 24 hours.

cyanobacteria: Blue-green algae.

cytokines: Molecules that regulate the functioning of the immune system.

cytoplasm: Protoplasm outside a cell nucleus.

delta waves: Brain waves with a frequency of 1 to 3 hertz that emanate from the forward portion of the brain during deep sleep in normal adults.

desynchronization: Lack of alignment between external signals and the biological clock.

diurnal: Active or occurring during the daytime; repeating once each 24 hours.

electroencephalogram (EEG): A measurement of the electrical activity associated with brain activity.

electromyogram (EMG): A measurement of the electrical activity associated with muscle movements.

electrooculogram (EOG): A measurement of the electrical activity associated with eye movements.

endocrine system: The ductless glands in the body that secrete hormones.

endogenous rhythms: Rhythms driven by an internal, self-sustaining biological clock rather than by signals that are external to the organism (for example, light).

endothermic animals: Animals that expend energy to maintain body temperature.

entrain: To reset or align with the biological clock.

enuresis: Bed-wetting.

exacerbate: To aggravate or increase the severity of.

exogenous rhythms: A rhythm that is directly regulated by an external influence, such as an environmental cue. They are not generated internally by the organism itself.

follicle stimulating hormone: A hormone produced in the pituitary gland that stimulates the growth of follicles in the ovary and induces spermatogenesis in the testes.

frequency: The number of times a periodic process occurs per unit of time.

hallucination: A false and distorted perception of objects or events.

homeostasis: The ability or tendency of an organism or cell to maintain internal equilibrium by adjusting its internal processes.

homeostatic regulation of sleep: Refers to the neurobiological signals mediating the pressure or urge to sleep.

hypnagogic hallucination: A "greater-than-life-like" dream experience that occurs during sleep. Hypnagogic hallucinations are sometimes associated with narcolepsy.

hypnogram: A graphical summary of the electrical activities occurring during a night's sleep.

hypothalamus: The part of the brain that lies below the thalamus and regulates body temperature and metabolic processes.

insomnia: Sleeplessness; chronic difficulty with sleep onset or maintenance of sleep, or a perception of nonrefreshing sleep.

luteinizing hormone: A glycoprotein secreted by the pituitary gland. It stimulates the gonads to secrete sex steroids.

melatonin: A hormone secreted by the pineal gland that is derived from the amino acid tryptophan, which helps synchronize biological clock neurons in the suprachiasmatic nucleus.

narcolepsy: A chronic sleep disorder characterized by excessive and overwhelming daytime sleepiness (even after adequate nighttime sleep).

neurotransmitter: A chemical produced by neurons that carries messages to other neurons.

nocturnal: Relating to or taking place at night.

non–rapid eye movement (NREM) sleep: The early phase of sleep with no rapid eye movement.

obstructive sleep apnea (OSA) (sleep apnea syndrome, sleep-disordered breathing): A disorder in which breathing is frequently interrupted for brief intervals during sleep, resulting in intermittent decreases in blood oxygen levels and transient arousals from sleep, leading to poor sleep quality and excessive daytime sleepiness.

oscillation: The state or act of swinging back and forth with a regular, uninterrupted pattern.

parasomnias: Sleep disorders that include sleepwalking, sleep talking, and sleep terrors.

photoperiod: The light/dark or day/night cycle.

photoreceptor: A molecule or structure that can detect light.

pons: The brainstem region critical for initiating REM sleep.

rapid eye movement (REM) sleep: Deep sleep with rapid eye movements in which dreaming takes place.

restless legs syndrome: A neurologic movement disorder that is often associated with a sleep complaint.

seasonal affective disorder (SAD): A form of depression caused by inadequate bright light reaching the biological clock in the suprachiasmatic nucleus. Consequently, treatment often involves the use of light therapy.

sleep hygiene: The collection of behaviors and environmental conditions that influence the length and quality of sleep.

sleep paralysis: The temporary inability to talk or move when falling asleep or waking up. It occurs normally during REM sleep.

suprachiasmatic nucleus (SCN): The part of the brain (in the hypothalamus) that contains the biological clock.

thalamus: The area of the brain that relays sensory information to the cerebral cortex.

thermoregulation: Maintenance of internal body temperature regardless of environmental temperature.

ubiquitous: Seeming to be everywhere.

ultradian rhythm: A perodicity of less than 24 hours.

unihemispheric sleep: A type of sleep in which one side of the brain is asleep while the other is awake. This phenomenon is observed most notably in birds (like those that make long, transoceanic flights) and aquatic mammals (like dolphins and porpoises).

References

1. Aserinsky, E. 1999. Eyelid condition at birth: relationship to adult mammalian sleep-waking patterns. In B.N. Mallick and S. Inoue, Eds. *Rapid Eye Movement Sleep* (p. 7). New Delhi: Naroca Publishing.
2. Bassetti, C., and Aldrich, M.S. 1996. Narcolepsy. *Neurologic Clinics*, *14*: 545–571.
3. Berson, D.M., Dunn, F.A., and Takao, M. 2002. Phototransduction by retinal ganglion cells that set the circadian clock. *Science, 295*: 1070–73.
4. Braun, A.R., Balkin, T.J., and Wesensten, N.L. 1998. Dissociated pattern of activity in visual cortices and their projections during human rapid eye movement sleep. *Science, 279*: 91–95.
5. Campbell, S.S., and Tobler, I. 1984. Animal sleep: a review of sleep duration across phylogeny. *Neuroscience and Biobehavioral Review*, *8*: 269–300.
6. Carskadon, M.A., Acebo C., Richardson, G.S., Tate, B.A., and Seifer, R. 1997. An approach to studying circadian rhythms of adolescent humans. *Journal of Biological Rhythms, 12*: 278–289.
7. Dave, A.S., and Margoliash, D. 2000. Song replay during sleep and computational rules for sensoring vocal learning. *Science, 290*: 812–816.
8. Dunlap, J.C. 1999. Molecular bases for circadian clocks. *Cell, 96*: 271–290.
9. Freedman, M.S., Lucas, R.J., Soni, B., von Schantz, M., Munoz, M., David-Gray, Z., and Foster, R. 1999. Regulation of mammalian circadian behavior by non-rod, noncone, ocular photoreceptors. *Science, 284*: 502–504.
10. Green, C. 1998. How cells tell time. *Trends in Cell Biology, 8*: 224–230.
11. Hall, J.C. 1997. Circadian pacemakers blowing hot and cold—but they're clocks, not thermometers. *Cell, 90*: 9–12.
12. Hastings, M. 1998. The brain, circadian rhythms, and clock genes. *British Medical Journal*, *317*: 1704–1707.
13. Hendricks, J.C., Finn, S.M., Panckeri, K.A., Chavkin, J., Williams, J.A., Sehgal, A., and Pack, A.I. 2000. Rest in *Drosophila* is a sleep-like state. *Neuron, 25*: 129–138.
14. Hong, C.H., Gillian, J.C., Dow, B.M., et al. 1995. Localized and lateralized cerebral glucose metabolism associated with eye movements during REM sleep and wakefulness: a positron emission tomography (PET) study. *Sleep, 18*: 570–580.
15. Kohyama, J. 1998. Sleep as a window on the developing brain. *Current Problems in Pediatrics, 27*: 73–92.
16. Kryger, M.H., Roth, Y., and Dement, W.C. 1989. *Principles and Practice of Sleep Medicine*. Philadelphia, PA: W.B. Saunders.
17. Lavigne, G.J., and Montplaisir, J.Y. 1994. Restless legs syndrome and sleep bruxism: prevalence and association among Canadians. *Sleep*, *17*: 739–743.
18. Lin, L., Faraco, J., Li, R., Kadotani, H., Rogers, W., Lin, X., Qiu, X., deJong, P.J., and

Mignot, E. 1999. The sleep disorder narcolepsy is caused by a mutation in the hypocretin (orexin) receptor 2 gene. *Cell,* 98: 409–412.

19. Loucks-Horsley, S., Hewson, P., Love, N., and Stiles, K. 1998. *Designing Professional Development for Teachers of Science and Mathematics*. Thousand Oaks, CA: Corwin Press.
20. Mellinger, G.D., Balter M.B., and Uhlenhuth, E.H. 1985. Insomnia and its treatment, prevalence and correlates. *Archives of General Psychiatry*, *42*: 225–232.
21. Moore, R.Y. 1997. Circadian rhythms: Basic neurobiology and clinical applications. *Annual Review of Medicine, 48*: 253–266.
22. National Heart, Lung, and Blood Institute. 1995. *Insomnia* (NIH Pub. No. 95-3801). Bethesda, MD: NHLBI.
23. National Heart, Lung, and Blood Institute. 1998. *Insomnia: Assessment and management in primary care* (NIH Pub. No. 98-4088). Bethesda, MD: NHLBI.
24. National Heart, Lung, and Blood Institute. 1997a. *Problem sleepiness* (NIH Pub. No. 97-4071). Bethesda, MD: NHLBI.
25. National Heart, Lung, and Blood Institute. 1997b. *Problem sleepiness in your patient* (NIH Pub. No. 97-4073). Bethesda, MD: NHLBI.
26. National Heart, Lung, and Blood Institute. 2000. *Restless legs syndrome: Detection and management in primary care* (NIH Pub. No. 00-3788). Bethesda, MD: NHLBI.
27. National Heart, Lung, and Blood Institute. 1995, reprinted 1999. *Sleep apnea: Is your patient at risk?* (NIH Pub. No. 99-3803). Bethesda, MD: NHLBI.
28. National Highway Traffic Safety Administration. 1998. Drowsy driving and automobile crashes. Retrieved July 13, 2000, from *http://www.sleepfoundation.org/activities/daaafacts.html.*
29. Pack, A.I., Pack, A.M., Rodgman, E., Cucchiara, A., Dinges, D.F., and Schwab, C.W. 1995. Characteristics of crashes attributed to the driver having fallen asleep. *Accident Analysis and Prevention, 27*: 769–75.
30. Phillis, J.W., and Wu, P.H. 1982. The effect of various centrally active drugs on adenosine uptake by the central nervous system. *Comparative Biochemistry & Physiology, Part C, Pharmacology, Toxicology, and Endrocrinology, 72*: 179–187.
31. Rattenborg, N.C., Lima, S.L., and Amlaner, C.J. 1999. Half-awake to the risk of predation. *Nature*, 397: 397–398.
32. Rechtschaffen, A. 1998. Current perspectives on the function of sleep. *Perspectives in Biological Medicine, 41*: 359–390.
33. Reppert, S.M. 1998. A clockwork explosion! *Neuron, 21*: 1–4.
34. Shaw, P.J., Cirelli, C., Greenspan, R., and Tononi, G. 2000. Correlates of sleep and waking in *Drosophila melanogaster*. *Science, 287*: 1834–1837.
35. Strohl, K.P., Haponik, E.E., Sateia, M.J., Veasey, S., Chervin, R.D., Zee, P., and Papp, K. 2000. The need for a knowledge system in sleep and chronobiology. *Academic Medicine, 75*: 819–21.
36. Tobler, I. 1989. Napping and polyphasic sleep in mammals. In D.F. Dinges and R.J. Broughton, Eds. *Sleep Alertness: Chronological, Behavioral, and Medical Aspects of Napping* (pp. 9–31). New York: Raven Press.
37. Toh, K.L., Jones, C.R., He, Y., Eide, E.J., Hinz, W.A., Virshup, D.M., Ptacek, L.J., and Fu, Y.H. 2001. An h*Per*2 phosphorylation site mutation in familial advanced sleep phase syndrome. *Science, 291*: 1040–1043.
38. University of California and Sleep Research Society. 1997. Basics of sleep behavior. Retrieved July 17, 2001, from *http://www.sleephomepages.org/sleepsyllabus/*.

Sleep Diary

Figure 0.1. Keeping a sleep diary enables students to explore their own sleep/wake cycles.

At a Glance

Overview

In this pre-lesson activity, students collect data concerning their own sleep habits. Students analyze these data in subsequent lessons. They explore and evaluate their own sleep/wake cycles, and for those with Internet access, compare their cycles with those of other students around the country. Students also attempt to observe a rhythmic pattern in their assessment of sleepiness throughout the day.

Objectives

By completing this activity, students gain experience gathering data for scientific analyses.

In Advance

Web-Based Activities

Activity	Web Version?
Pre-lesson	No

Photocopies

Pre-lesson	Master 0.1, *Sleep Diary* (Make 1 copy per student.) Master 0.2, *Recording Bedtimes and Wake Times* (Make 1 copy per student.) Master 0.3, *Sleepiness Scale* (Make 1 copy per student.) Master 0.4, *Calculating Average Bedtime and Wake Time* (Make 1 copy per student.)

Materials

Pre-lesson	For each student: calculator (for use on last day of activity)

Preparation

Plan to have calculators available for students, or ask them to bring their own, for the last day (day 10, the second Monday) of this activity. Consider copying Masters 0.1 and 0.3 back-to-back so that students have just one piece of paper to keep track of.

Plan when you will teach the lessons. Students will need 10 days to complete this pre-lesson activity before beginning Lesson 1. We recommend that students begin their sleep diary on a Friday. This schedule allows students to collect data about their sleep/wake cycles and daily rhythms over two weekends and one full weekday period before you begin the module on a Monday. On the Friday after students begin completing their sleep diaries, remind them that they will need to bring their diaries to class on Monday to begin Lesson 1.

Students will need their completed sleep diary and the sleepiness scale in subsequent lessons.

Procedure

1. **Inform the class that students will be collecting data about their own sleep habits over the next 10 days. Explain that sleep medicine specialists use similar information to provide insight into a patient's sleep patterns.**

   The sleep diary in this activity is simplified and deals only with sleep/wake times and the consumption of caffeine-containing beverages. From more extensive sleep diaries, scientists and doctors who study sleep can also learn about how environmental factors, emotions, medications, or drugs affect sleep. Such data can help the doctor investigate whether the individual suffers from a sleep disorder or from inadequate sleep due to a very busy schedule.

Sleep diaries rely on self-reporting, which may not always be accurate. Also, some important symptoms of sleep disorders, such as breathing problems, snoring, and excessive body movements, occur during sleep and therefore aren't reported by the individual.

Sleep specialists also use sleepiness scales in analyzing sleep issues, but the one in this activity should not be used to assess your students' health.

2. **Give each student one copy of both Master 0.1, *Sleep Diary*, and Master 0.2, *Recording Bedtimes and Wake Times*. Ask students to first look at Master 0.1. Inform them that they will be recording the times that they go to bed at night and wake up in the morning for 10 days, beginning with bedtime on that night (the Friday they receive their copies). Explain that they will record these times to the nearest quarter hour. For example, if a student goes to bed at 10:25 p.m., he or she would say bedtime was 10:30 p.m. Also explain that they will need to record the total number of hours they slept each night, the number of times they remember waking up during the night, and the number of caffeine-containing drinks (coffee, tea, colas, or other caffeinated beverages) they consumed during the day.**

   Make sure students understand that wake time refers to the time in the morning when they awoke for the day. It does not refer to the times during the night when they may have awakened for a brief period. Also, remind students to record the number of caffeine-containing drinks they consume each day.

3. **Give each student one copy of Master 0.3, *Sleepiness Scale*. Explain that scientists who study sleep use charts like this to gather information about just how sleepy people are at different times of the day.**

   As with aspects of the Sleep Diary, this relies on self-reporting rather than a completely objective measure. Encourage students to respond as accurately as possible.

4. **Instruct students to look at Master 0.3, *Sleepiness Scale*. Explain that on day 4 (a Monday), day 7 (Thursday), and day 11 (the second Monday), they will need to record how sleepy they are at different times during the day. At the times listed on the chart on Master 0.3, students will judge how sleepy they are and base their responses on the information in the chart at the top of Master 0.3.**

You may elect to change the times requested for data entry, but only as follows. The 10:00 a.m. time can be adjusted to correspond with first or second class periods, and the 2:00 p.m. time can be adjusted to correspond with the end of the school day. These times were selected to maximize the chance of detecting the morning rise in alertness and the midafternoon dip in alertness.

5. **You might draw the following diagram on the board to illustrate the tasks the students have and when they should be accomplished:**

Day										
1	2	3	4	5	6	7	8	9	10	11
Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
Begin daily diary entries			1st sleepiness scale entries			2nd sleepiness scale entries				3rd sleepiness scale entries; begin Lesson 1

6. **On the Friday (day 8) of the week during which students are collecting their data, remind them that they will need their sleep diary and their sleepiness scale data with them on Monday (day 11) so that they can begin to analyze and evaluate their data.**

7. **Explain to students that calculating an average bedtime or average wake time is somewhat complicated by our system of telling time (24 hours in a day, 60 minutes per hour, and a.m. vs. p.m.). Instruct students to use Master 0.4, *Calculating Average Bedtime and Wake Time*, to obtain their average values. Students should also calculate their average total sleep time, average number of awakenings during the night, and average number of caffeine-containing drinks consumed.**

Calculating the average bedtime and average wake time is complicated, but the worksheets should guide students through these calculations. Calculating the averages for total sleep time, number of awakenings, and caffeinated drinks is much more straightforward. If, however, you feel it is appropriate for your students, review how to calculate an average with them.

8. **Students should keep their copies of Master 0.1, *Sleep Diary,* and Master 0.3, *Sleepiness Scale,* for use in later lessons.**

Pre-lesson Organizer

What the Teacher Does	Procedure Reference
Give each student a copy of Master 0.1, *Sleep Diary*, and Master 0.2, *Recording Bedtimes and Wake Times*. • Explain to the class how sleep diaries are used and how they will fill out one of their own.	Pages 44–45 Steps 1 and 2 M
Give each student a copy of Master 0.3, *Sleepiness Scale*. • Explain to the class how the sleepiness scale is used and how they will use it in their sleep diary.	Pages 45–46 Steps 3 and 4 M
Draw a diagram on the board that shows the students' tasks and when they should be performed. • On Friday of the week they collect their data, remind students that they will need their diaries on the following Monday.	Page 46 Steps 5 and 6
Give each student a copy of Master 0.4, *Calculating Average Bedtime and Wake Time.* • Explain how to calculate average bed and wake times.	Page 46 Step 7 M
Instruct the class to keep their sleep data for use in later lessons.	Page 46 Step 8

M = Involves copying a master.

Sleep Diary

Name ______________________________

Date begun___________________________

Note to students: For the period **FRI.**/*Saturday*, indicate your bedtime Friday night and your wake time on Saturday morning. Treat other time periods similarly: day in **bold** capital letters for **bedtime**; day in *italics* for *wake time*.

	FRI. *Saturday*	**SAT.** *Sunday*	**SUN.** *Monday*	**MON.** *Tuesday*	**TUES.** *Wednesday*	**WED.** *Thursday*	**THURS.** *Friday*	**FRI.** *Saturday*	**SAT.** *Sunday*	**SUN.** *Monday*	**AVERAGE**
Bedtime (to nearest quarter hour)											
Wake time (to nearest quarter hour)											
Total sleep time (hours)											
Number of awakenings during the night											
Number of caffeinated drinks	**Friday** Morning: Afternoon: Evening:	**Saturday** Morning: Afternoon: Evening:	**Sunday** Morning: Afternoon: Evening:	**Monday** Morning: Afternoon: Evening:	**Tuesday** Morning: Afternoon: Evening:	**Wednesday** Morning: Afternoon: Evening:	**Thursday** Morning: Afternoon: Evening:	**Friday** Morning: Afternoon: Evening:	**Saturday** Morning: Afternoon: Evening:	**Sunday** Morning: Afternoon: Evening:	Morning: Afternoon: Evening:

Have you been told by a family member that you snore? yes_____ no_____

Do you believe that you often have difficulty sleeping (falling asleep, awakening during the night, awakening unrefreshed)? yes_____ no_____

Recording Bedtimes and Wake Times

If your bedtime is:	Record this number as your bedtime in your Sleep Diary	If you wake up at:	Record this number as your wake time in your Sleep Diary
9:30 p.m.	9.50	5:30 a.m.	5.50
10:00	10.00	5:45	5.75
10:15	10.25	6:00	6.00
10:30	10.50	6:15	6.25
10:45	10.75	6:30	6.50
11:00	11.00	6:45	6.75
11:15	11.25	7:00	7.00
11:30	11.50	7:15	7.25
11:45	11.75	7:30	7.50
12:00 a.m.	12.00	7:45	7.75
12:15	12.25	8:00	8.00
12:30	12.50	8:15	8.25
12:45	12.75	8:30	8.50
1:00	13.00	8:45	8.75
1:15	13.25	9:00	9.00
1:30	13.50	9:15	9.25
1:45	13.75	9:30	9.50
2:00	14.00	9:45	9.75
2:15	14.25	10:00	10.00
2:30	14.50	10:15	10.25
2:45	14.75	10:30	10.50
3:00	15.00	10:45	10.75

Sleepiness Scale

Name ______________________ Date _________________

Use the following scale to assess your sleepiness at the times indicated in the table below.

Score	Description
1	feeling active and vital, alert; wide awake
2	functioning at high level, but not at peak; able to concentrate
3	not at full alertness, but responsive and awake
4	not at peak; let down; a little foggy
5	beginning to lose interest in remaining awake; slowed down; foggy
6	prefer to be lying down; fighting sleep; woozy
7	losing struggle to remain awake; sleep onset soon; or asleep

Day/Time	Sleepiness Scale Score
1st Monday	
6:00–7:00 a.m.	
10:00 a.m.	
2:00 p.m.	
4:00 p.m.	
7:00 p.m.	
10:00–11:00 p.m.	
Thursday	
6:00–7:00 a.m.	
10:00 a.m.	
2:00 p.m.	
4:00 p.m.	
7:00 p.m.	
10:00–11:00 p.m.	
2nd Monday	
6:00–7:00 a.m.	
10:00 a.m.	
2:00 p.m.	
4:00 p.m.	
7:00 p.m.	
10:00–11:00 p.m.	

Calculating Average Bedtime and Wake Time

Name ____________________ Date ________________

To calculate an average bedtime, follow the steps below. Consider the following hypothetical data:

Day of Week	Bedtime	Bedtime (as recorded in diary)
Friday	11:45 p.m.	11.75
Saturday	1:00 a.m.	13.00
Sunday	11:00 p.m.	11.00
Monday	10:30 p.m.	10.50
Tuesday	10:45 p.m.	10.75
Wednesday	11:00 p.m.	11.00
Thursday	10:30 p.m.	10.50
Friday	11:45 p.m.	11.75
Saturday	12:15 a.m.	12.25
Sunday	11:00 p.m.	11.00

In this example, the average bedtime is calculated as the sum of the bedtimes (113.5) divided by the total number of bedtimes recorded (10). This gives an average of 113.5/10 = 11.35. Rounding this number to the nearest quarter hour (the decimals would be 0.0 for the hour itself; 0.25 for 15 minutes after the hour; 0.5 for the half hour; 0.75 for 45 minutes after the hour) gives us 11.25, or 11:15 p.m., as the approximate average bedtime.

Calculating the approximate **average time you woke up** in the morning is done in a similar way.

For your data:

Average bedtime

1. Add all bedtimes recorded in sleep diary: _____
2. Number of bedtimes recorded: _____
3. Average bedtime (line 1 divided by line 2): _____
4. Round answer on line 3 to nearest quarter hour to get average bedtime: _____

Average wake time

1. Add all wake times recorded in sleep diary: _____
2. Number of wake times recorded: _____
3. Average wake time (line 1 divided by line 2): _____
4. Round answer on line 3 to nearest quarter hour to get average wake time: _____

Lesson 1
Engage

What Is Sleep?

At a Glance

Overview

The purpose of the lesson is to enable students to express what they believe they know about sleep and to encourage them to explore the topic further. Students also evaluate entries in their sleep diary.

Major Concepts

Sleep is an essential, biologically motivated behavior. Adequate amounts of sleep are necessary for normal motor and cognitive functions. Sleep is required for survival, and the drive to sleep is intense.

Objectives

After completing this lesson, students will

- understand that sleep is a behavior,
- become more aware of their own sleep/wake cycles, and
- be able to develop and test hypotheses relating to sleep using data in the sleep diary.

Teacher Background

Consult the following sections in Information about Sleep:

1 Introduction (pages 19–20)
2 Misconceptions about Sleep (pages 20–21)
3.6 Homeostasis and sleep (pages 30–31)
3.8 Functions of sleep (pages 32–33)
3.10 Sleep loss and wakefulness (pages 34–35)

In Advance

Web-Based Activities

Activity	Web Version?
1	No
2	Yes

Photocopies

Activity 1	Master 1.1, *What Do You Know (or Think You Know) about Sleep?* (Make 1 copy per student.)
Activity 2	no photocopies needed

Materials

Activity 1	no materials needed
Activity 2	completed sleep diaries from pre-lesson (Master 0.1) computers with Internet connection

Preparation

If using the Web version of Activity 2, make sure that the Internet connection is working and that you have entered your class identifier and other descriptive data on the administration site.

Procedure

Activity 1: *What Do You Know (or Think You Know) about Sleep?*

Teacher note

The purpose of this activity is to assess students' prior knowledge about sleep.

1. **Begin by asking the class, Do you think you get all the sleep you need every night? How do you feel the day after you have not slept enough or not slept well?**

   Students may respond that if they haven't had enough sleep, they feel drowsy, not alert, cannot think properly, and have less energy.

2. **Ask, How much sleep per day is necessary for good health (write the responses on the board)?**

   Students may respond that eight hours of sleep per day are needed for good health. Other students, based on their own experience, may believe that only five or six hours of sleep are needed for good health.

3. **Ask the class, What would happen to us if we were not allowed or able to sleep at all for a long period of time (such as several days in a row)?**

   Among other responses, students may say that they would eventually die from lack of sleep. (It is known that severe sleep deprivation can produce behavioral changes and hallucinations in humans. No human, as far as science is aware, has died from lack of sleep. However, laboratory rodents will die if not allowed to sleep.) If no student mentions this possibility, initiate a discussion of what human behaviors are required for us to survive. Students should begin to consider sleep an essential behavior, and they should begin thinking about what sleep does for us.

   When discussing what behaviors are necessary for survival, a graphic organizer such as the following may prove useful in summarizing the discussion.

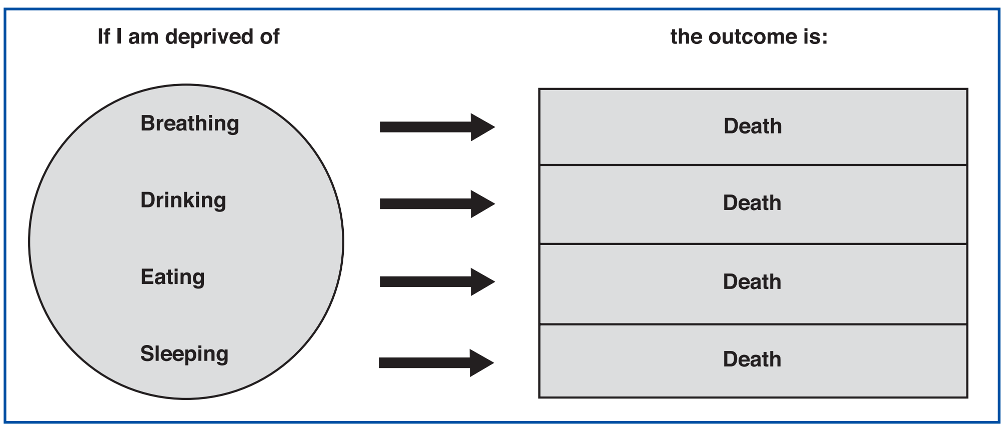


Figure 1.1. *Graphic organizer.*

   Students will recognize that breathing, drinking, and eating are essential for life to continue. We can do without breathing for only a period of minutes, in contrast to drinking (days) and eating (weeks). This discussion should help students understand that sleeping is another essential behavior, one that is required for survival.

4. **Explain to the class that you now are going to explore what they know about sleep. Stress that this activity is not a test and that their responses will not be graded.**

5. **Give each student a copy of Master 1.1, *What Do You Know (or Think You Know) about Sleep?* Stress that their answers will help them gauge their own understanding of sleep.**

6. **After the class has had a few minutes to complete their responses, engage the students in a discussion of why they answered as they did. If you prefer, have students write their responses on a piece of paper.**

Teacher note
At the module's conclusion, students will be presented with the statements again and asked to write down their responses. They will then compare their responses with their earlier ones and discuss how the module has changed their thinking about sleep.

Master 1.2, *Supplemental Information—What Do You Know (or Think You Know) about Sleep?*, provides information about each of the 10 statements on Master 1.1. This information is for your benefit. After Lesson 5, you may decide to make a copy of this material available to students. Additional information is found in the Information about Sleep material.

Activity 2: *Sleep Diary*

Teacher note
After students assess their present knowledge about sleep in Activity 1, they evaluate their own sleep habits using the data they have recorded in their sleep diaries.

For classes using the Web-based version of this lesson:

1. **Go to the Web site page *http://science.education.nih.gov/supplements/sleep/student* and click on "Teacher Database Administration."**
   - **When prompted, enter the username "sleepadmin" and password "admin" (all in lowercase letters).**
   - **Enter the requested information on the form.**

   For the latitude entry, refer to the latitude map. If your location is equally distant from two latitude lines, then enter the higher one.

2. **Once you have entered your class information, click on "Generate Class Codes." You will receive a unique class code for each class that you entered on the previous form. Each class code consists of a color followed by a five-digit number.**
   - **Next, click on "Done"; this will take you back to the Web site home page.**
   - **Click on "Web Portion of Student Activities" (or have students log onto the student Web site) and then on "Lesson 1—What Is Sleep?"**
   - **Enter the unique class code that you were assigned (and that was e-mailed to you) to access the pages for entering data, viewing data, or creating reports. At this site, you (or your students) may enter the averages from each student's sleep diary (that is, average bedtime, average wake time, average number of awakenings, average total sleep time, average number of caffeine-containing drinks for morning, afternoon, evening) along with each student's corresponding sleepiness scale scores.**
   - **Note that after entering an average bedtime and wake time, the computer will calculate the average total sleep automatically.**

3. **Instruct students to work individually or in small teams. They should develop a hypothesis, test it by using the data in the sleep database, and provide a short, written summary of their findings.**

When using the Web version of this activity, students have the opportunity to analyze a much larger database. They can generate many different hypotheses and reports keyed to specific descriptors to test each hypothesis, as described below.

Students have a number of options for building custom reports of records in the database, such as

a. **all** students who have entered data
b. **females** who have entered data
c. **males** who have entered data
d. those who have entered "**yes**" to snoring
e. those who have entered "**no**" to snoring
f. those who have entered "**yes**" to sleeping difficulties
g. those who have entered "**no**" to sleeping difficulties
h. those with a **specific** total sleep time

There are many more options. These summary reports provide the calculated average for each parameter based on the portion of the database that you selected. This database allows students to formulate and test many different hypotheses by generating the appropriate report and evaluating the resulting data. For example, hypotheses that can be tested by using information in the database include

- Males sleep longer than females.
- Evening consumption of two or more caffeinated beverages

results in later bedtimes.
- People go to bed earlier in the winter months.
- Snoring is associated with more frequent awakenings during the night.

Students are limited by their imagination, but their hypotheses must be answerable using the available data.

Content Standard A: Design and conduct scientific investigations.

Content Standard A: Communicate and defend a scientific argument.

4. **After the class has had the opportunity to test their hypotheses, ask for a volunteer to report his or her hypothesis and findings. Ask the student why he or she chose that hypothesis.**

Make sure that students are testing hypotheses that can be investigated using the available data.

5. **If a student isn't sure that the data support the hypothesis, ask why and consider what additional data could help resolve the question.**

   Even if the student has asked an appropriate question of the database, there may be too few entries to reach a firm conclusion. The database can address questions regarding the effects of gender, snoring, and caffeinated drinks but does not contain information to address other variables such as the effects of dreaming, allergies, or physical exercise.

   This is an opportunity to discuss what types of data are needed to properly evaluate a hypothesis.

6. **As time permits, ask other students to report their hypotheses and findings. Try to elicit different hypotheses.**

   To enrich the discussion, encourage students to ask questions and challenge the conclusions of the presenters.

Assessment: Instruct students to write a brief report that states their hypothesis, the data from sleep diaries used to test it, and their conclusions. If the data do not support a firm conclusion, instruct students to explain what additional information would be needed to reach a conclusion.

7. **To conclude the activity, explain to the class that people feel pressure to sleep in daily cycles. Scientists refer to this need-to-sleep cycle as "homeostatic regulation." Ask students to draw a graph that depicts the need to sleep (*on the y-axis*) versus the time of day (*on the x-axis*).**

   Students should conclude that the need to sleep increases throughout the day, reaching some level that is sufficient (in combination with other factors) to induce sleep. Sleep itself causes a decline in the need to sleep. This is depicted in Figure 1.2.

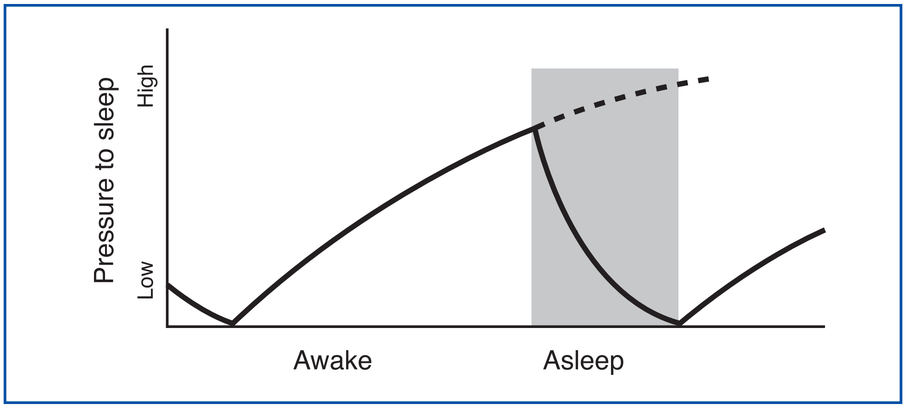


Figure 1.2. Homeostatic regulation of sleep refers to the pressure or urge to sleep. Sleep pressure increases (dashed line) as one stays awake longer into the normal sleeping hours.

Students may depict the line as more linear than not. The important point, however, is that homeostatic regulation of sleep is cyclic, rising during wakefulness and then declining during sleep.

8. **Ask the class what the graph would look like if it represented an individual deprived of sleep during the day and night.**

Students should show the line continuing to increase throughout the period of sleep loss. The pressure to sleep does not reach a plateau but continues to increase until sleep occurs and the pressure (or need to sleep) declines.

Alternate version of Activity 2 for classes without access to the Internet:

Teacher note
If you are using the print-based version of this activity, students can compare their own sleep patterns with those of their classmates.

1. **Collect data from the student sleep diaries. Instruct students to write their data on the board. Compile their data for the following categories:**
   a. **average** bedtime
   b. **average** wake time
   c. **average** number of awakenings during the night

d. **average** total sleep time
e. **average** number of caffeine-containing drinks in morning, afternoon, and evening
f. **number** of students who snore
g. **number** of students who report sleeping difficulties

2. **Instruct students to calculate the class average for each of the items a through e in Step 1 (pages 59-60).**

   Please ensure that a copy of the class data is retained for later reference. Ask students to a) compare their own data with the class data (for example, How does their average total sleep time compare with the average total sleep time of the class?); b) compare the data entered by males with that entered by females; and c) determine whether there is a correlation between evening consumption of caffeine and average bedtime or average total sleep time.

3. **Ask the class to generate a hypothesis about sleep that can be answered using the class data.**

   There are a number of possibilities. For example, students might hypothesize that individuals who snore sleep less per night than individuals who do not snore. Another possibility is that students might observe that their calculated *average* sleep time is quite unlike either their usual weekday sleep times or their usual weekend sleep times. Perhaps students are sleeping far less on weekdays than on weekends. Such analysis leads to discussion of sleep debt and good sleep habits, which will be addressed in Lessons 4 and 5. There is also the option of compiling data separately for males, females, and the class as a whole.

4. **To conclude the activity, explain to the class that we feel pressure to sleep in daily cycles. Scientists refer to this need-to-sleep cycle as "homeostatic regulation." Ask students to draw a graph that depicts the need to sleep (*on the y-axis*) versus the time of day (*on the x-axis*).**

   Students should conclude that the need to sleep increases throughout the day, reaching some level that is sufficient (in combination with other factors) to induce sleep. Sleep itself causes a decline in the need to sleep. This is depicted in Figure 1.2.

   Students may draw the line more-or-less linear. The important point, however, is that homeostatic regulation of sleep is cyclic, rising during wakefulness and then declining during sleep.

NSES

Content Standard A: Design and conduct scientific investigations.

Content Standard A: Communicate and defend a scientific argument.

Content Standard A: Students should develop abilities to formulate and revise scientific explanations and models using logic and evidence.

5. **Ask the class what the graph would look like if it represented an individual deprived of sleep during the day and night.**

   Students should show the line continuing to increase throughout the period of sleep loss. The pressure to sleep does not reach a plateau but continues to increase until sleep occurs and the pressure (or need to sleep) declines.

What the Teacher Does	Procedure Reference
Ask the class some questions about their sleep habits: • Do you think you get enough sleep each night? • How do you feel when you do not get enough sleep? • How much sleep is needed for good health? • What would happen if you were not allowed to sleep for a very long time?	Pages 54–55 Steps 1–3
Explain that you will explore their knowledge of sleep. Give each student a copy of Master 1.1, *What Do You Know (or Think You Know) about Sleep?* • Have students respond to a series of statements about sleep. • Ask students to explain why they answered as they did.	Pages 55–56 Steps 4–6 M

What the Teacher Does	Procedure Reference
Log on to the teacher administration site and enter the requested data about your school.	Page 56 Step 1 www

M = Involves copying a master.

www = Involves using the Internet.

Log onto the student Web site, click on "Lesson 1—What Is Sleep?", and enter your class code. Then click "Enter Sleep Data." • Use the class code you created on the teacher administration page to enter the averages from each student's sleep diary along with each student's corresponding sleepiness scale scores.	Page 57 Step 2
Divide the class into small teams and instruct them to think of a hypothesis about sleep that can be answered using information from the sleep database. • They should test their hypothesis by building custom reports. • They should write a short summary of their findings.	Pages 57–58 Step 3
Ask for volunteers to state their hypotheses and findings. • Have students explain why they chose their question. • If their data are inconclusive, ask what additional data they would need to answer their question.	Page 58 Steps 4–6
Introduce the concept of homeostatic sleep regulation and have students draw a graph depicting the need to sleep versus the time of day. • Ask the class, What would your graph look like if it represented an individual deprived of sleep day and night?	Pages 58–59 Steps 7 and 8

Lesson 1 Organizer: Print Version

What the Teacher Does	Procedure Reference
Ask the class some questions about their sleep habits: • Do you think you get enough sleep each night? • How do you feel when you do not get enough sleep? • How much sleep is needed for good health? • What would happen if you were not allowed to sleep for a very long time?	Pages 54–55 Steps 1–3
Explain that you will explore their knowledge of sleep. Give each student a copy of Master 1.1, *What Do You Know (or Think You Know) about Sleep?* • Have students respond to a series of statements about sleep. • Ask students to explain why they answered as they did.	Pages 55–56 Steps 4–6 M

What the Teacher Does	Procedure Reference
Collect data from students' sleep diaries on the board. Use the following categories: • Average bedtime • Average wake time • Average number of awakenings during the night	Pages 59–60 Step 1

M = Involves copying a master.

• Average total sleep time • Average number of caffeine-containing drinks in morning, afternoon, and evening • Number of students who snore • Number of students who report sleeping difficulties	
Instruct students to calculate the class averages for each of the items from Step 1.	Page 60 Step 2
Ask the class to think of a hypothesis about sleep that can be answered using the class data.	Page 60 Step 3
Introduce the concept of homeostatic sleep regulation and have students draw a graph depicting the need to sleep versus the time of day.	Page 60 Step 4
Ask the class, What would your graph look like if it represented an individual deprived of sleep day and night?	Page 61 Step 5

What Do You Know (or Think You Know) about Sleep?

Name ____________________ Date ________________

Indicate whether you agree or disagree with the following statements by circling "Agree" or "Disagree."

1.	Everyone has a biological clock.	Agree	Disagree
2.	Drinking coffee cures drowsiness.	Agree	Disagree
3.	Safe drivers don't have to worry about being sleepy.	Agree	Disagree
4.	Nearly everyone gets enough sleep.	Agree	Disagree
5.	Being sleepy makes it hard to think straight.	Agree	Disagree
6.	Most teenagers need at least nine hours of sleep each night.	Agree	Disagree
7.	Driving makes you sleepy.	Agree	Disagree
8.	Sleep is time for the body and brain to shut down for rest.	Agree	Disagree
9.	The body quickly adjusts to different sleep schedules.	Agree	Disagree
10.	Getting one hour less sleep per night than I need will not have any effect on my daytime performance.	Agree	Disagree

Supplemental Information—What Do You Know (or Think You Know) about Sleep?

TRUE 1. **Everyone has a biological clock.** The human biological clock resides in a part of the brain called the *suprachiasmatic nucleus*, or *SCN*. It functions through a cycling of the expression of specific genes. The timing for sleep in humans is regulated by our internal biological clock.

FALSE 2. **Drinking coffee cures drowsiness.** Coffee contains caffeine, which is a stimulant. Coffee and other caffeine-containing drinks and over-the-counter medicines can be helpful, temporary remedies for sleepiness, but their effects last only a short time. If you are seriously sleep-deprived, drinking coffee is not the answer. You may still experience brief uncontrollable "naps" that last a few seconds (these are called microsleeps), even while driving. Consider what could happen if you drive while drowsy at 55 miles per hour. How far could you travel in five seconds while asleep? Keep in mind, there is no substitute for sleep to relieve sleepiness.

FALSE 3. **Safe drivers don't have to worry about being sleepy.** Sleepiness is associated with decreased alertness, and decreased alertness is not compatible with safe driving under any circumstances.

FALSE 4. **Nearly everyone gets enough sleep.** According to recent surveys, over half of the American population reports occasional sleeping difficulties. A frequent complaint is not feeling rested upon waking. The average person requires eight hours of sleep per night (adolescents need nine or more hours of sleep per night), and this is often not achieved.

TRUE 5. **Being sleepy makes it hard to think straight.** A drowsy individual does not process information as quickly or as accurately as one who is alert. The ability to split attention between multiple tasks and inputs is lost. Reaction times are decreased, and one's field of vision narrows with sleepiness.

TRUE 6. **Most teenagers need at least nine hours of sleep each night.** Teens and young adults actually need more sleep than older adults. However, changing behaviors, attitudes, and responsibilities may cause teens and young adults to sleep less than they need to. Being able to stay up late is not the same as requiring less total sleep.

FALSE 7. **Driving makes you sleepy.** Driving does not make you sleepy but only makes your actual level of sleepiness apparent. Consequently, it is better to drive during those times when you are normally alert and to avoid driving when your functioning is normally at a low level.

FALSE 8. **Sleep is time for the body and brain to shut down for rest.** Sleep is an active process involving specific cues for onset and regulation. Although there are modest decreases in metabolic rates, there is no evidence that any major organ or regulatory system in the body shuts down during sleep. In fact, some brain activities increase dramatically. During sleep, the endocrine system increases the secretion of certain hormones, such as growth hormone and prolactin. Sleep is a very dynamic process.

FALSE 9. **The body quickly adjusts to different sleep schedules.** The circadian clock attempts to function according to a normal day/night schedule, even when people try to change it. People who work night shifts naturally feel sleepy when nighttime comes. This conflict with the natural biological rhythm leads to a decrease in cognitive and motor skills. The biological clock can be reset but only by one or two hours per day. Changing certain behaviors, such as sleeping in a dark, quiet room and getting exposure to bright light at the right time, may reduce the problem. However, continued shift work will affect the quality of a person's sleep.

FALSE 10. **Getting one hour less sleep per night than I need will not have any effect on my daytime performance.** Even this seemingly small decrease in nightly sleep, if it occurs regularly, can have a significant effect on daytime performance. Many people try to correct sleep deprivation through sleep compensation. For example, many individuals will sleep later on the weekends than they do on weekdays. Sleep compensation may be qualitatively different from normal sleep, and thus not true compensation for lost sleep.

Houston, We Have a Problem

Figure 2.1. Astronauts in zero gravity don't "lie down" to sleep.

At a Glance

Overview

In this lesson, students explore the major stages of sleep and the physiological changes that occur during sleep as compared with wakefulness. An astronaut scenario is used to provide the context for the student explorations. Physiological data are provided for three astronauts. Students evaluate the data and determine the state of sleep or wakefulness of each astronaut. This lesson requires students to make observations, evaluate and interpret data, and draw conclusions.

Major Concepts

Sleep is divided into two major states: NREM and REM. Bodily systems function in characteristic ways during wakefulness, NREM sleep, and REM sleep. Evaluating these functions provides a means of determining an individual's state of wakefulness or sleep.

Objectives

After completing this lesson, students will

- recognize that there are two major sleep states: NREM and REM;
- understand that key bodily systems function in characteristically different ways during wakefulness, NREM, and REM;

- understand the basic concepts underlying the physiological parameters of EEG, EMG, and EOG;
- recognize EEG, EMG, and EOG patterns characteristic of wakefulness, NREM, and REM; and
- understand that sleep is a dynamic process.

Teacher Background

Consult the following sections in Information about Sleep:

3.1 Sleep is a dynamic process (pages 21–23)
3.2 Physiological changes during sleep (pages 23–24)
3.3 Sleep and the brain (page 24)

In Advance

Web-Based Activities

Activity	Web Version?
1	Yes

Photocopies

Activity 1	**For the Web-based version** Master 2.2, *Astronaut Telemetry Evaluation Form* (Make 1 copy per student.) **For the print-based version** Master 2.1, *Astronaut Scenario* (Prepare an overhead transparency.) Master 2.2, *Astronaut Telemetry Evaluation Form* (Make 1 copy per student or team.) Master 2.3, *Telemetry for Astronaut Jordan* (Make 1 copy per student.) Master 2.4, *Telemetry for Astronaut Rodriguez* (Make 1 copy per student.) Master 2.5, *Telemetry for Astronaut Chen* (Make 1 copy per student.) Master 2.6, *Sleep Medicine Reference Manual* (Make 1 copy per student.)

Materials

For the Web-based version, you will need computers with an Internet connection and a sound card.

Preparation

No preparations needed (except for photocopying).
Make sure that the Internet connections are working and that the sound is functioning.

Procedure

For classes using the *Web-based version* of this lesson:

1. **Explain to students that they will use a hypothetical scenario to learn about the physiology and major stages of sleep. You can refer to statement 8 on Master 1.1: "Sleep is time for the body and brain to shut down for rest." (False.) How did the students respond and why? Is sleep really a time when not much is occurring physiologically? Students can now investigate this idea.**

2. **Instruct the students to go to *http://science.education.nih.gov/supplements/sleep/student* and click on "Lesson 2—Houston, We Have a Problem."**

   Students are free to navigate through the lesson in whatever sequence they prefer. This means that they may select the astronauts in any order. They may obtain information on the seven physiological parameters for each astronaut in any order they choose.

   As an alternative, students may work in teams of three. If they work in teams, have each student analyze data for a different astronaut and discuss it with their team. This approach ensures that each student is actively participating in the activity.

3. **Give each student a copy of Master 2.2, *Astronaut Telemetry Evaluation Form.***

   Explain that they will use it to record their determinations of the astronauts' sleep states.

4. **Ask students to evaluate the data for each astronaut using the information in the *Sleep Medicine Reference Manual*. Student observations, interpretations, and conclusions should be entered on Master 2.2, *Astronaut Telemetry Evaluation Form*.**

   Students should concentrate on their reasoning and indicate which data were useful in making their determinations, which data were not useful, and in both cases, why.

5. **After students have had an opportunity to complete their analyses, ask them, What is the state of wakefulness or sleep for each of the three astronauts?**

   Astronaut Jordan is in REM-stage sleep. Astronaut Rodriguez is in NREM-stage sleep. Astronaut Chen is awake.

NSES

Content Standard A: Students should develop understandings about scientific inquiry.

6. **Ask the class, Which physiological data are useful for determining a person's state of wakefulness or sleep?**

   Students should conclude that the important parameters for distinguishing between sleep states and wakefulness are EEG, EMG, and EOG. The other four parameters—heart rate, blood pressure, respiratory rate, and body temperature—might be useful in combination with EEG, EMG, and EOG data, but they are not sufficient by themselves. For instance, heart rate increases during REM, but it also may increase with physical activity during wakefulness.

7. **Ask students, How can you distinguish between REM and NREM sleep? Between REM and wakefulness? NREM and wakefulness?**

   The EEG, EOG, and EMG data are reproduced in Figure 2.2. First consider astronaut Jordan. Jordan's EEG does not appear to represent NREM sleep, although students may have difficulty distinguishing between REM and wakefulness EEGs. However, the lack of muscular activity (EMG) during REM as compared with activity during NREM or wakefulness is the key for determining that this individual is in REM-stage sleep. Rodriguez and Chen can be distinguished from each other based on their EEGs (that is, the increased amplitude and decreased frequency of brain waves during NREM compared with the pattern during REM and wakefulness) and their EOGs (that is, large eye movements during wakefulness as compared with little or no eye movements during NREM).

8. **Explain to the students that during a normal night's sleep, we cycle through NREM and REM sleep several times. This cycling is called an *ultradian rhythm* because the cycle time is less than 24 hours. Conclude the lesson by asking, What can you conclude about sleep from this investigation?**

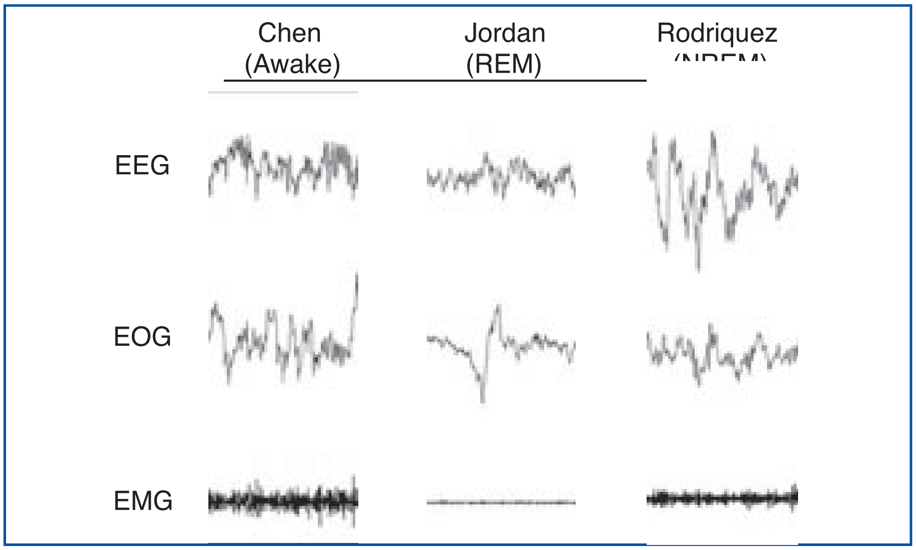


Figure 2.2. Astronaut data.

Student comments should reflect that sleep is a dynamic process. This means that the body remains physiologically active with characteristic changes in brain and muscle activity, as well as changes in other physiological parameters. Sleep is not uniform, but rather consists of discrete stages that cycle throughout the night.

For classes using the *print-based version* of this lesson:

1. **Introduce the *print-based version* of this lesson by explaining to the class that they will use a hypothetical scenario to learn about the physiology and major stages of sleep.**

   You can refer to statement 8 on Master 1.1: "Sleep is time for the body and brain to shut down for rest." (False.) How did the students respond and why? Is sleep really a time when not much occurs physiologically? Students can now investigate this idea.

2. **Show the class the transparency of Master 2.1, *Astronaut Scenario*, and read it aloud.**

3. **Give each student a copy of Master 2.2, *Astronaut Telemetry Evaluation Form,* and single copies of Masters 2.3, 2.4, and 2.5, which contain the telemetry data for the three astronauts.**

   As an alternative, students may work in teams of three. If they work in teams, have each student analyze data for a different astronaut and discuss it with their team. This approach ensures that each student is actively participating in the activity.

Assessment:
Instruct students to answer questions about animal sleep such as a) Do other animals sleep? b) How is their sleep similar to human sleep? and c) How is their sleep different from human sleep? Make available to students relevant information from the Information about Sleep section and from Web sites listed in the Additional Web Resources for Teachers section.

4. **Explain that these data are sufficient to tell if an astronaut is awake or asleep, and if asleep, whether in NREM or REM sleep. Further explain that not all of the data may be useful for determining the astronauts' sleep states.**

5. **Give each student a copy of Master 2.6, *Sleep Medicine Reference Manual*. Explain that this is a resource to help them interpret the data they have in front of them and relate it to the astronauts' sleep states.**

6. **Instruct students to evaluate the data for each astronaut, using the information in the *Sleep Medicine Reference Manual* for comparison. Student observations, interpretations, and conclusions should be entered on Master 2.2, *Astronaut Telemetry Evaluation Form*.**

7. **After students have had an opportunity to complete their analyses, ask the class, What is the state of wakefulness or sleep of each of the three astronauts?**

   Astronaut Jordan is in REM-stage sleep. Astronaut Rodriguez is in NREM-stage sleep. Astronaut Chen is awake.

8. **Ask the class, Which physiological data are useful for determining a person's state of wakefulness or sleep?**

   Students should conclude that the important parameters for distinguishing between sleep states and wakefulness are EEG, EMG, and EOG. The other four parameters—heart rate, blood pressure, respiratory rate, and body temperature—might be useful in combination with EEG, EMG, and EOG data, but they are not sufficient by themselves. For instance, heart rate increases during REM, but it also may increase with physical activity during wakefulness.

NSES

Content Standard A: Students should develop understandings about scientific inquiry.

9. **Ask students, How can you distinguish between REM and NREM sleep? Between REM and wakefulness? NREM and wakefulness?**

   The EEG, EOG, and EMG data are reproduced in Figure 2.2 (page 73). First consider astronaut Jordan. Jordan's EEG does not appear to represent NREM sleep, although students may have difficulty distinguishing between REM and wakefulness EEGs. However, the lack of muscular activity (EMG) during REM as compared with activity during NREM or wakefulness is the key for determining that this individual is in REM-stage sleep. Rodriguez and Chen can be distinguished from each other based on their EEGs (that is, the increased amplitude and decreased frequency of brain waves during NREM compared with the pattern during REM and wakefulness) and their EOGs (that is, large eye movements during wakefulness as compared with little or no eye movements during NREM).

10. **Explain to the class that during a normal night's sleep, we cycle through NREM and REM sleep several times. This cycling is called an *ultradian rhythm* because the cycle time is less than 24 hours. Conclude the lesson by asking, What can you conclude about sleep from this investigation?**

    Student comments should reflect that sleep is a dynamic process. This means that the body remains physiologically active with characteristic changes in brain and muscle activity, as well as changes in other physiological parameters. Sleep is not uniform, but rather consists of discrete stages that cycle throughout the night.

Assessment:
Instruct students to answer questions about animal sleep such as a) Do other animals sleep? b) How is their sleep similar to human sleep? and c) How is their sleep different from human sleep? Make available to students relevant information from the Information about Sleep section and from Web sites listed in the Additional Web Resources for Teachers section.

What the Teacher Does	Procedure Reference
Explain that this lesson uses a hypothetical scenario to investigate physiology and the major stages of sleep. • Ask the class to reflect on their responses to the statement from Lesson 1, "Sleep is time for the body and brain to shut down for rest." (False.)	Page 71 Step 1
Divide the class into student teams. Instruct them to log onto the Web site and click on "Lesson 2—Houston, We Have a Problem."	Page 71 Step 2
Give each student a copy of Master 2.2, *Astronaut Telemetry Evaluation Form*.	Page 71 Step 3
After they have listened to the introduction, have students evaluate data for each astronaut and write down their observations, interpretations, and conclusions using Master 2.2, *Astronaut Telemetry Form*.	Page 72 Step 4
Discuss the sleep state of each astronaut and ask, • Which data are useful for making such determinations? • How can we distinguish between REM and NREM sleep? • How can we distinguish between REM and wakefulness? • How can we distinguish between NREM and wakefulness?	Page 72 Steps 5–7
Explain that during the night, we cycle between NREM and REM sleep several times. • Introduce the concept of an ultradian rhythm. • Ask the class, What can you conclude about sleep from this investigation?	Pages 72–73 Step 8

= Involves using the Internet. = Involves copying a master.

Lesson 2 Organizer: Print Version

What the Teacher Does	Procedure Reference
Explain that this lesson uses a hypothetical scenario to investigate physiology and the major stages of sleep. • Ask the class to reflect on their responses to the statement from Lesson 1, "Sleep is time for the body and brain to shut down for rest." (False.)	Page 73 Step 1
Show the transparency of Master 2.1, *Astronaut Scenario*, and read it to the class.	Page 73 Step 2 T
Give each student a copy of Master 2.2, *Astronaut Telemetry Evaluation Form,* and single copies of Masters 2.3, 2.4, and 2.5, which contain the telemetry data for the three astronauts. • Explain that these data are sufficient to tell if an astronaut is awake or asleep, and if asleep, whether in NREM or REM sleep.	Pages 73–74 Steps 3 and 4 M
Give each student a copy of Master 2.6, *Sleep Medicine Reference Manual.* • Explain that it is a resource to help them interpret the astronauts' data.	Page 74 Step 5 M
Instruct students to evaluate the data for each astronaut and enter their conclusions on Master 2.2, *Astronaut Scenario*.	Page 74 Step 6

T = Involves using a transparency.

M = Involves copying a master.

Discuss the sleep state of each astronaut and ask, • Which data are useful for making such determinations? • How can we distinguish between REM and NREM sleep? • How can we distinguish between REM and wakefulness? • How can we distinguish between NREM and wakefulness?	Page 74 Steps 7–9
Explain that during the night, we cycle between NREM and REM sleep several times. • Introduce the concept of an ultradian rhythm. • Ask the class, What can you conclude about sleep from this investigation?	Page 75 Step 10

Astronaut Scenario

The scene is mission control at Space Command Central. Video and audio communications with our three astronauts in space have suddenly been lost. Communications have been out for some time, and repeated attempts by mission control technicians to fix the problem have been unsuccessful. Space Command Central would like to know if the astronauts are aware of the problem and if they are trying to fix it from their end. Unfortunately, it is supposed to be nighttime for the astronauts, and they may be asleep. What, if anything, is going on in space?

Space Command Central decides to assemble their medical team. Even though audio and video communications are out, medical telemetry (that is, data on the status of key body systems) is still being received. The engineers at Space Command Central need help interpreting all of the medical data they are receiving. Your expertise is needed to determine the state of wakefulness or sleep for each of the astronauts. If the astronauts are asleep, are they in NREM or REM sleep?

Astronaut Telemetry Evaluation Form

Space Command Medical Team Report

Name(s)____ Date ____________________

Overall Evaluation: Medical telemetry for **astronaut Jordan** indicates (circle one):

wakefulness NREM sleep REM sleep data inconclusive

1. Which data were useful in making your determination, and, specifically, how were they helpful?

2. Which data were *not* helpful in making your determination, and why were they not helpful?

Overall Evaluation: Medical telemetry for **astronaut Rodriguez** indicates (circle one):

wakefulness NREM sleep REM sleep data inconclusive

1. Which data were useful in making your determination, and specifically, how were they helpful?

2. Which data were *not* helpful in making your determination, and why were they not helpful?

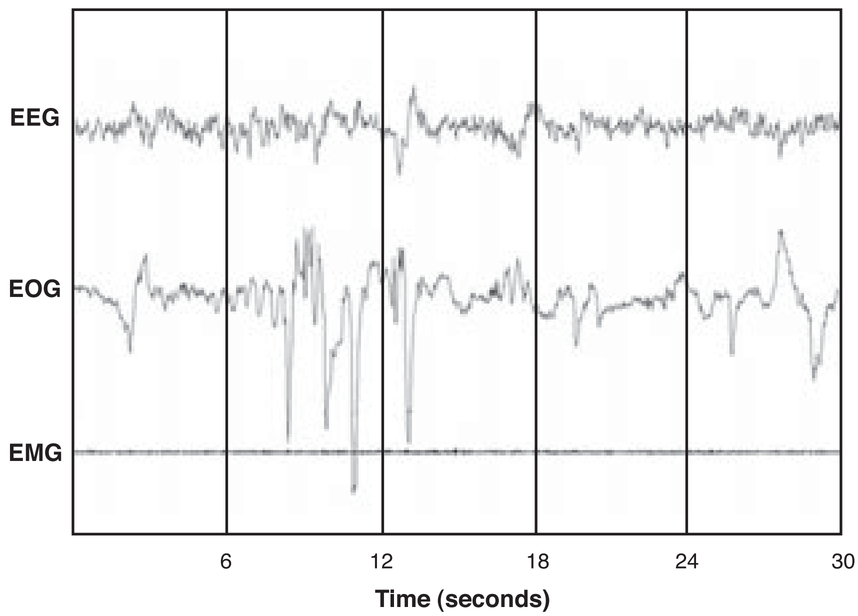
Overall Evaluation: Medical telemetry for **astronaut Chen** indicates (circle one):

wakefulness NREM sleep REM sleep data inconclusive

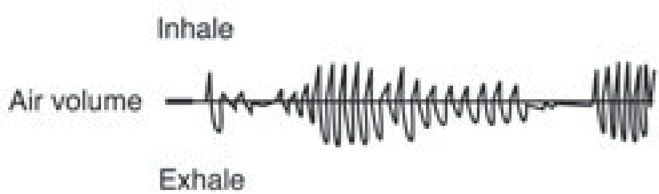
1. Which data were useful in making your determination, and specifically, how were they helpful?

2. Which data were *not* helpful in making your determination, and why were they not helpful?

Astronaut Jordan

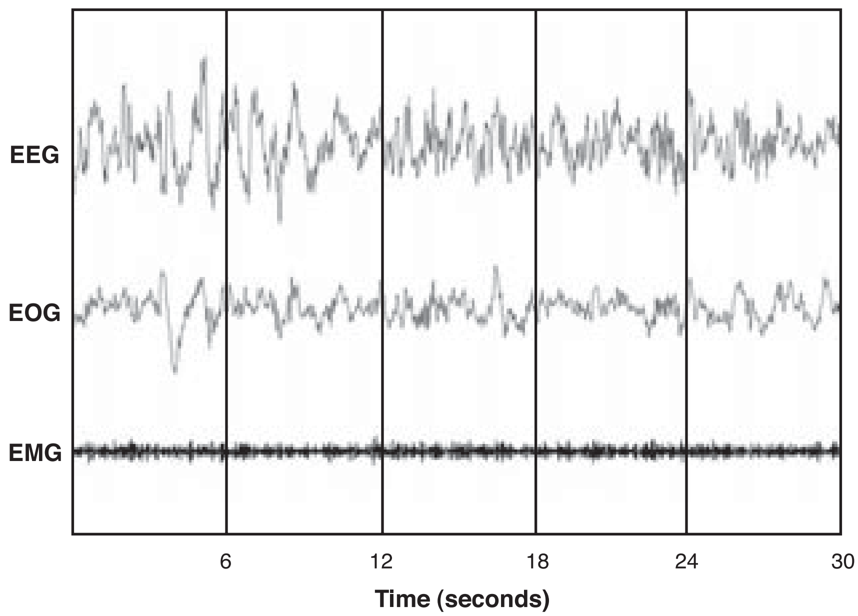


Respiration:

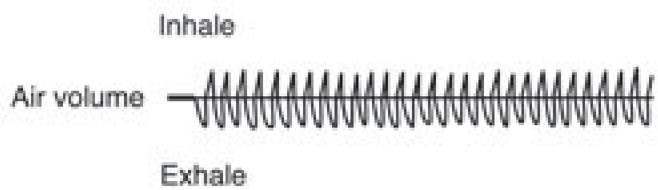


Body Temperature:	97.0°F 36.1°C
Heart Rate:	90 bpm
Blood Pressure:	125/85 mm Hg

Astronaut Rodriquez

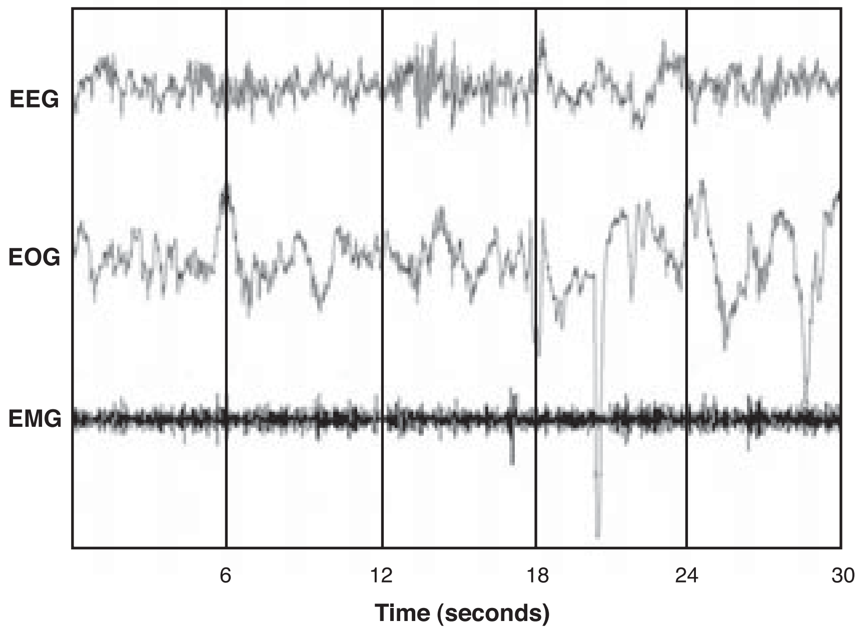


Respiration:



Body Temperature:	98.6°F 37.0°C
Heart Rate:	65 bpm
Blood Pressure:	115/73 mm Hg

Astronaut Chen



Respiration:

Body Temperature:	99.0°F 37.2°C
Heart Rate:	70 bpm
Blood Pressure:	110/75 mm Hg

Sleep Medicine Reference Manual

SLEEP MEDICINE REFERENCE MANUAL

Contents

Electroencephalography (EEG)
Electromyography (EMG)
Electrooculography (EOG)
Sleep Stages
- EEG
- EMG
- EOG
- Hypnograms
- Heart Rate
- Blood Pressure
- Body Temperature
- Respiration

Electroencephalography

Sleep is not a passive event. It is an active process involving characteristic physiological changes in the organs of the body. Scientists study sleep by measuring the electrical changes in the brain using a technique called electroencephalography (EEG). Normally, electrodes are placed on the scalp; these are usually fairly numerous and placed in a symmetrical pattern, as seen in the figure.

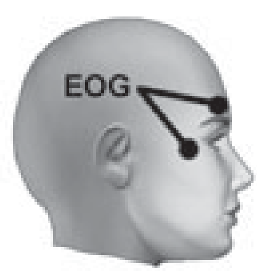
They measure very small voltages that are thought to be caused by synchronized activity in very large numbers of synapses (nerve connections) in the cerebral cortex. EEG data are represented by curves, which are classified according to "rhythm." The wavy lines of the EEG are what most people know as "brain waves."

Electromyography

Scientists measure the electrical activity associated with active muscles, using electromyography (EMG). This is accomplished by placing electrodes on the skin overlying a muscle. In humans, an EMG is generally recorded by placing electrodes under the chin, since muscles in this area demonstrate very dramatic changes during the various stages of sleep. Electrodes may also be placed on the lower leg.

Electrooculography

If an electrode is placed on the skin near the eye, changes in voltage are measurable as the eye rotates in its socket. This produces an electrooculogram (EOG).



Sleep Stages

Sleep is a highly organized sequence of events that follow a regular cycle each night. For instance, the EEG, EMG, and EOG patterns change in predictable ways several times during a single sleep period. Study of these events has lead to the identification of two basic stages, or states, of sleep: non–rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep. Physiologic characteristics, such as body temperature, blood pressure, heart rate, respiration, and hormone release, are also different during wakefulness, NREM sleep, and REM sleep.

NREM sleep, also known as slow wave (SW) sleep, is subdivided into four stages according to the amplitude and frequency of brain wave activity, eye movements, and voluntary muscle activity that typify each substage. Generally, these four stages differ primarily in their EEG patterns, while the general physiology of these stages is fairly similar. Therefore, in this manual, emphasis will be on NREM sleep in general, and not on its individual substages.

Sleep Stages, continued

Sleep is a cyclical process. During sleep, people experience repeated cycles of NREM and REM sleep, beginning with an NREM phase. This cycle lasts approximately 90 to 110 minutes and is repeated three to six times per night. As the night progresses, however, the amount of NREM sleep decreases and the amount of REM sleep increases. The term ultradian rhythm (that is, rhythm occurring with a periodicity of less than 24 hours) is used to describe this cycling through sleep stages.

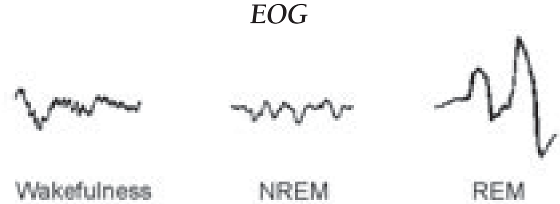
EEG

Wakefulness and REM-stage sleep are both characterized by low-amplitude, random, fast wave patterns. In contrast, NREM-stage sleep is characterized by high-amplitude, slow waves.

EMG

During wakefulness, the EMG may vary between moderate and high, depending on the activities in which the individual is engaged. EMGs in NREM-stage sleep are moderate to low. In REM-stage sleep, voluntary muscle activity is inhibited and the EMG is virtually absent.

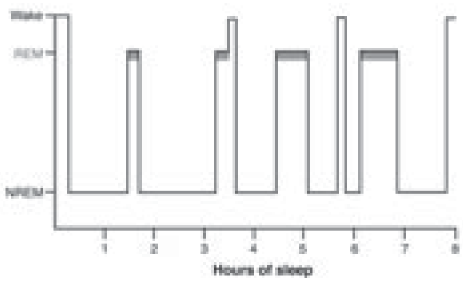
EOG



During wakefulness, rapid eye movements may be very frequent or scarce, depending on the extent to which vision is being used. Eye movement is absent during NREM, although some brain activity may be picked up by the testing equipment and be recorded incorrectly as eye activity. During REM-stage sleep, there are bursts of rapid eye movements, in between which there are periods of no eye movements.

Hypnograms

Hypnograms were developed to summarize the voluminous chart recordings (EEG, EMG, and EOG) that are made when recording electrical activities occurring during a night's sleep. As a simple graphic, they provide a simple way to evaluate data that would originally have been collected on many feet of chart paper or stored as a large digital file on a computer. This hypnogram summarizes how a typical night's sleep for a young, healthy adult is organized into stages.



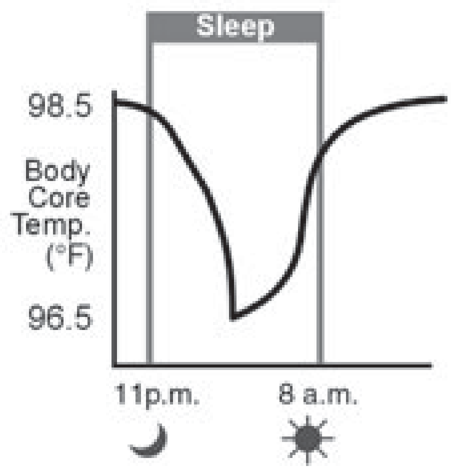
Heart Rate

During wakefulness, heart rate (in beats per minute, or bpm) can vary considerably depending on the level of activity in which the individual is engaged. During NREM-stage sleep, the heart rate exhibits less variability and may be slightly lower than what is observed during resting or less active wakefulness. Heart rate during REM-stage sleep exhibits pronounced changes and may rise to levels seen during moderate to strenuous exercise.

Body Temperature

Body temperature is relatively constant during wakefulness. However, it is maintained at a lower set point during NREM-stage sleep, thus resulting in a lower body temperature during NREM as compared with wakefulness. Body temperature is not regulated during REM-stage sleep, and it will drift toward the environmental temperature.

There also is a biological clock–related component to body temperature. This means that the body temperature will vary in a regular way with the time of day. For instance, body temperatures will be higher at midafternoon and reach their low point in the early morning hours before awakening, as seen below.



Blood Pressure

During wakefulness, blood pressure can vary considerably, for instance, with activity and stress levels. Blood pressure tends to decrease slightly during NREM-stage sleep and exhibits less variability. During REM-stage sleep, blood pressure is highly variable and may occasionally increase up to 30 percent over the resting level. During REM sleep, the diameter of blood vessels decreases (that is, they undergo vasoconstriction), which may be the cause of the rise in blood pressure.

Respiration

During wakefulness, respiration may vary with activity, stress, and emotional levels. During NREM-stage sleep, breathing slows, and the inhalation and exhalation of air decrease in magnitude compared with those of wakefulness. Breathing during NREM sleep is generally very regular. In REM-stage sleep, breathing can be very irregular.

Lesson 3 Explore/ Explain

Do You Have Rhythm?


Figure 3.1. Animals, like humans, have biological rhythms that determine when they are active.

At a Glance

Overview

In this lesson, students explore circadian rhythms and biological clocks. First, students read about a Frenchman who lived alone for two months in a cave, and they learn how it affected his sense of time. Second, students analyze their sleepiness scale responses (from their sleep diaries), graph the data, and look for a rhythmic variation in sleepiness and alertness. Students can formulate and test hypotheses using the sleep diary and sleepiness scale database.

Major Concepts

Humans, and many other animals, have an internal biological clock. This clock operates on a cycle of just over 24 hours. Environmental cues, especially light, reset the clock, keeping it in time with the day/night cycles. The clock directs the rhythmic secretion of hormones, such as melatonin, that influence our sleep cycle. If the biological clock becomes out of phase with the environment, various types of sleep problems can result.

Objectives

After completing this lesson, students will

- recognize the existence of biological clocks,
- understand the concept of circadian rhythms,

- describe the relationship between circadian rhythm and sleep/wake cycles,
- explain why external cues are required to reset our biological clock, and
- understand how disruption in circadian rhythms can affect sleep/wake cycles.

Teacher Background

Consult the following section in Information about Sleep:
3.5 Biological clock (pages 26–30).

In Advance

Web-Based Activities

Activity	Web Version?
1	No
2	Yes

Photocopies

Activity 1	Master 3.1, *Michel Siffre Story* (Make 1 copy per student.) Master 3.2, *The Rhythms of Sleep* (Make 1 copy per student and cut the copies in half along the dotted line.)
Activity 2	Master 3.3, *Sleepiness Scale Graph Template* (Make 1 copy per student.) Master 3.4, *Thinking about Sleepiness and Sleep Cycles* (Make 1 copy per student.)

Materials

Activity 1	no materials needed
Activity 2	computers with an Internet connection

Preparation

Activity 1
No preparations needed (except for photocopying).

Activity 2
Students should have their sleep diaries containing sleepiness scale data available. The day *before* you do this activity in class, ask students to complete the graphing exercise described in Step 1 of the procedure (page 90).

Procedure

Activity 1: *Michel Siffre Story*

1. **Introduce this activity by reminding students of statements 1, "Everyone has a biological clock" (true), and 9, "The body quickly adjusts to different sleep schedules" (false), on Master 1.1. How did students respond to these statements and why?**

   This activity and the next will allow students to investigate biological clocks and our ability to adapt to changing environmental cues.

2. **Give each student a copy of Master 3.1, *Michel Siffre Story*, and ask them to read it.**

3. **Ask students to explain why Siffre's "day" varied so much, and why his average "day" was longer than 24 hours.**

4. **If students are having trouble understanding why Siffre's days became so long, ask them how they know when it is time to sleep.**

   Of course, students will mention that they use a clock. Ask them to think about how our body can tell what time of day it is.

5. **Give each student a copy of the top half of Master 3.2, *The Rhythms of Sleep*, and ask them to read it.**

6. **Ask students if the information in their handout helps them understand why Siffre's day began to grow longer than 24 hours.**

   The important point made in the handout is that the circadian clock operates on a cycle that is a bit longer than 24 hours (more like 24.5 hours). Students should appreciate that this helps explain why Siffre's day grew longer. Although the circadian clock can be reset using artificial light, Siffre had no way of telling time and his use of artificial light did not help him maintain regular sleep/wake cycles.

7. **Next, ask the students, Why don't you experience a day-lengthening effect similar to Michel Siffre's?**

   If students have trouble answering this question, direct the discussion toward how our body uses light to sense the time of day. Light is the signal that resets our clock.

NSES

Content Standard C:
Organisms have behavioral responses to internal changes and to external stimuli.

8. **Give each student a copy of the bottom half of Master 3.2, *The Rhythms of Sleep*, and ask them to read it.**

9. **Ask the class what they think happened to Michel Siffre's sleep cycle after he left the cave.**

   Students should predict that light cues reset his biological clock and his sleep cycle returned to normal.

Activity 2: *Sleepiness Scale, Introduction to Rhythms*

1. **Give each student a copy of Master 3.3, *Sleepiness Scale Graph Template*. Have them refer to their sleepiness scale entries in their sleep diaries (from Lesson 1) and graph the average of their scores for each time point (for example, wake time).**

   If you have time, you may consider having students calculate the average sleepiness scale scores using all of the class data. Doing this emphasizes the nature of science since there is a greater likelihood of seeing a rhythm when using more data for analysis. Students can then compare their own data with the average class data.

2. **Ask students to describe the graph of their sleepiness scale data. Is a pattern detectable?**

   Ideally, students will observe that their sleepiness scale graph resembles the following example:

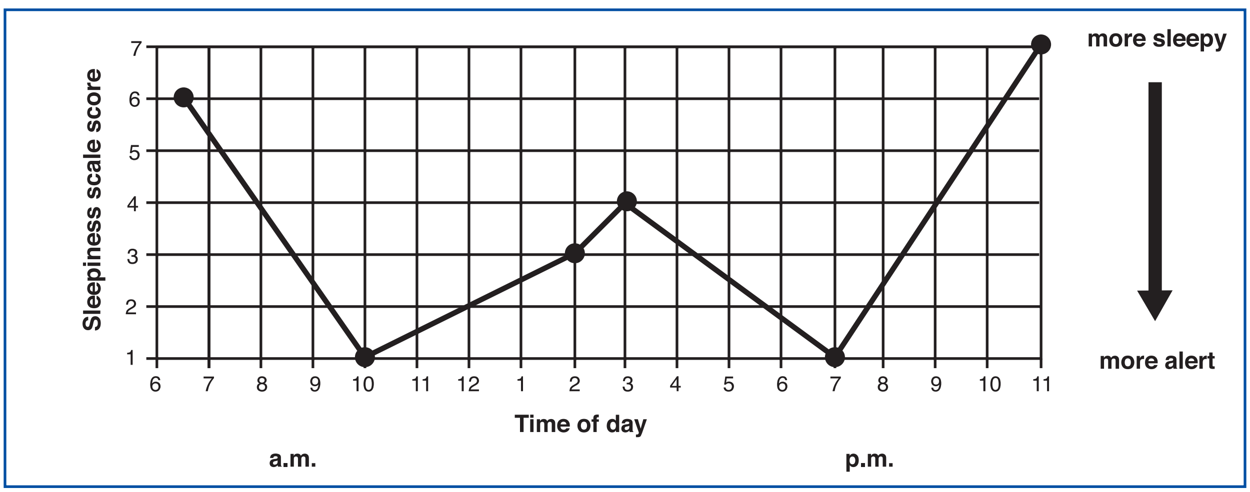


Figure 3.2. Sample sleepiness scale graph.

Alertness first increases (sleepiness decreases) in midmorning, then alertness decreases during the afternoon. Alertness then increases again in the early evening before sleepiness takes over at bedtime.

and

3. **For those classrooms with access to the Internet, you may access your class data at *http://science.education.nih.gov/supplements/sleep/student*. Click on "Lesson 1—What Is Sleep?" and then enter your class code. Click on "Generate Report" and select one of the sleepiness scale options.**

   For classrooms without access to the Internet, collect students' sleepiness scale data on the board and calculate class averages for each time point.

4. **Instruct students to work individually or in small teams. They should develop a hypothesis, test it by using the data in the sleep database, and provide a short written summary of their findings.**

   As in Lesson 1, students can formulate hypotheses, build a custom report, and evaluate the data presented in the report. Classes without Internet access can test their hypotheses using the class data set. Classes not using the sleep database have less data available for their use. Therefore, it is important that you also provide them with the sleep diary data used in Lesson 1. Students can then test hypotheses that relate data from the sleep diary to those from the sleepiness scale.

   Make sure that students are testing answerable questions using information in the database. Some appropriate hypotheses include
   a. there are male/female differences in the cycling of alertness during the day;
   b. school start time has an effect on the timing of the dips in alertness and peaks of sleepiness during the day;
   c. latitude affects the timing of the dips in alertness and peaks of sleepiness during the day; and
   d. total sleep time affects the timing of the dips in alertness and peaks of sleepiness during the day.

5. **After the class has had the opportunity to test their questions, ask for volunteers to share their hypothesis and findings. Ask students why they asked the questions they did.**

6. **If students can't determine whether the data support their hypothe-**

Content Standard A: Identify questions and concepts that guide scientific investigations.

Content Standard A: Communicate and defend a scientific argument.

Assessment: Instruct students to write a brief report that states their hypothesis, the type of data from sleep diaries used to test the hypothesis, and their conclusions. If a firm conclusion is not supported by the data, instruct students to explain what additional information would be needed to reach a conclusion.

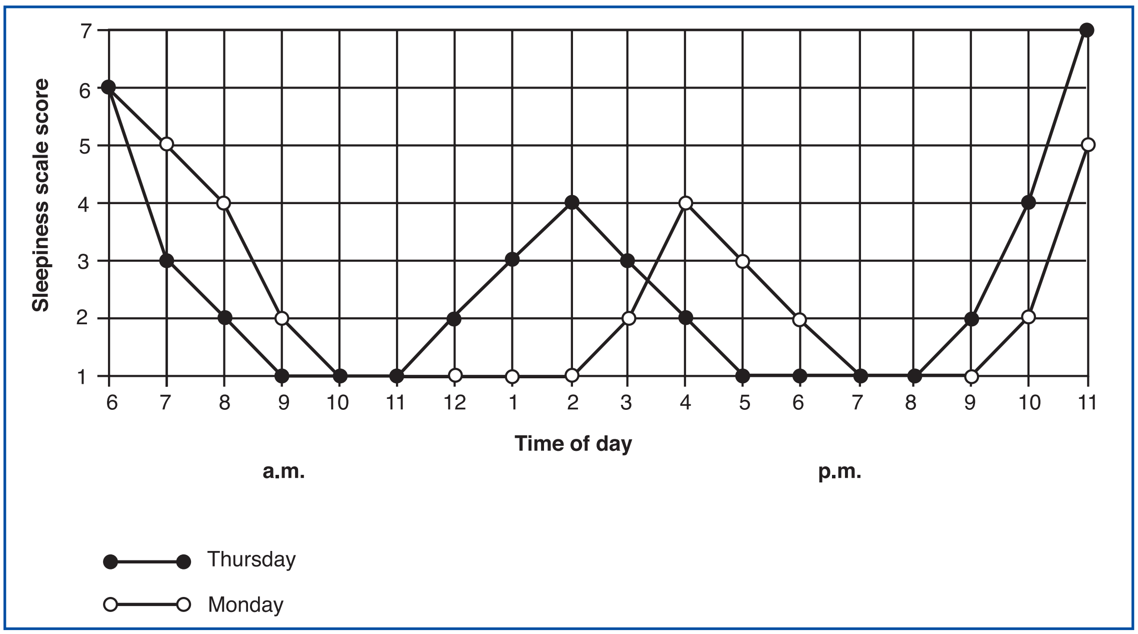
sis, ask what additional data could help resolve the questions.

This is an opportunity to assess whether students have asked a question that can be answered using information in the database. Even if students have asked appropriate questions of the database, there may be too few cases to allow them to reach a firm conclusion. This is an opportunity to discuss what type of data are needed to properly analyze their hypotheses.

7. **Give each student a copy of Master 3.4, *Thinking about Sleepiness and Sleep Cycles*, and ask them to respond to the questions.**

Answers to questions on Master 3.4, *Thinking about Sleepiness and Sleep Cycles.*

Question 1. The graph below contains sleepiness scale data from an individual who recorded entries every waking hour during a Monday



and a Thursday. Describe how the data for Monday differ from those for Thursday. Can you suggest an explanation for this difference? Students should observe that the morning increase in alertness and the afternoon increase in sleepiness occur later on Monday as compared to Thursday. This "phase shift" may occur if an individual sleeps later on Saturday and Sunday than they do on weekdays. In effect, the change in sleep habits on the weekend may cause a resetting of the individual's biological clock. The reason for having the students record data on two Mondays is so that any difference between the first Monday's data and Thursday's data may be confirmed with data from the second Monday. This point can be made as a means of indicating how science is done. Ask students if their data showed such a phase shift.

Question 2. During the past several activities, you have learned about different types of cycles associated with sleep. List three different cycles and provide a brief description of each one.

Three cycles associated with sleep are 1) the NREM/REM cycles that occur during sleep (ultradian rhythm); 2) the cycling of the need to sleep (homeostatic regulation); and 3) the circadian rhythm governing our propensity to sleep. It is more important that students recognize that there are different rhythms associated with sleep than that they remember the technical names for them.

Assessment: Having students write their answers before sharing their thoughts with the class gives you an opportunity to evaluate each student's understanding. It also helps students organize their thoughts before class discussion.

What the Teacher Does	Procedure Reference
Remind the class of their responses to two of the statements about sleep from Lesson 1: • Everyone has a biological clock. (True.) • The body adjusts quickly to different sleep schedules. (False.)	Page 89 Step 1
Give each student a copy of Master 3.1, *Michel Siffre Story*, and instruct them to read it. • Ask students to explain why his "day" varied so much. • Ask students how they know when it is time to sleep.	Page 89 Steps 2–4 M
Give each student a copy of the top half of Master 3.2, *The Rhythms of Sleep*, and instruct them to read it. • Ask the students whether this information helps them understand why Siffre's day grew longer than 24 hours. • Ask why our own biological clocks don't cause our days to grow longer.	Page 89 Steps 5–7 M
Have the class read the bottom half of Master 3.2, *The Rhythms of Sleep.* • Ask students what happened to Siffre's sleep cycle after leaving the cave.	Page 90 Steps 8 and 9 M

M = Involves copying a master.

www = Involves using the Internet.

Activity 2: *Sleepiness Scale, Introduction to Rhythms*

What the Teacher Does	Procedure Reference
Give each student a copy of Master 3.3, *Sleepiness Scale Graph Template*. • Instruct students to graph their sleepiness scale entries from their sleep diaries.	Page 90 Step 1
Ask the class to describe the graphed results of their sleepiness scale data. • Is a pattern detectable?	Pages 90–91 Step 2
Log onto the student Web site, click on Click on "Lesson 1—What Is Sleep?" and then enter your class code. Click on "Generate Report" and select one of the sleepiness scale options.	Page 91 Step 3
Divide the class into small teams and instruct them to think of hypotheses about sleepiness that can be answered using information from the sleep database. • They should test their hypothesis by generating appropriate reports. • They should write a short summary of their findings.	Page 91 Step 4
Ask for volunteers to state their hypotheses and findings. • Have students explain why they chose their question. • If their data are inconclusive, ask what additional data they would need to answer their question.	Pages 91–92 Steps 5 and 6
Give each student a copy of Master 3.4, *Thinking about Sleepiness and Sleep Cycles.* • Have students respond to the questions and discuss the answers.	Pages 92–93 Step 7

Lesson 3 Organizer: Print Version

What the Teacher Does	Procedure Reference
Remind the class of their responses to two of the statements about sleep from Lesson 1: • Everyone has a biological clock. (True.) • The body adjusts quickly to different sleep schedules. (False.)	Page 89 Step 1
Give each student a copy of Master 3.1, *Michel Siffre Story*, and instruct them to read it. • Ask students to explain why his "day" varied so much. • Ask students how they know when it is time to sleep.	Page 89 Steps 2–4 M
Give each student a copy of the top half of Master 3.2, *The Rhythms of Sleep*, and instruct them to read it. • Ask the students whether this information helps them understand why Siffre's day grew longer than 24 hours. • Ask why our own biological clocks don't cause our days to grow longer.	Page 89 Steps 5–7 M
Have the class read the bottom half of Master 3.2, *The Rhythms of Sleep.* • Ask students what happened to Siffre's sleep cycle after leaving the cave.	Page 90 Steps 8 and 9 M

M = Involves copying a master.

What the Teacher Does	Procedure Reference
Give each student a copy of Master 3.3, *Sleepiness Scale Graph Template*. • Instruct students to graph their sleepiness scale entries from their Sleep Diaries.	Page 90 Step 1 M
Ask the class to describe the graphed results of their sleepiness scale data. • Is a pattern detectable?	Pages 90–91 Step 2
Collect students' sleepiness scale data on the board. • Instruct students to calculate class averages for each time point.	Page 91 Step 3
Divide the class into small teams and instruct them to think of hypotheses about sleepiness that can be answered using information from their class data set. • They should write a short summary of their findings.	Page 91 Step 4
Ask for volunteers to state their hypotheses and findings. • Have students explain why they chose their question. • If their data are inconclusive, ask what additional data they would need to answer their question.	Pages 91–92 Steps 5 and 6
Give each student a copy of Master 3.4, *Thinking about Sleepiness and Sleep Cycles.* • Have students respond to the questions and discuss the answers.	Pages 92–93 Step 7 M

Michel Siffre Story

How did you celebrate the new millennium? Like many of you, Frenchman Michel Siffre rejoiced in a New Year's celebration. Yet unlike most of you, Michel celebrated three days late!

Michel Siffre, a 61-year-old cave explorer, descended 2,970 feet into a cave located in southern France as part of an experiment. In this deep cave, Michel lived for two months with no contact with the outside world. He had no instrument to measure the time of day. He found it difficult to keep track of time while living without cues of any kind to help him tell if it was day or night. While in the cave, Michel used artificial light to read novels and journals and to cook. Of course, he napped. The naps were the key to throwing off Michel's sense of time.

Scientists were (and still are) interested in learning about human sleep patterns. They wanted to study Michel's sleep habits while he was in the cave. Michel wore electrodes on his body that allowed scientists at the cave opening to monitor his sleep. They observed that Michel's sleep/wake cycles varied considerably. His "day" (the time between major sleep periods) varied between 18 and 52 hours (average "day" = 27.5 hours). Scientists are using information from monitoring Michel and from other experiments to help astronauts follow healthy sleep habits during long space voyages.

This was not Michel's first journey underground for a great length of time. He spent two months in a cave on the French-Italian border in 1962, and another 205 days in a Texas cave in 1972.

The Rhythms of Sleep

The Biological Clock

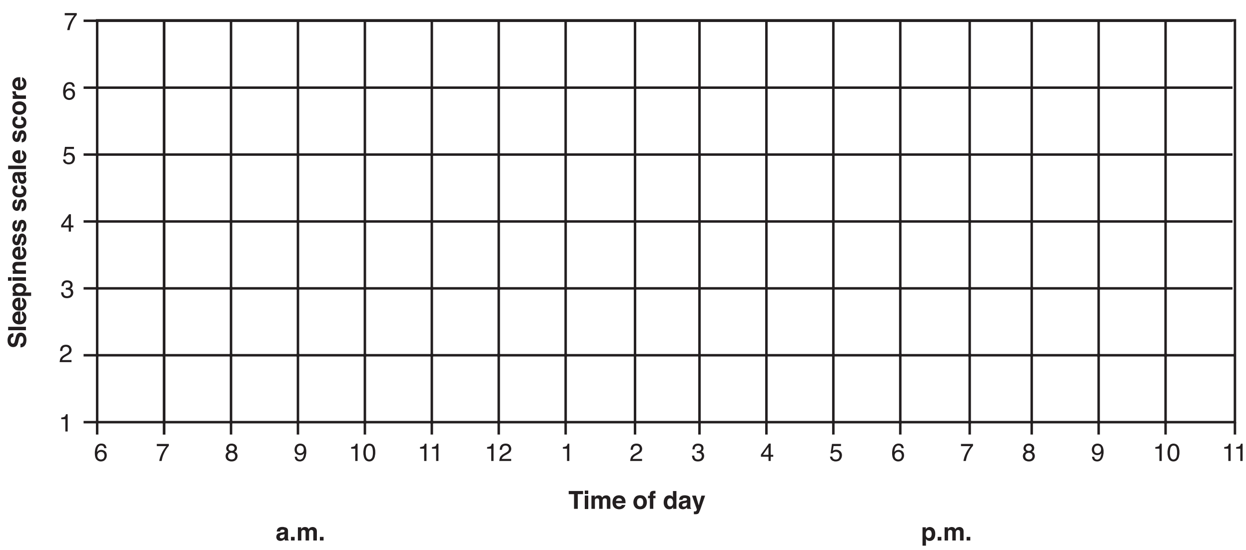
The timing for sleep in humans is regulated by our internal biological clock. Biological clocks are not like other clocks with which we are all familiar. Rather, they are physiological systems that allow organisms to live in harmony with the rhythms of nature, such as day/night cycles and the changing of seasons. The most important function of our biological clock is that it regulates our sleep/wake cycle. Our clock, because it cycles once per day, is called a *circadian clock*. In humans, this clock is located in a very small area of the brain called the *suprachiasmatic nucleus* (SCN). The SCN receives light signals from the retina, interprets them, and sends signals to another area of the brain, the pineal gland, to release hormones that affect our sleep/wake cycle. Clock genes maintain the clock cycle by directing the synthesis of proteins that slowly enter the cell nucleus and turn off the clock genes. Over a period of about 24.5 hours, these proteins break down and the genes become active again. This type of biochemical cycle is called a *negative feedback loop*.

Resetting the Clock

The circadian clock in humans actually cycles at just over 24 hours. This means that the clock must be reset to match the environmental photoperiod (that is, the light/dark, or day/night, cycle). The cue for resetting the clock is light. Light receptors in the eye transmit signals to the SCN, which in turn directs the pineal gland to secrete a hormone called *melatonin*. Melatonin levels rise during the night and decline at dawn. The rhythmic secretion of hormones such as melatonin influences our sleepiness. If the clock fails to reset properly, it becomes out of sync with the environment and can produce various problems such as jet lag, seasonal affective disorder, and Monday morning blues.

Sleepiness Scale Graph Template

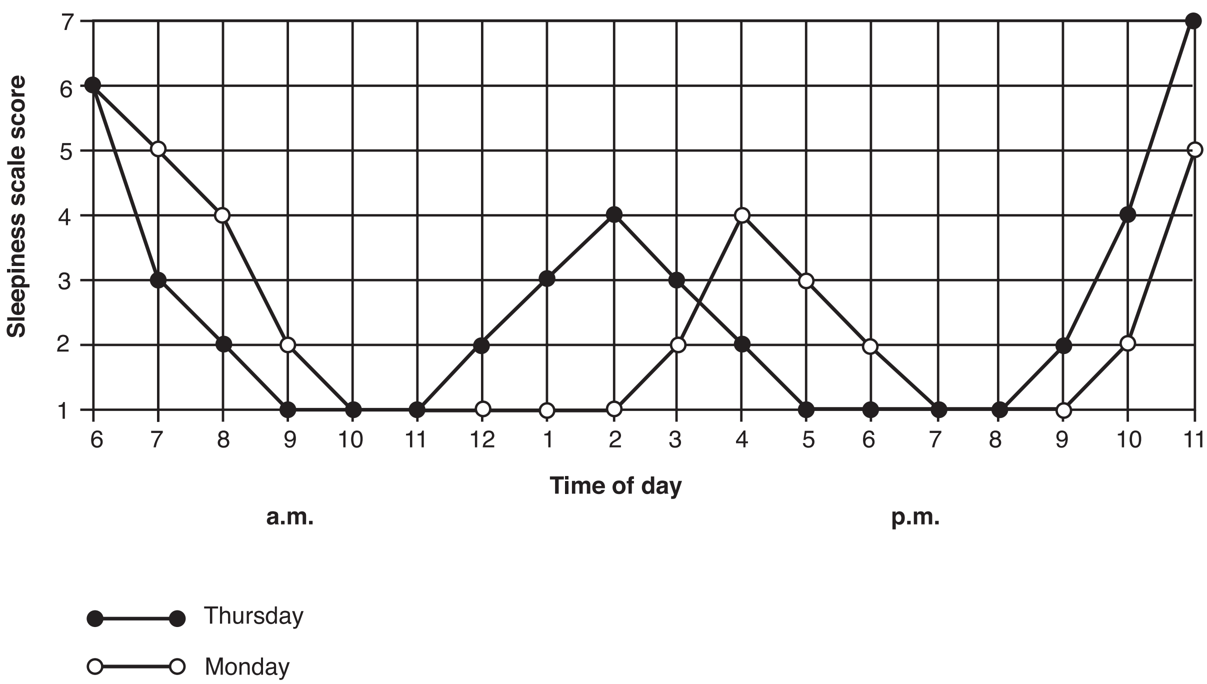
Name______________________________ Date______________



Thinking about Sleepiness and Sleep Cycles

Name____ Date____________________

1. The graph below contains sleepiness scale data from an individual who recorded entries every waking hour during a Monday and a Thursday. Describe how the data for Monday differ from those for Thursday. Can you suggest an explanation for this difference?



2. During the past several activities, you have learned about different types of cycles associated with sleep. List three different cycles and provide a brief description of each one.

Lesson 4
Elaborate

Evaluating
Sleep Disorders

Figure 4.1. Accredited sleep centers evaluate people with sleep disorders, usually with an overnight sleep recording.

At a Glance

Overview

The lesson begins with students reading several short stories about snoring. Students engage in a discussion about sleep disorders. Also, students recall and use information obtained in Lesson 1 (the Sleep Diary). Students then assume the role of a sleep specialist. They evaluate five fictional case histories involving sleep problems. Using the reference materials provided, students analyze data and arrive at a "diagnosis." They select a treatment based on their diagnosis. In a written report, students provide the rationale for their diagnosis and treatment selection, and they predict the expected outcome of the treatment.

Major Concepts

Many factors affect the quality and quantity of sleep. Insomnia is the most prevalent sleep disorder. Other major sleep disorders include sleep apnea, restless legs syndrome, and narcolepsy.

Objectives

After completing this activity, students will

- recognize that many different sleep disorders exist,
- understand that nearly everyone, at some time, experiences difficulty sleeping,

- understand that external and internal factors affect sleep and sleep patterns, and
- understand that treatments are available for sleep disorders.

Teacher Background

Consult the following section in Information about Sleep:
4 Sleep Disorders (pages 35–37)

In Advance

Web-Based Activities

Activity	Web Version?
1	No
2	No

Photocopies

Activity 1	Master 4.1, *Snoring—Believe It or Not!* (Make 1 copy per student.) Master 4.2, *Snoring Survey* (Make 1 copy per student.)
Activity 2	(per team of 4 students) See Preparation for information about number of copies needed. Master 4.3, *Case History 1* (Make 1 copy per team.) Master 4.4, *Case History 2* (Make 1 copy per team.) Master 4.5, *Case History 3* (Make 1 copy per team.) Master 4.6, *Case History 4* (Make 1 copy per team.) Master 4.7, *Case History 5* (Make 1 copy per team.) Master 4.8, *Sleep Specialist's Evaluation Form* (Make 1 copy per student.) Master 4.9, *Sleep Disorders Reference Manual* (Make 1 copy per team.)

Materials

Activity 1	no materials needed
Activity 2	no materials needed

Preparation

Activity 2

Students will be working in teams for this activity. Divide the class into teams of four students. Each team will evaluate two case histories. If necessary, have more than one team evaluate the same case histories.

Cut Masters 4.3, 4.4, 4.5, 4.6, and 4.7 along the dotted lines separating the Primary Information, the Secondary Information, and the Discussion Questions for each case history.

Procedure

Activity 1: *Snoring—Believe It or Not!*

1. **Give each student a copy of Master 4.1, *Snoring—Believe It or Not!*, and ask them to read it (these are all true stories).**

2. **Ask students to comment on their experiences with snoring.**

   Remind students that they have information from their own sleep diary, as well as information from their class and other classes around the country, that would allow them to gauge the incidence of snoring among high school students using this supplement.

3. **Give a copy of Master 4.2, *Snoring Survey*, to each student and allow a few minutes for the class to answer the questions.**

4. **After the students have completed their surveys, discuss the answers. Steer the discussion toward sleep disorders.**

   Sample answers to questions on Master 4.2, *Snoring Survey.*

   Question 1. How common is snoring?

   Student responses will vary. They might use the reported frequency of snoring by their classmates from the sleep diaries as the basis for their answer. In fact, everyone seems to snore a little. A poll taken several years ago indicated that about 50 percent of the American population reported snoring. Half of this group was habitual snorers. Snoring is becoming increasingly common because fatigue and being overweight aggravate the problem. Convey this information and that provided for the other questions to set the stage for evaluating sleep disorders.

   Question 2. What is snoring?

   Students may simply respond that snoring is a noise made during sleep. Try to elicit from them the idea that snoring involves breathing. Snoring is an indication that air is not flowing freely through the area where the throat joins the nasal passages. In that area, the tongue and upper throat meet the soft palate and the uvula, which is the fleshy structure that dangles from the back of the palate into the throat. Individuals with narrowed or partially blocked airways must pull in air quickly, creating turbulence that makes the structure vibrate, thus resulting in snoring.

Question 3. Is snoring a normal part of sleeping, or is it an indication of a medical problem?

Since students know people who snore and don't appear sick, they might respond that snoring can be a normal part of sleeping. Even though everyone seems to snore at least a little, it is *not* considered a normal part of sleep; that is, it does not serve a function during sleep. It may or may not be a symptom of a medical problem, depending on its cause and severity.

Question 4. Is snoring associated with sleeping problems, that is, with sleeping disorders?

Snoring is often associated with certain sleep disorders. Students might be asked if there appears to be an association between the incidence of snoring and some of the entries in the sleep diaries (Lesson 1) such as total sleep time or number of awakenings at night. At this point, the discussion should begin to focus on sleep disorders.

Question 5. Are sleep disorders life threatening, or are they just annoying?

Sleep disorders can be life threatening, as in the case of sleep apnea. Even mild insomnia, if causing problem sleepiness, can contribute to injury such as workplace accidents and auto crashes.

Figure 4.2. People being treated for sleep apnea sometimes wear a medical mask that helps keep their airways open.

Question 6. Have you, or a member of your family, ever experienced a sleep disorder?

Student responses will vary. Some may not realize that occasional trouble sleeping is a mild form of insomnia and is considered a sleep disorder. By this measure, most students have some experience with a sleep disorder.

Activity 2: *Diagnosis Unknown*

1. **For this activity, divide the class into teams of four students. Each team will receive two case histories to evaluate.**

2. **Explain to the class that they will assume the role of specialists in sleep medicine. They will review case histories of patients, make diagnoses, and recommend treatments.**

3. **Give each team a copy of the primary information for the two case histories they are to evaluate. The primary information is the top portions of Masters 4.3, 4.4, 4.5, 4.6, and 4.7. Ask students to read the primary information for each case history.**

4. **Give each student a copy of Master 4.8, *Sleep Specialist's Evaluation Form*. Instruct the students to write down what they consider to be the key aspects of their patients' sleep disorders in the appropriate box.**

5. **Give each team a copy of Master 4.9, *Sleep Disorders Reference Manual*. Instruct students to make a preliminary diagnosis for each case history by using information contained in the *Sleep Disorders Reference Manual*. Have students enter their preliminary diagnoses in the appropriate boxes on their evaluation form.**

6. **Students should list the matching symptoms of the sleep disorders that match the key aspects of their case histories.**

7. **Ask students if they are certain about their diagnoses.**

   Some students may indicate that they are not completely sure about their conclusions about a case. Ask them what steps they could take to either support or refute their diagnosis. Depending on the specifics of the case, there are a number of ways to obtain additional information relevant to the patient, including a physical exam, observation in a sleep clinic, additional patient history, and interviews with bed partners.

NSES

Content Standard F: Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices.

8. At this point, explain to the class that some additional information regarding each case has come to light. Give each team the middle portions of the appropriate case histories that contain the Secondary Information.

9. Ask students to read the Secondary Information for each case and use this new information to reevaluate their diagnoses. They should indicate on the evaluation form whether they want to confirm their initial diagnoses.

NSES

Content Standard A: Formulate and revise scientific explanations and models using logic and evidence.

Content Standard A: Communicate and defend a scientific argument.

10. If students have changed a diagnosis, they should enter the new diagnosis, together with the reason for the change, in the appropriate boxes on the evaluation form.

At the bottom of the evaluation form is space to recommend a treatment and indicate its expected outcome. Ideally, students should indicate how the treatment(s) might affect the patient's symptoms. However, students may respond simply that the treatment they have selected will correct or manage the patient's disorder. This type of response is acceptable. The purpose of asking students to provide this information is two-fold. First, students become aware that sleep disorders can be managed and that the expertise of a specialist is required for proper diagnosis and treatment. Second, it requires students to focus on treating or managing specific symptoms.

Assessment: Encourage all team members to participate in their reports to the class. This will help you assess how well each student understands the information.

11. Give each team the bottom portion of the appropriate case histories that contains discussion questions, and instruct the students to answer them.

12. Discuss each of the case histories in turn, asking the students how they arrived at their diagnoses.

The questions are designed to help guide the student to the information that is important to making an accurate diagnosis. If students disagree on a diagnosis, allow each to explain their rationale and make an argument for their point of view. Allow students to consider what additional information, not included in the activity, might help to confirm a diagnosis.

Key aspects of case studies and answers to discussion questions

CASE HISTORY 1:

From Primary Information	
Key aspects	• Excessive daytime sleepiness • Possible genetic connection through mother • Vivid dreams • Inability to move after waking in the morning • Weakness associated with emotion
Diagnosis	Narcolepsy
Matching symptoms	• Excessive daytime sleepiness • Cataplexy • Sleep paralysis
After reading Secondary Information	
Is your initial diagnosis confirmed?	Answers will vary.
If no, what is your new diagnosis?	Answers will vary.
If no, what caused you to change your mind?	Entering REM sleep early is consistent with vivid dreams and hypnagogic hallucinations characteristic of narcolepsy.
Recommended treatment	Medication and lifestyle changes such as frequent napping
Expected outcome (effect of treatment on patient symptoms)	Control of most symptoms

ANSWERS TO DISCUSSION QUESTIONS

1. *Why is it important to consider that the patient's mother reportedly had a similar problem?*

   It establishes the possibility of a genetic link for the patient's disorder. Genetics is implicated in some sleep disorders and not others. In fact, a gene responsible for narcolepsy in dogs has been discovered.

2. *Of what significance is it that this patient's sleepiness began during her teen years?*

   The excessive sleepiness characteristic of narcolepsy usually begins during a person's teen years or early twenties.

3. ***Is it important that this patient experienced feeling weak when laughing or being tickled?***

   Yes, it is. About 60 percent of those with narcolepsy experience this sudden, brief loss of muscle tone, often following an emotional stimulus.

CASE HISTORY 2:

From Primary Information	
Key aspects	• Excessive daytime sleepiness • Snoring • Regular breathing (rules out OSA)
Diagnosis	Insomnia
Matching symptoms	• Excessive daytime sleepiness • Snoring
After reading Secondary Information	
Is your initial diagnosis confirmed?	Answers will vary.
If no, what is your new diagnosis?	Answers will vary.
If no, what caused you to change your mind?	Excessive caffeine consumption, drinking alcohol before bedtime, and awakening during the night are all consistent with insomnia.
Recommended treatment	• Improved sleep hygiene, especially reducing consumption of caffeine and alcohol • Medication if necessary
Expected outcome (effect of treatment on patient symptoms)	Improved sleep

ANSWERS TO DISCUSSION QUESTIONS

1. ***Why is it important that the patient's wife confirms that although he snores, his breathing is normal during sleep?***

   These observations help rule out obstructive sleep apnea (OSA) as the patient's disorder.

2. ***The wife never witnessed any unusual events while the patient was asleep. What "unusual events" might she have noticed?***

   She might have noticed his sleepwalking, talking in his sleep, excessive body movements, or agitation.

3. *How would you suggest that this patient improve his sleep hygiene?*

A number of improvements can be made, including maintaining a regular sleep/wake schedule that allows for adequate sleep, avoiding caffeine after the early afternoon, avoiding alcohol before bedtime, unwinding before bedtime and leaving the day's troubles behind, and ensuring a good sleep environment.

CASE HISTORY 3:

From Primary Information	
Key aspects	• Patient in generally good health • Sleepwalking as a child • Vivid dreams that are acted out • Sleep-related behaviors acted out late in the sleep period • Patient relatively young and female • No other apparent sleep disorders present
Diagnosis	Parasomnia (REM motor behavior disorder)
Matching symptoms	• Movement to another location (is excessive for REM motor behavior disorder) • Acting out vivid dreams • Behavior occurs later in sleep period • The patient presents symptoms that do not indicate a clear diagnosis. Both sleepwalking and REM motor behavior disorder are possibilities.
After reading Secondary Information	
Is your initial diagnosis confirmed?	Answers will vary.
If no, what is your new diagnosis?	Answers will vary.
If no, what caused you to change your mind?	Secondary information is consistent with diagnosis of REM motor behavior disorder.
Recommended treatment	• Improved sleep hygiene, getting enough sleep, maximize safety of sleeping environment, and consult a specialist for an evaluation • Possibly medication
Expected outcome (effect of treatment on patient symptoms)	Reduced frequency of parasomnia episodes

ANSWERS TO DISCUSSION QUESTIONS

1. ***The patient reports these episodes occurring at 3:30 a.m. and 4:00 a.m. Is this important?***

   Yes. Sleepwalking, another disorder characterized by walking or moving about during sleep, typically occurs during the first third of a night's sleep. This patient's abnormal episodes occur later than that.

2. ***In general terms, what would you expect this patient's EMG during sleep to look like if she is experiencing REM motor behavior disorder and not sleepwalking?***

   One would expect to see periods during REM sleep in which muscle activity increases if the patient is experiencing REM motor behavior disorder. Sleepwalking occurs during NREM sleep.

CASE HISTORY 4:

From Primary Information	
Key aspects	• Patient is male and relatively young • Has no trouble falling asleep • Has multiple awakenings during the night • Excessive daytime sleepiness • Recently gained weight
Diagnosis	Obstructive sleep apnea
Matching symptoms	• Has multiple awakenings during the night • Excessive daytime sleepiness • Obesity
After reading Secondary Information	
Is your initial diagnosis confirmed?	Answers will vary.
If no, what is your new diagnosis?	Answers will vary.
If no, what caused you to change your mind?	Patient snores, and stops breathing for up to 30 seconds.
Recommended treatment	Use a positive airway pressure device, weight loss, avoid alcohol, avoid sleeping on back, possibly surgery
Expected outcome (effect of treatment on patient symptoms)	More normal breathing during sleep and less snoring

ANSWERS TO DISCUSSION QUESTIONS

1. *Why is it significant that the patient has gained 55 pounds in the past two years?*

   Being overweight is a major risk factor for sleep apnea. Thickening of airway walls and soft tissue in the neck also increase risk, and this is related in part to excess fatty tissue.

2. *Why do patients with sleep apnea wake up feeling unrefreshed?*

   Sleep apnea is associated with multiple awakenings during the night, thus causing sleep to be fragmented. Also, because breathing stops many times per night, less oxygen is available for body tissues.

3. *Would you expect naps to be helpful in treating obstructive sleep apnea?*

   No. Naps generally are of little help to those with sleep apnea because the sleep quality is not sufficient to be beneficial. Extra sleep will not eliminate the apnea episodes and the risk of cardiovascular problems.

CASE HISTORY 5:

From Primary Information	
Key aspects	• Difficulty sitting for prolonged periods • Excessive daytime sleepiness • Difficulty getting to sleep
Diagnosis	Restless legs syndrome
Matching symptoms	• Sitting still for long periods is difficult. • Symptoms interfere with sleep.
After reading Secondary Information	
Is your initial diagnosis confirmed?	Answers will vary.
If no, what is your new diagnosis?	Answers will vary.
If no, what caused you to change your mind?	Patient complains that he feels as though bugs are crawling under his skin on his arms and legs is characteristic of restless legs syndrome.
Recommended treatment possibly medication	Exercise, massages, avoid alcohol and caffeine
Expected outcome (effect of treatment on patient symptoms)	Lessening of symptoms and better sleep

ANSWER TO DISCUSSION QUESTION

1. *Why is it significant that the patient has difficulty in the classroom?*

   Symptoms worsen during periods of relaxation and decreased activity.

Lesson 4 Organizer

What the Teacher Does	Procedure Reference
Give each student a copy of Master 4.1, *Snoring—Believe It or Not*, and instruct them to read it. • Have students comment on their experiences with snoring.	Page 105 Steps 1 and 2 M
Give each student a copy of Master 4.2, *Snoring Survey*, and instruct them to complete it. • Discuss the students' responses and relate them to sleep disorders.	Pages 105–107 Steps 3 and 4 M

What the Teacher Does	Procedure Reference
Divide the class into student teams and have each team review two case histories. For each case history, hand out • preliminary information (top portion of Masters 4.3, 4.4, 4.5, 4.6, and 4.7) and • Master 4.8, *Sleep Specialist's Evaluation Form*.	Page 107 Steps 1–4 M
Instruct student teams to use Master 4.9, *Sleep Disorders Reference Manual*, to make preliminary diagnoses for their case histories.	Page 107 Steps 5 and 6 M

M = Involves copying a master.

Ask students if they feel confident about their diagnoses.	Page 107 Step 7
Give each student the secondary information parts of their case histories (the middle portion of Masters 4.3, 4.4, 4.5, 4.6, and 4.7) and ask them to read them. • Students should reevaluate their diagnoses in light of this new information. • Students should enter final diagnoses on the *Sleep Specialist's Evaluation Form* where indicated.	Page 108 Steps 8–10 M
Give each student the discussion questions for their case histories (the bottom portion of Masters 4.3, 4.4, 4.5, 4.6, and 4.7) and instruct them to answer them.	Page 108 Step 11 M
Discuss the case histories. • Ask students how they answered the discussion questions. • Ask students how they arrived at their diagnoses.	Page 108 Step 12

Snoring—Believe It or Not!

A burglar was in the process of robbing an apartment when the occupants came home. He quickly hid under the bed, where he remained while the occupants went about their business. Later that day, the occupants heard a strange noise. They tracked the noise to their bedroom, where they discovered the burglar asleep under their bed and snoring like a chain saw. The police were called and the burglar was arrested.

Did you know—in Massachusetts, snoring is prohibited unless all bedroom windows are closed and locked securely?

In Davis, Calif., a city ordinance prohibits noise pollution. This law was meant to prevent college students from having loud parties. However, the Davis Police Department also enforced it against a woman whose duplex neighbor complained that she snored too loudly (the neighbors' bedrooms had an adjoining wall). The case made national headlines, and the Davis City Council promptly passed a resolution that loud snoring was not prohibited under the ordinance.

According to the *Guinness Book of World Records*, a man in Great Britain holds the record for loudest snore, rated at 92 decibels. For comparison, heavy traffic is rated at 80 decibels and a loud shout, at 90 decibels.

Snoring Survey

Name____ Date_________________

Question 1. How common is snoring?

Question 2. What is snoring?

Question 3. Is snoring a normal part of sleeping, or is it an indication of a medical problem?

Question 4. Is snoring associated with sleeping problems, that is, with sleeping disorders?

Question 5. Are sleep disorders life threatening, or are they just annoying?

Question 6. Have you, or a member of your family, ever experienced a sleep disorder?

Case History 1

Case History 1
Primary Information: The patient is a female in her mid-20s. She reports difficulty staying awake while away at college. In fact, while in high school, her teachers complained of her falling asleep during class. Her mother also had this problem, although she never sought help from a specialist.

The patient feels excessively sleepy during the day. She also reports that her dreams are very vivid, especially during naps. At times, she's not sure if she's dreaming or if something is actually happening to her. Additionally, she describes feeling like she's glued to her bed when she first wakes in the morning. Finally, she mentions that she feels weak when she laughs or is tickled.

Case History 1
Secondary Information: When examined in a sleep laboratory, it was found that this patient fell asleep relatively quickly and entered into REM sleep within 10 minutes after sleep onset.

Case History 1
Discussion Questions

1. Why is it important to consider that the patient's mother reportedly had a similar problem?

2. Of what significance is it that this patient's problems began during her teen years?

3. Is it important that this patient experienced feeling weak when laughing or being tickled?

Case History 2

Case History 2
Primary Information: The patient is the CEO of a large corporation. He reports that he suffers from excessive fatigue and sleepiness during the day. He often has had difficulty concentrating and performing his routine tasks. He has even dozed off in the early afternoon while sitting at his computer. His wife reports that he snores, although she indicated that his breathing appears normal during sleep. She has never witnessed any unusual events during the night. He is seeking help because he is concerned about being sleepy during his afternoon work hours.

Case History 2
Secondary Information: A physical exam of this patient reveals no significant problems. With further questioning, the patient discloses that he drinks several cups of coffee and has several diet colas in the afternoon to increase alertness. He also states that he often drinks an alcoholic beverage or two before bedtime. He sleeps soundly during the first part of the night, but he then awakens and has difficulty going back to sleep.

Case History 2
Discussion Questions

1. Why is it important that the patient's wife confirms that, although he snores, his breathing is normal during sleep?

2. The wife never witnessed any unusual events while the patient was asleep. What "unusual events" might she have noticed?

3. How would you suggest that this patient improve his sleep hygiene?

Case History 3

Case History 3
Primary Information: This patient is a female in her early 30s. Her medical history is unremarkable for any major problems or diseases. She indicates that she has no sleep problems of which she is aware, although she did sleepwalk as a child but not beyond age 10. She falls asleep readily, does not believe she snores, and generally awakens feeling refreshed. She has no bed partner to provide confirmation of sleep behaviors. She seeks help because of two recent incidents. In the first, she awoke at 3:30 a.m. to find herself on the roof of her house, apparently having climbed a ladder to get there. She stated that during the day she had been concerned about a tree branch that was rubbing on her roof but had forgotten about it that night. When she awoke on the roof, she thought she had just dreamed about climbing a ladder and inspecting the tree branch. The second incident occurred five weeks later. The patient reported having a good day and falling asleep readily. She awoke at 4:00 a.m. sitting under a favorite tree in a nearby park and drinking a glass of wine. Upon awakening in the park, she thought she had been dreaming about being on a picnic with her boyfriend.

Case History 3
Secondary Information: Patient history indicates no injuries to the head, no seizures, and no fainting. Her childhood and teen years were normal in all regards. No family members have ever had sleep-related experiences similar to hers. She is deeply concerned about her safety and the safety of others. What if she were to “dream” that she was driving a car?

Case History 3
Discussion Questions

1. The patient reports these episodes occurring at 3:30 a.m. and 4:00 a.m. Is this important?

2. In general terms, what would you expect this patient’s EMG during sleep to look like if she is experiencing REM motor behavior disorder and not sleepwalking?

Case History 4

Case History 4
Primary Information: This patient is a male in his early 30s. His wife has made him seek help, although he doesn't see the need. He reports that he has no trouble falling asleep. However, he has multiple awakenings during the night and does not know why. He awakes feeling unrefreshed. He experiences excessive daytime sleepiness. A physical exam is performed. This patient is 6 feet tall and weighs 255 pounds. His neck measures 21 inches. Two years ago, he weighed 200 pounds.

Case History 4
Secondary Information: The patient indicates that he does snore and that he awakens with his mouth feeling very dry. An interview with the patient's wife reveals that the patient will stop breathing for up to 30 seconds. This is followed by a loud snort. The patient is also known to snore when lying flat, lying on his side, or sitting up.

Case History 4
Discussion Questions

1. Why is it significant that the patient has gained 55 pounds in the past two years?

2. Why do patients with sleep apnea wake up feeling unrefreshed?

3. Would you expect naps to be helpful in treating obstructive sleep apnea?

Case History 5

Case History 5
Primary Information: The patient is an 18-year-old male who reportedly has trouble sitting in class. He complains of feeling tired during the day and of not being able to get to sleep at night. His mother reports that he does not settle down at night to do his homework. His teachers consider him to be bored, hyperactive, and disruptive in class.

Case History 5
Secondary Information: The patient complains that he feels like bugs are crawling under his skin on his arms and legs.

Case History 5
Discussion Question

1. Why is it significant that the patient has difficulty in the classroom?

Sleep Specialist's Evaluation Form

Name____ Date______________________

From Primary Information

	Case history number ______	Case history number ______
Key aspects		
Initial diagnosis		
Matching symptoms		

After reading Secondary Information

Is your initial diagnosis confirmed?	❑ yes ❑ no	❑ yes ❑ no
If no, what is your new diagnosis?		
If no, what caused you to change your diagnosis?		
Recommended treatment		
Expected outcome (effect of treatment on patient symptoms)		

Sleep Disorders Reference Manual

Introduction: Sleep is a behavioral state that is a normal part of every individual's life. In general, we spend about one-third of our lives asleep. Problems with sleep are widespread. A 1999 poll conducted by the National Sleep Foundation found that most Americans are sleep deprived, getting on average one hour less sleep per night than the eight hours that are recommended. Sleep problems affect the ability to think, to perform, and to remain healthy.

Problems with sleep can be due to lifestyle choices and can result in problem sleepiness, that is, feeling sleepy at inappropriate times. Environmental noise, temperature changes, changes in sleeping surroundings, and other factors may affect our ability to get sufficient restful sleep. Short-term problem sleepiness may be corrected by getting additional sleep to overcome the sleep deficit. In other cases, problem sleepiness may indicate a sleep disorder requiring medical intervention. More than 70 sleep disorders have been described. This manual describes some of them, listed in alphabetical order.

Insomnia: This is the most prevalent sleep disorder. Insomnia is the perception of inadequate sleep due to difficulty falling asleep, waking up frequently during the night, waking up too early, or feeling unrefreshed after waking. Insomnia is more common in women than men and tends to increase with age. Short-term and transient (that is, it comes and goes) insomnia may be caused by emotional or physical discomfort, stress, environmental noise, extreme temperatures, or jet lag, or it may be the side effect of medication. Chronic insomnia may result from a combination of physical or mental disorders, undiagnosed or uncontrolled sleep disorders (such as sleep apnea, restless legs syndrome, narcolepsy, or circadian rhythm disorders), and effects of prescription or nonprescription medications.

Treatments: Treatment is generally tailored to meet the needs of the individual. First, any medical or psychological problems must be identified and treated. Additionally, behaviors that may contribute to or worsen insomnia must be identified. Treatment may include behavioral modification (such as learning to relax or learning to associate the bed and bedtime with sleep), following good sleep hygiene practices (such as following a specific nighttime routine, reducing caffeine and alcohol intake, or reducing afternoon napping), and light therapy.

Pharmacological treatments may alleviate symptoms in specific cases. Some individuals try to overcome the problem of insomnia by drinking alcohol-containing beverages. Alcohol inhibits REM sleep, disrupts sleep during the last part of the night, and does not promote good sleep.

Narcolepsy: Narcolepsy is a chronic sleep disorder that usually becomes evident during adolescence or young adulthood and can strike both men and women. In the United States, it affects as many as 200,000 people, although fewer than 50,000 are diagnosed. The main characteristic of narcolepsy is excessive and overwhelming daytime sleepiness (even after adequate nighttime sleep). A person with narcolepsy is likely to suddenly become drowsy or fall asleep, often at inappropriate times and places. Daytime sleep attacks may occur with or without warning and may be irresistible. In addition, nighttime sleep may be fragmented. Three other classic symptoms of narcolepsy, which may not occur in all people with the disorder, are cataplexy (sudden muscle weakness triggered by emotions such as anger, surprise, laughter, and exhilaration), sleep paralysis (temporary inability to talk or move when falling asleep or waking up), and hypnagogic hallucinations (dreamlike experiences that occur while dozing or falling asleep). People with narcolepsy can fall asleep quickly at any time during any activity. Narcolepsy is not the same as simply becoming tired or dozing in front of the TV after a day's work.

Treatments: Although there is no cure yet for narcolepsy, treatment options are available to help reduce the various symptoms. Treatment is individualized depending on the severity of the symptoms, and it may take weeks or months for the best regimen to be worked out. Treatment is primarily through medications, but lifestyle changes are also important. Medications for narcolepsy have unpleasant side effects and some patients opt to take frequent naps, allowing them to reduce the dosages of their medications. Recently, researchers discovered a gene for narcolepsy in dogs, which opens the door to identifying narcolepsy gene in humans. This may lead to developing new treatments and possibly a cure for this disabling sleep disorder.

Obstructive Sleep Apnea: Obstructive sleep apnea (OSA) is a serious disorder of breathing during sleep that is potentially life-threatening. OSA is characterized by a repeated collapse of the upper airway during sleep and, as a result, the cessation of breathing. These breathing pauses may occur 20 to 30 times per hour throughout the night, and each one may last from 10 seconds to 2 minutes. This decreases the amount of oxygen available to the sufferer. Virtually all sleep apnea patients have a history of loud snoring, although not everyone who snores has OSA. They also have frequent arousals during the night, resulting in excessive daytime sleepiness. It is estimated that approximately 12 million Americans have OSA, which can occur in children as well as adults.

People at high risk for OSA are those who have chronic, loud snoring and excessive daytime sleepiness and are observed to have gasping, choking, or no-breathing episodes during sleep. Additional risk factors include obesity and high blood pressure. Also, people who have OSA are at special risk for developing high blood pressure, which is a major risk factor for cardiovascular diseases.

Treatments: The most common treatment is **c**ontinuous **p**ositive **a**irway **p**ressure, or CPAP. This procedure involves wearing a medical mask over the nose during sleep. The mask is connected to a hose that is connected to a unit that produces a constant push of air. The flow of air can be controlled so that the nasal passages and the trachea don't collapse during sleep. Surgical procedures may be used to enlarge the nasal cavity, correct a physical problem like a deviated septum, or remove excess tissue in the throat (including tonsils). Also helpful may be behavior modification, including weight loss, avoiding alcohol before sleep, and avoiding an on-the-back sleeping position.

Parasomnias: These arousal disorders are characterized by behaviors and experiences that occur during sleep. Generally, though not always, they are mild and occur infrequently. Two examples of parasomnias are provided.

1. ***Sleepwalking (somnambulism)***: This disorder is characterized by walking or moving about during sleep. Objects may be carried from one place to another for no apparent reason. These behaviors occur during NREM sleep, typically in the first third of the night. Sleepwalking is more common in children than in adolescents or adults. Children affected by sleepwalking usually have no memory of such events. Sleepwalking is more common in children whose families have a history of this behavior. This suggests that genes play a role in this sleep disorder.

Treatments: Those suffering from sleepwalking may do the following:

- Get enough rest, since being overtired can trigger a sleepwalking episode.
- Unwind before bedtime, because stress also can trigger sleepwalking.
- Maximize the safety of the sleeping environment.
- Consult a specialist for a complete evaluation.

2. ***REM Motor Behavior Disorder:*** Patients with this sleep disorder, which occurs during REM sleep, experience episodes in which they act out some or all of their dreams. The dreams generally are vivid, intense, and action-packed, and they may be violent. More than 85 percent of those with this disorder are older men (the average age of onset is in the early 50s), although it can affect both females and males of any age.

   Treatments: Medication and ensuring a safe sleeping environment.

Restless Legs Syndrome: Restless legs syndrome (RLS) is a neurologic movement disorder that is often associated with a sleep complaint. RLS may affect up to 15 percent of the population. People with RLS suffer an almost irresistible urge to move their legs, usually due to disagreeable leg sensations that are worse during inactivity and often interfere with sleep. RLS sufferers report experiencing creeping, crawling, pulling, or tingling sensations in the legs (or sometimes the arms), which are relieved by moving or rubbing them. Sitting still for long periods becomes difficult; symptoms are usually worse in the evening and night and less severe in the morning. Periodic leg movements, which often coexist with restless legs syndrome, are characterized by repetitive, stereotyped limb movements during sleep. Periodic limb movement disorder can be detected by monitoring patients during sleep.

Treatments: Some people with mild cases of restless legs syndrome can be treated without medication through exercise, leg massages, and by eliminating alcohol and caffeine from the diet. Others may require pharmacological treatment, and it may take some time for the right medication or combination of medications to be determined for the individual.

Sleepiness and Driving: What You Don't Know Can Kill You

Figure 5.1. The National Highway Traffic Safety Administration has estimated that each year, about 100,000 motor vehicle crashes result from drowsy driving.

At a Glance

Overview

In this lesson, students begin by identifying both good and bad sleep habits. Then they participate in a role-playing scenario about sleepiness and driving. Marcia Sinton, daughter of a friend of the governor, has been killed in a car crash in which the driver of the other car fell asleep while driving. In response, the governor wants to incorporate questions about sleep and driving into the state's driver's license test. It is the governor's belief that knowing about sleep and the consequences of poor sleep habits will produce safer drivers and fewer sleep-related car crashes. Students assume the role of sleep specialists who have been asked to come up with the sleep questions.

Major Concepts

Sleep loss has a number of negative impacts on society including loss of productivity, increased accident rates, and increased medical costs.

Objectives

After completing this lesson, students will

- identify good and bad sleep habits;
- explain that lack of sleep is widespread and has negative impacts on society;

- recognize that drowsy driving is a major cause of auto crashes;
- identify those groups most at risk for driving while fatigued; and
- understand that social policies are not "right" or "wrong," but rather reflect society's view at that time.

Teacher Background

Consult the following section in Information about Sleep:
3.10 Sleep loss and wakefulness (pages 34–35)

In Advance

Web-Based Activities

Activity	Web Version?
1	No

Photocopies

Activity 1	Master 5.1, *Good and Bad Sleep Habits* (Make 1 copy per student.) Master 5.2, *Newspaper Articles* (Make 1 copy per student.) Master 5.3, *Memo from the Governor* (Make 1 copy per student.) Master 1.2, Supplemental Information—*What Do You Know (or Think You Know) about Sleep?* (Make 1 copy per student, optional.)

Materials

Activity 1	flip-chart paper (1 piece per team) markers (1 per team)

Preparation

No preparations needed (except for photocopying).

Activity 1: *Sleepiness and Driving—What You Don't Know Can Kill You*

1. **Introduce the lesson by asking the class to think about good and bad sleep habits. Give each student a copy of Master 5.1, *Good and Bad Sleep Habits,* and give them a few minutes to compile their lists.**

2. **Ask the class for their list of good sleep habits and list them on the board. Then ask students to share the bad sleep habits they listed. Write those on the board.**

   For more information, refer to Table 5.1, on page 132. It provides a list of some good sleep habits and can be used to supplement student responses.

Good Sleep Habits	Bad Sleep Habits
Go to bed at a regular time	Keep changing bedtimes
Use a comfortable bed	Use an uncomfortable bed
Make sure bedroom is dark and quiet	Sleep in a bedroom that is too light and/or noisey
Avoid meals right before bedtime	Eat meals right before bedtime
Avoid nicotine and alcohol	Use nicotine and alcohol
Get exercise	Avoid exercise, or exercise right before bedtime

Figure 5.2. A typical list of good and bad sleep habits suggested by students.

3. **Ask the class if there are consequences to having bad sleep habits. Write responses on the board.**

   Students may respond that simply being tired during the day is a consequence of poor sleep habits. Ask if there are consequences to daytime (and nighttime) fatigue and sleepiness. Begin to focus the discussion on both consequences for the individual and for society.

Table 5.1. Good Sleep Habits: Getting a Good Night's Sleep

Both internal and external factors are important in determining the quality of our sleep. Advice for developing good sleep habits includes the following:

1. Maintain the same sleep/wake cycle on both weekdays and weekends. This prevents our internal biological clock from being reset by altered bedtimes and wake times.

2. Avoid alcohol. Alcohol inhibits REM sleep and disrupts sleep during the last part of the night. Alcohol does not promote good sleep and it can exacerbate existing sleep disorders, especially apnea.

3. Avoid caffeine from midafternoon on. Caffeine is a stimulant that interferes with sleep onset and the rhythm of sleep. Caffeine may take up to 8 hours to be cleared from the body.

4. Avoid nicotine. In addition to other health-related issues of smoking, nicotine is a stimulant, which produces changes in the body and brain that are not compatible with good sleep.

5. Engage in exercise. Exercise during the day improves the quality of NREM sleep. However, exercise up to four hours prior to bedtime can interfere with sleep.

6. Control your bedroom environment. Make your room and bed as comfortable as possible. At bedtime, keep your room as dark and quiet as possible. Keep the temperature on the cool side. A temperature of 65°F is recommended for good sleep.

7. Avoid late evening meals, although a light snack (not too much) is okay. Foods such as milk, bananas, fish, and turkey, which contain the amino acid tryptophan, may have some benefit in promoting sleepiness.

8. Try to get outside in natural sunlight for at least 30 minutes each day. Daylight is important in regulating our circadian rhythm.

9. Try to relax and leave the day's problems behind. Unwind by reading or listening to the radio. Don't watch the clock and worry about getting to sleep.

10. If you believe you have a serious problem, there are sleep specialists who can help. Begin by talking with your physician.

4. Give each student a copy of Master 5.2, *Newspaper Articles,* and ask them to read it. Explain that they will assume the role of sleep specialists engaged by the governor to help with an important project.

5. Give each student a copy of Master 5.3, *Memo from the Governor,* and ask them to read it. You, the teacher, are the "committee chairperson" appointed by the governor.

6. As chairperson of the governor's special committee, instruct the students to each prepare a list of three questions about sleep as directed in the memo.

   Students must also answer their questions and justify including those questions in the driver's exam.

7. Next, have the class form into teams of four or five students. Give each team one piece of flip-chart paper. Instruct each team to discuss the proposed questions and choose the top five (with answers and justification) that they believe should be included in the final list submitted to the governor. Have each group select a spokesperson to report their results to the class.

8. After the teams complete their task, reconvene the class. Ask each spokesperson to post their questions (on the flip-chart paper) and explain their choices to the rest of the class.

9. Engage the class in a discussion of the questions on the flip-chart paper with the goal of selecting the final list of 10 questions to submit to the governor.

   If desired, you can have the students vote on each question. The 10 questions receiving the highest votes will be put on the final list.

10. To wrap up the lesson, ask students to critique the questions that made the final list.

    - Do the questions cover basic sleep concepts?
    - Will knowledge of these concepts contribute to a better understanding of sleep and the consequences of poor sleep habits?
    - Will a better understanding of good sleep habits be gained?

    Students should justify their responses.

11. You may also engage the class in a discussion about whether or not driver's license applicants need to know anything about sleep and the consequences of poor sleep habits. The following questions will help the discussion:

Content Standard F: Hazards and the potential for accidents exist.

Content Standard A: Identify questions and concepts that guide scientific investigations.

Assessment: Students should include, as part of their justification, facts about sleep that they have learned from the previous lessons in the module.

- **Is knowledge about sleep important for automobile drivers to have? Why or why not?**

Most students will conclude that sleep knowledge is helpful to drivers. It allows them to connect sleep loss to auto crashes, to recognize when they are putting themselves (and others) at risk, and to avoid sleepy driving situations.

- **Should sleep knowledge be required for those seeking driver's licenses? Justify your answer.**

Those who agree with the law will justify their position by stressing the costs to society of sleepiness-related crashes. Those who oppose the law may defend their positions on the grounds that such knowledge will not prevent crashes or that sleep is being singled out as important to driving while other equally important issues are ignored.

- **Can you suggest other individuals who could benefit from knowledge about sleep?**

Students may mention airline pilots, air traffic controllers, operators of various forms of public transportation, doctors, and certain military personnel, among others.

If students are interested and want to learn more about impacts of sleep loss on society, besides drowsy driving, help them do so. Make available to students relevant information from the Information about Sleep section and from Web sites listed in the Additional Web Resources for Teachers section.

Lesson 5 Organizer

What the Teacher Does	Procedure Reference
Give each student a copy of Master 5.1, *Good and Bad Sleep Habits*. Have students write their own lists of good and bad sleep habits.	Page 131 Step 1 M
Summarize the class responses on the board.	Page 131 Step 2
Ask the class to suggest consequences of bad sleep habits and list them on the board.	Page 131 Step 3
Give to each student a copy of Master 5.2, *Newspaper Articles*, and Master 5.3, *Memo from the Governor.* Instruct the class to read them. • Explain that they will assume the role of sleep specialists hired by the governor to help with an important project.	Page 133 Steps 4 and 5 M
Instruct each student to prepare a list of three questions about sleep.	Page 133 Step 6
Divide the class into student teams and instruct each team to select their top five sleep questions. • Have each team select a spokesperson.	Page 133 Step 7

M = Involves copying a master.

Reconvene the class and have each spokesperson report their team's list of questions. • Have teams post their lists in front of the class. • Have each spokesperson justify their team's reasoning.	Page 133 Step 8
Discuss the questions with the class and agree on a final set of 10 questions to give to the governor.	Page 133 Step 9
Ask the class to critique the final set of questions: • Do the questions cover basic sleep concepts? • Will knowledge of these concepts contribute to a better understanding of sleep and the consequences of poor sleep habits? • Will a better understanding of good sleep habits be gained?	Page 133 Step 10
Discuss whether or not driver's license applicants need to know anything about sleep and the consequences of poor sleep habits. Ask the class, • Is knowledge about sleep important for automobile drivers? • Should sleep knowledge be required for those seeking driver's licenses? • Can you suggest other individuals who could benefit from knowledge about sleep?	Pages 133–134 Step 11

Good and Bad Sleep Habits

Name____ Date________________________

Good Sleep Habits	Bad Sleep Habits

Newspaper Articles

The Gotham Daily Herald

SPECIAL EDITION

State Senator's Daughter Dies in Auto Crash

Marcia Sinton, 16, daughter of State Senator Otis Sinton, was killed in a two-car crash on the State Beltway at 3:00 p.m. yesterday. Police said that a car driven by Thomas Meecham, 19, crossed the median and struck Ms. Sinton's vehicle. Mr. Meecham, returning home after completing a 10-hour shift at work, said, "I don't know what happened. Before I realized it, I was in the other lane with a car coming right at me."

Mr. Meecham was injured in the crash and was taken to Memorial Hospital, where he is listed in serious condition. At this time, no charges have been filed pending completion of the investigation.

A spokesperson for Senator Sinton said he was out of town, but had been informed of his daughter's death and was returning home in the morning. Ms. Sinton was an honor student at North High School.

The Gotham Daily Herald

MORNING EDITION

Governor Wages War on Drowsy Drivers

Governor Shawn Smithers has taken a bold and controversial step toward making our state's roads and highways safer from drowsy drivers. He proposes to require prospective drivers to display a basic knowledge about sleep.

Many believe this action was prompted by the recent death of Marcia Sinton, daughter of State Senator Otis Sinton, a close friend. Citing recent reports, Governor Smithers said, "There are far too many crashes on the road that are caused by sleepy or sleeping drivers." The governor then outlined his plan. "I want those citizens of our state who drive to know something about sleep, what it is, and what it takes to ensure that they do not drive while drowsy." The governor indicated that he is asking a panel of sleep specialists to prepare a list of questions about sleep to include on the new state driver's license test next year.

According to the governor's proposal, anyone applying for or renewing a driver's license must be able to correctly answer a series of sleep-related questions. "Sleep-related crashes cost us too much as a society—too many lives lost and too much money spent unnecessarily—and I intend to do something about it," he said emphatically.

Memo from the Governor

From the Office of Governor Shawn Smithers

To: Member, Committee for Sleep Questions

I am calling on you, as a sleep specialist and a member of the Committee for Sleep Questions, for your assistance. Please submit to my office a list of 10 questions about sleep that will be included on our state driver's license test. The questions should test an applicant's knowledge of basic sleep concepts; for example, what is sleep, why do we need it, how much is enough, how do we get good sleep, and what are the effects of sleep loss? I think you get the basic idea; after all, you are the expert. The committee chairperson will provide you with further instructions. My office has compiled the following statistics for use by your committee. Thank you for your assistance in this important matter.

Shawn Smithers

Facts about drowsy driving in the United States:

1. There are about 100,000 police-reported crashes per year where driver drowsiness is a principal cause.
2. About 4 percent of all crash fatalities are sleep related.
3. At least 71,000 people are injured each year in crashes involving driver drowsiness.
4. At least 1 million crashes (about one-sixth of the total) are caused by lapses in driver attention; such lapses are associated with lack of sleep.

Who is at risk?

1. Drivers who are sleep deprived or fatigued.
2. Young drivers:
   - A North Carolina study found that 55 percent of sleep-related crashes involved drivers between the ages of 16 and 25; 78 percent were males.
3. Shift workers who work nights or long, irregular hours:
   - 25 million Americans are rotating-shift workers.
   - 20 to 30 percent of them report having a sleep-related driving mishap within the prior year.
4. Commercial drivers, especially truck drivers:
   - They drive high numbers of miles per year.
   - Many must drive at night.
   - Studies find that driver fatigue is associated with 30 to 40 percent of all heavy truck crashes.
5. People with untreated sleep disorders:
   - Untreated chronic insomnia, sleep apnea, and narcolepsy can lead to excessive daytime sleepiness.
   - Sleep-related problems affect 50 to 70 million Americans.

Additional Web Resources for Teachers

1. National Center on Sleep Disorders Research at the National Heart, Lung, and Blood Institute
   http://www.nhlbi.nih.gov/ sleep

   This site is a resource for sleep researchers as well as the general public. If you click on "Patient and Public Information," you can access
   - Test Your Sleep IQ (an interactive sleep quiz)
   - Publications and Materials
   - Sleep in Youth
   - Organizations and Resources

2. National Center for Biotechnology Information
   http://www.ncbi.nlm.nih.gov/Coffeebreak/CB3_Clock/page.html

   This includes a feature called Coffeebreak that provides information on selected topics of biological interest, including biological clocks.

Appendix I
More About the National Institutes of Health

Begun as a one-room Laboratory of Hygiene in 1887, the National Institutes of Health today is one of the world's foremost medical research centers, and the federal focal point for medical research in the United States.

What Is the NIH Mission and Organization?

The NIH mission is to uncover new knowledge that will lead to better health for everyone. NIH works toward that mission by

- conducting research in its own laboratories;
- supporting the research of nonfederal scientists in universities, medical schools, hospitals, and research institutions throughout the country and abroad;
- helping in the training of research investigators; and
- fostering communication of medical information.

The NIH is one of eight health agencies of the Public Health Service, which, in turn, is part of the U.S. Department of Health and Human Services. NIH's Institutes and Centers encompass 75 buildings on more than 300 acres in Bethesda, Md. The NIH budget has grown from about $300 in 1887 to more than $23.5 billion in 2002.

What Is the Goal of NIH Research?

Simply described, the goal of NIH research is to acquire new knowledge to help prevent, detect, diagnose, and treat disease and disability, from the rarest genetic disorder to the common cold.

How Does the NIH Help Scientists Reach This Goal?

Approximately 82 percent of the investment is made through grants and contracts supporting research and training in more than 2,000 research institutions throughout the United States and abroad. In fact, NIH grantees are located in every state in the country. These grants and contracts make up the **NIH Extramural Research Program**.

Approximately 10 percent of the budget goes to NIH's **Intramural Research Programs**, the more than 2,000 projects conducted mainly in its own laboratories.

The Intramural Research Programs are central to the NIH scientific effort. First-rate intramural scientists collaborate with one another regardless of institute affiliation or scientific discipline, and have the intellectual freedom to pursue their research leads in NIH's own laboratories. These explorations range from basic biology, to behavioral research, to studies on treatment of major diseases. NIH scientists conduct their research in laboratories located on the NIH campus in Bethesda and in several field units across the country and abroad.

NIH Research Grants

Final decisions about funding extramural research are made at the NIH headquarters. But long before this happens, the process begins with an idea that an individual scientist describes in a written application for a research grant.

The project might be small, or it might involve millions of dollars. The project might become useful immediately as a diagnostic test or new treatment, or it might involve studies of basic biological processes whose practical value may not be apparent for many years.

Peer Review

Each research grant application undergoes a peer-review process.

A panel of scientific experts, primarily from outside the government, who are active and productive researchers in the biomedical sciences, first evaluates the scientific merit of the application. Then, a national advisory council or board, composed of eminent scientists as well as public members who are interested in health issues or the biomedical sciences, determines the project's overall merit and priority in advancing the research agenda of the particular NIH funding institute.

Altogether, about 38,500 research and training applications are reviewed annually through the NIH peer-review system. At any given time, NIH supports 35,000 grants in universities, medical schools, and other research and research training institutions, both nationally and internationally.

Who Are the Scientists NIH Supports?

Scientific progress depends mainly on the scientist. About 50,000 principal investigators—working in every state and in several foreign countries, from every specialty in medicine, every medical discipline, and at every major university and medical school—receive NIH extramural funding to explore unknown areas of medical science.

Supporting and conducting NIH's extramural and intramural programs are roughly 15,600 employees, more than 4,000 of whom hold professional or research doctoral degrees. The NIH staff includes intramural scientists, physicians, dentists, veterinarians, nurses, and laboratory, administrative, and support personnel, plus an ever-changing array of research scientists in training.

The NIH Nobelists

The roster of those who have conducted NIH research, or who have received NIH support over the years includes the world's most illustrious scientists and physicians. Among them are 97 scientists who have won Nobel prizes for achievements as diverse as deciphering the genetic code and identifying the causes of hepatitis.

Five Nobelists made their prize-winning discoveries in NIH laboratories. You can learn more about Nobelists who have received NIH support at *http://www.nih.gov/about/almanac/nobel/index.htm*.

What Impact Has NIH Had on the Health of the Nation?

NIH research has played a major role in making possible the following achievements of the last few decades:

- Mortality from **heart disease**, the number one killer in the United States, dropped by 36 percent between 1977 and 1999.
- Death rates from **stroke** decreased by 50 percent during the same period.
- Improved treatments and detection methods increased the relative five-year survival rate for people with **cancer** to 60 percent.
- Paralysis from **spinal cord injury** is significantly reduced by rapid treatment with high doses of a steroid. Treatment given within the first eight hours after injury increases the likelihood of recovery in severely injured patients who have lost sensation or mobility below the point of injury.
- Long-term treatment with anticlotting medicines cuts **stroke** risk by 80 percent from a common heart condition known as atrial fibrillation.
- In **schizophrenia**, where patients suffer frightening delusions and hallucinations, new medications can reduce or eliminate these symptoms in 80 percent of patients.
- Chances for survival increased for infants with **respiratory distress syndrome**, an immaturity of the lungs, due to development of a substance to prevent the lungs from collapsing. In general, life expectancy for a baby born today is almost three decades longer than one born at the beginning of the century.
- With effective medications and psychotherapy, the 19 million Americans who suffer from **depression** can now look forward to a better, more productive future.
- Vaccines protect against **infectious diseases** that once killed and disabled millions of children and adults.

- Dental sealants have proved 100-percent effective in protecting the chewing surfaces of children's molars and premolars, where most **cavities** occur.
- In 1990, NIH researchers performed the first trial of **gene therapy** in humans. Scientists are increasingly able to locate, identify, and describe the functions of many of the genes in the human genome. The ultimate goal is to develop screening tools and gene therapies for cancer and many other diseases.

NIH Research in the 21st Century

NIH has enabled scientists to learn much since its humble beginnings. But many discoveries remain to be made:

- Better ways to prevent and treat cancer, heart disease, stroke, blindness, arthritis, diabetes, kidney diseases, Alzheimer's disease, communication disorders, mental illness, drug abuse and alcoholism, AIDS, and other unconquered diseases.
- Ways to continue improving the health of infants and children, women, and minorities.
- Better ways to understand the aging process, and behavior and lifestyle practices that affect health.

These are some of the areas where the NIH's investment in health research promises to yield the greatest good for the greatest number of people.

For more about NIH visit its Web site at *http://www.nih.gov.*

Appendix II

More About the National Heart, Lung, and Blood Institute and Its Research

The National Heart, Lung, and Blood Institute (NHLBI) is one of 27 institutes and centers that compose the National Institutes of Health (NIH), the principal biomedical research agency of the federal government. NIH is a component of the Public Health Service within the Department of Health and Human Services.

Each year NHLBI assesses progress in the scientific areas for which it is responsible and updates its goals and objectives. As new opportunities are identified, the Institute expands and revises its areas of interest. Throughout the process, the approach used by the Institute is an orderly sequence of research activities that includes

- Acquisition of knowledge
- Evaluation of knowledge
- Application of knowledge
- Dissemination of knowledge

The programs of the NHLBI are implemented through its Division of Heart and Vascular Diseases, the Division of Lung Diseases, the Division of Blood Diseases and Resources, the Division of Epidemiology and Clinical Applications, the Division of Intramural Research (DIR), the National Center on Sleep Disorders Research (NCSDR), and the Office of Prevention, Education, and Control. The Divisions and the NCSDR pursue their own scientific mission but cooperate in areas of common interest. They use a variety of funding mechanisms, including research grants, program project grants, contracts, centers, and research training programs.

The National Center on Sleep Disorders Research (NCSDR) was established within the NHLBI specifically to coordinate and support NIH research, training, health-information dissemination, and other activities with respect to sleep and sleep disorders, including biological and circadian rhythms research, basic understanding of sleep, and chronobiological and other sleep-related research. The NCSDR also coordinates its activities with other federal agencies, including the other components of NIH and other public and nonprofit entities. In addition to identifying and supporting key research in sleep and sleep disorders, education programs for students, teachers, parents, and physicians are an important component of the NCSDR's mandate.

As part of its mandate, the NCSDR has developed the National Sleep Disorders Research Plan. This plan is broad in scope and multidisciplinary in nature. Its vision is "to improve the health, safety, and productivity of Americans by promoting basic, clinical, and applied research on sleep and sleep disorders." The plan calls for strengthening existing sleep research programs, training new investigators, and creating new programs that address important research gaps and opportunities. Sleep education programs for students, teachers, parents, and physicians are an important component of the NCSDR's mandate. The 2003 National Sleep Disorders Research Plan is available on the NCSDR's Web site. Go to *http://www.nhlbi.nih.gov/* and click on "Research."

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