TEACHER'S GUIDE

What's Up With José?

Produced by Harvard Medical School
Minority Faculty Development Program
of Faculty Development and Diversity

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Principal Investigator

Joan Y. Reede, M.D., M.P.H., M.S.
Associate Dean
Faculty Development and Diversity
Director of Minority Faculty Development Programs
Director of Community Outreach Programs
Harvard Medical School

Principal Authors

Kenneth P. Wright Jr., Ph.D.
Research Fellow in Medicine
Circadian, Neuroendocrine
And Sleep Disorders Section
Harvard Medical School
Brigham and Women's Hospital

Keffrelyn Brown, Ed.M.
Learning and Teaching/Curriculum Development
Harvard Graduate School of Education

Contributing Authors

Edwin J. Furshpan, Ph.D., M.A.
Robert Henry Pfeiffer Professor of Neurobiology
Department of Neurobiology
Harvard Medical School

David D. Potter, Ph.D.
Robert Winthrop Professor of Neurobiology
Department of Neurobiology
Harvard Medical School

Joan Y. Reede, M.D., M.P.H., M.S.
Assistant Professor of Medicine, HMS
Assistant Professor in the Department of Maternal and Child Health in the Faculty of Public Health

Sandra T. Sims, M.T.P.W.
Director of K-12 Programs
Faculty Development and Diversity
Harvard Medical School

Institutional Partners

Marlene Y. MacLeish, Ed.D.
Professor of Medical Education
Principal Investigator
National Space Biomedical Research Institute
Education and Outreach Program
Morehouse School of Medicine

Ronald J. White, Ph.D.
Associate Director
National Space Biomedical Research Institute
Baylor College of Medicine

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The Rationale for Case-Based/Problem-Based Learning

"What's Up With José?" contains a realistic description of a medical problem. The intent is to use this case as an exercise in problem-based learning. The case presents a real problem that must be dealt with, for the sake of the distressed patient: consequently, it can stimulate and motivate learning about the cluster of scientific and medical issues embedded in the case. In this format, one starts with the problem, not with a conventional classroom discussion of the scientific issues (e.g. a chapter in the textbook and some lectures). Ideally, the teacher's role is to guide the discussion, advise the students where answers can be found, encourage them to explore this problem, and develop their own insights. Educational research indicates that one's own insights are remembered better than insights provided by someone else, and that independent or group studies are better than managed passive studies. By reaching the desired understandings themselves, students gain self-confidence and interest in the subject.

Real-life problems, like this medical case, often do not have conventional scientific boundaries; this reminds the students of the seamlessness of science, and it gives them an opportunity to rehearse important scientific ideas that are not narrowly biological. The case surfaces the important fact that current understandings of this problem are not complete; the hope is that some student(s) will be encouraged to join the honorable struggle to understand and cope. This case offers a view of the variety of careers that are relevant to coping with this problem.

The case is divided into several parts (e.g. IA, IB, IIA, etc.). Each of these parts corresponds with a specific lesson. For this reason, **the case should not be passed out in its entirety at the outset**. Students should receive the part of the case that is discussed in the lesson. Thus, each part of the case is provided only after students have fully considered preceding parts. This is what happens in real life and it encourages students to be detectives – to pay close attention to the facts of the case as they unfold and to be creative in formulating hypotheses.

Good luck in using this case!

Key Concepts in Brain Structure and Function

(Adapted with permission from Mary's Mystery, Minority Faculty Development Department HMS)

At the heart of this medical case is a problem of the sleep and circadian cycle. It provides an opportunity to learn (or review) some basic understandings about sleep and circadian rhythms and, more generally, how the nervous system can produce not only the behaviors described in this case but also an extraordinary range of mental activity and behavior regulation. It is these activities and behaviors that help to define us as a unique species. These include our highly developed language abilities. Closely related are the complex cultures that we develop and transmit (for example: through education). We have an aesthetic sense (art); we have an ethical sense (rules and laws). We have opposable thumbs and the wonderful manipulative abilities of our hands that allow us to make elaborate devices and do complex things with them. These, of course, are functions generated or controlled by our nervous systems. Our brains are our strong suit.

Another way of getting to this is by comparing ourselves to some other species with native abilities that surpass ours:

> Unlike birds and insects, we cannot fly.
> Unlike fish and whales, we cannot spend long periods underwater.
> Unlike porcupines or tigers, we are not well protected against predators.
> Unlike polar bears or seals we are not well protected against extreme cold
> Unlike bees, we cannot see light in the ultraviolet part of the spectrum.
> We cannot move as fast over the ground as jaguars or horses.
> We are not as strong as elephants or gorillas.

However, we manufacture airplanes, submarines, weapons, clothing, automobiles, bulldozers, etc. that allow us to exceed the native abilities and feats of these species. It is our inventiveness, skills and social/economic structures that allow us to build and distribute these products. This has allowed us to spread into ecological niches where we otherwise could not survive. Again, it is our brains that are the seat of our ingenuity, skills and social behavior.

How, then, does this wonderful nervous system work? First, let us remind ourselves what a tough question this is by examining more specifically some of the functions the brain carries out:

PERCEPTIONS: For example, the rich, colorful, 3D moving pictures we have in our heads (i.e. our ongoing visual sensations) or the rich experience of sound (e.g. music). This stream of visual (or auditory) images is constructed by the brain.

THINKING: This includes calculation (e.g. math) and forward planning (e.g. we don't need to do the experiment of stepping in front of an oncoming car to see what happens) – also hopes, fantasies and, perhaps, dreams.

MEMORY AND LEARNING: We can store and retrieve vast amounts of information and, also, through repetition, greatly improve our skills (as in playing a sport or musical instrument).

EMOTIONS and MOODS: These appear to be labels conveying something about the *significance* to us of our perceptions, thoughts or memories. Emotions and moods are quite diverse: love, affection, hate, annoyance, anger, fear, sadness, joy, anxiety, etc. This diversity seems to reflect the variety of threats and opportunities we encounter in our complex physical and social environments.

DESIRES and MOTIVATIONS: Why do we get up in the morning; why do we care about other peoples' opinions of us? One of the tenets of psychology is that all behavior is motivated, that rewards (and punishments) help to shape our behaviors.

BEHAVIOR: The evolutionary significance of each of these functions, in the end, is that they influence our behaviors. We can move about and interact with our environments to enhance our chances of surviving and thriving.

Finally, and perhaps most mysteriously, the brain is the seat of CONSCIOUSNESS: the source of our awareness, the insistent sense of self we have, and our awareness of the external world.

Although an enormous amount of knowledge has been accumulated by neuroscientists in the last several decades, the brain is so complex that a huge amount remains to be learned. However, we can now see the basic principles and broad outlines of how the nervous system works. Knowledge of these basic attributes provides a framework for organizing the rapid development of new information and understanding. In the paragraphs that follow, five of these attributes, or *key concepts*, are described (they appear capitalized and in bold). Vocabulary words relevant to the biology of the nervous system are underlined.

The nervous system is a fantastically complex **COMMUNICATIONS NETWORK (Key Concept 1)**. As in any communications network there are individual units that generate signals which allow the units to interact with each other – like transistors in a computer or computers in a network. In the nervous system the interacting units, of course, are primarily the nerve cells or <u>neurons</u>. They interact with each other at <u>synapses</u>. A synapse is a specialized structure formed at a point of contact between the <u>axon</u> of the sending neuron and the <u>dendrite</u> of the receiving neuron. Axons and dendrites are generally highly branched, forming "trees" or arborizations. The axonal and dendritic components of the synapse, then, are usually small branches. The axonal branch may end at a synapse or it may continue on to make another synapse elsewhere on the dendritic tree of the same or another neuron. The axon terminal is specialized to secrete a particular active chemical, a neurotransmitter. (There is a variety of different transmitters at different types of synapses.) The dendrite – particularly the part of the dendrite contacted by the axon terminal – is also specialized. It has receptors that recognize that particular neurotranmitter and can respond to it. Depending on the identities of the neurotransmitter and receptors, the effect on the receiving neuron may be either excitatory or inhibitory.

On an individual neuron there is a flickering variation, from one fraction of a second to the next, in the constellation of synapses activated by the arrival of axonal nerve impulses. If, at any moment, aggregate excitation in the receiving neuron, evoked by the secreted puffs of excitatory neurotransmitter, sufficiently exceeds aggregate inhibition, evoked by the puffs of inhibitory neurotransmitter, the neuron generates its own impulses which travel down its divergent axonal branches, activating a new population of synapses on the array of its target neurons. This convergent and divergent spread of neuronal activity appears to endow the impulses in a given neuron with a certain symbolic significance. And as we go up the neuronal hierarchy, further from the primary sensory inputs, the significance (the meaning) of the impulses becomes more complex and abstract. Synapses are not only the sites of communication, but where learning appears to take place. Synapses are at the center of the operations of the brain. Of course the nerve impulses or action potentials are also essential in this process.

As stated above, the neuronal communications network of the brain is complex. The more we learn about it, the more complex it seems to be. Gram for gram the human brain appears to be the most complex thing in the known universe – complex in the sense of the number of specified particularities. One aspect of this complexity is the sheer number of things. In the human brain there appear to be 10^{11} – 10^{12} neurons. Moreover, a typical neuron receives hundreds or thousands of synapses. The total number of synapses in the brain is on the order of 10^{15}. But the complexity is not just a matter of large numbers. A microscopically small drop of water contains as many molecules as the synapses in the brain, yet does not exhibit a lot of meaningful complexity because a water molecule can associate with any others it encounters. In contrast, a neuron does not communicate with just any other neuron. Which neurons talk to which is very particular. The neurons are synaptically interconnected with great specificity and precision. In essence, there is a wiring diagram. So the next major notion we need, to account for the what the brain can do, is its **COMPLEXITY (Key Concept 2)**. The third notion is the **SPECIFICITY (Key Concept 3)** of wiring of the brain. The two are closely related because most of the complexity is a reflection of the specificity (together with the huge numbers of neurons and synapses).

The wiring diagram is a very important concept – it specifies how information is processed and over what routes the information, in the form of nerve impulses, flows. Ultimately, the wiring diagram determines the relationship between what comes into the nervous system and what goes out. In short, it determines behavior – not just simple reflexes, but also complex behavior. Information comes in through many sensory pathways and is brought together with huge amounts of stored information, and may be modified by emotional context. All of this leads to the activation of complex and subtle motor programs which may be highly dependent on learning, on training. Of course, this includes the muscles that control speech and writing with all that that implies.

This is not meant to imply that the nervous system is hard-wired in the sense that the same input always gives the same output. On the contrary, the nervous system is always changing. We say it exhibits **PLASTICITY (Key Concept 4)**. One way the brain is changed is by its interaction with the environment. How does this come about? In at least a couple of ways. We know, for example, that the strength of synaptic transmission, whether a synapse transmits a strong or a weak message, can be quite variable. This may occur because the activity of a given synapse is altered by hormones or by neurotransmitter compounds (like dopamine, serotonin or neuropeptides) secreted from neighboring neurons which, in turn, may be responding to environmental contingencies. In addition, when a synapse is activated intensively, simply the fact that it has been heavily used may alter its function. Such changes appear to underlie learning. Whenever we learn something, changes occur in our brain, apparently in our synapses. So, we see that the neuronal networks not only process information, they are changed by the information they process. It is hard to emphasize too strongly that the brain is a highly plastic device. In terms of evolution, the plasticity of synapses in the brain is a major source of our adaptability to our environments – we learn how to cope. It seems unlikely that we could survive without this ability.

So what we see as hallmarks of the nervous system are a large number of elements and great complexity, with precise specificity of interconnections, and extensive plasticity; complex, modifiable neuronal circuits. These are major principles we need to pay attention to in trying to understand how our nervous systems work.

There is a fifth important principle. Although the brain is complex, it exhibits impressive **ORDERLINESS (Key Concept 5)**. If you examine a brain, you will find that it has major divisions and within each division, subdivisions and subsubdivisions, etc. There is a huge number of discernably different areas. If you then look at another brain, you will find the same patterns. This may not seem surprising. It just means that the brain has an anatomy like every other part of the body. On the other hand, it is a great relief that in spite of the enormous complexity of the brain, it is not just a jumble. The orderliness of the brain appears, to a large extent to be a result of orderly mechanisms during development that determine the specificity of the neuronal connections. The orderliness of the brain means that it can be studied – one brain is so similar to another that people can make reproducible observations and experiments. In addition, the orderliness of structure underlies the orderliness of function. This means that a neurologist can predict where a lesion is in the brain by paying attention to the symptoms – something you may practice during the this case. Knowing *where* the problem is in the nervous system is almost always the first step in understanding *what* the problem is.

"What's Up With José?" Includes Aspects of the Following National Science Education Standards:

Grades 5 - 8

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science

- Properties and changes of properties in matter
- Transfer of energy

Life Science

- Structure and function in living systems
- Regulation and behavior
- Diversity and adaptation of organisms

Earth and Space Science

- Structure of the earth system
- Earth in the solar system

Science and Technology

- Understanding about science and technology

Science in Personal and Social Perspectives

- Personal health
- Populations, resources and environments
- Risks and benefits
- Science and technology in society

History and Nature of Science

- Science as a human endeavor
- Nature of science

Grades 9 - 12

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science

- Structure and properties of matter
- Interactions of energy and matter

Life Science

- Matter, energy and organization in living systems
- Behavior of organisms

Science and Technology

- Understanding about science and technology

Science in Personal and Social Perspectives

- Personal and community health
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge

"What's Up With José?" Includes Aspects of the Following National Council of Teachers of Mathematics Curriculum and Evaluation Standards:

GRADES 5 – 8

- Problem solving
- Communication
- Reasoning
- Connections
- Computation and estimation
- Patterns and functions
- Measurement

GRADES 9 – 12

- Problem solving
- Communication
- Reasoning
- Connection

Notes for the Teacher's Guide to "What's Up With José?"

Each of the lessons includes classroom activities. This allows the classroom teacher to *personalize* each lesson to the needs of the students. To assist the teacher in choosing *pertinent* activities, the following scale is used in each lesson:

Core – lessons, demonstrations, or lectures that are **core** to the case. These activities sections are in black ink.

Supplemental – **supplemental information** to major topics covered in the case. These sections are in blue ink.

Extension – information that is an **extension** into related areas. These sections are in violet ink and can be found in full in the Appendix at the back of this document.

- – indicates key items or questions the teacher may want to have the **students focus** on.

Hypothesis Testing Packet

The Hypothesis Testing Packet[1] is used throughout the case as a way for students to keep track of their observations and hypotheses throughout the case. The packet is divided into 5 columns which will guide the students through all the steps of the scientific method:

- Date/Lesson
- The Problem
- Your Observations
- Your Hypothesis/es
- Hypothesis Testing

In this manner, students will be able to apply the scientific method and use an iterative process to revise their hypotheses as they discover more about the case, sleep mechanisms, and "What's Up With José?" At the end of the case, the students will be able to observe how their ideas, knowledge and conclusions evolved throughout the examination of the case: this will show them how scientists conduct research by formulating hypotheses, testing them, and revising them.

Portfolio Assessment

The activities found in "What's Up With José?" allow students to use the concepts and information they are learning about neuroscience and space. While some of the activities require one session to complete, others are on-going and encourage students to use and reflect on what they have learned in previous lessons. One way that both students and teachers can record what the students have learned is to develop a portfolio throughout the case. Portfolios demonstrate what students have learned. The format for "What's Up With José?" allows flexibility in choosing the most appropriate portfolio design for the classroom. Please feel free to have students use the portfolio system to document, maintain and reflect on their understanding of the material found in "What's Up With José?"

[1] See Appendix 2

Notes for the Teacher's Guide to "What's Up With José?"

This page represents the typical breakdown of the lessons contained in this Guide:

Lesson Objective: What the lesson will cover

Benchmarks for Science Literacy:
American Association for the Advancement of Science: Benchmarks met by the lesson

Example of Regional Standards:
Boston Public Schools (BPS) Learning Standards: District standards met by the lesson

Materials: Items needed for the lesson

I. **Lesson Opening**: Activity to prepare students for the lesson

II. **Lesson Body**

All the lessons contain clearly marked sections setting out the suggested sequence of activities. In the various headings, there is an indication of which part of the case the lesson relates to (e.g. Lesson II Parts IIA and IIB). Vocabulary words are underlined and definitions are provided in the Glossary, at the end of the Teacher's Guide.

a. **Teacher Directed Instruction**: The teacher directly gives information to the students.

b. **Teacher Guided Inquiry**: The teacher guides students through concepts raised by the case.

c. **Student Guided Inquiry**: Students are actively engaged in questioning and exploring new concepts.

III. **Independent Activity/Homework**

Students use information learned during the lesson; this can be done in class or as homework.

“What’s Up With José?”

The Case

"What's Up With José?" – Preliminary Activity

Activity Objective

Students will record their sleep habits and the sleep habits of one other household member. This activity should be completed at least two weeks prior to the start of this case. The log must include at least one weekend and must be accurate with respect to time and amounts of sleep. Refer to Appendix 1 for the Sleep Log. The information obtained from these sleep logs will be used in several exercises during the case, to develop key concepts in sleep and circadian rhythms and to stimulate discussions on core and supplemental topics. The students will compare their own findings on other students and household members. This activity emphasizes the usefulness of math in science.

"What's Up With José?" - Part I

I would like to tell you a story about my best friend José. During High School, José was the kind of person that everyone liked. He was the captain of the basketball team and a great friend who was always there for you. José was also a good student. During our senior year everything was going great for him. Because of his good grades and performance on the basketball court, he was being considered for both athletic and academic college scholarships.

Shortly before basketball season, José purchased a used sports car. Unfortunately, he had to take a part-time after-school job to pay for this car. He worked three nights every week after basketball practice at "Buzz", the local coffee house. José also worked the morning shift during weekends. As I mentioned, José was a good student. To maintain his grades and his chance for a college scholarship, José would study every night after work.

One day Coach B. approached José about his recent performance. Coach asked José if he was taking drugs. José said that he was not taking drugs and that he was just stressed out. Coach then spoke with me about his concerns; he thought José was acting "different." During the next basketball game, José scored only 3 points, well below his average of 18 points per game. Frustrated by his performance, José also "fouled-out", something that had never happened in his high school career.

A week later, Mrs. Van Horn, José's math teacher, brought José to the school nurse because he was sleeping in class, and Mrs. Van Horn thought that José might have Mono (mononucleosis). Mrs. Van Horn was further concerned that José had not been doing well on his homework recently and that on his last exam he had received a "D", a grade that he had not received since his freshman year. The school nurse spoke with José and his Mom, and it was agreed that José's doctor should examine him.

"What's Up With José?" - Part IIA

José went to see his primary care physician Dr. Cartess. José's mother joined Dr. Cartess and José in the examining room. Dr. Cartess and José had the following conversation:

Dr. Cartess: Why did you come to see me today?
José: I have no problem, everyone is just bugging. My coach, teacher and parents are all on my case.
D: Is there anything going on in your life currently that is stressing you out?
J: Nothing.
D: Are you having fun in school?
J: Yeah, but I can't wait till I'm playing basketball in college next year.
D: What position do you play?
J: Forward.
D: Do you get along with your friends?
J: I'm hanging with my friends.
D: How about your parents and teachers?
J: They are bugging about nothing.
D: How are you eating?
J: My appetite is never a problem.
D: How are you sleeping?
J: Sometimes at night I have difficulty falling asleep.
D: How often do you have difficulty falling asleep?
J: Several nights a week.
D: Do you do anything to help you sleep at night?
J: No, I just watch TV or read until I feel tired.
D: Are you sleepy during the day?
J: No.

José's mom mentioned that he fell asleep in class.
José responded: "Oh yeah, that was just one time. I'm O.K. now."

D: Are you using drugs such as: Marijuana?

J: No.

D: Cocaine?

J: No.

D: Alcohol?

J: No.

D: Nicotine?

J: No.

D: Any other drugs?

J: No.

D: Over the counter medications?

J: No.

José's Mother provided the family history of medical problems. José's Grandmother has high blood pressure, and a thyroid problem, and his Grandfather was just diagnosed with cancer.

The doctor performed a physical on José and collected the following information:

Age	17-year-old male
Height	6'3"
Weight	180 lbs.
Blood Pressure	118/70
Heart Rate	60
Temp	98.9
Pupils	2-3 mm, equal and reactive to light
Reflexes	2+ and symmetrical

“What’s Up With José?” - Part IIB

Patient complained of having difficulty falling asleep several nights a week. Since José was young and did not show symptoms of a thyroid problem, Dr. Cartess did not think that it was necessary to run any blood tests. José stated that he did not use drugs and there were no indications of drug usage from the physical. From this information, it was unlikely that José’s problems are a result of drug use. Though unlikely, Dr. Cartess had not ruled out drugs as a possible factor, but he thought this unlikely.

Dr. Cartess decided to obtain more information on José’s sleep. The doctor requested that José keep track of how much sleep he was getting.

“What’s Up With José?” - Part III

During the follow-up visit, José’s father mentioned that José’s aunt has a sleep disorder. His father could not remember which sleep disorder, but she had fallen asleep while driving several times.

Reviewing José’s sleep log, Dr. Cartess saw that José was averaging about 6 hours of sleep at night.

Given the new information of a family history of sleep disorders and the lack of any apparent problems with José’s physical health, Dr. Cartess referred José to a sleep specialist.

"What's Up With José?" - Part IVA

Dr. Cartess referred José to sleep specialist Dr. Knight, from a Sleep Disorders laboratory in a local hospital.

José's parents told Dr. Knight that his aunt Caroline had been told that she has sleep apnea.

Dr. Knight asked to meet with José alone (without his parents).

Dr. Knight asked José about his sleeping habits and his drug intake:
Dr. Knight: How is your sleep?
José: I have a problem falling asleep 2-3 nights a week.
D: How long does it take you to fall asleep?
J: About 30 minutes.
D: Do you do anything to help you fall asleep?
J: I read in bed or watch TV until I fall asleep.
D: Do you awaken at night?
J: Once or twice a week I get up to go to the bathroom.
D: Do you have any difficulty falling back asleep?
J: No, not really.
D: Do you have any difficulty staying awake during the day?
J: No; well, sometimes when class is boring.
D: When do you go to bed at night?
J: Around midnight.
D: When do you wake up in the morning?
J: Six-fifteen.
D: How about on weekends?
J: On Friday night I go to bed about midnight and wake up to go to work at 6:30. Saturday night I usually go to bed later and wake up around 8 so I can be at work by 9.
D: Do you wake up on your own or do you use and alarm clock.
J: (laughs) I always use an alarm clock.
D: Do you nap?
J: No, I have no time to nap.
D: Do you snore?
J: No, not that I know of.
D: Do you sleep walk?
J: When I was 13, but not recently.
D: Do you experience vivid dreams when you first fall asleep?
J: Once in a while.
D: Do you experience times of muscle weakness, especially when you laugh or are emotional?

J: No.
D: Do you ever fall asleep at inappropriate times?
J: Well, one time in class I just had to put my head on the desk and go to sleep. I could not stay awake. Another time I almost fell asleep when driving to work one Saturday morning.
D: How are your grades in school?
J: Not too good lately. I find it difficult to concentrate on what the teacher is saying. My mind seems to wander a lot.
D: How is your appetite?
J: Ok.
D: Now I am going to ask you questions about drug intake.
J: Ok.
D: Do you drink alcohol?
J: No.
D: Never?
J: Well, sometimes.
D: How often?
J: I drink 1-2 beers every weekend.
D: Have you used Marijuana?
J: Once or twice when I was a sophomore.
D: How about Cocaine?
J: No.
D: Amphetamines?
J: No.
D: Other street drugs?
J: No.
D: Over-the-counter medications?
J: No.
D: Herbal or dietary supplements?
J: No.
D: How about soda?
J: A few a week.
D: Coffee?
J: When I work at the coffee shop I have a cup.
D: Is it caffeinated or decaf?
J: Usually caffeinated.
D: Tea?
J: No.
D: Chocolate?
J: I like a candy bar after basketball practice.

"What's Up With José?" - Part IVB

To collect further information, Dr. Knight asked José to keep a log of his sleep and drug intake for the next 2 weeks, until his next appointment.

"What's Up With José?" - Part VA

A close look at José's sleep log shows that he drank a lot of coffee and soda; especially after work around 9pm to 10pm when he went home to study. He also drank a lot of coffee on weekends during his morning shifts at work. José also reported that he reads in bed before going to sleep.

Sleep Log

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date	2/13	2/14	2/15	2/16	2/17	2/18	2/19
Bedtime: Fell Asleep at: (Hr:min)	12:05 12:45 *Monday night*	12:34 12:40 *Tuesday night*	12:01 12:40 *Wednesday night*	12:23 12:55 *Thursday night*	1:45 1:45 *Friday night*	11:54 12:00 *Saturday night*	12:00 12:40 *Sunday night*
Waketime (Hr:min)	6:00 *Tuesday morning*	6:10 *Wednesday morning*	6:00 *Thursday morning*	6:00 *Friday morning*	6:30 *Saturday morning*	8:00 *Sunday morning*	6:00 *Monday morning*
Naps	none	none	none	none	none	12-1	none
Soda, coffee and tea consumption	1 soda 1:05 pm 1 soda 3:15 pm 1 coffee 9:00 pm 1 coffee 10:15 pm *Monday*	1 soda 10 am 1 soda 2:30 pm 1 soda 5:10 pm *Tuesday*	1 soda 2:30 pm 1 coffee 9:10 pm 1 coffee 10:00 pm *Wednesday*	1 coffee 9:00 pm 1 coffee 9:15 pm 1 coffee 10:15 pm 1 coffee 11:00 pm *Thursday*	1 soda 10 am 1 soda 2 pm 1 soda 5 pm 1 coffee 9 pm *Friday*	1 coffee 7:30 am 1 coffee 8:45 am *Saturday*	1 coffee 7 am 1 coffee 8 am *Sunday*

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date	2/20	2/21	2/22	2/23	2/24	2/25	2/26
Bedtime: Fell Asleep at: (Hr:min)	11:55 12:15 *Monday night*	12:15 12:25 *Tuesday night*	12:38 1:05 *Wednesday night*	12:01 1:00 *Thursday night*	12:30 12:35 *Friday night*	12:04 12:15 *Saturday night*	12:00 12:15 *Sunday night*
Waketime (Hr:min)	6:00 *Tuesday morning*	6:00 *Wednesday morning*	6:00 *Thursday morning*	6:00 *Friday morning*	6:30 *Saturday morning*	8:00 *Sunday morning*	6:00 *Monday morning*
Naps	none	none	none	none	none	none	none
Soda, coffee and tea consumption	1 soda 3:00 pm 1 coffee 9:00 pm 1 coffee 10:00 pm *Monday*	1 soda 9:35 am 1 soda 2:30 pm 1 soda 6:40 pm *Tuesday*	1 soda 2:30 pm 1 coffee 9:00 pm 1 coffee 10:15 pm *Wednesday*	1 coffee 9:00 pm 1 coffee 10:05 pm 1 coffee 11:00 pm *Thursday*	1 soda 3 pm 1 coffee 6 pm *Friday*	1 coffee 7:30 am 1 coffee 9:00 am *Saturday*	1 coffee 7 am 1 coffee 9 am *Sunday*

“What’s Up With José?” - Part VB

Dr. Knight concluded that José drinks too many beverages that contain caffeine, does not get enough sleep, and that his behaviors of reading or watching television in bed while trying to fall asleep is disrupting his ability to fall asleep even more. He has a Stimulant-Dependent Sleep problem and Poor Sleep Hygiene. Dr. Knight prescribed more time reserved for sleep, a reduction in his caffeine intake and no eating, reading or watching TV in bed.

"What's Up With José?" - Part VC

Follow-Up: José removed most of his caffeine intake (except during the weekend morning shift) and decided to work one hour less a night and work only one weekend morning. These changes allowed José to obtain one more hour of sleep a night and to "sleep in" one weekend morning. He no longer reads or watches television in bed.

Within two weeks, José slept better and his school and basketball performances improved to their levels before his problem. He did not feel as frustrated as he had been, and he also reported that he felt more alert and better about himself.

“What’s Up With José?”

The Lesson Guides

LESSON I: Using the Scientific Method

Guide for Part I

Lesson Objectives:

- Introduce students to the case.
- Students will form hypotheses about José's condition.

National Science Education Standards:

Science As Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Use mathematics in all aspects of scientific inquiry.
- Understandings about scientific inquiry.

Benchmarks for Science Literacy – American Association for the Advancement of Science:

1A: Scientific World View

- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.
- Scientific knowledge is subject to modifications as new information challenges prevailing theories and as a new theory leads to looking as old observations in a new way.
- No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends, This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

1B: Scientific Inquiry

- Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the investigation (or even to identify all the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations.
- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).

12D: Communication Skills

- Participate in group discussion on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

12E: Critical-Response Skills

- Notice and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given.
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one's own or that of others—can be judged.
- Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the ones worth consideration, with no mention of other possibilities.

Example of Regional Standards – Boston Public Schools Learning Standards:

Students will develop the abilities necessary to conduct scientific inquiry by:

- Designing and conducting scientific investigations
- Formulating and revising scientific explanations and models using logic and evidence
- Communicating and defending a scientific argument

Materials

- Appendix 1 (Sleep Log)
- Appendix 2 (The Scientific Method)
- Appendix 3 (Hypothesis Testing Packet)

Lesson Opening (Part I)

Explain to the students that they will work with a case called "What's Up With José?". The case is about the sleep and circadian rhythms. Medical case studies are a method used by medical schools to teach medical students basic concepts and principles of medical science within a real-life context. Students will be given information sleepwise, and their task is to think about what happened to José and why. They must decide how they might find the answers. They will use the scientific method, in an approach similar to that of detectives. This is not an easy task.

Lesson Body

Teacher Directed Instruction (Core Part I - Lesson I)

Have the students read Part I. Ask students what they think is going on in the case.

- **Using drugs?**
- **Cold/Flu?**
- **Exhausted from working/playing too much?**
- **Depressed?**
- **Family problems?**
- **Broke up with girlfriend?**
- **Fighting with friends?**

Allow the students to generate as many explanations for José's problem as they can. Encourage students to include evidence from what they have read to support their answers. If students have difficulty doing this, use the following questions to assist their effort:

What do you know from what you read?
What evidence do you have to support your idea(s)?

Listen carefully to student responses to determine whether responses are direct, factual observations or inferences based on what they have read. Explain to the students that scientists use the scientific method to increase their understanding of the unknown. They rely on collected evidence and progressively rule out some possibilities, while focusing on others. The method prevents hasty, unsupported conclusions.

The following is a review of the steps of the **Scientific Method**:
(Adapted with permission from "Mary's Mystery", Minority Faculty Development, HMS)

1. Stete a question about the problem you are dealing with or the phenomena that you have observed.
2. Based upon what you already know, formulate a hypothesis [make a guess] to answer the question.
3. Gather data to test your hypothesis.
4. Evaluate the data to determine whether the data fit the hypothesis.
5. Based on your evaluation of the data you can:
   a. Conclude that your hypothesis is a plausible explanation for your observations for now,
   b. Revise your hypothesis in a way that accounts for the data, or
   c. Reject the original hypothesis and devise another.
6. When there is new information, original hypotheses are reevaluated.

What is "scientific truth"? In science, a concept is generally considered "understood" or accepted as "true" until someone, provides a better explanation and evidence to support it. In science, a theory is different from an hypothesis or speculation. A theory is a well-supported explanation that is effective in helping us to understand natural phenomena. It has survived repeated experimental tests and provides useful predictions. A durable theory is as close to "truth" as we get in science. Einstein's theory of relativity and Darwin's theory of evolution are examples.

Teacher Guided Inquiry (Core Part I)

Use the following questions to guide whole-class discussion:

If you were José's doctor, what would you want to know in order to understand José's condition?
What questions would you ask?
Why did you choose those questions?

Independent Activity/Homework: (Core Part I)

Have students, either in class or independently as homework, consider what might have affected José's behavior. Students should share their thoughts with the class.

Students should record their observations and hypotheses about José's condition in their individual hypothesis-testing packets.

LESSON II: A Visit to the Doctor

Guide for Parts IIA and IIB

Lesson Objectives
- Students will observe the use of the scientific method in medical practice.

National Science Education Standards:
Science As Inquiry
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Use mathematics in all aspects of scientific inquiry.
- Understandings about scientific inquiry.

Science in Personal and Social Perspectives
- Personal and community health.

Benchmarks for Science Literacy – American Association for the Advancement of Science:
1A: Scientific World View
- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.
- Scientific knowledge is subject to modifications as new information challenges prevailing theories and as a new theory leads to looking as old observations in a new way.
- No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends, This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

1B: Scientific Inquiry
- Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the investigation (or even to identify all the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations.
- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).

1C: The Scientific Enterprise
- Scientists are employed by colleges and universities, businesses and industry, hospitals, and many government agencies. Their places of work include offices, classrooms, laboratories, farms, factories, and natural field settings ranging from space to the ocean floor.

- Scientists disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some subdisciplines spin off to become new disciplines in their own right.
- Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups about their perceived interests.

8F: Health Technology

- The ability to measure the level of a substance in body fluids has made it possible for physicians to make comparisons with normal levels, make very sophisticated diagnosis, and monitor the effects of the treatments they prescribe.

12A: Values and Attitudes

- Know why it is important in science to keep honest, clear, and accurate records.
- Know that hypotheses are valuable, even if they turn out to be not true, if they lead to fruitful investigations.
- Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct.

12B: Computation and Estimation

- Consider the possible effects of measurement errors on calculations.

12C: Manipulation and observation

- Read analog and digital meters on instruments used to make direct measurements of weight.

12D: Communication Skills

- Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer data bases.
- Understand writing that incorporates circle charts, bar and line graphs, two-way data tables, diagrams, and symbols
- Participate in group discussion on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

12E: Critical-Response Skills

- Notice and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given.
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one's own or that of others—can be judged.
- Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the ones worth consideration, with no mention of other possibilities.

Example of Regional Standards – Boston Public Schools Learning Standards:

Students will develop the abilities necessary to conduct scientific inquiry by:

- Designing and conducting scientific investigations.
- Formulating and revising scientific explanations and models using logic and evidence.
- Communicating and defending a scientific argument.

Human Body Systems

- The organization of all human systems (i.e., cell, tissue, organ, system).

Science Domains: Life

- Human Body Systems: circulatory, nervous.

Materials

- Part IIA and Part IIB of "What's Up With José?"
- Appendix 4 (Pupillary Light Reflex)
- Appendix 5 (What is Sleep?)

Lesson Opening (Part II)

Begin by having students read Part IIA. Discuss the definitions of any unfamiliar terms or concepts.

Lesson Body
Teacher Directed Instruction (Core Part II)

The following section is a description of some of the tests that were performed on José:
By consensus, the "normal range" for BP is between 90 and 140 mm/Hg (millimeters of mercury) systolic, and between 60 and 90 mm/Hg diastolic. However, your blood pressure can be higher or lower at times (e.g., after exercise, drug use). Systolic indicates the blood pressure in the arteries as the heart squeezes out blood during each beat. Diastolic indicates the blood pressure as the heart relaxes before the next beat. A person with a systolic level over 140 mm/Hg and a diastolic level over 90 m/Hg is considered to have hypertension or high blood pressure. People with consistently high blood pressure may be at higher risk for heart attacks, strokes (brain attacks), heart failure and kidney disease. A systolic level below 90 mm/Hg and a diastolic level below 60 m/Hg is considered hypotension or low blood pressure. Low blood pressure can be the sign of diabetes, other endocrine disorders, pregnancy or drug use.

The heart beats between 55-80 times per minute at rest and can beat as fast as 200 beats per minute during exercise. Your resting heart rate is related to your fitness level. A healthy, fit heart requires fewer beats per minute (less effort) to pump blood to the body.

Most people consider 98.6 degrees Fahrenheit as a normal body temperature. (37 degrees Celsius: conversion factor from Fahrenheit to Celsius; C=F-32 x 5/9). This is an average. In fact, body temperature changes across the day. A temperature between 97.5 and 99.5 is considered normal. In general, during the daytime your body temperature is higher and during the night is lower. Many things including activity, posture, food and drug intake, and menstrual cycle phase affect temperature. When a person is sick a fever is common: a temperature above 101 in adults is considered fever.

Pupil size is highly variable, depending on the intensity of the ambient light on mood (e.g., fright or anger) and on individual differences. Under usual indoor lighting conditions, pupil size is often about 3-4 mm. If pupils are not equal in size and not reactive to stimuli, such as a light shined in the eyes, there may be a problem, but for some people unequal pupils are normal. Another potential problem is fixed pupils that are stationary and unresponsive to all stimuli. If one of the pupils is dilated and the other one is responsive this could be the sign of brain damage. The use of certain drugs also changes pupil size and responsivity (see Appendix 4, the Pupillary Light Reflex).

A reflex response that is too large (**hyper**responsive) or too small (**hypo**responsive) is considered problematic.

Teacher Guided Inquiry (Core Part II)

Have students recall each of the steps in the scientific method. This discussion should help students recognize that Dr. Cartess asked certain questions and performed certain procedures according to his initial hypotheses about José's condition. Ask the students why Dr. Cartess asked each question in the interview. This task will remind students that doctors ask questions for specific reasons.

Ask students to consider the various types of questions asked by Dr. Cartess.
What types of information do you think he was seeking? How might this information relate to your hypothesis? Have students share their responses with the entire class. Record their responses.

Discuss some of the methods used by scientists, researchers, physicians, statisticians and others for collecting data/information with the students:

- **Self-Report and asking others: distinguish between information given by a person (first hand), and information given by others (second hand)**
- **Observation**
- **Testing**
- **Experimenting**
- **Review of information gathered previously (newspapers, literature, medical records, journals, books, magazines, the web)**
- **Speaking with or listening to experts**

Ask students what methods were used to collect data in Part I and IIA?

The students might suggest:

- **The basketball coach observed José's behavior**
- **The math teacher observed José's behavior**
- **José reported to the coach that he was not taking drugs and was stressed out.**
- **Observations by Dr. Cartess**
- **Information from José's mom**

Teacher Directed Instruction (Supplemental Part II)

What are Validity and Reliability?

Explain to the students that science depends on valid and reliable data.

What is validity?

Validity is the extent to which an observation accurately measures or tests something relevant to the question.

What is reliability?

Reliability is the extent to which a measurement or test repeatedly produces similar results. For example, each time you ask "Information" for the telephone number for recorded weather information, you are told: 936-1234. If, however, you were repeatedly told it was 966-1234, it would be reliable but invalid.

Consider validity and reliability in the context of clocks. How do we know what time it is? Who keeps the Master Clock?

The system of atomic clocks at the Department of the Navy serves as the country's official timekeeper. The "Master Clock" facility is located at the Washington Naval Observatory. http://tycho.usno.navy.mil/what.html The "Master Clock" is based on a system of cesium atomic clocks and a dozen hydrogen maser clocks. These clocks are very accurate and stable across time. For more information please refer to:
http://tycho.usno.navy.mil/clocks.html

Is our wrist watch a valid and reliable measure of time?

If our watch kept perfect time with the atomic clocks at the Naval Observatory from minute to minute, hour to hour, day to day, month to month, year to year, then our watch would be a valid timekeeper. If we have another watch that we compare to the atomic clocks, and we find that this watch registered the time as 1700 hr (5:00 p.m.) when the atomic clocks registered the time as 1710 hr (5:10 p.m.), and an hour later our clock registered 1800 hr when the atomic clocks registered 1810 hr, then our clock would be considered reliable since it measured the duration of 1 hour correctly (i.e., for both our watch and the atomic clocks 1 hr elapsed between measurements). However, our clock would not be considered valid since the time was incorrect by 10 minutes at each measurement. Alternatively, our invalid watch could be too slow or too fast which would make our watch unreliable and invalid for most of the day. For most purposes, the accuracy of watches is adequate in that they maintain a sufficiently close approximation of real time.

Scale Demonstration

The purpose of the next exercise is to help students rehearse the concepts of validity and reliability. The students should know that validity and reliability are not synonymous. The student should recognize that a test can be reliable but not valid.

Directions

The teacher should bring an off-balance bathroom scale to class. Prior to the demonstration, the teacher should choose one student as an assistant. Have the student stand on the scale in front of the class. Record the weight. The weight is incorrect because the scale is not properly adjusted. If the student recognizes this, do not discuss it—yet. Repeat this procedure three times. Record each score.

Ask the students the following questions:
Were the results reliable?
Were the results valid?
What is the difference between reliability and validity?

If a test is valid then it must, by definition, be reliable; however, a test can be reliable but not valid as in this scale example.

What Is Done With Data After It Is Collected?

Tell students that once valid data is collected the data is interpreted. Share the following example with the class: Data is collected on the weight of everyone in the class. We know the results are valid and reliable. Suppose we find that males, on the average, are heavier than the females.

What does this mean?

> **One interpretation is that the males eat more than the females. Another interpretation is that males are genetically predisposed to have bigger bones and muscles.**

Are these valid interpretations? How can we be sure that an interpretation is valid?

> **Point out that interpretations considered valid today may be found to be invalid when further research is done. Sometimes scientists make mistakes**

when interpreting data. For example, scientists might fail to recognize the effect of a third variable, such as in the following anecdote. There is a strong relationship between the number of ice cream sales and the number of people who die from drowning. The more ice cream sold, the more people die from drowning. Given this relationship, is it clear that a person should not eat ice cream and go swimming because of the likelihood of drowning? Students should consider other factors that might cause both events. In this example, both ice cream sales and drowning deaths increase during the summer because it is hot outside. The summer heat is a third variable.

Teacher Directed Instruction (Core Part II)

Have students read Part IIB. Explain to the students that a toxicological screen, or drug test, is sometimes ordered by medical practitioners. In a toxicological screen, a person's blood, urine, saliva or other bodily tissues are tested for drugs, medications, poisons and other foreign chemicals.

Given the new information in Part IIB, ask the students to review their original hypotheses and consider whether they need to be changed. Changes should be noted in each student's hypothesis testing packet. Place in portfolio.

Teacher Guided Inquiry (Extension Part II)

This extension explores the controversy related to mandatory drug testing for minors. See Appendix A1, p. 90.

Independent Activity/Homework (Core Part II)

A. To emphasize the importance of proper methods for collecting data, ask students to consider how incorrect information might affect their individual hypotheses. They should specify, for each kind of misinformation, how would it affect their own hypothesis.
B. Students should read "What Is Sleep?" found in Appendix 5 on the nature and function of sleep. They should look up any terms that are unfamiliar and also write a brief summary of one of the topics discussed. This homework will be reviewed in the beginning of Lesson III.

Independent Activity/Homework (Supplemental Part II)

Students should research the local city/state laws, or speak to health care professionals with regard to a parent's or school's right to test an individual for drugs without the individual's consent.

LESSON III: The Science of Sleep

Guide for Part III

Lesson Objectives
Students will learn the basic principles of sleep.

National Science Education Standards:
Life Science
- Biological evolution.
- The behavior of organisms.

Physical Science
- Chemical reactions.
- Conservation of energy and the increase in disorder.
- Interactions of energy and matter.

Benchmarks for Science Literacy – American Association for the Advancement of Science
2A: Mathematics, Science and Technology
- Mathematics provides a precise language for science and technology—to describe objects and events, to characterize relationships between variables, and to argue logically.

5A: Diversity of Life
- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.

5C: Cells
- All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.
- Within every cell are specialized parts for the transport of materials, energy transfer, protein building, waste disposal, information feedback, and even movement. In addition, most cells in multicellular organisms perform some special functions that others do not.
- Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

5D: Interdependence of Life
- Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

6F: Mental Health
- Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances.

11A: Systems
- Any system is connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

11C: Constancy and change
- Many systems contain feedback mechanisms that serve to keep changes within specified limits.

12B: Computation and Estimation
- Find the mean and median of a set of data.
- Use computer spreadsheet, graphing, and data base programs to assist in quantitative analysis.
- Compare data for two groups by representing their averages and spreads graphically.
- Consider the possible effects of measurement errors on calculations.

12C: Manipulation and observation
- Use computers to store and retrieve information in topical, numerical, and key-word files, and create simple files of their own devising.
- Use computers for producing tables and graphs and for making spreadsheet calculations.

12D: Communication Skills
- Read simple tables and graphs produced by others and describe in words what they show.
- Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer data bases.
- Understand writing that incorporates circle charts, bar and line graphs, two-way data tables, diagrams, and symbols
- Participate in group discussion on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

12E: Critical-Response Skills
- Be aware that there may be more than one good way to interpret a given set of findings.

Example of Regional Standards – Boston Public Schools Learning Standards:

Human Body Systems
- The organization of all human systems (i.e., cell, tissue, organ, system).
- The main function of each system; how they are interrelated and how each interacts with the environment.

Science Domains: Life
- Human Body Systems: endocrine, skeletal, respiratory, nervous.
- Adaptation.

Cells (Single cell life, Cells in multicellular organisms)
- Cells appear to be the fundamental unit of living things.
- Different body tissues and organs are made up of different kinds of cells.

Varieties of Life on Earth
- Species.

Materials
- Appendix 6 (Sleep Hypnogram)
- Appendix 7 (Ions and Impulses)

Lesson Opening (Part III)

The following lesson contains considerable information about the nature of sleep. While most of the information presented is core to the understanding of sleep, it might be difficult to include all of the data in one class period. Consider the dynamics of the class to choose the most effective way of introducing this material.

Students should read Part III. After the reading, ask students to consider the previous night's homework findings. Begin the discussion by asking students the following question:

What is sleep?

Incorporate the following questions in the discussion:

What are the two dominant patterns of sleep?
What are some of the differences between NREM and REM sleep?

Lesson Body
Teacher Directed Instruction (Core Part III)

While students should have read the following section for homework in Lesson II, they may have had difficulty recognizing and identifying the main concepts of the selection. Please review their understanding by reinforcing (or in some cases, pointing out) the main points from the section. **These ideas are bolded throughout this selected piece**.

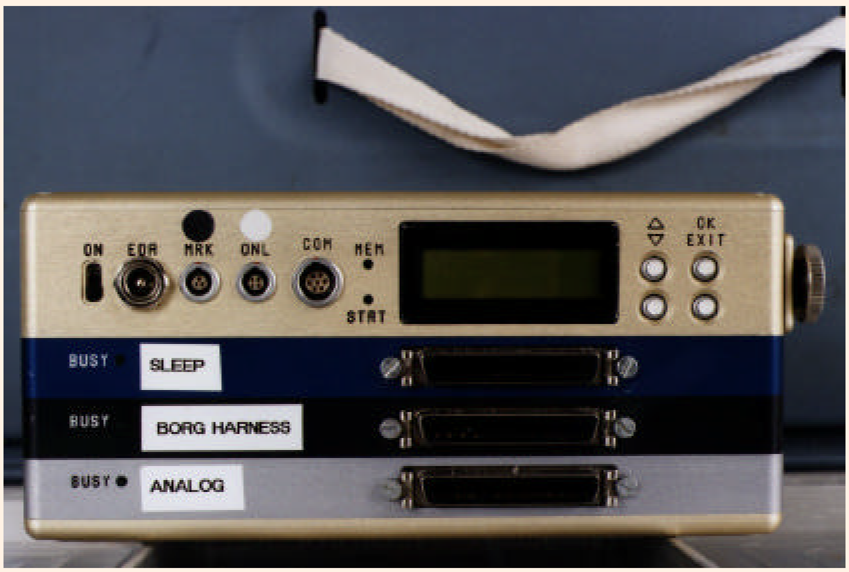
What is Sleep? How Do You Know Someone is Sleeping?

Sleep is a behavior and a biological brain state. A behavioral description of sleep includes the following. Sleep is a period of relative inactivity and lowered responsiveness to stimuli in the environment. People typically sleep with their eyes closed and in a lying down posture. People dream during sleep. A very important aspect of sleep is that it is quickly reversible, unlike coma.

Sleep is not a time when the brain is "turned off" like a lamp. The brain is active when we sleep (see below).

Scientists define sleep by changes in brain wave activity also called the electroencephalogram or EEG. The EEG is a recording of the electrical activity of the brain. The brain is made up of hundreds of billions of nerve cells called neurons. **As part of the way neurons normally communicate with each other they produce pulses of electricity.** In order to view and record the electrical activity of the brain, scientists place sensors (electrodes) on the scalp and use a machine called an electroencephalograph. Figure 1 shows an example of a digital sleep recorder. This piece of equipment is a technological advance over the bulky electroencephalographs still widely used to record sleep physiology. This device can perform the job that a machine more than ten times its size performs in sleep laboratories around the world. It stores information on a computer disk instead of the standard 3-inch-thick paper record. The electroencephalograph contains amplifiers which can detect the tiny electrical brain waves that are on the order of microvolts in amplitude. A microvolt is one millionth of a volt. The voltage of brain waves is about one nine-millionth the voltage of a 9-volt battery used to power hand-held video games.

(Image courtesy of K. P. Wright)



The digital sleep recorder can record many physiological variables including brain wave activity (EEG) eye movement activity (EOG), muscle activity (EMG) , heart rate activity (EKG), respiration and skin conductance (sweat response). The actual digital sleep recorder is twice the size of the picture above.

Figure 1

Figures 2-4 display EEG brain wave tracings for various stages of sleep and wakefulness.

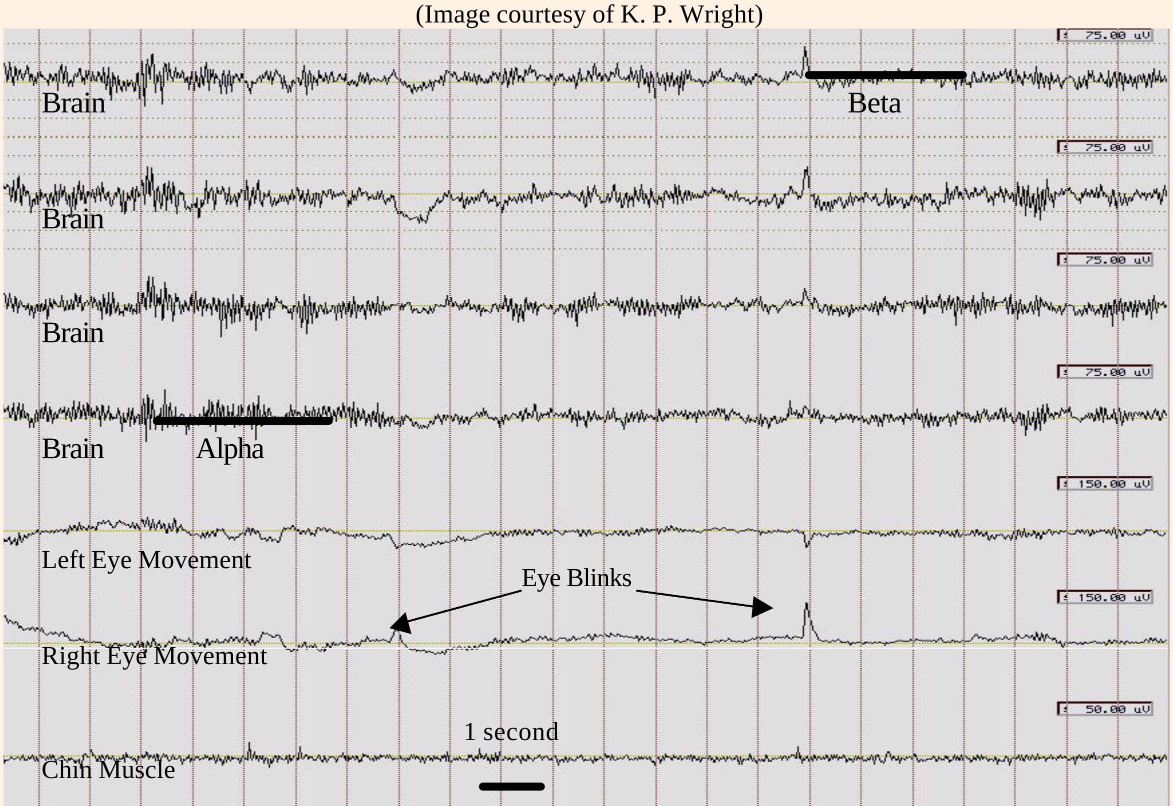
When a person is awake and alert, such as when performing mathematical calculations, the brain is very active. When you close your eyes and relax, the brain slows down and becomes relaxed. Figure 2 shows examples of both of these brain wave patterns.

Sleep scientists have found it useful to categorize sleep into distinct stages based upon changes in EEG brain wave activity, eye movements and muscle activity.

During sleep, there are two distinct patterns of brain activity referred to as non-rapid eye movement (NREM, pronounced non-REM) and rapid eye movement (REM) sleep. During NREM sleep, most of the brain slows down and becomes less active compared to that during wakefulness. During REM sleep the brain and the eyes are very active, similar to wakefulness, whereas the skeletal muscles are paralyzed. Without muscle paralysis (muscle inhibition) during REM sleep, people would act out their dreams.

AWAKE

(Image courtesy of K. P. Wright)

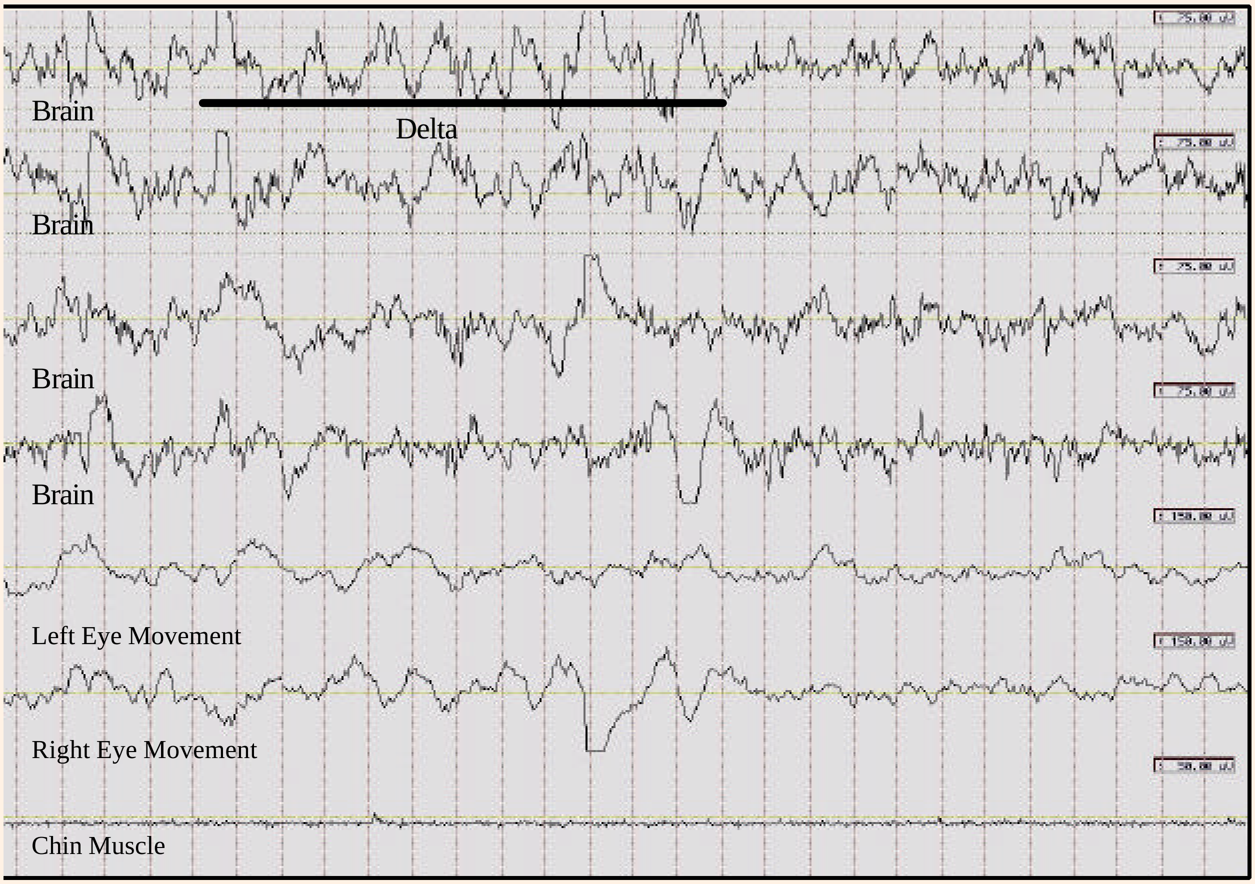


The top four traces in this figure show brain wave activity (EEG), recorded simultaneously from four places on the scalp. The fifth and sixth traces show eye movement activity (EOG) recorded from the eyes; the bottom trace is recorded directly from a chin muscle (EMG) on a human who is awake. When the eyes are closed and is the person is relaxed, the brain is relaxed and shows alpha activity. When the eyes are open and blinking, the brain wave pattern is active (fast frequency and low amplitude waves) and shows beta activity. The chin muscle (EMG) is active during wakefulness.

Figure 2

NREM Sleep

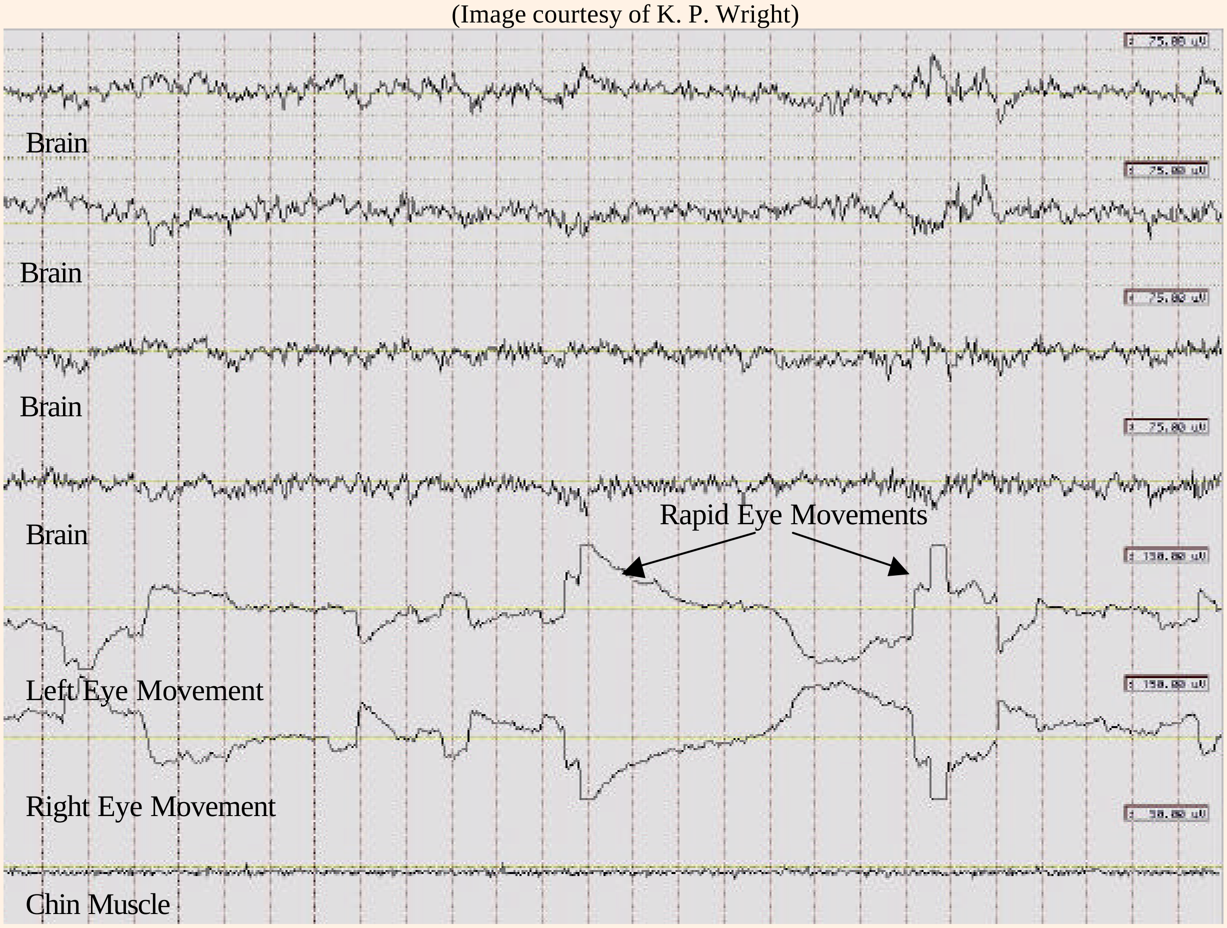
(Image courtesy of K. P. Wright)



This figure shows delta brain wave activity and quiet eye movement and chin muscle activity for a human who is in deep NREM sleep. NREM is made up of 4 sleep stages (Stages 1, 2, 3 and 4). As a rule, the higher the stage number (1-4), the deeper the sleep. Note: The eyes are so quiet that in this example, the eye senders are actually showing brain wave activity from the frontal lobe (front of the brain).

Figure 3

REM Sleep
(Image courtesy of K. P. Wright)



During REM sleep, the brain shows a pattern of theta activity which is slower than the EEG observed during wakefulness but faster than observed during deep NREM sleep. The eyes exhibit rapid movements.

Figure 4

Additional examples of the sleep EEG can be found on the World Wide Web at http://www.sleephomepages.org/sleepsyllabus/a.html

Brain Mechanisms of Sleep and Wakefulness

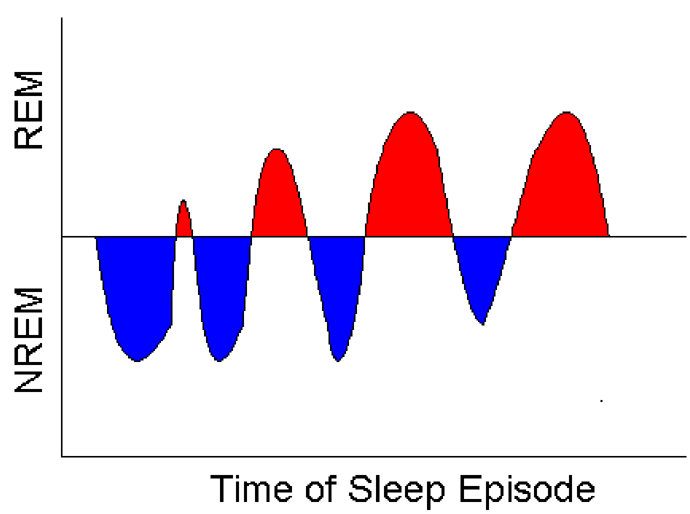
As noted, the brain does not simply shut off during sleep. In fact, **different regions of the brain actively produce either wakefulness or sleep. There are specific cells in the brain (e.g., in the brain stem and midbrain) that are predominantly active during wakefulness and that make you alert. Stimulating these brain cells will awaken a sleeping animal.**

There are also specific cells in the brain that turn on during NREM (e.g., in the Basal Forebrain, Ventral Lateral Pre-Optic Area) or during REM sleep in the (Pons of the Brain Stem). Some of these cells inhibit (turn off) brain areas that promote active wakefulness. Stimulating these brain regions can produce NREM or REM sleep.

The Pattern of Sleep Across The Night

In healthy adult humans NREM and REM sleep alternate throughout the night approximately every 80 to 100 minutes. Figure 5 shows the cyclic nature of NREM and REM sleep across the

(Image courtesy of K. P. Wright)



Every 80 to 100 minutes the pattern of sleep alternates between NREM (bottom) and REM (top) sleep. **NREM sleep is highest in the first half of the night and REM sleep is highest in the second half.**

night.

Appendix 6 includes a hypnogram showing the minute to minute changes in sleep stages across the night.

In addition to changes in brain-wave activity, there are many physiological and behavioral differences between the various sleep stages and wakefulness. **Muscle activity** is highest during wakefulness, generally decreases during NREM sleep and is **absent during REM sleep**. During REM, cells in the pons, a region of the brain stem block motor signals from the brain to the spinal cord, producing a state of muscle atonia or muscle paralysis. This muscle atonia prevents an animal from acting out its dreams. Scientists measure muscle atonia by recording muscle activity of the chin muscles in humans.

Eye movements are rapid and oscillating during wakefulness, as we pay attention to variousobjects in the environment. When one falls asleep, the eye lids close and the eyes move more slowly. During deep NREM sleep the eyes are relatively quiet with little movement. REM sleep is characterized by rapid eye movements underneath closed eye lids; however, there can also be times during REM sleep when the eyes are quiet and show little movement.

Heart rate and respiration are rapid and variable during wakefulness, slow down when one falls asleep, and are regular and slow during NREM sleep. **During REM sleep, the heart beats fast and irregularly and respiration is more variable, both of which indicate an aroused state.**

Increased blood flow to the genitalia occurs in men and women during REM sleep resulting in penile and clitoral erections. These erections are not related to any sexual content of dreaming but are normal physiological characteristics of REM sleep. Sleep disorder laboratories commonly test for erections during sleep in impotent males to determine if there is a physiological or psychological basis to impotence.

Waking, Consciousness and Dreaming during sleep During alert wakefulness we process information and respond to stimuli in the environment. Conscious thinking, learning, and the formation of new memories all occur during wakefulness. During sleep, the brain can still process stimuli in the environment; however, unless we wake up, we typically do not remember what happened. The sleeping brain appears to be incapable of forming new memories; however, classical conditioning can occur during sleep. The fact that new memories cannot be formed during sleep explains why some people do not report that they dream. Unless you awaken from a dream, you do not remember it. When awakened from REM sleep people report a vivid dream about 80% of the time. If awakened from NREM sleep, people typically report that they were thinking, but dream reports also occur. The fact that new memories cannot be formed during sleep indicates that you should not spend your money or time on products that claim you can learn a new skill while you sleep. **There is no scientific evidence indicating that people can learn new**

information while asleep. Importantly though, research has shown that the retention of information learned during wakefulness is improved by subsequent REM sleep. These data suggest that students who study at least for several nights before a test and get a good night's sleep before taking a test will perform much better than someone who pulls an "all-nighter" and crams at the last minute. Other research shows that, in addition to studying the material prior to the night before an exam, reviewing the material the morning of and immediately before a test also helps to improve test performance. These and other research findings suggest that one of the functions of sleep, specifically REM sleep, is the processing and storage of information acquired earlier during the waking day (see below). Appendix 12 includes a table showing some of the physiological and behavioral characteristics of sleep and wakefulness.

Hypotheses about the Function of Sleep

Sleep is an evolutionary survival strategy. This hypothesis assumes that sleep evolved as a means for animals to keep themselves out of harm's way (e.g., the visual system of many animals, including humans, does not function well in the dark) and to be active when food is available.

Energy conservation: This hypothesis suggests that sleep saves energy and allows the body to recover. However, **sleep does not appear to be necessary for the body to rest or recover**. The body can conserve the same amount of energy just by resting.

Rest for the brain: This hypothesis suggests that sleep is for brain restoration and recovery**. Sleep does appear to be more important for brain than body function**. However, what sleep does for brain restoration is unknown. Replenishment of neurotransmitters? protein synthesis? Removal of waste products that result from wakefulness?

Important for brain development early in life: Because infant humans sleep nearly twice as long as adults and have twice as much REM sleep, this hypothesis postulates that sleep is important for development.

Memory consolidation: This hypothesis suggests that during sleep, the brain processes information collected during wakefulness. A related hypothesis proposes that sleep serves to remove unnecessary information from memory – e.g., clean shop. REM sleep serves as a time to facilitate or relearn old memories/instinctual behaviors. For example, dogs seem to dream of chasing or playing with another animal, barking, whining and kicking their legs during REM sleep (Dogs are not so completely paralyzed during REM sleep as are humans).

Sleep as a safe place to release intense emotions: During REM sleep, we can have all the physiological arousal associated with emotion and yet not remember it unless we awaken.

Teacher Directed Instruction (Extension Part III)

If you want to learn more about how the brain produces its electrical activity, see Appendix 7, "Ions and Impulses." This essay describes some of the basic principles of electricity (for possible interdisciplinary connections) and how nerve and muscle cells make use of these principles to generate their resting and action potentials.

Teacher Directed Instruction (Core Part III)

Ask students to consider the following question:

Do animals sleep?

Phylogeny and Sleep

As we discussed previously, we can define sleep by observing the behavior of an animal and by recording brain wave activity. In some species behavioral quiescence or periods of inactivity have been observed but not EEG patterns of sleep.

Who Sleeps?

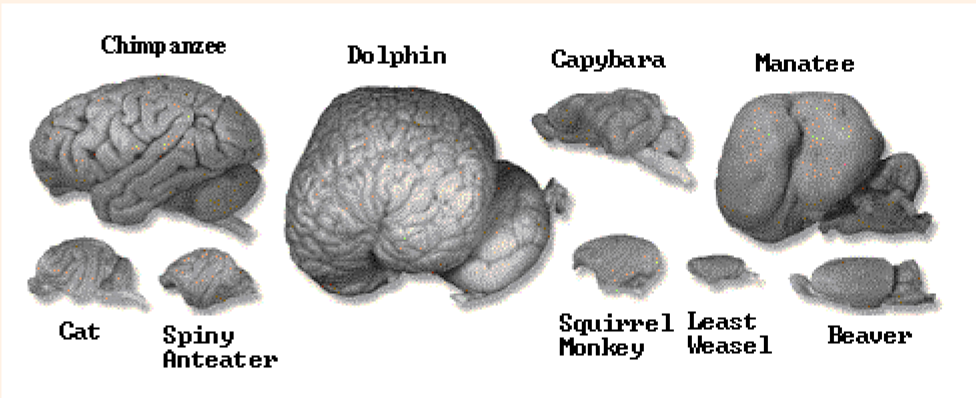
Birds	Behavioral inactivity - Yes; EEG defined sleep -Yes, confirmed for both REM and NREM sleep. **Most birds do not have muscle atonia during REM sleep. This explains why they do not fall off their perch when they sleep.**
Reptiles	Turtles, crocodiles, alligators, lizards, snakes: Behavioral inactivity - Yes; EEG defined sleep –Yes, however only strong evidence for NREM.
Amphibians	Frogs, toads, salamanders: Behavioral inactivity - Yes; EEG defined sleep –some evidence, however not conclusive.
Insects	Periods of inactivity have been described in insects such as, but not limited to, bees, butterflies, grasshoppers and flies. Recording EEG activity is difficult in these species.
Fish	Behavioral inactivity –Yes; EEG defined sleep - some evidence.
Mammals	Behavioral inactivity-Yes, EEG defined sleep -Yes for both REM and NREM. It was once thought that the echidna or spiny anteater was a mammal that did not exhibit REM sleep; however, more recent research suggests that this mammal does have REM sleep. Most marine mammals with the possible exception of the bottle-nosed dolphin exhibit REM sleep.

Ask the students the following question:

How might marine mammals such as dolphins adapt to sleep in the ocean environment given the fact that they need to breathe air to stay alive?

All mammalian brains are composed of two nearly symmetrical halves called hemispheres. Figure 6 compares the brain shapes and sizes for several mammals.

(Images courtesy of National Science Foundation and Neuroscience for Kids)



All brains are relative scale, but smaller than actual size for the purpose of this photo.

Figure 6

Ocean mammals such as the dolphin and some whales adapted to sleep in the ocean by having one hemisphere of the brain sleep at a time while the other hemisphere remains awake and keeps the animal from drowning. Scientists have also found that some birds also exhibit sleep in one brain hemisphere and wakefulness in the other.

Independent Activity/Homework (Core Part III)

Part One

Students will need a copy of the sleep data they previously collected for themselves and one household member. They should identify, compute and record the mean, median, standard deviation, and range values for each category listed on both logs. Students will focus on duration of sleep, the time of sleep onset and the time of awakening.

Have students compute values separately for the week and weekend. For the school week use data for Monday though Friday mornings, Sunday through Thursday nights. For the weekend use data from Saturday and Sunday mornings and Friday and Saturday Nights.

Part Two

Ask students to find an example of a problem, disorder, or disease that is associated with sleep. Students can use the web, books, magazines, etc. to find this information.

Independent Activity/Homework (Supplemental Part III)

Ask students to consider the similarities and differences between sleep and hibernation. If students are interested in hibernation versus sleep refer to one of the books in the suggested reading in the References section or have them do a literature search.

Sleep versus Hibernation

Hibernation occurs in some mammals in the winter months. During hibernation body temperature levels fall, brain activity is slowed as during NREM sleep and sometimes is difficult to measure. However, there are periods of brain activation during hibernation. Animals are thought to hibernate in order to lower their metabolism in response to environmental pressures such as the lack of food during winter and thus conserve energy. If students are interested in hibernation, refer them to one of the books in the suggested reading in the References section or have them do a literature search.

LESSON IV: Visit to the Clinical Sleep Laboratory in the Hospital

Guide for Part IV

Lesson Objectives

- Students will learn about several sleep disorders including; Narcolepsy, Sleep Apnea and Insomnia Supplemental information is provided.
- Students will examine data from their own sleep logs.

National Science Education Standards:

Life Science

- Biological evolution.
- The behavior of organisms.
- Structure and function in living systems
- Regulation and behavior

Physical Science

- Chemical reactions.
- Conservation of energy and the increase in disorder.
- Interactions of energy and matter.

Earth and Space Science

- The origin and evolution of the earth system.

Science and Technology

- Understandings about science and technology.

Science in Personal and Social Perspectives

- Personal and community health.
- Science and technology in society.

History and Nature of Science

- Nature of science.
- Nature of scientific knowledge.

Benchmarks for Science Literacy – American Association for the Advancement of Science:

1C: The Scientific Enterprise

- Scientists' disciplines differ in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some subdisciplines spin off to become new disciplines in their own right.
- Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups about their perceived interests.

2A: Mathematics, Science and Technology

- Mathematics provides a precise language for science and technology—to describe objects and events, to characterize relationships between variables, and to argue logically.

3A: Technology and Science

- Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection, and treatment, measurement, data collection, and storage, computation, and communication of information.

5A: Diversity of Life
- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.

5C: Cells
- All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.
- Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

5D: Interdependence of Life
- Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

5E: Flow of Matter and Energy
- Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.

6F: Mental Health
- Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances.

9B: Symbolic relationships
- Graphs can show a variety of possible relationships between two variables. As one variable increases uniformly, the other may do one of the following: increase or decrease steadily, increase or decrease faster and faster, get closer and closer to some limiting value, reach some immediate maximum or minimum, alternately increase and decrease indefinitely, increase or decrease in steps, or do something different from and of these.
- Tables, graphs, and symbols are alternative ways of representing data and relationships that can be translated from one to another.

9D: Uncertainty
- The mean, median, and mode tell different things about the middle of a data set.
- The middle of a data distribution may be misleading—when the data are not distributed symmetrically, or when there are extreme high or low values, or when the distributions is not reasonably smooth.

11C: Constancy and change
- Physiological and biological systems tend to change until they become stable and then remain that way unless their surroundings change.
- Cycles, such as the seasons or body temperature, can be described by their cycle length or frequency, what their highest and lowest values are, and when these values occur. Different cycles range from many thousands of years don to less than a billionth of a second.

12B: Computation and Estimation
- Find the mean and median of a set of data.
- Insert instructions into computer spreadsheet cells to program arithmetic calculations.
- Use computer spreadsheet, graphing, and data base programs to assist in quantitative analysis.
- Compare data for two groups by representing their averages and spreads graphically.
- Consider the possible effects of measurement errors on calculations.

12C: Manipulation and observation
- Use computers to store and retrieve information in topical, numerical, and key-word files, and create simple files of their own devising.
- Use computers for producing tables and graphs and for making spreadsheet calculations.

12D: Communication Skills
- Organize information in simple tables and graphs and identify relationships they reveal.
- Read simple tables and graphs produced by others and describe in words what they show.

- Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer data bases.
- Understand writing that incorporates circle charts, bar and line graphs, two-way data tables, diagrams, and symbols
- Participate in group discussion on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

12E: Critical-Response Skills

- Be aware that there may be more than one good way to interpret a given set of findings.
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one's own or that of others—can be judged.
- Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the ones worth consideration, with no mention of other possibilities.

Example of Regional Standards – Boston Public Schools Learning Standards:

Students will develop the abilities necessary to conduct scientific inquiry by:

- Designing and conducting scientific investigations
- Formulating and revising scientific explanations and models using logic and evidence
- Communicating and defending a scientific argument

Human Body Systems

- The organization of all human systems (i.e., cell, tissue, organ, system)
- The main function of each system; how they are interrelated and how each interacts with the environment.

Science Domains: Life

- Human Body Systems: endocrine, skeletal, respiratory, nervous.
- Adaptation.

Varieties of Life on Earth

- Many systems contain feedback mechanisms that serve to keep changes within specified limits.
- Species

Cells (Single cell life, Cells in multicellular organisms)

- Different body tissues and organs are made up of different kinds of cells.

Materials:

- Appendix 8 (Fatigue-Related Accidents)
- Appendix 9 (Helping Yourself to a Good Night's Sleep)
- Appendix 10 (How Sleepy are You?)
- Appendix 11 (Fall-Asleep Crashes are Common Among Young People)

Lesson Opening (Part IV)

Begin the lesson by reviewing what the students found in their homework from Lesson III. List all of the problems, disorders, or diseases associated with sleep that the students found. After the students have shared their findings, ask the following question:

What did you learn about sleep disorders?

Allow students to share the information they gathered. In the event that students did not uncover adequate data, use the following section to supplement the students' understanding about sleep disorders.

Narcolepsy is characterized by extreme daytime sleepiness, and physiological abnormalities during wakefulness that are associated with REM sleep. These abnormalities include **cataplexy** (muscle weakness) to the point of falling down and not being able to move. Cataplexic events are often related to an intense emotional experience. **Sleep paralysis** is another symptom of narcolepsy, which appears to be a carry over of the muscle atonia of REM sleep into wakefulness. A person awakening from sleep may be unable to move for a short period of time. Sleep paralysis is seen in normal healthy people but is more pronounced in narcoleptics. Narcoleptics also experience **vivid dreams and hallucinations during wakefulness and when falling asleep. Narcoleptics enter REM sleep immediately upon falling asleep which is very different from the normal 80-90 minute latency in healthy adults. Narcolepsy is thought to have a genetic component.**

Treatment: Narcolepsy is treated with naps and stimulants to counter the daytime sleepiness and with anti-depressant medications to inhibit the REM like symptoms (cataplexy, sleep paralysis, vivid dreams and hallucinations).

Sleep Apnea is characterized by the cessation of breathing during sleep usually followed by a reduction of oxygen content in the blood. Apnea can result from either a collapse of the airway (Obstructive Sleep Apnea) or from a failure of the brain mechanisms controlling breathing (Central Sleep Apnea). Loud snoring with brief periods of silence is a common symptom. Apneas result in frequent arousals from sleep to start breathing again. These arousals lead to unrestful sleep and excessive daytime sleepiness. During wakefulness, apnea patients can keep the airway open by breathing voluntarily and maintaining high muscle tone. Unfortunately, this ability is lost during sleep. Some researchers propose that sleep apnea is one of the causes of sudden infant death syndrome (SIDS).

Treatment: Obstructive Sleep Apnea can be treated with either surgery or a machine called CPAP (Constant Positive Air Pressure) that uses air pressure delivered though a mask worn over the nose and mouth to keep the airway open. Weight loss is also indicated for people with sleep apnea since many are overweight. Central Sleep Apnea is caused by a failure of the brain mechanisms controlling breathing resulting in no effort to breath. Central apnea can be treated with stimulant drugs such as theophylline.

Insomnia is a condition characterized by difficulty falling asleep, difficulty with frequent awakenings during the night or difficulty with waking too early and not being able to fall back to sleep. These sleep difficulties commonly lead to reduced feelings of well-being during the day and anxiety about sleep during the night.

In a recent poll of Americans by The National Sleep Foundation "1999 Sleep in America" 56% of adults reported symptoms of insomnia. (http://www.sleepfoundation.org/PressArchives/lead.html)

Treatment: Some cases of insomnia can be treated in the short term with hypnotics, or by behavioral and cognitive psychotherapies.

Nightmares are dreams that produce anxiety and occur during REM sleep. Nightmares are a common experience. However, in some instances they are chronic and lead to disrupted sleep and excessive daytime sleepiness.

Treatment: Psychotherapy is the treatment of choice for chronic nightmares.

REM Sleep Behavior Disorder is characterized by a release from muscle atonia during REM sleep that leads a person to act out their dreams. This syndrome can be dangerous for the dreamer and the bed partner.

Treatment: REM Sleep Behavior Disorder has been treated with potent benzodiazepines (tranquilizers; auxiolytics) such as clonazepam.

Parasomnias (sleep walking, sleep talking, night terrors, bruxism) are movement and arousal disturbances occurring during NREM sleep; especially in stages 3 and 4.

Sleep Walking and Talking are initiated during NREM sleep and lead to complex behaviors such as walking or talking while the brain still exhibits signs of deep sleep. **The sleep walking and talking behaviors are typically not associated with a dream.**

Night Terrors are characterized by sudden arousals from stage 3 and 4 sleep with a feeling of intense fear and with little or no dream-like mentation. The person experiencing the night terror commonly awakens screaming or crying, with their heart racing, their skin flushed and their muscles tense. Night terrors are common in children. Napping during the day and ensuring adequate nighttime sleep can reduce the frequency of night terrors. Naps may help by reducing the depth of sleep at night. Night terrors are also treated with psychotherapy and medication.

Bruxism is characterized by the grinding of the teeth at night leading to tooth damage. This syndrome may be treated with dental appliances, biofeedback and psychotherapy.

Inform students that all affective and psychological disorders and degenerative neurological disorders such as Alzheimer's and Parkinson's disease are associated with sleep problems.

Lesson Body
Teacher Guided Inquiry (Core Part IV)

Have students read Part IVA. Now that students have learned more about specific sleep disorders that can affect individuals, they should be able to recognize why Dr. Knight asked José particular questions during his visit. Dr. Knight asked specific questions to help her understand if José's problem is related to a particular sleep disorder.

Begin this activity by writing on the board, each of the sleep disorders covered in the lecture. Remind students to use this information during the next activity. Read some of the questions Dr. Knight asked José and ask students to hypothesize why the question was asked. Students might make several suggestions that are different than the reasons listed below. Please accept all student responses, but make sure that students provide support and/or a rationale for their answers.

Dr. Knight's Question	Reason for Dr. Knight's Question
How is your sleep?	General question to inquire how José is sleeping
How long does it take you to fall asleep?	Insomnia, Most sleep disorders; looking for insomnia or excessive sleepiness
Do you awaken at night?	Insomnia
Do you have any difficulty falling back asleep?	Insomnia
Do you have any difficulty staying awake during the day?	Most sleep disorders. Looking for a complaint of daytime sleepiness
Do you snore?	Apnea
Do you experience vivid dreams when you first fall asleep?	Narcolepsy
Do you experience times of muscle weakness, especially when you laugh or are emotional?	Narcolepsy

How are your grades in school?	Most sleep disorders cause a problem in daily activities
Do you drink alcohol?	Drug effects on sleep

When the table is complete, students should reconsider their current hypotheses concerning José's condition and make any necessary changes/revisions. Have students read Part IVB.

Teacher Guided Inquiry (Core Part IV)

Use the following section to discuss the varying amount of sleep that different animals obtain in a 24 hour day. The students should consider the following question:

How much sleep do we need?

Students will need to use the information in their sleep logs to answer this question. All of the students should have computed the mean and range of their sleep habits during the week and for one weekend. Use each student's scores to compute classwide mean, median, standard deviation, and range scores.

Point out to the students that scientists and researchers can display data through the use of graphs. Some of these are:

- Scatterplot
- Bar Graph
- Line Graph
- Pie Chart

Have students decide which type of graph best represents the sleep data for the class. Use this method for displaying the classwide data.

Once students have computed the classwide mean, median, standard deviation and range for their sleep, students should consider the following questions:

How much sleep do people report during the week?

Answers will vary.

How much sleep do people report during the weekend?

Answers will vary.

Why might people report more sleep during the weekends, than during the week?

- **School requirements—having to get up too early on school days.**
- **Job requirements after school result in getting to bed late.**

- **Insufficient sleep during the week leads to catching up on lost sleep whenever possible.**

Do all humans need the same amount of sleep?

- **A newborn human baby sleeps about 16 hours in a 24 hour period.**
- **The average adult human sleeps between 7 and 8 hr in a 24 hour period.**
- **A 75 year old person will, on average, have spent 1/3 of their life or around 25 years of their life asleep. Five of those 25 years will have been spent dreaming during REM sleep. While the average human reports sleeping between 7 and 8 hours a night, some people report that they require less than 7 hours while others report that they can not stay awake during the day unless they sleep 10 or more hours a night. The reason why some people need more or less sleep than others is unknown.**

How much sleep do you think other animals need?

- **Most bats sleep for nearly 20 hours in a 24 hour period**
- **Dogs and cats usually sleep 10-13 hours in a 24 hour period**
- **Elephants and giraffes sleep from 2-4 hours in a 24 hour period**

Share the following graph, "Percentage of Day Some Animals Sleep," with the class. The graph is a visual representation of the data discussed in the previous section.

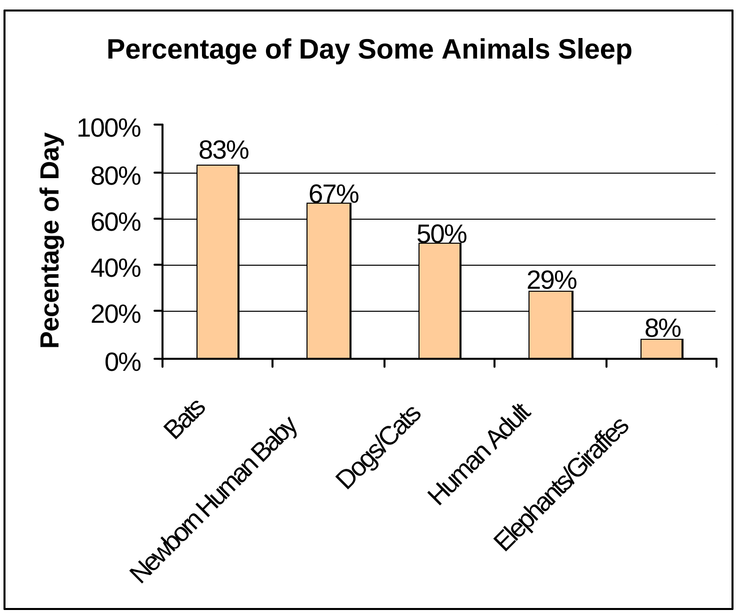


Figure 7

Ask the students what patterns they notice, if any.

The duration of sleep is negatively related to the size of the brain and body.

Do You Think You Get Enough Sleep?

Many sleep scientists believe that we live in a society where most people do not get all the sleep they need. Therefore, the amount of sleep people reported earlier in the case may not reflect the need for sleep, but rather the amount of sleep obtained. This section will discuss what happens when people are so deprived of sleep that they do not function properly.

Have students consider the consequences of sleep deprivation.

Sleep is a biological necessity. If we forgo sleep and stay up all night, the brain will eventually take over and make us go to sleep.

Student Guided Inquiry (Core Part IV)

Demonstration of Physiological Limits

Have a student or several students volunteer for a demonstration to illustrate the point that a physiological pressure that overrides our will even though we try hard not to let it happen. Ask student volunteer(s) to hold a book with their arm(s) extended straight and horizontal. Ask the volunteers to describe what happens to their arms, the longer it remains extended. Eventually their muscles will become painful and their brains allow their arms to drop.

Explain to the students that when the person has not received enough sleep, the brain similarly takes over, causing the person to fall asleep uncontrollably.

Ask students to consider the following questions:

What do you think will happen to an animal if it is deprived of sleep?

Research shows that an animal continuously deprived of sleep will eventually die. Animals selectively deprived of REM sleep also eventually die. Why animals die from sleep-deprivation is unknown, but it is clear that sleep is very important.

If instead of sleep-depriving the animals until they die, we let the animal sleep after sleep deprivation, we observe an increase in the amount of deep NREM sleep.

Do we ever make up all the sleep we miss?

The answer to this question appears to be "no". If someone normally sleeps 8 hr and stays up all night, he/she does not sleep for 16 hours the next night.

How long do you think a person can go without sleep?

The answer is unknown. Some experts think that we can go without sleep for as long as we can without food. A number of sleep deprivation studies have kept humans awake for 7 days and nights and several humans have reportedly remained awake for more than 11 days and nights.

Teacher Directed Instruction (Supplemental Part IV)

Sleep Extension

Additional evidence that we live in a sleep deprived society comes from research where people are allowed to sleep as long as they need. Both long and short sleepers show an increase in the total amount of sleep when given the opportunity. Some studies show as much as a 2 hour increase in the amount of sleep each night. This increased amount of nighttime sleep is associated with improved alertness during the daytime.

Sleep Inertia: Why Do I Feel Sleepy After Waking Up?

When we wake up from sleep, people may feel slow, groggy, and not ready to begin the day. These symptoms are temporary, lasting minutes to hours, but are similar to those of sleep deprivation. The phenomena of sleepiness upon awakening from sleep is called sleep inertia. Under these conditions, the shift from a sleeping brain to an alert waking brain appears to take a while.

When people nap in the afternoon, they are more likely to awaken from deep NREM sleep and feel the effects of sleep inertia.

Independent Activity/Homework (Core Part IV)

A. Students will look at the data on when accidents are most likely to occur. This information is provided in Appendix 8.

What are the consequences of inadequate sleep?

> **Some answers are: excessive daytime sleepiness, poor performance on the job or in school, problems with social life and family, health problems, or accidents**

Point out to students that The National Sleep Foundation's, "1999 Sleep in America" poll reported that 40% of Americans say that sleepiness does interfere with their daily activities.[2] However, only 4% of adults who report frequent sleep problems are currently seeking treatment. Tell students that the National Commission on Sleep Disorders Research reports that over 20 million Americans have difficulty sleeping at night.

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[2] This poll can be found at http://www.sleepfoundation.org/PressArchives/lead.html

Sleep deprivation will impair a person's ability to maintain alert wakefulness. If we do not obtain enough sleep, our performance is poor, reaction time is slow, the ability to think clearly and make decisions is impaired, our memory fails us, and we become more irritable.

Inform students that the effects of sleep loss on performance are similar to the effects of alcohol on performance. In fact, driving drowsy can be more dangerous than driving drunk. When someone falls asleep at the wheel, the crashes tend to be fatal. They often drive off the road and crash at high speed. Suggest that students read some of the following reports from the National Sleep Foundation Web page:

The following can be found in Appendices 7 and 8.

The National Highway Traffic Safety Administration reported that at least 100,000 crashes each year are caused by people driving when drowsy.
http://www.sleepfoundation.org/PressArchives/lead.html

Fall-asleep crashes are common among young people
http://www.sleepfoundation.org/PressArchives/youngpeople.html

Sleepiness and fatigue that result from sleep deprivation or chronic sleep restriction also have a high cost to society leading to poor job performance and an increased risk.

B. Students will consider the possible effects of sleep deprivation on the following occupations. They are: airline pilot, emergency room health provider and long-distance truck driver.

Do you think a person can be at their best with inadequate sleep?
What are the consequences of sleep deprivation in these professions?
Please fully explain and support your answer with information you have learned about sleep.

LESSON V: The Science of Biological Timing

Guide for Part V

Lesson Objective:

- Students will learn the basic principles of biological timing.
- The following questions and topics are considered; Circadian physiology, the timing of sleep and wakefulness.

National Science Education Standards:

Physical Science

- Chemical reactions.
- Conservation of energy and the increase in disorder.
- Interactions of energy and matter.
- Transfer of energy

Life Science

- Biological evolution.
- Matter, energy, and organization in living systems.
- The behavior of organisms.
- Structure and function in living systems
- Regulation and behavior

Earth and Space Science

- The origin and evolution of the earth system.
- Earth in the solar system.

Science in Personal and Social Perspectives

- Personal and community health.
- Science and technology in society.

History and Nature of Science

- Nature of science.
- Nature of scientific knowledge.

Benchmarks for Science Literacy – American Association for the Advancement of Science:

1C: The Scientific Enterprise

- Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups about their perceived interests.

4A: The Universe

- Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them.

4B: The Earth

- We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although other, similar systems may be discovered in the universe)
- Because the earth turns daily on its axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in heating of the earth's surface produces the planet's seasons and weather patterns.
- Life is adapted to conditions on the earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of radiation from the sun that allows water to cycle between liquid and vapor.

4E: Energy Transformation

- Energy can not be created or destroyed, but only changed from one form to another.

4F: Motion

- Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white.
- Something can be "seen" when light waves emitted or reflected by it enters the eye—just as something can be "heard" when sound waves from it enter the ear.
- Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation—visible light. Differences of wavelength within that range are perceived as differences in color
- A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x-rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma waves, the shortest. In empty space, all electromagnetic waves move at the same speed—the "speed of light."

5A: Diversity of Life

- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.

5C: Cells

- All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.
- Within every cell are specialized parts for the transport of materials, energy transfer, protein building, waste disposal, information feedback, and even movement. In addition, most cells in multicellular organisms perform some special functions that others do not.
- Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

5D: Interdependence of Life

- Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

5E: Flow of Matter and Energy

- Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.

5F: Evolution of Life

- Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.

6A: Human Identity

- Like other animals, human beings have body systems for obtaining and providing energy, defense, reproduction, and the coordination of body functions.
- Human beings use technology to match or excel many of the abilities of other species.
- Written records and photographs and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. No other species uses such technologies.

6C: Basic Functions

- Organs and organ systems are composed of cells and help to provide all cells with basic needs.
- Hormones are chemicals from glands that affect other body parts. They are involved in helping the body respond to danger and in regulating human growth, development and reproduction.
- Interactions among the senses, nerves, and brain make it possible the learning that enables human beings to cope with changes in their environments.

- The nervous system works by electrochemical signals in the nerves and from one nerve to the next. The hormonal system exerts its influences by chemicals that circulate in the blood. These two systems also affect each other in coordinating body systems.
- Communication between cells is required to coordinate their diverse activities. Some cells secrete substances that spread only to nearby cells. Others secrete hormones, molecules that are carried in the bloodstream to widely distributed cells that have special receptor sites to which they attach. Along nerve cells, electrical impulses carry information much more rapidly than is possible by diffusion or blood flow. Some drugs mimic or block the molecules involved in transmitting nerve or hormone signals and therefore disturb normal operations of the brain and body.

6F: Mental Health

- Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances.

8F: Health Technology

- Almost all body substances and functions have daily or longer cycles. These cycles often need to be taken into account in interpreting normal ranges for body measurements, detecting disease, and planning treatment of illness. Computers aid in detecting, analyzing, and monitoring these cycles.

11A: Systems

- Any system is connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.
- A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts.

11C: Constancy and change

- Physiological and biological systems tend to change until they become stable and then remain that way unless their surroundings change.
- Many systems contain feedback mechanisms that serve to keep changes within specified limits.
- Cycles, such as the seasons or body temperature, can be described by their cycle length or frequency, what their highest and lowest values are, and when these values occur. Different cycles range from many thousands of years don to less than a billionth of a second.

12D: Communication Skills

- Read simple tables and graphs produced by others and describe in words what they show.
- Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer data bases.
- Understand writing that incorporates circle charts, bar and line graphs, two-way data tables, diagrams, and symbols
- Participate in group discussion on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

Example of Regional Standards – Boston Public Schools Learning Standards:

Human Body Systems

- The organization of all human systems (i.e., cell, tissue, organ, system)
- The main function of each system; how they are interrelated and how each interacts with the environment.

Science Domains: Life

- Human Body Systems: endocrine, skeletal, respiratory, nervous.
- Adaptation.

Science Domains: Physical

- Forms of energy.
- Energy transformations.

Science Domains: Earth and Space

- Spectrum.

Varieties of Life on Earth

- Species.

Force, Motion, and Machines
- Energy.

Cells (Single cell life, Cells in multicellular organisms)
- Cells appear to be the fundamental unit of living things.
- Different body tissues and organs are made up of different kinds of cells.

Astronomy
- The sun.

Lens (Optics)
- The eye.

Materials:
- Appendix 12 (Physiological and Behavioral Characteristics of Sleep and Wakefulness)

Lesson Opening (Part V)

Students should read Part VA (José's Sleep Log). Students should use the previous day's lesson and everything they have learned about sleep so far in the case when responding to the following questions:

What patterns do you see in José's sleep log?
What does the log tell Dr. Knight about the timing of José's sleep?
What do you think is going on with José?
What is your hypothesis concerning José's condition?
Is there any other information that you can get from the sleep log that may be important?

Ask students to describe any similarities and differences between their sleep log and the sleep log for José. If the students do not metion that most everyone sleeps at night, point this fact out and ask the question, "Why might this be so?" This question should lead into a discussion of the biological clock.

Lesson Body
Teacher Directed Instruction (Core Part V)

Suppose you agree to participate in the following experiment. For two weeks you go into a cave, alone, where you are completely cut off from contact with the outside world, although you can signal for help in an emergency. The cave is specially fitted out to meet your needs for food, water, sleep, bodily waste elimination, etc. You also have access to books and recorded music. However, there are no clocks or any other information about the time of day – whether it is light or dark outside. In fact, the lights in the cave are maintained at a very dim level. Suppose you normally go to sleep at 11:00 PM and wake up at 7:00 AM. What do you think would happen to the timing of your sleep and wakefulness pattern during the two-week period?

Students might suggest:

- **That you would sleep unpredictably and with no particular rhythm, whenever you felt tired; that might be after 24 hours or at another time, say, after 4 hours of being awake.**
- **That you would keep your normal sleep pattern and continue to go to sleep at 11:00 PM and awaken at 7:00 AM.**
- **That you would adopt some new sleep-wake pattern, like alternating 4 hours of waking with 2 hours of sleeping.**
- **That you would need much less sleep, for example; taking only 10-minute naps every few hours.**

Teacher-Guided Instruction (Core Part V)

Biological clocks. Experiments similar to this have been done many times, both with people and with experimental animals. The answer to the question is that you would maintain a roughly similar pattern of sleep and wakefulness except that the duration of sleep and the frequency of naps might increase. The percentage of sleep compared to wakefulness would remain about the same. The timing of sleep would gradually drift so that you might eventually be sleeping during the (outside) day and staying awake during the (outside) night (see below). These studies demonstrate that you have built-in timing mechanisms that maintain a nearly normal pattern of sleep and wakefulness. Another way of saying this is that you have a built-in clock, a biological clock.

Nearly all living organisms, including plants, animals and single cell bacteria have internal biological clocks that regulate the rhythms of sleeping (or inactivity) and waking (or activity). The internal clock also regulates the timing of other bodily functions (e.g. rhythmic variations in body temperature and hormone release; see below).

Circadian rhythms. Not everyone's biological clock oscillates at the same rate. Some clocks are a little faster and some are a little slower than 24 hours – the period for one cycle is "about a day". For this reason these oscillations are referred to as circadian rhythms (from the Latin: circa = about, dies = day). The average **intrinsic period** of the human circadian pacemaker is about 24.2 hours. **Some people's clocks have a longer period, while others have a shorter period. People with faster clocks prefer to go to bed earlier, and to wake up earlier, than those with slower clocks.** These data help to explain why some people are morning larks and others are night owls.

The clock period (Tau). Why might the period of biological clocks be close to 24 hours long? **One of the environmental constants throughout the evolution of life on Earth has been the daily light-dark cycle associated with the rotation of the Earth on its axis.** As we know, the time it takes for one rotation – one cycle of light and darkness – is very close to 24 hours (23.93 hours). Some organisms, like ourselves, are adapted to sleep when it is dark and be active when it is light (perhaps because our highly important visual systems are then most effective; see section on "Theories about the Function of Sleep" in Lesson III). Other organisms, like hamsters and cockroaches, are nocturnal; they have evolved to sleep during the day and be active at night. Others, like bats, are crepuscular; they are most active near dusk or shortly before dawn. Some animals, such as dogs, may be active or be asleep at any time of day or night. (You might ask students to speculate about the evolutionary advantages of these different sleep patterns.)

Biological clocks are entrained to light/dark stimuli in the environment. If the period of our internal clock is only approximately 24 hours, why doesn't our sleep rhythm gradually drift (like that of the person in the cave) so that after a while we go to sleep at, say, 6:00 AM and awaken at 2:00 PM? **The answer is that our internal biological clock is reset on a daily basis in order to remain synchronized with the environment. This <u>entrainment</u> is a fundamental property of biological clocks by which their intrinsic period is made equal to that of an environmental time signal. The light-dark cycle is the most powerful time signal for resetting, or entraining, biological clocks.**

Suppose that in the cave experiment the intrinsic period of your circadian clock is 24 hours and 30 minutes. Assume that on the first night you go to bed at midnight and sleep for 8 hours. How much later would you be going to sleep by the end of the two-week long period?

> **Without time cues, your "day" would be 30 minutes longer than the near 24-hour Earth day. You would tend to go to sleep 30 minutes later every day and by the end of the two-week long period, you would be going to sleep 7 hours later (0.5 hours x 14 days) than the original midnight (i.e. at 7:00 AM). Entrainment by external cues (e.g. the dark/light cycle) normally prevents this from happening and keeps you on a near 24-hour day.**

Where is our internal clock? The master <u>circadian pacemaker</u> in mammals is located in a brain region called the SCN (suprachiasmatic nucleus). The SCN contains about 10,000 neurons and is about the size of the head of a pin. **If the SCN is removed from an animal's brain, the animal can no longer keep time. The animal may be asleep or awake at any time of day, showing no predictable pattern. The period of the animal's endogenous rhythms are determined by the biological clock (SCN in mammals).**

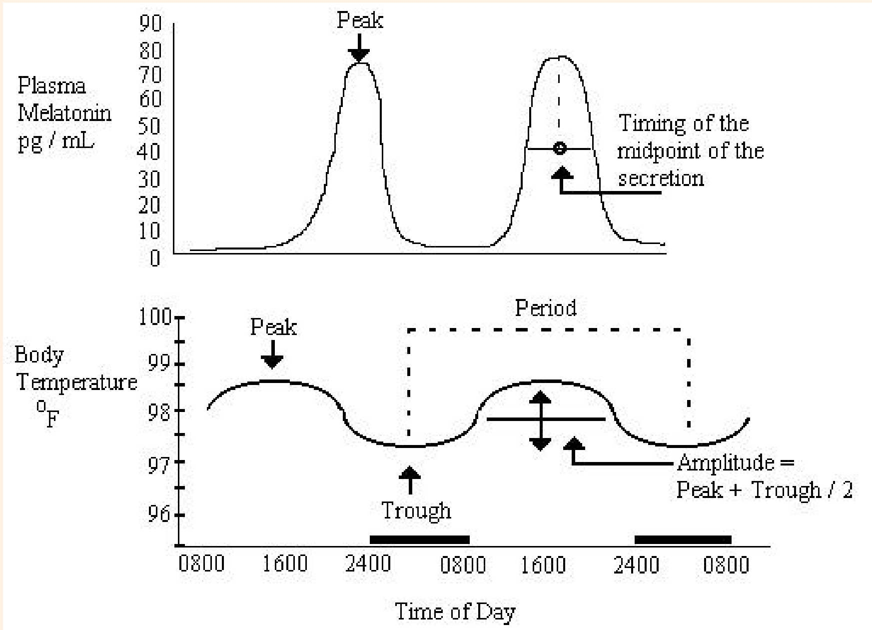
Ask students what might be a consequence of this change in behavior?

> **Students may suggest that the animal may not survive because it is awake or asleep at dangerous times. E.g., a mouse may be eaten by a hawk if the mouse was outside of its burrow during the daytime.**

If the SCN from a slow-clock animal is replaced with the SCN of a fast-clock animal, the slow-clock animal now behaves like a fast-clock animal. Scientists are now using the tools of molecular genetics to study the molecular mechanisms that generate circadian rhythms in the SCN.

Other circadian rhythms. In addition to telling us when to be awake and active (e.g. seeking food and water), and when to sleep (being inactive and resting), our internal clock also regulates daily rhythms in many physiological functions includingbody temperature, urine production, blood pressure and the timing of hormone release. Hormones are chemicals produced by the body and released into the bloodstream. Hormones can influence many functions including, reproduction, growth, blood pressure, metabolism and sleep. Figures 16 and 17 show circadian rhythms in the pineal hormone, melatonin, and in core body temperature from a 21-year-old woman.

(Images courtesy of S. Sweeney)



These graphs show that temperature is high during the day time when typically awake and low at night when typically asleep (back bars). Melatonin shows a rhythm opposite to that of temperature. Melatonin is high during the night and low during the day. Both these rhythms are generated by the biological clock in the brain and are considered to be markers of internal time.

The graphs also define terms commonly used to describe periodic processes such as circadian rhythms. The peak (acrophase) or trough (nadir) of a rhythm are phases or times; the amplitude of the rhythm is its magnitude. For example, if we consider waves on the ocean, the larger the waves, the larger the amplitude. The period is a measure of the time it takes to complete one cycle or the duration of the rhythm; e.g., the time it takes to get from one peak to the next.

Teacher Directed Instruction (Supplemental Part V)

Fundamental Principles of Biological Timing

There are three fundamental properties of a circadian rhythm. The first is that the rhythm is self-sustaining; that is, it will continue to oscillate under constant conditions, as occurred in the cave experiment. The second, is that biological clocks are not affected by changes in the temperature of the environment. They are temperature compensated. This is true even in organisms like insects, that do not regulate their internal temperatures. This does not mean that the biology of the system is not sensitive to temperature extremes, just that in the physiological range of the species, the ambient temperature does not influence the intrinsic period of the clock. The third property of a circadian rhythm is that it can be entrained to a period of near 24 hours by environmental stimuli, the most powerful of which is light.

Does the intrinsic period of the biological clock affect the survival of the organism?

> **Yes. Research has shown that the intrinsic period of an organism can affect the fitness or survival of the organism when its intrinsic period is close to the day length. For example, if organisms with fast and slow clocks are placed on either a fast (short) or slow (long) day length it can be demonstrated that fast clock organisms will survive better than the slow clock organisms when both experience a short day length. The opposite is true for long day lengths. This is not because the day length is too short or too long. An organism with a fast or slow clock can survive on a long or short day if there is no competition for nourishment; however, if there is competition, the organism with the intrinsic period closest to the day length is more likely to survive.**

Ask the students when the shortest and longest days of the year occur. How does day length change with the seasons?

> **The day length is shortest in the fall and longest in the summer. This is especially true the further one travels from the equator. During summer in the arctic, there are days when the sun never sets and during the winter there are days when the sun never rises.**

The time of year when some animals reproduce and plants flower is dependent upon day length or the amount of light and darkness which the organism receives. In this case the biological clock helps to ensure that offspring are born at the time of year best for their survival. These animals are referred to as seasonal breeders. Some animals mate and produce young when the days are short and nights are long as during winter (e.g. herd animals), whereas others mate when the days are long and nights are short as during summer (e.g. birds). By regulating the light-dark cycle we can regulate the reproductive status of plants and seasonal breeding animals in the laboratory. Note that as the relative lengths of day and night change with the seasons, the duration of one day-night cycle is still near 24 hours.

Teacher Directed Instruction (Extension Part V)

This lesson extension covers additional information about the properties of light and light perception. See Appendix A1.

Teacher Directed Instruction (Core Part V)

The Regulation of Sleep and Wakefulness

Now that we have discussed the biological clock, it is important to understand that when and how well we sleep is influenced by an interaction between the endogenous circadian pacemaker and sleep homeostasis. Sleep homeostasis is determined largely by the amount of prior wakefulness. In other words, the homeostatic need for sleep builds up when we are awake and is reduced by sleep.

Ask the students to think of other homeostatic drives in biology.

Hunger and thirst: the longer we go without food and water, the hungrier and thirstier we become.

The circadian pacemaker and sleep homeostasis are fundamental biological processes of the central nervous system that serve to regulate sleep and wakefulness so that humans can be alert during the daytime and sleep at night.

Ask students the following questions:

In previous homework assignments on sleep and work, what patterns did you notice about shift workers and people who work at night?
Do you think shift-workers and other people who work at night are sleep deprived?

As noted earlier, sleep deprivation results in a high cost to society. Given what students have learned thus far, have them consider the following question:
At what time of day is their performance the best? At what time of day is their performance the worst?

Here are a few "time of day" statistics:
- **Physical performance is best during the early evening around 1900 hours.**
- **Physical and cognitive performance is worst in the early morning hours (between 0200 and 0600 hrs).**

Teacher Guided Inquiry (Core Part V)

Circadian Sleep Disorders and Jet Lag

Jet lag occurs when people rapidly fly across multiple time zones resulting in a misalignment between the circadian pacemaker and the external environment. For example, a person flying from Boston to Rome will fly across 6 time zones. When this person wakes up at 8:00 am Rome time, the person's clock is sill at 2:00 am Boston time. As we discussed previously, between the hours of 2:00 and 6:00 am is the time of day when alertness and performance are at their worst. The person who flew from Boston to Rome will find it very difficult to wake up and function at 8:00 am Rome time. The symptoms of jet lag can last for several days or even weeks, and include stomach upset, insomnia, daytime sleepiness and poor performance.

Is there anything that can be done to adjust your biological clock?
Prior to departing for your new destination, you can begin to shift your biological clock. If flying east (Boston to Rome), wake up earlier several days before you leave for your trip, get out in the sun or turn on bright lights in the house, avoid artificial light in the evening and go to bed early, if possible. The sunlight or bright light in the morning will begin to shift your biological clock to an earlier time (phase advance). If flying west (Boston to Hawaii) stay up a little later several days before you leave for your trip and turn on bright lights in the house at night, avoid artificial light and sun light in the morning and wake up later than usual if possible.

If you cannot begin to adapt your schedule before hand, immediately adopt the schedule of the new time zone. That is, when you arrive in Rome "do as the Romans do". Get up when they get up and go to bed when they go to bed. It is better to stay up during the Roman day, get plenty of sunlight even though you may be tired, and try to sleep during the Roman night. Adopting the new schedule will shorten the amount of time necessary to adjust to the new time zone.

Taking exogenous melatonin can also help you sleep better at your new destination. Research shows that melatonin, in pill form, can reduce the time it takes to fall asleep when taken at a time when the circadian pacemaker is promoting wakefulness (e.g. when your internal biological clock thinks it is daytime). Melatonin may also be able to shift the circadian pacemaker helping adjustment to a new time zone. However, children should not take melatonin. Puberty is associated with a rapid decline in endogenous melatonin levels. Theoretically, taking exogenous melatonin might interfere with sexual development. Furthermore, the melatonin that is bought in health food stores is not regulated by the FDA (Food and Drug Administration) and, therefore, the quantity and quality of the drug is unknown. In addition, most preparations of melatonin sold in the stores raise melatonin levels thousands of times higher than normal.

More information on jet lag can be found at:

http://www.sleepfoundation.org/publications/travel/html

More information on Melatonin can be found at:
http://www.sleepfoundation.org/publications/melatoninthefact.html

Advanced and Delayed Sleep Phase Syndromes are characterized by a chronic inability to fall asleep, or to wake up, at the desired time. These sleep problems are associated with a misalignment of the circadian clock and the preferred sleep-wake schedule. For example, a person who wants to go to bed at midnight but cannot fall asleep until 3:00 a.m. every night (delayed sleep phase syndrome) may have a problem with their circadian pacemaker being much later than normal. A person who wants to stay up to midnight but falls asleep at 9:00 p.m. may have a problem with their circadian pacemaker being much earlier than normal. Both of these problems can be treated with properly timed exposure to bright light and possibly by the use of exogenous melatonin.

Sleep In Altered Environments

A number of environmental factors can influence the quality of sleep and subsequently the quality of wakefulness (the ability to maintain alert wakefulness across the day). As an example, we will discuss Sleep in Space.

Sleep in Space

Since the early 1960's it has been known that humans can sleep in space. Over the past 30 years the National Aeronautics and Space Administration (NASA) has flown several experiments that have researched sleep in space. Recently, NASA flew three space shuttle missions that included experiments to study the sleep EEG, circadian rhythms and human performance in space. The first of these studies was in June of 1996 aboard STS-78 on the Space Shuttle Columbia. This mission was devoted to life science research including human physiology and space biology. In April of 1998, NASA flew Neurolab aboard STS-90 on the Space Shuttle Columbia. This research mission was devoted to the study of the brain. One of the experiments on Neurolab examined the effects of the space environment and melatonin on sleep, circadian rhythms and human performance. In October of 1998 NASA performed the Neurolab sleep experiment, for a second time, aboard STS-95 on the Space Shuttle Discovery.

Figure 2-4 shown earlier that displayed EEG brain wave tracings for various stages of sleep and wakefulness were recorded from an Astronaut aboard one of the recent Space Shuttle missions.

Figures 8 and 9 show Astronauts Dafydd Williams and John Glenn outfitted with the equipment used to record EEG, eye movements (EOG), heart rate (EKG), chin muscle contraction (EMG) and respiration while they slept in space.

(Image courtesy of NASA)

"Astronaut Dafydd (Dave) R. Williams, a mission specialist representing the Canadian Space Agency (CSA), is a test subject for the Sleep Studies experiment in the Neurolab aboard the Earth-orbiting Space Shuttle Columbia. The sleep cap monitors and measures electrical impulses from the brain, muscles, eyes, and heart." (courtesy of NASA)

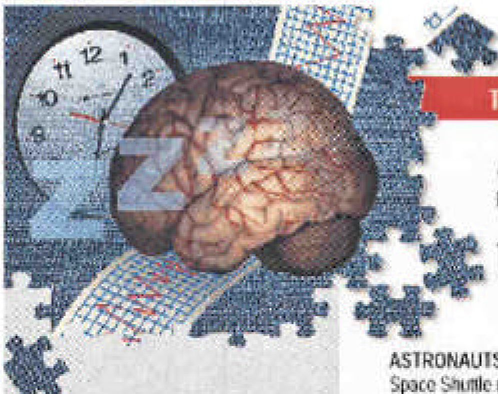
Figure 8

(Image courtesy of NASA)

"John H. Glenn Jr., equipped with sleep monitoring equipment, stands near his sleep station on the mid deck of the Earth-orbiting Space Shuttle Discovery."

Have the Students read part of the Neurolab brochure entitled "Seeking a Solution to the Sleep Problem" and the STS-95 brochure "Sleeping Better in Space: Sleep Studies and Clinical Trials of Melatonin as a Hypnotic". Ask students to think about some reasons why astronauts may have problems sleeping in space.

(Image courtesy of NASA)



The SLEEP TEAM

Seeking a Solution to the Sleep Problem

Principal Investigators:

C. A. Czeisler, M.D., Ph.D.
Clinical Trial of Melatonin As Hypnotic for Neurolab Crew, Brigham and Women's Hospital and Harvard Medical School, USA

J. B. West, M.D., Ph.D., D.Sc.
Sleep and Respiration in Microgravity, University of California at San Diego, USA

ASTRONAUTS OFTEN SLEEP POORLY on Space Shuttle missions. Crewmembers on Shuttle missions have reported an average sleep period of 5 to 6 hours, compared to the typical period of 7 to 8 hours on Earth. Some sleeping difficulties are expected. On missions, astronauts may have to become shift workers to handle the myriad tasks related to the Shuttle and the mission. There is little privacy, quarters are confined, and noises or other interruptions may occur. One survey shows that more than 50 percent of crewmembers use sleeping medication at some point during a mission.

Along with the inconvenience of disturbed sleep, crewmembers also face the cumulative effects of sleep loss or the carry-over effects of a sleeping pill—a deterioration in alertness and cognitive performance during the active hours of the workday. Sleep difficulty has prompted a number of insightful studies, but a clear understanding of the problem, as well as a solution, remain as missing pieces in the puzzle of how the body works in space. With the trend toward extended missions and the advent of the Space Station, the issues become compelling.

On Neurolab, investigators will seek both answers and an effective countermeasure through two individual but complementary studies, the overall goal being to improve the quality of sleep for future astronauts. Dr. C. Czeisler and his group will study the naturally occurring hormone melatonin to determine its value as a sleep aid and its effects on daytime performance.

Dr. J. West and his group will study how changes in respiration alter sleep and how sleep disturbances alter breathing.

Melatonin Testing on Neurolab

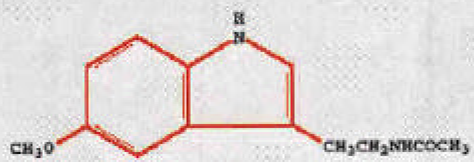
During flight, astronauts will be given either melatonin or a placebo before sleep. Use of a double-blind crossover protocol will ensure that neither astronauts nor investigators will know who receives the melatonin. When sleeping, the subjects will wear a sleep cap which will monitor and measure the electrical impulses from the brain, muscles, eyes, and heart. Sleep stages, including the rapid eye movement (REM) stage in which dreaming occurs, will be documented. Urine will be collected and analyzed to determine urinary melatonin excretion levels. Using these measurements along with body temperature measurements, Dr. Czeisler will document the subjects' circadian rhythms—the physiological patterns in the body that recur every 24 hours and regulate body temperature, melatonin hormone levels, sleep/wake episodes, and many other periodic physiological processes. Following sleep, the astronauts will provide subjective data regarding the quality of their sleep, mood, and alertness by responding to a questionnaire. They will also participate in cognitive tests to measure factors such as performance level, vigilance, and short-term memory.

> *"As we seek a solution to the problems of sleep experienced by astronauts in space flight, we face the exciting prospect of also benefiting groups of people everywhere who have a high prevalence of insomnia."*
> **—Dr. C. Czeisler**

In the Spacelab, the Neurolab crew will use a sophisticated lung function system that tests how the brain controls the concentrations of carbon dioxide and oxygen in the blood. Crewmembers will breathe into a mouthpiece, and premeasured gas test mixtures will be delivered to them as part of the test protocol. In this photo, Payload Specialist Jay Buckey prepares to initiate a test of the equipment during crew training.

(Image courtesy of NASA)

Melatonin—How Does It Work?



Although the hormone melatonin was identified more than 30 years ago, its suspected importance to humans has only recently come under serious scientific investigation. What is known is that, triggered by darkness, the pineal gland in the brain secretes melatonin. Melatonin may serve as the body's marker of night and day, and sleepiness has been correlated with melatonin levels. This has led to the question of whether giving a person melatonin would help to induce sleep—particularly in people who have changed their internal clock by crossing time zones or working on a night shift.

Studies show that melatonin, administered as a sleep aid, increases sleepiness and facilitates the onset of sleep, much like an over-the-counter sleeping pill. However, melatonin does not appear to have the residual effects of other sleeping pills, such as impaired memory, alertness, or reaction time.

Data from extensive clinical investigations of melatonin initiated by Dr. Czeisler in the Circadian, Neuroendocrine, and Sleep Disorder Section, Brigham and Women's Hospital and Harvard Medical School, in preparation for the Neurolab sleep study, plus the data derived during the Neurolab mission, will contribute significantly to our knowledge of this little understood, but potentially very important, hormone.

By correlating the repeated patterns of the astronauts' circadian rhythms with quality of sleep and next-day performance, Dr. Czeisler and his group will determine the effectiveness of melatonin as a sleep aid.

Why Study Respiration?

Changes in respiration may be one of the reasons why sleep in space is disturbed. During space flight, the respiratory patterns and motions of the chest and abdominal wall are altered. Irregular breathing patterns, high carbon dioxide levels in the blood, or low blood oxygen levels cause sleep problems on Earth. On Neurolab, Dr. West and his group will test the hypothesis that sleep disturbances in space are the result of changes in the control of breathing, which in turn, can lead to altered levels of oxygen and carbon dioxide in the blood and irregular breathing patterns, subsequently causing the astronaut to awaken.

To test this hypothesis, crewmembers on Neurolab will breathe varying gas mixtures while gas compositions and flow rates are recorded using a sophisticated gas analyzer. In addition, motions of the rib cage and abdomen, oxygen levels in the blood, arterial blood pressure, and heart rate will be recorded. Dr. West and his colleagues will use this array of measurements to correlate the changes in respiratory patterns and oxygen levels in the blood that occur during sleep and with sleep disturbances. ■

During crew training, Mission Specialist Dave Williams (seated) and Alternate Payload Specialist Alex Dunlap instrument themselves for sleep studies in the mockup of the Space Shuttle's middeck. The equipment includes the sleep net (a mesh cap that monitors and records brain waves); a Respiratory Inductance Plethysmograph (RIP) suit used to monitor respiration; and an activity monitor, a device worn on the wrist to detect and record body movement. Data on brain waves, eye movements, respiration, heart rate, and oxygen concentration are routed to a portable data recorder. The entire system has capabilities similar to a fully equipped sleep laboratory on Earth.

THE NEUROLAB SLEEP studies are expected to benefit not only astronauts but Earth-based individuals as well. Whether through an expanded understanding of the physiologic effects of melatonin or the causes of sleep disruption, the studies will be applicable to many groups of individuals with a high incidence of insomnia, such as shift workers, the elderly, and people traveling across time zones. The sleep studies have also resulted in technical advancements. A new portable system for recording sleep and respiration during space flight has been developed for the mission. This technology allows for sophisticated sleep studies to be performed at home, rather than in hospital diagnostic sleep laboratories. ■

(Courtesy of NASA)

Astronauts can have difficulty sleeping during space flight. Most likely, a combination of factors contributes to these sleep problems. These factors include the novelty and excitement of space flight itself, ambient noise in the close confines of the spacecraft, and the absence of normal day/night cycles. In fact, the sun rises and sets every 90 minutes in low Earth orbit.

Sleep disruption can lead to fatigue and decrements in performance for astronauts. To improve sleep quality, many astronauts take sleep aids such as the benzodiazepine hypnotic Restoril. These medications, however, may have undesirable side effects on performance and mental alertness. In the search for a better sleep aid, researchers have targeted melatonin, a naturally occurring hormone produced in the pineal gland of the brain. Ground-based research indicates that melatonin may facilitate sleep, an attribute that is particularly important if astronauts are scheduled to sleep at a time of day when their bodies are not producing the hormone.

The investigation, Clinical Trial of Melatonin as a Hypnotic, will determine whether the use of melatonin improves the quality of sleep for astronauts during space flight, thereby improving their ability to perform the mentally challenging and physically rigorous tasks required of them. Although melatonin is currently available in health food stores as a food supplement, the dosages available are typically 10-20 times greater than levels found in the human body. This study is designed to evaluate whether a near-physiologic dose of the hormone can be effective in promoting sleep.

Aside from improving the sleep quality of astronauts during space flight, this research has direct application for many people here on Earth. Sleep disorders affect a wide range of people from those who perform challenging jobs involving night shift work to the many Americans who often experience sleep disorders as they age. This investigation will be the first to assess the effects of space flight on the sleep patterns of an older astronaut.

The sleep quality and mental functions of crewmembers will be assessed before, during, and after flight. Before each sleep period of the mission, crewmembers will take an unmarked capsule that contains either melatonin or placebo. The crewmembers will wear an unobtrusive wrist actigraph to monitor their sleep-wake cycle. In addition, astronauts' sleep will be characterized more completely via recordings that assess several sleep parameters. During each of the four intensive monitoring sessions, crewmembers will wear an electrode net on their heads . These electrodes will be connected to a Digital Sleep Recorder that monitors brain waves, eye movements, muscle tension, body movements, and respiration. Astronauts will be assisted in troubleshooting this high-tech setup by an artificial intelligence computer system developed jointly by the Massachusetts Institute of Technology and NASA Ames.

Other factors related to sleep quality, such as mental performance and environmental parameters, will also be assessed to complement data collected with the sleep recorder. After each night of wearing the electrode net, crewmembers will use a laptop computer to fill out a record of sleep quality and complete a 20-minute battery of cognitive performance and subjective mood tasks. Body temperature will be recorded continuously from flight day 2 through flight day 9 using an ingested radio-telemetry pill. These readings will be compared with similar recordings pre- and postflight. Ambient light levels in work and rest areas will also be measured to correlate environmental light cues with sleep patterns. Crew members will don the electrode net for six nights of monitoring before flight and three nights of monitoring after flight to complement the data collected inflight.

The reason why astronauts find it difficult to sleep in space is unknown. Possible reasons include:

Microgravity: On earth, we commonly lie down when we go to sleep. This change in posture is associated with changes in the sympathetic and parasympathetic nervous systems and shifts in body fluids. In space, there is no lying down, no up or down. This lack of gravity and loss of associated physiological changes with changes in posture may be related to poor sleep in space.

Temperature: If the ambient temperature is too cold or too hot people awaken from sleep more frequently, especially from REM sleep.

Excitement: Being excited or nervous can disrupt the ability to fall asleep and stay asleep.

Noise: a noisy environment will disrupt sleep.

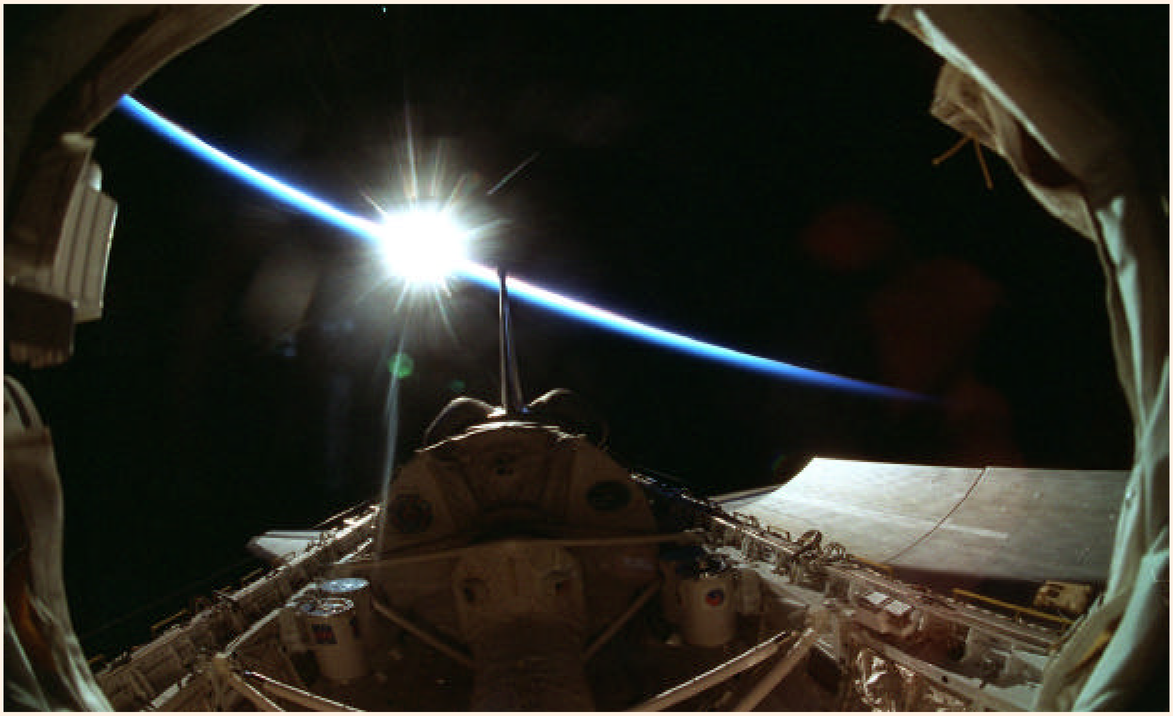
Light-dark schedule and light intensity: The 90-minute light-dark cycle associated with the orbit of the space shuttle around Earth and the very dim artificial lights in the space craft may lead to misalignment between the circadian pacemaker and sleep-wake schedules. Astronauts may thus experience jet lag in space. That is, the astronauts internal clock says its time to go to bed when he or she is trying to stay awake and perform his or her responsibilities during the daytime.

Unplanned work/rest disruptions – Emergency situations or extensive work loads can delay or interrupt sleep.

Understanding the difficulties that astronauts have sleeping in space and developing countermeasures to help them sleep is crucial as humans enter the era of long duration space travel including a manned mission to Mars. The research conducted also has clinical benefit for people with sleep problems on Earth.

Current research supported by NASA and the National Space Biomedical Research Institute is aimed at improving sleep and performance in astronauts for long duration space missions.
http://www.nsbri.org/research/sleep.html

(Courtesy of NASA)



The Space Shuttle is exposed to a 90 minute light-dark cycle as it orbits the Earth. Every 45 minutes the sun rises and sets. This picture provides a "view from the Space Shuttle Columbia's cabin. The Spacelab Science Module, hosting 16-days of Neurolab research, is in frame center The tunnel that leads from the cabin to the science module in the cargo bay is at bottom center. The sun can be seen bursting over Earth's horizon".

Figure 10

Teacher Directed Instruction (Supplemental Part V)

Ask the students the following question: What do you think might happen to astronauts located on a space station that is both outside of our solar system and that also has a different day length from Earth?

Students might suggest the following answers:

- **Our clocks will entrain to the new day length.**
- **Our clocks will not entrain to the new day length and we will be sometimes sleeping during the day.**

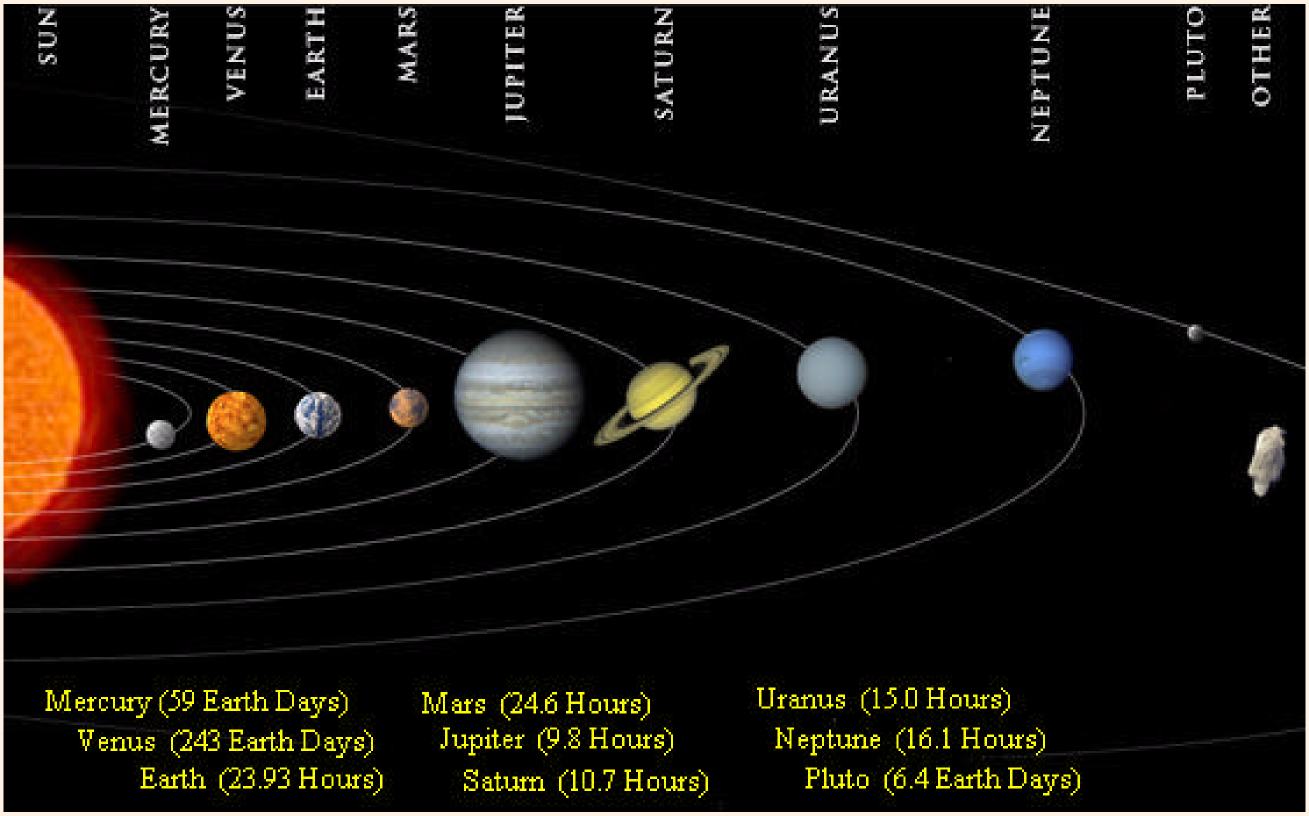
Consider what it would be like to build and inhabit a space station on another planet in our solar system. The planets are listed in the order of distance from our sun:

Planet	Duration of one day-night cycle, given in Earth days or hours for each planet (One period of day and night for the planet)
Mercury	59 Earth days
Venus	243 Earth days
Earth	23.93 hours (1 Earth day)
Mars	24.60 hours (a little longer than 1 Earth Day)
Jupiter	9.8 hr (shorter than 1 Earth Day)
Saturn	10.7 hr (shorter than 1 Earth Day)
Uranus	15 hr (shorter than 1 Earth Day)
Neptune	16.1 hr (shorter than 1 Earth Day)
Pluto	6.4 Earth days

The answer to the question of what might happen when astronauts set up a space station on another planet in our solar system that has a different day length, is that we do not know. Current research is devoted to finding out whether human circadian rhythms can adjust to Martian or other day lengths.

Ask students to consider what might be the pattern of behavior, sleep and wakefulness of an alien from another planet with a day length very different from that of Earth?

(Image courtesy of NASA)



Independent Activity/Homework (Core Part V)

A. Students should use what they have learned about sleep to write reflections about their own sleep habits. The essay should include an analysis of their sleep history and what they may need to do in order to improve their sleep.

B. Using the information from this lesson, students should reconsider the effects of altered sleep schedules and of sleep deprivation on the following occupations: airline pilot, emergency room health provider, long distance truck driver, and astronaut. Students should write up their responses. Examples of sleep schedules and performance for airline pilots are presented in Figures 11 and 12.

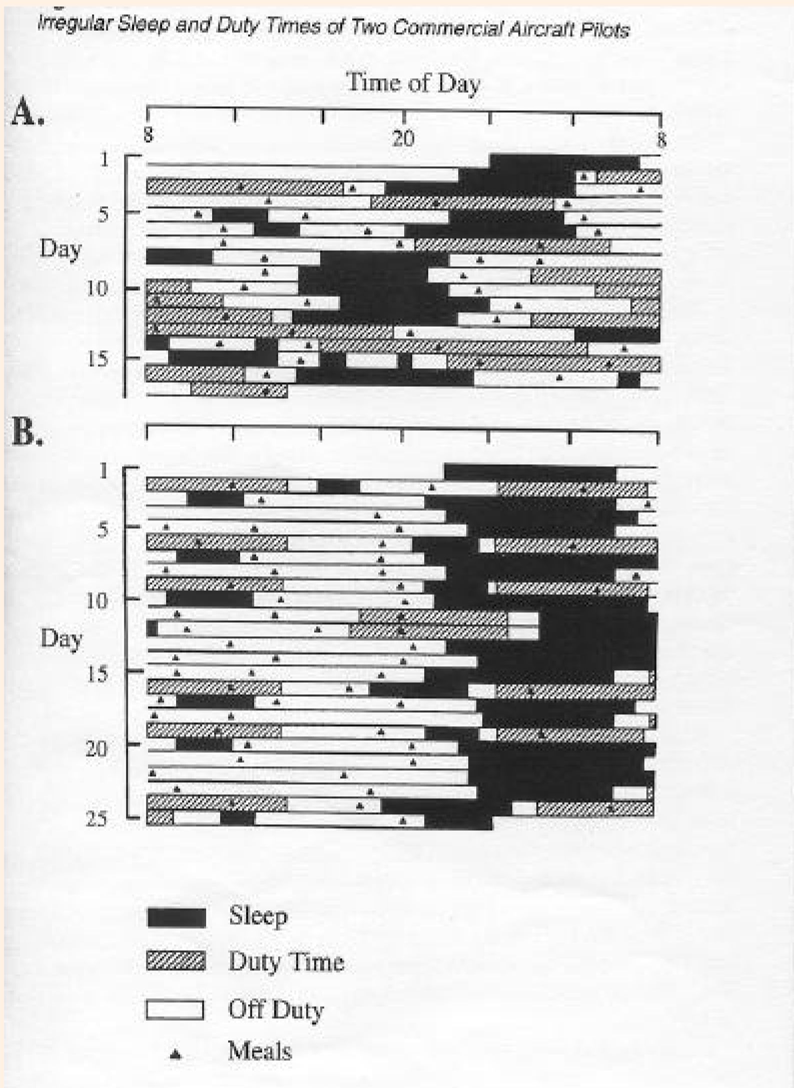
C. Have students think about the requirements for getting a good nights sleep. Students should read, "Helping yourself to a good nights sleep." This selection is found in Appendix 9.
Http://www.sle epfoundation.org/publications/goodnights.html

According to what we have learned about the timing and regulation of sleep and wakefulness by the endogenous circadian pacemaker, our brains are built to be awake during the day and sleep during the night. The consequence of going against this basic biological drive is an inability to sleep well during the day and sleepiness and fatigue during the work shift at night. There are additional consequences of working the night shift. Have students read:

Sleep-deprived shift workers at risk for serious accidents and health problems in Appendix 11.
http://www.sleepfoundation.org/PressArchives/youngpeople.html

and Lack of Sleep America's top health problem, doctors say:
http://cnn.com/HEALTH/9703/17/nfm/sleep.deprivation/index.html

(Image courtesy of The Twenty-Four-Hour Society)

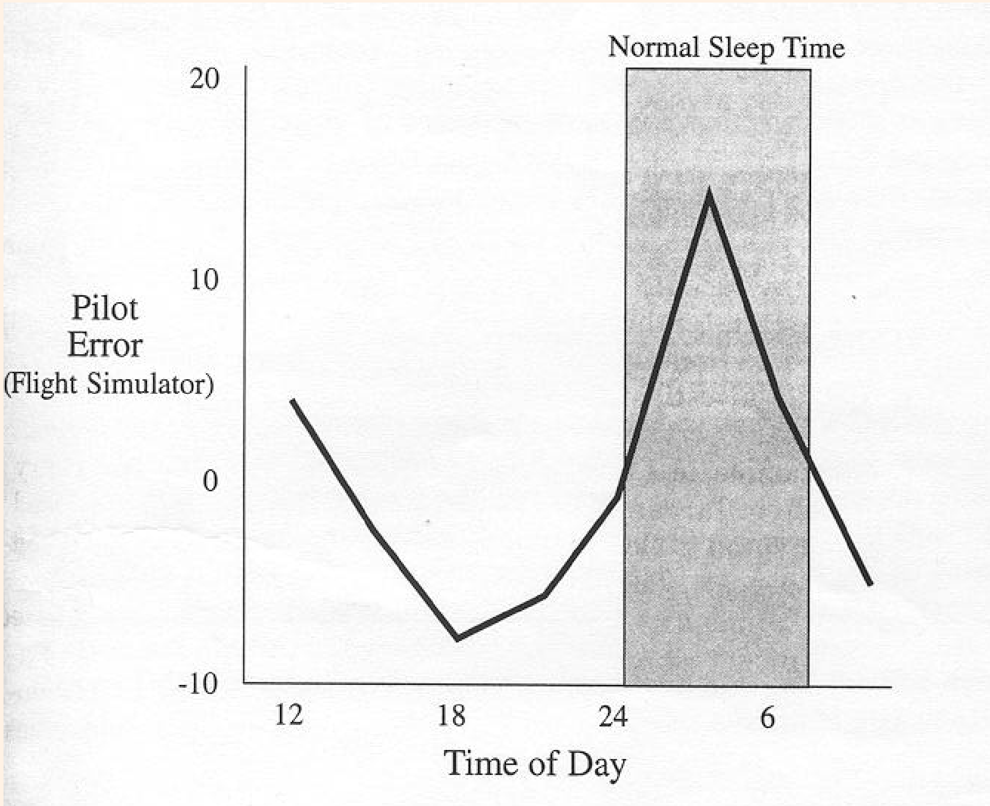


What might the consequence of this schedule be?

Schedules like this have resulted in plane crashes.

Figure 11

(Image courtesy of The Twenty-Four-Hour Society)



The diagram serves to illustrate the amount of pilot errors recorded in a flight simulator throughout the day. The chart begins at 12 noon and advances in 6 hour increments (e.g., 18 = 6 pm; 24 = midnight; 6 = 6 am).

Figure 12

LESSON VI: Return Visit to Dr. Knight and Case Wrap-Up

Guide for Part VC and Wrap-Up

Lesson Objective:

➢

Benchmarks for Science Literacy – American Association for the Advancement of Science:

1C: The Scientific Enterprise

➢ Scientists are employed by colleges and universities, businesses and industry, hospitals, and many government agencies. Their places of work include offices, classrooms, laboratories, farms, factories, and natural field settings ranging from space to the ocean floor.

5C: Cells

➢ Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

6D: Learning

➢ Language and tools enable human beings to learn complicated and varied things from others.

6E: Physical Health

➢ Toxic substances, some dietary habits, and some personal behavior may be bad for one's health. Some effects show up right away, others may not show up for many years. Avoiding toxic substances, such as tobacco, and changing dietary habits to reduce the intake of such things as animal fat increases the chances of living longer.

6F: Mental Health

➢ Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances.

11A: Systems

➢ Any system is connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

12D: Communication Skills

➢ Read simple tables and graphs produced by others and describe in words what they show.

➢ Participate in group discussion on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.

➢ Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

Example of Regional Standards – Boston Public Schools Learning Standards:

➢ Adaptation.

Materials:

➢ Sleep Logs

Lesson Opening

Ask students to reflect on the case and identify the major topics covered. Record these responses and use them to guide the next section.

Ask the students:

Based on everything you have learned and read, what do you know about Jose?

What do you think is wrong with Jose?

What is your hypothesis at this time?

Do you think that Jose's problem is common among adolescents? Among older people? Among people who work?

Students should read Part VB. When students are finished ask the students to consider the following questions:

What is caffeine?

> **Caffeine is a powerful stimulant drug. Caffeine is the most commonly used drug in the world.**

What are some of the effects of caffeine on sleep?

Lesson Body
Teacher Directed Instruction (Core Part VI)

How Do Drugs Affect Sleep?

Common beverages and foods that contain caffeine include coffee, soda, tea, chocolate, chocolate ice cream, cakes and cookies that contain chocolate. Caffeine can result in problems falling asleep and in staying asleep.

Alcohol can make someone sleepy and help him or her to fall asleep; however, alcohol use disrupts sleep later in the night leading to next-day sleepiness.

Exogenous melatonin can help people to fall asleep and stay asleep during the daytime, but it has little to no effect on sleep at night when endogenous melatonin in the blood is high.

Antihistamines are drugs used commonly for allergies. Antihistamines make people sleepy; however, they do not produce normal sleep.

Benzodiazepines (Ben-zo-dia-aso-peens) are the most commonly prescribed sleeping pills (Hypnotics). They make people sleepy, and help them to fall and stay asleep. Benzodiazepines do not produce a normal sleep pattern. Furthermore, people commonly develop tolerance to the drug, and some benzodiazepines cause carry-over daytime sleepiness the next day. When people stop taking benzodiazepines, they may experience withdrawal symptoms that include increased difficulty in falling asleep. Over-the-counter hypnotics/sleep aids do not produce natural sleep.

More information on hypnotics can be found at:
http://www.sleepfoundation.org/publications/sleepaids.html

For this section, students will think about things that make a person sleepy or alert. Begin by posing the following questions to the students:

What makes a person alert and promotes wakefulness?

The students might suggest:

- **Coffee (Caffeine) and Tea (Theophylline): Caffeine and Theophylline are powerful stimulant drugs that can help promote alertness. However, they can not replace sleep in the long term.**
- **Getting enough sleep: This is one of the best things that can be done to enhance alertness and performance.**
- **Naps: Yes, even a short nap can enhance alertness and performance.**
- **Physical Activity: In the short term activity can help reduce sleepiness, but cannot prevent sleepiness in the long term.**
- **Turn up the Music: In the short term it may be alerting; however, loud music does not help much if people are driving while drowsy.**
- **Rolling down the window in a car does not help much.**

What makes a person sleepy?

The students might suggest:

- **How long the person has been awake. Yes**
- **The time of their internal clock. Yes**
- **How well someone last slept. Yes**
- **If it is warm. Yes**

- **Exercise. Yes, but if it occurs too close to bedtime, exercise can interfere with sleep.**
- **Drugs including alcohol. Yes, but alcohol does not aid normal sleep (see below).**
- **Boring situations. Yes.**

Have students read Part VC.

Teacher Directed Instruction (Extension Part VI)

The following lesson extension (Appendix A1) covers basic facts about drugs and their receptors.

Teacher Guided Inquiry (Core Part VI)

Ask students to reflect on the case and think about the major topics that were covered. After the students have shared their ideas, use the following selection to guide the class through the main points of the case:

Ask students to list the various medical and science-based careers related to this case. The following list describes careers that students might want to learn more about.

A. Sleep Doctor – A doctor specializing in sleep problems may have a specialty in pulmonology which focuses on problems of the respiratory system, or a specialty in neurology which focuses on problems of brain function, or psychiatry and psychology, which focus on problems of brain function and behavior. Doctors with these specialties have M.D. or Ph.D. degrees. A clinical sleep doctor can work in a hospital, clinic or university.

B. Clinical Sleep Technician – A clinical sleep technician is responsible for helping the sleep doctor diagnose sleep problems. The technician performs a sleep study in the laboratory and helps interpret the sleep EEG recordings. A clinical sleep technician can work in a hospital, clinic or university.

C. Engineer – An engineer is responsible for developing and maintaining equipment used in sleep studies for research and clinical purpose. The equipment developed can include computer software and hardware, machines and tools necessary to carry on the studies. An engineer can work in a research and development company, a hospital, clinic or university.

D. Sleep Researcher – A sleep researcher is a scientist who does research on one or more of the many areas of sleep discussed in “What’s Up With José?” A sleep researcher can work in a hospital, clinic, or government research lab, but most work in university research labs.

E. Sleep Technician (research) – A research sleep technician is responsible for assisting a sleep researcher carry out research studies on sleep by testing research subjects and analyzing the data. A sleep research technician can work in a hospital, clinic, government research lab or industry research lab.

“Does José Have A Problem?”

Master Glossary

GLOSSARY

This section contains keywords from the case narrative (in black), as well as definitions of words included in the Teacher's Guide (in blue).

Adenosine: A neuromodulator that is secreted locally in the brain by some active nerve cell, and that inhibits neighboring nerve cells.

Affective: Having to do with emotion.

Agonist: A substance that mimics or enhances the action of a neurotransmitter, hormone, or drug at its receptor.

Alzheimer's Disease: A disease of the brain that impairs thinking and is common as people grow older.

Antagonist: A substance that blocks the action of a neurotransmitter, hormone, or drug at its receptor.

Anti-depressant: A drug used to treat depression. Anti-depressants used commonly today block the re-uptake of neurotransmitters seratonin and norepinephrine.

Benzodiazepines: Drugs used as sleeping pills or to treat anxiety. Benzodiazepines enhance the actions of the inhibitory neurotransmitter GABA.

Biological Clock: Internal oscillator that keeps internal time for the organism.

Brain Stem: Lower part of the brain. Involved in the regulation of wakefulness and REM sleep.

Caffeine: A methylxanthine that blocks the action of adenosine at adenosine receptors, and thereby stimulates brain function.

Cataplexy: Muscle weakness or loss of muscle tone.

Central Sleep Apnea: A breathing disorder where the airway becomes blocked or collapses resulting in the cessation of breathing and the reduction of oxygen in the blood.

Circadian: (From Latin; *Circa* = about, *Dies* = day) About a day, nearly 24 hr.

Circadian Pacemaker: See Biological Clock.

Circadian Rhythm: Referring to a rhythm or oscillation with a periodicity near 24 hours or near 1 day in duration (e.g. body temperature rhythm).

Classical Conditioning: A type of learning where one stimulus (A) becomes associated with another (B) and then produces the same response as (B) if (A) is then presented alone. For example, a light turned on does not make a dog salivate. If every time we turn the light on we immediately give the dog a treat, eventually the dog will salivate when we turn on the light, even though we do not give the dog a treat.

Clitoral: Referring to part of the female genitalia that receives increased blood flow during sexual arousal and during REM sleep.

Conscious: Term commonly used to describe when a person/animal is awake, active, alert and interacting with the environment.

Crepuscular: Active at dawn or dusk.

Dream: Cognitive activity occuring during sleep that is commonly fantasy-like.

EEG: Electroencephalogram

Electroencephalogram: (from Latin; Electro = electrical, encephalo = brain, gram = to write) A recording of the electrical activity of the brain.

Electrooculogram: (from Latin; Electro = electrical, oculo = eye, gram = to write) Abbreviated EOG. A recording of the electrical activity of the eye muscles (or movements).

Endocrine: A body system that uses hormones to regulate physiology and behavior.

Endogenous: Originating from the inside.

Entrainment: When the period of a biological clock is made equal to that of an environmental stimulus (See Lesson V).

EOG: See Electrooculogram.

Exogenous: Originating from the outside.

FDA: Food and Drug Administration

Genitalia: Sexual organs.

Hallucinations: Perceiving a stimulus that is not really there.

High blood pressure: (hypertension) A blood pressure greater than or equal to 140 mm Hg (mm mercury) systolic pressure or greater than or equal to 90 mm Hg diastolic pressure. Often measured with a blood pressure cuff around the arm. High blood pressure increases the risk of heart disease and can lead to heart attacks and strokes (brain attacks).
Treatment: Diet, exercise, losing weight, drug therapy.

Homeostasis: Process by which the body maintains an optimal environment for the functioning of its cells and organs.

Hypothyroidism: Occurs when the level of thyroid hormone is below the body's need. Symptoms may include the following: fatigue, tingling in the fingers, loss of equilibrium, dry skin and cold intolerance, weight gain, muscle swelling and pain, slowed heart rate, depression, memory and mental impairment, constipation, coarseness or loss of hair, hoarseness, enlarged thyroid, irregular or heavy menstruation, infertility or miscarriages. Hyperthyroidism occurs when the level of thyroid hormone produced is higher than the body's need. Symptoms may include, weight loss, and weakness.

Hypnotics: Sleeping pills.

Hypotension: Low blood pressure.

Impotence: Inability to perform sexually or reproduce.

Intrinsic Period: The time it takes for the internal clock to complete one cycle.

K-Complex: An EEG waveform that is a high-amplitude negative and then positive deflection lasting at least 0.5 sec. K-Complexes are recorded from the cortex, but are generated by the thalamus in the brain. The thalamus is a relay center in the brain that sends information from the sensory organs to the cortex. Sleep spindles and K-complexes are believed not to be consistent with the flow of information from the senses to the cortex.

Melatonin: A hormone produced by the pineal gland at night. The timing of melatonin production is regulated by the biological clock in mammals.

Misalignment: The timing of Internal Rhythms are no longer synchronized.

Mononucleosis: Presence of abnormally large numbers of mononuclear leukocytes in the circulating blood. Symptoms may include: fever, sore throat, headaches, feeling tired and not feeling hungry, white patches on the back of the throat, enlargement of the lymph nodes (glands in the neck) and spleen.

Motor Signals: Nerve impulses by which the brain signals the motor neurons in the spinal cord to change their level of activity, and therefore a state of muscle contraction.

Neuron: A nerve cell.

Neurotransmitter: A chemical that communicates information from one neuron to another.

Nocturnal: Occurs at night; active at night.

NREM sleep: Non-REM sleep. Sleep stages 1,2 3, and 4.

Obstructive Sleep Apnea: A sleep disorder associated with obstruction of the airway, the cessation of breathing and the reduction of oxygen to the blood.

Parasympathetic: Part of the autonomic nervous system that relaxes the body.

Parkinson's Disease: A brain disorder resulting in disturbances in cognitive and motor function.

Penile: Referring to the male sexual organ.

Period: The duration of one cycle in an ongoing oscillation.

Phylogeny: The study of species differences.

Protein Synthesis: Complex biochemical process by which a specific sequence of amino acids is built up to produce specific proteins.

Psychological: Referring to higher mental functions of the brain.

Quiescence: Lack of activity.

Receptor: A protein structure in the cell membrane to which a neurotransmitter or drug will bind.

Reliability: The extent to which a measurement or test produces similar or repeatable results.

REM sleep: Rapid Eye Movement Sleep. The sleep stage where most dreaming occurs. Brain wave activity is desynchronized (low amplitude, rapid deflections) and resemble that of the waking brain. In fact, some parts of the brain are more active in REM sleep than in alert wakefulness. There are frequent rapid eye movements, but other muscle activity is suppressed.

SCN: See Suprachiasmatic Nucleus.

SIDS (Sudden Infant Death Syndrome): A syndrome where infants die without explanation.

Sleep Paralysis: An inability to move upon awakening from sleep.

Sleep Spindles: An EEG wave form of 12 – 14 cycles per second observed during stage 2 sleep.

Slow-wave Sleep: Sleep stages composed of slow, high amplitude EEG.

Spinal Cord: Part of the central nervous system that relays information to and from the brain and body.

Suprachiasmatic Nucleus: Location of the master circadian pacemaker in mammals.
The SCN is a brain structure located in the hypothalamus of the brain (above the optic chiasm).

Sympathetic: Part of the autonomic nervous system that arouses the body.

Tau: Intrinsic period of the circadian pacemaker. The average intrinsic period of humans is slightly longer than 24 hr (current estimates are 24.1-24.2 hr).

Theophylline: A chemical found in tea that is stimulating like caffeine.

Thyroid: A gland that regulates metabolism through the secretion of thyroid hormone into the blood.

Validity: The extent to which an observation measures or tests something appropriately and accurately.

References

Basics of Sleep Behavior - The complete book is available free online through the Sleep Research Society at http://bisleep.medsch.ucla.edu/sleepsyllabus/

Boston Public Schools Citywide Science Learning Standards. Version 98.1. 1998.

Carskadon. *Encyclopedia of Sleep and Dreaming.* MacMillan Publishing. 1993.

Dement, Kryger, and Roth. *Principles and Practices of Sleep.* W. B. Saunders. 1993.

Hobson. *The Dreaming Brain.* Basic Books. 1989.

J. A. Horne. *Why We Sleep: The Functions of Sleep in Humans and Other Mammals.* Oxford Unversity Press. 1990.

Kleitman. *Sleep and Wakefulness.* University of Chicago Press. 1987.

Mary's Mystery, Neurosciences: Explorations in Mind and Brain. Minority Faculty Development Program, Harvard Medical School. 1993.

Mitler, Carskadon, Czeisler, Dement, Dinges, and Graeber. *Catastrophes, Sleep, and Public Policy: Consensus Report.* From the journal, “Sleep”. Raven Press, Ltd. 1988.

Moore, Klein, Reppert. *Suprachiasmatic Nucleus: The Mind’s Clock.* Oxford University Press. 1991

M. Moore-Ede. *The Twenty-Four-Hour Society.* Addison Wesley Longman. 1994.

M. Moore-Ede, F. M. Sulzman, and C. A. Fuller. *The Clocks That Time Us.* Harvard University Press. 1985.

Related Web Sites

The following is a list of web sites related to associations, activities, and research efforts on sleep.

NASA WEB SITES

The NASA Web Site
http://www.nasa.gov

NASA Spacelink – An Aeronautics & Space Resource for Educators
http://spacelink.msfc.nasa.gov/index.html

Imagine the Universe!
http://imagine.gsfc.nasa.gov/

OTHER SITES

American Association for the Advancement of Science - Benchmarks for Science Literacy
http://project2061.aaas.org/tools/benchol/bolframe.html

Sleep Home Pages: Brain Information Service
http://bisleep.medsch.ucla.edu/

Basics of Sleep Behavior
http://bisleep.medsch.ucla.edu/sleepsyllabus/

How We Take Our Time
http://www.med.harvard.edu/publications/Focus/Apr28_1995/On_and_Off.html

National Space Biomedical Research Institute: Sleep Team
http://www.nsbri.org/research/sleepd.html

Sleep Medicine Home Page
http://www.users.cloud9.net/~thorpy/

National Sleep Foundation
http://www.sleepfoundation.org/

National Science Foundation
http://www.neurophys.wisc.edu/brain/

National Science Foundation: Center for Biological Timing
http://www.cbt.virginia.edu/

Neuroscience for Kids – Brain Comparisons
http://weber.u.washington.edu/~chudler/compare2.html

The Sleep Well
http://www-leland.stanford.edu/~dement/

National Academy Press – National Science Education Standards
http://www.nap.edu

“What’s Up With José?”

Appendices

Teacher Guided Inquiry (Part II)

This extension explores the controversy related to mandatory drug testing for minors.

Many people believe that mandatory drug testing violates an individual's rights. Nevertheless, some states are considering laws that would hold parents responsible for their child's actions. These issues fuel the debate over mandatory drug testing for minors.

Have the students discuss the following questions:

Should José be tested for drug use?
If José does not want to be tested, should/do the school or José's parents have the right to make him take a drug test?
Does it make a difference that José is a minor?

Student Guided Inquiry (Part II)

See Appendix 4 for directions on the Pupillary Light Reflex Test demonstration. This test is a standard part of a neurological exam. The doctor shines a light in the patient's eye and observes the effect on the pupil.

Pupillary Light Reflex Test

Have students pair off. Distribute necessary materials. Make certain that room lights are dim, because bright light will make the response more difficult to see. Remind students that the penlight beam should be directed at the eye from the side, not the front, to prevent the "patient" from blinking. The penlights come with plastic sleeves over the metal contact point; to make them work slide the sleeve off the contact and press the clip so it touches the metal square.

Have students record each other's pupillary responses using the guide on the penlights to measure pupil sizes before and after illumination. (If you are using lights without accompanying scales, copy and distribute the scale provided in the Appendix.) Direct students to check both:

- the direct response of the eye into which light is pointed,
- and the consensual response of the opposite eye. (See Appendix 4 on the pupillary light reflex)

Record results on a blackboard and discuss how differences fall into a range.

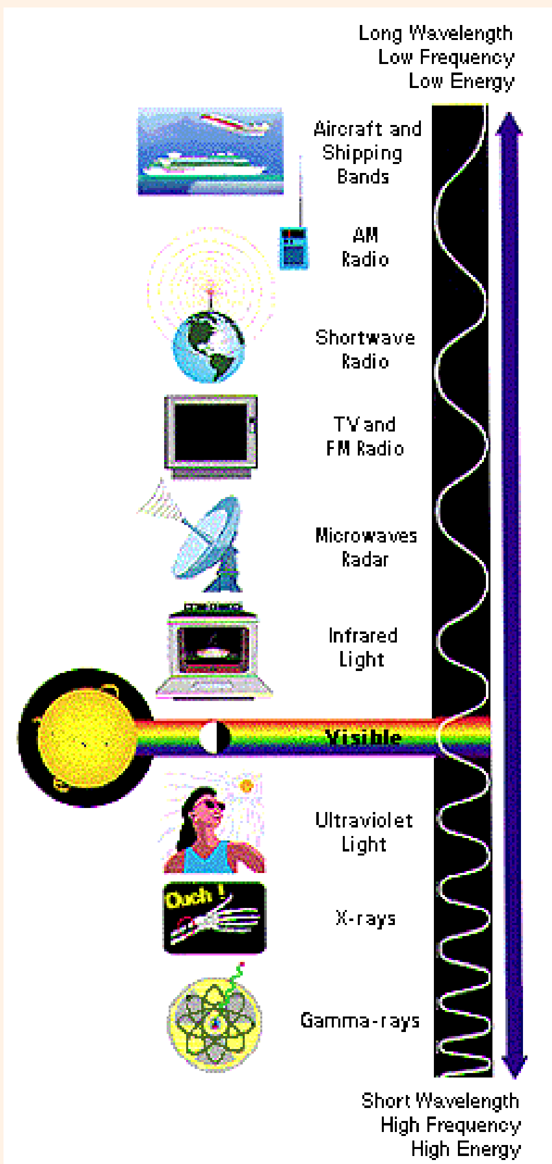
Teacher Directed Instruction (Part III)

If you want to learn more about how the brain produces its electrical activity, see Appendix 7, “Ions and Impulses.” This essay describes some of the basic principles of electricity (for possible interdisciplinary connections) and how nerve and muscle cells make use of these principles to generate their resting and action potentials.

Teacher Directed Instruction (Part V)

What is Light?

(Image courtesy of NASA)



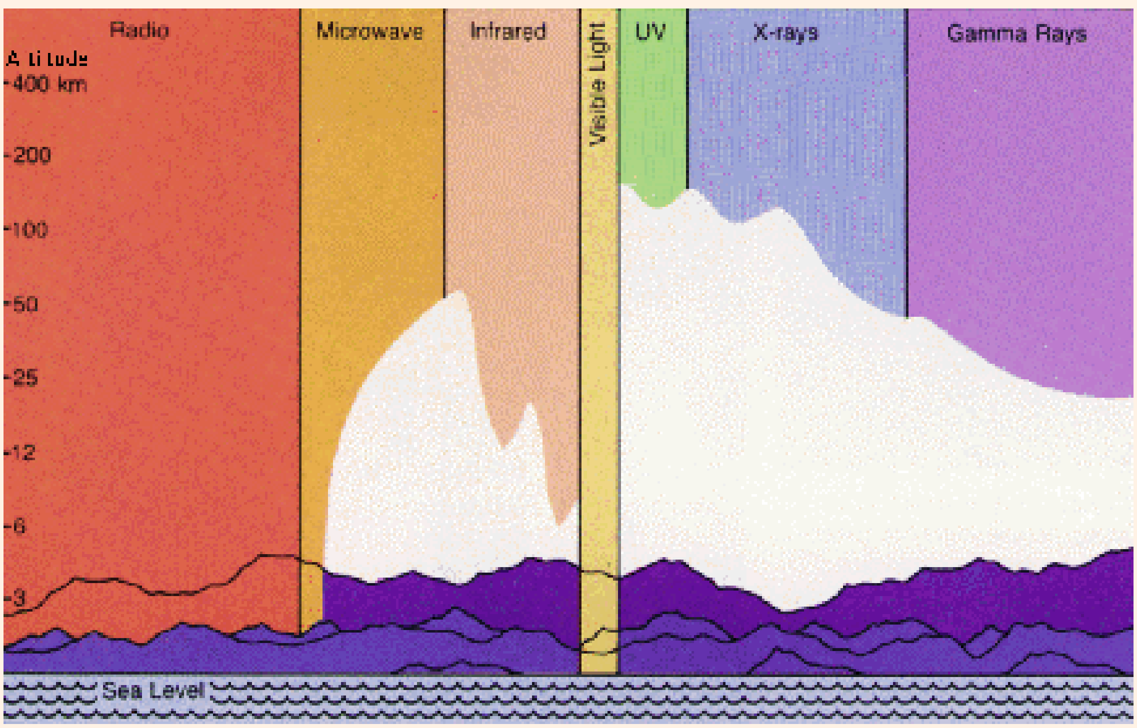
Light is electromagnetic energy. The electromagnetic spectrum varies from very low frequency waves such as radio transmissions and radar to higher frequency waves such as x-rays and cosmic rays. Visible light is a small part of the electromagnetic spectrum with wave lengths from 350 to 750 nanometers (billionths of a meter). The spectrum of visible light for humans is a continuum of wavelengths that appear red to violet.

Refer to:
http://sulu.lerc.nasa.gov/dictionary/content.html
for a dictionary of technical aerospace terms including information on light.

Basic Mechanisms of Vision (Light Perception)

In mammals, light energy is absorbed by the eyes. Energy in the form of electromagnetic radiation enters the eyes and is absorbed by light receptors the rods and cones. When struck by light, light receptors (photoreceptors), transform light energy into electrical energy. The electrical energy that is generated in the eyes is in the form of neural signals that are carried from the eyes to the brain via the optic nerve. Light energy is important for both conscious vision and circadian vision. Circadian vision is light perception by the circadian pacemaker. There are two different neural pathways for conscious vision and circadian vision. One neural pathway goes from both eyes to parts of the brain responsible for conscious vision. The other pathway goes from the eyes to the circadian pacemaker in the SCN. The fact that these two separate pathways exist allows some blind people to provide light input into the biological clock even though the pathway or brain regions responsible for conscious vision are damaged. The photoreceptors for circadian vision in the eye appear to be different than the rod and cone receptors responsible for conscious vision. Additional information about mechanisms of light perception can be found in Appendix 4.

(Image courtesy of NASA)



Teacher Directed Instruction (Part V)

In previous sections we referred to several drugs: caffeine, theophyllin, alcohol, melatonin, etc. The next section discusses the structure and function of drugs.

Some Basic Facts About Drugs And Their Receptors

What is a drug? In the most general definition, a drug is any chemical substance that affects any process in a living organism. In a more restrictive definition, the term is applied only to agents that are not naturally present in (not normally made by) the body – for example aspirin, caffeine or morphine. But, in a broader definition, even substances that are naturally present (endogenous) in the body but are administered to supplement the natural compound are considered to be drugs – for example, melatonin, a hormone made by the pineal gland, is taken to improve the sleep of someone experiencing jetlag. Pharmacology, the study of drugs and their actions, is a very broad subject. It's not surprising that standard textbooks of pharmacology may be more than 1500 pages long even when their focus is limited to agents used medically. This is partly because the variety of drugs is enormous but also because a rational approach to pharmacology requires, in addition to a knowledge of drugs, an understanding of the bodily functions they affect. Any of the immense number of bodily functions could be affected by a drug. You could ask your class how many bodily functions they can think of. They might want to organize their list by organ systems. Such a list might include the following body systems/functions (and many others):

Cardiovascular: Regulation of blood pressure and heart rate (each of which is a complex function with several components); carrying oxygen and nutrients to the tissues and carbon dioxide and other waste products away from the tissues; carrying immune cells and antibodies to the tissues; carrying platelets and clotting factors to a wound.

Respiratory: Gas exchange (bringing oxygen from the atmosphere to the blood and carbon dioxide from the blood to the atmosphere); regulation of the rate of gas exchange according to need; inhaling (sniffing) in the service of olfaction.

Digestive: Control of secretion (of saliva, of gastric and intestinal digestive enzymes; of bile; of mucous); absorption of nutrients into the blood; control of smooth muscle contraction (as in peristalsis and the opening and closing of sphincters eventually leading to the elimination of solid waste).

Renal: Control of the amount and composition of urine in order to regulate the overall concentration of solutes (osmotic pressure), the concentrations of individual salts (like sodium and potassium), the pH (acidity) and the concentration of drugs or waste products (like urea) in the blood and extracellular fluids. Secretion of hormones.

Reproductive: Generating germ cells (eggs and sperm); processes required for bringing egg and sperm together; implantation and nurturing of the embryo; processes involved in giving birth; lactation.

Nervous: Control of movement (behavior); thinking (planning, calculating, day-dreaming, etc.); remembering (events, people, places, things) and learning (e.g. skills); having moods (elation, depression) and emotions (pleasure, fear, anger, love, hate, lust, anxiety); having sensory perceptions (visual, auditory, tactile, olfactory, pain etc.); being motivated to act; experiencing consciousness.

Endocrine: The secretion of hormones that regulate functions of all the other tissues – functions like cellular metabolism, the release of secretory products (like other hormones), the uptake of nutrients (like glucose).

Musculo-Skeletal: Maintaining postures and moving (how to stay erect against the force of gravity and how to walk, run, swim, climb, dance, throw, fight, eat, breathe, etc.); generating heat for the maintenance of normal body temperature.

Integumentary: Prevention of dessication, protection from harmful agents in the environment; assisting in regulation of body temperature.

Mechanisms of Drug Action

Drugs act on the body in many different ways. A sampling is given here with an emphasis on drugs that affect the nervous system. In some cases drugs *imitate endogenous substances* like neurotransmitters and hormones; for example nicotine imitates the neurotransmitter, acetylcholine. Drugs may *block the action* of an endogenous substance; for example caffeine blocks the action of adenosine, another neurotransmitter. Alternatively, a drug may *enhance* the action of an endogenous substance; for example benzodiazepines, like Valium, enhance the actions of the neurotransmitter gamma-aminobutyric acid [GABA]. Drugs may change the concentration of endogenous substances; for example, antidepressants (like Prozac) *block the reuptake* of the neurotransmitter serotonin so that, after it is released into the synaptic cleft, it persists there for a longer time and at a higher concentration. Another drug, pyridostigmine, used in the therapy of myasthenia gravis, also enhances the concentration of a neurotransmitter – in this case, acetylcholine released by motor nerve endings in skeletal muscle; however, it does this by *inactivating an enzyme* (acetylcholinesterase) that breaks down the acetylcholine after it has acted.

These kinds of effects – activating or blocking receptors, inhibiting enzymes, affecting membrane transport – account for a large part of drug action, not only in the nervous system, but throughout the body. Another important mechanism is to affect any of the numerous second-messenger systems inside of cells. In addition, some "drugs" like alcohol appear to affect function, not only by binding to receptors, but also (at high concentration) by dissolving in the membrane or, as in the case of the semicircular canals, dissolving in the endolymph and changing its viscosity or specific gravity.

Drug Receptors

Fundamental to an understanding of drug action is the concept of *receptors*. With the exception of the last mechanism mentioned above (dissolving of an agent in membrane lipids or in endolymph) drugs act by binding to a "receptor" or "acceptor", usually a specific site or pocket in a protein (or nucleic acid) which the drug fits into – sometimes referred to as "lock and key". This accounts for the specificity of drug action; only chemical agents with the correct shape and charge groups can occupy the site. Sometimes, as with neurotransmitter antagonists (like caffeine or curare) the agent binds to the same receptor as the neurotransmitter, preventing the transmitter from binding, but, unlike the transmitter, the agent fails to activate (cause a conformational change in) the receptor. Sometimes the agent binds to a particular site on an enzyme molecule. This may prevent the binding of the substrate molecule that the enzyme is designed to act on. Alternatively, the binding of the agent to its acceptor site may make an abnormal change in the conformation of the enzyme, preventing it from catalyzing its normal chemical reaction, or it might prevent the normal change in conformation that is required for the enzyme to act.

One consequence of drug/receptor interactions is that the more tightly a drug fits into its binding pocket, the higher the affinity of the binding. This means that the drug is more potent – it works at a lower concentration. One of the major challenges in developing effective drugs is to find chemical compounds that fit neatly into acceptor sites on molecules of interest. The more specific the binding (ideally, to the acceptor site on one, and only one, species of macromolecule) the fewer the side effects of that drug. A sophisticated understanding of organic chemistry and of protein structure is highly useful in this enterprise.

Pharmacokinetics

The preceding sections were concerned with the effects of drugs on the body (pharmacodynamics). Reciprocally, the body has effects on drugs (pharmacokinetics). The body usually inactivates drugs by metabolizing them – changing them into compounds that are inactive. However some drug metabolites are also active, sometimes even more active than the parent drug. Removal of drugs, and of their metabolites, also occurs through excretion. Each of these actions occurs with a time course that varies from drug to drug. The concentration of a drug may also be altered because the drug binds to non-target sites. Some drugs are absorbed slowly, taking a long time to reach an effective concentration at their target sites, while other drugs are absorbed rapidly. One of the factors that affects absorption of a drug, say from the digestive tract into the blood or from the blood into individual cells, depends on the ability of the drug to cross cell membranes. Is the drug lipid soluble; are there specific carriers that transport it across membranes? In order to prescribe the intelligent use of a drug, a physician must be aware of all these factors and, in addition, must know about the appropriate routes of administration of drugs (e.g. insulin, a protein, cannot be absorbed from the digestive tact and must be injected).

Name ______________________ Date _______________________

Sleep Log

Sleep Log

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date							
Bedtime: Fell Asleep at: (Hr:min)	*Monday night*	*Tuesday night*	*Wednesday night*	*Thursday night*	*Friday night*	*Saturday night*	*Sunday night*
Waketime (Hr:min)	*Tuesday morning*	*Wednesday morning*	*Thursday morning*	*Friday morning*	*Saturday morning*	*Sunday morning*	*Monday morning*
Naps							
Soda, coffee and tea consumption	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*	*Sunday*

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date							
Bedtime: Fell Asleep at: (Hr:min)	*Monday night*	*Tuesday night*	*Wednesday night*	*Thursday night*	*Friday night*	*Saturday night*	*Sunday night*
Waketime (Hr:min)	*Tuesday morning*	*Wednesday morning*	*Thursday morning*	*Friday morning*	*Saturday morning*	*Sunday morning*	*Monday morning*
Naps							
Soda, coffee and tea consumption	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*	*Sunday*

Example	
Date	8/27/99
Bedtime	11:38 pm
Waketime	7:15: am
Naps	none
Soda, coffee, tea	1 coffee at 10:00 am, 1 soda at 6:00 pm 1 soda at 7:30 pm

Name ____________________________ Date _____________

The Scientific Method

Used with permission from Mary's Mystery

The following is a review of the steps of the **Scientific Method**:

1. State a question about the problem you are dealing with or the phenomena that you have observed.
2. Based upon what you already know formulate a hypothesis [make a guess] to answer the question.
3. Gather data to test your hypothesis.
4. Evaluate the data to determine whether the data fit the hypothesis.
5. Based on your evaluation of the data you can:
   a. Conclude that your hypothesis is a plausible explanation for your observations for now,
   b. Revise your hypothesis in a way that accounts for the data, or
   c. Reject the original hypothesis and devise another.
6. When there is new information, original hypotheses are reevaluated.

Name ______________________ Date ___________

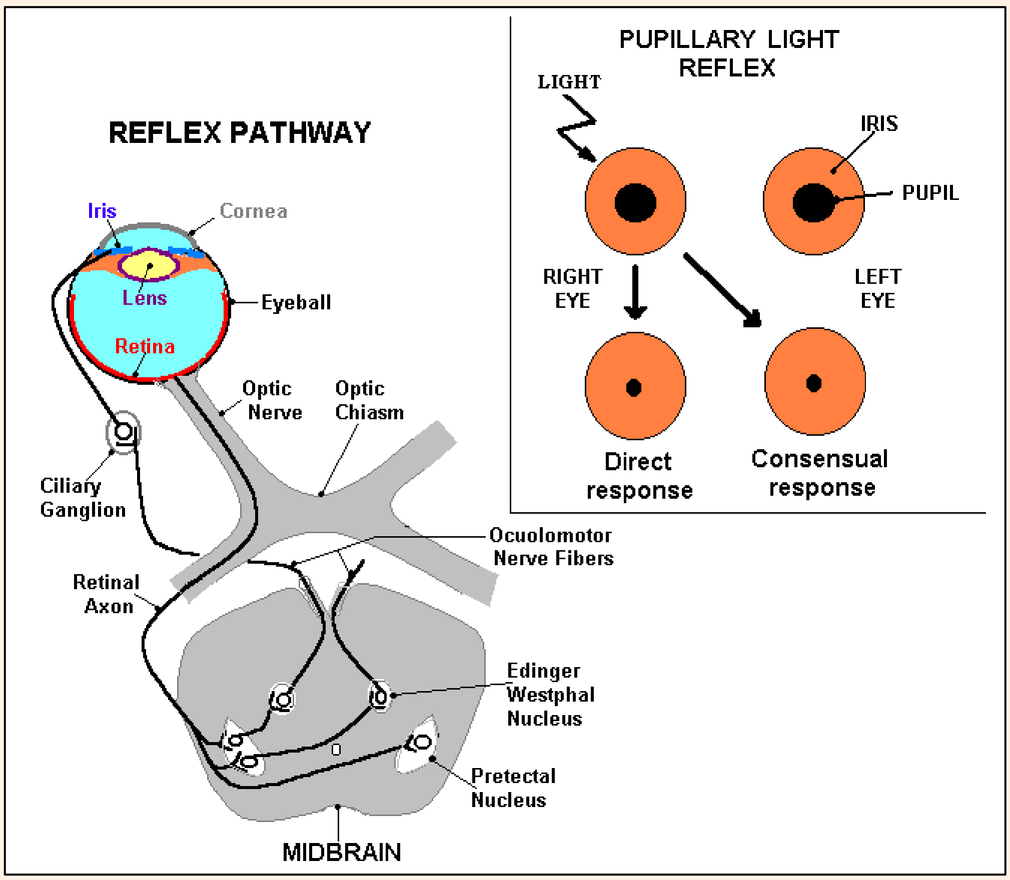
Hypothesis Testing Packet

Date Lesson	The Problem	Your Hypothesis/es	Your Observations	Hypothesis/es Testing

Pupillary Light Reflex

(Image and text courtesy of Mary's Mystery)

THE PUPILLARY LIGHT REFLEX. This reflex shows that even a simple-seeming action – the pupils' response to light – can involve complex, specific circuitry: Light absorbed by the rods and cones in the **retina** evokes (by way of intermediate neurons) trains of nerve impulses in the **optic nerve**. Then there is sequential activation, by way of axonal nerve impulses and excitatory synapses, of the series of neurons that make up the rest of the reflex pathway: Impulses in some of the optic nerve fibers activate neurons in the midbrain (in the bilateral **pretectal nuclei**). The pretectal neurons activate neurons in another pair of midbrain nuclei (**Edinger-Westphal nuclei**). The axons of these neurons go, by way of the **oculomotor nerve**, to the **ciliary ganglion** at the back of the eyeball. Finally, the ciliary ganglion neurons go to the iris; when they are activated they cause contraction of the smooth muscle fibers that surround the pupil (**pupillary sphincter muscle**). This causes the pupil to constrict, similar to the closure of a purse or laundry bag by a drawstring. (A separate reflexly controlled set of radial muscle fibers opens the pupil in the dark, or when we are startled). Because the optic nerve fibers from one eye go to both pretectal nuclei, light shining in one eye causes pupillary constriction in both eyes. If there is damage to the left oculomotor nerve, light shining into the left eye fails to cause constriction of the left pupil (the *direct* light response is absent, see inset), but still causes constriction of the right pupil (the *consensual* light response is intact, see inset). This reflex can also be used to test for lesions in this region of the midbrain.



What is Sleep?

How Do You Know Someone is Sleeping?

Sleep is a behavior and a biological brain state. A behavioral description of sleep may include the following. Sleep is a period of relative inactivity and lowered responsiveness to stimuli in the environment. People typically sleep with their eyes closed while lying down. People dream during sleep. A very important aspect of sleep is that it is quickly reversible, unlike coma.

Sleep is not a time when the brain is "turned off" like the turning off of a light switch. The brain is active when we sleep (see below).

Scientists define sleep by changes in brain wave activity also called the electroencephalogram or EEG. The EEG is a recording, from the scalp, of the electrical activity of the brain. The brain is made up of hundreds of billions of nerve cells called neurons. **As part of the way neurons normally communicate with each other they produce pulses of electricity.** In order to view and record the electrical activity of the brain, scientists place sensors on the scalp and use a machine called an electroencephalograph. Figure 1 shows an example of a digital sleep recorder. This piece of equipment represents a technological advance over the standard electroencephalographs used to record sleep physiology. This device can perform the job that a machine more than ten times its size performs in sleep laboratories around the world. Moreover, the information is stored on a computer disk versus a folded paper chart record that is over 3 inches thick. The electroencephalograph contains amplifiers which can record the tiny electrical brain waves that are on the order of microvolts. A microvolt is one millionth of a volt. As a comparison, the voltage of brain waves are about one-nine millionth of the voltage of 9 volt batteries used to power hand-held video games.

(Image courtesy of K. P. Wright)

The digital sleep recorder can record many physiological variables including brain wave activity (EEG), eye movement activity (EOG), muscle activity (EMG), heart rate activity (EKG), or respiration and skin conductance (sweat response).

Figure 1

What is Sleep?

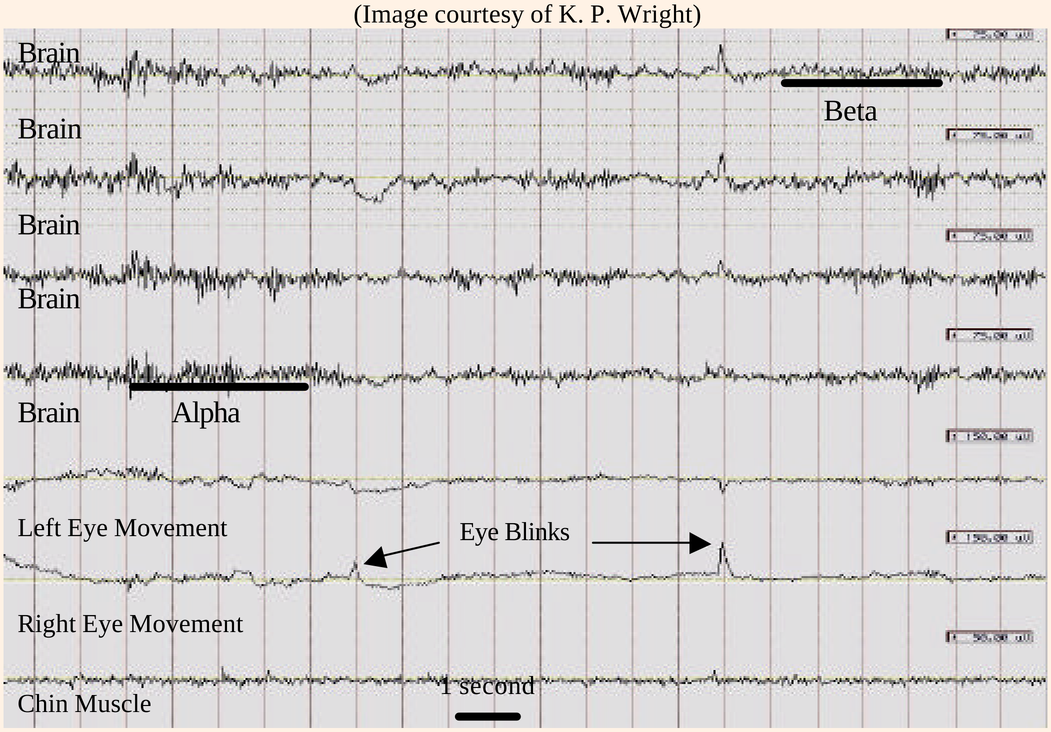
To investigate whether a patient is sleeping, doctors sometimes record the EEG. Figures 2-4 display EEG tracings for various stages of sleep and wakefulness.

When you are awake and alert, such as when performing mathematical calculations, your brain is very active. When you close your eyes and relax, the brain slows down and becomes relaxed. Figure 2 shows examples of both of these brain wave patterns.

Sleep scientists have found it useful to categorize sleep into distinct stages based upon changes in EEG brain wave activity, eye movements and muscle activity.

AWAKE

(Image courtesy of K. P. Wright)



This figure shows brain wave activity (EEG), eye movement activity (EOG) and chin muscle activity (EMG) for a human who is awake. When the eyes are closed and is the person is relaxed, the brain is relaxed and shows alpha activity. When the eyes are open and blinking, the brain wave pattern is active (fast frequency and low amplitude waves) and shows beta activity. The chin muscle (EMG) is active during wakefulness.

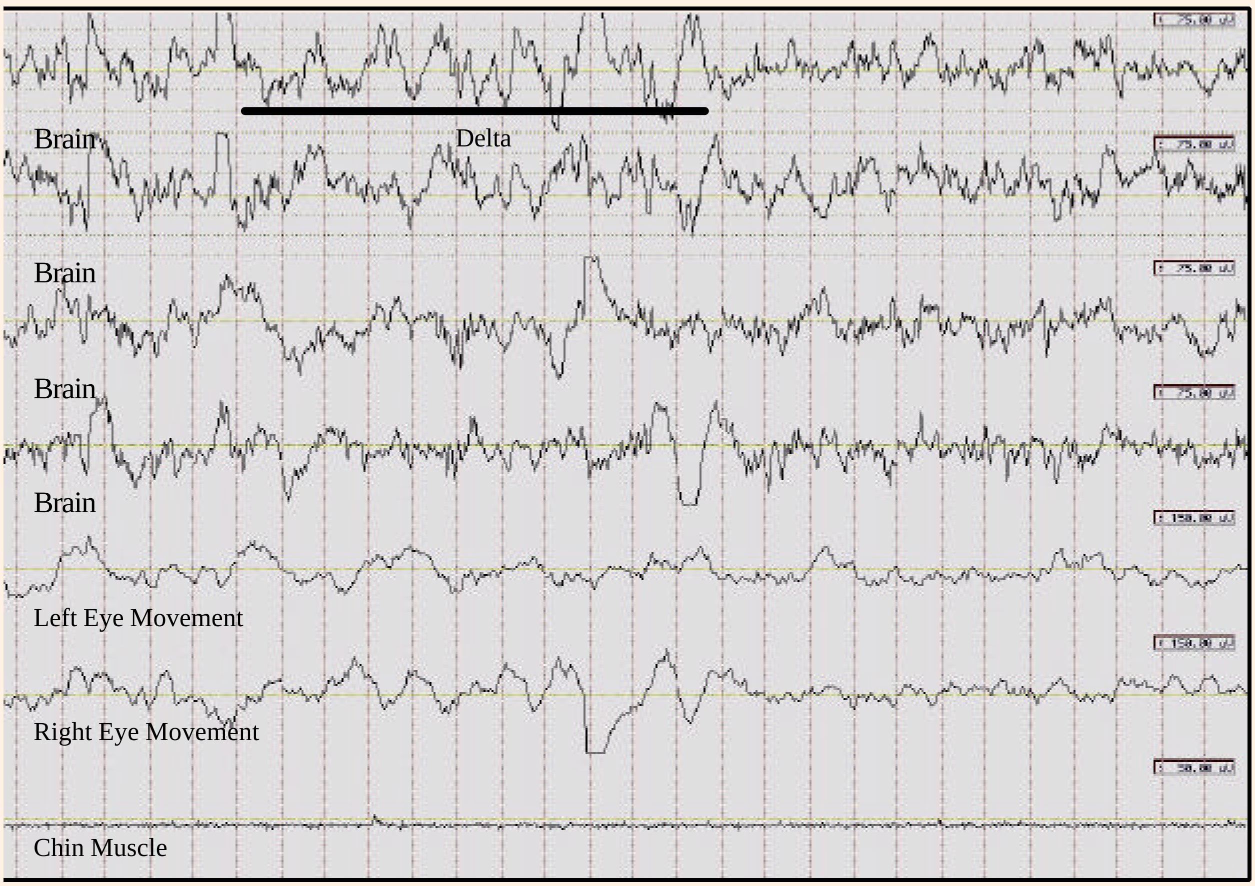
Figure 2

What is Sleep?

During sleep, there are two distinct patterns of brain activity referred to as non-rapid eye movement (NREM, pronounced non-REM) and rapid eye movement (REM) sleep. During NREM sleep, most of the brain slows down and becomes less active compared to that during wakefulness. During REM sleep the brain and the eyes are very active, similar to wakefulness, whereas the skeletal muscles are paralyzed because the parts of the brain that controls skeletal muscles are shut down. Without this muscle paralysis during REM sleep, people would act out their dreams.

NREM Sleep

(Image courtesy of K. P. Wright)

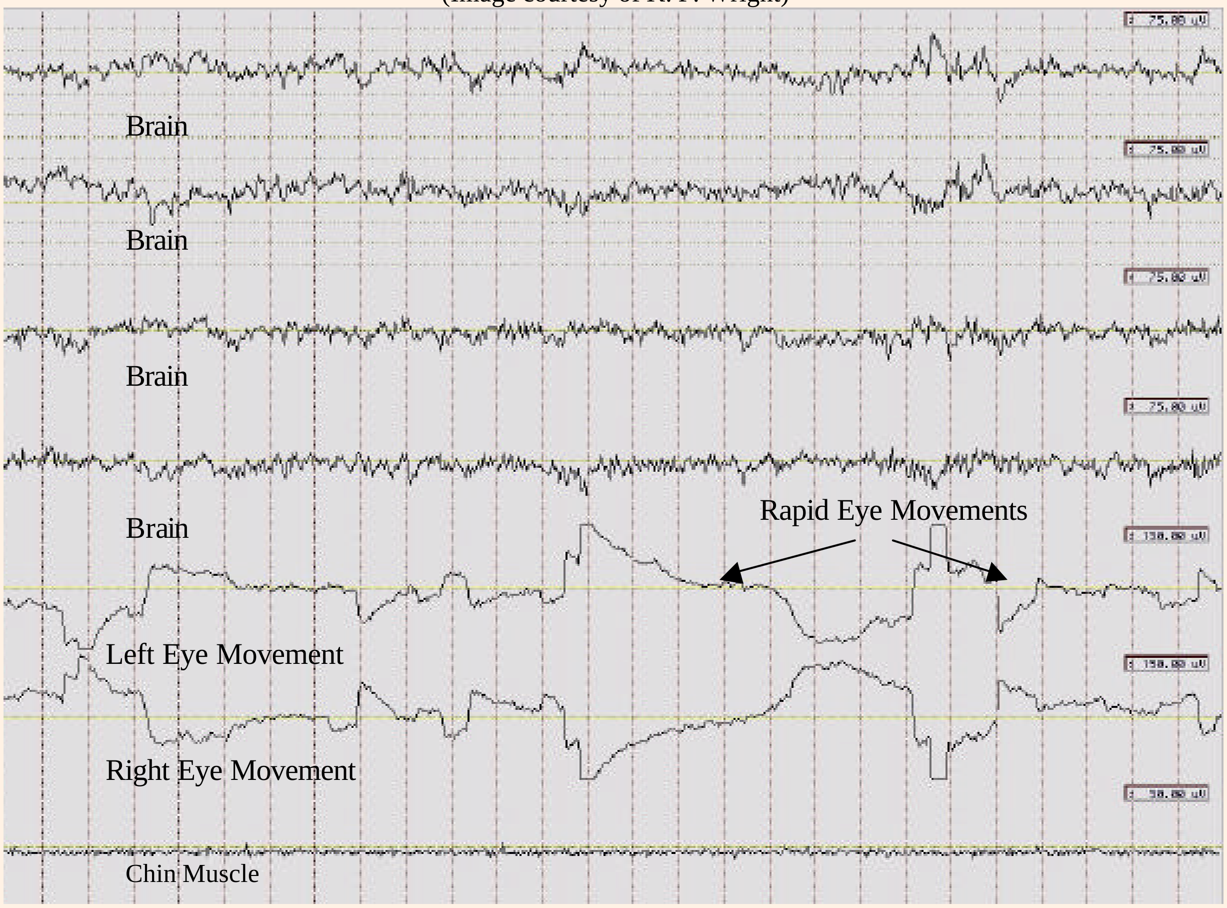


This figure shows delta brain wave activity and quiet eye movement and chin muscle activity for a human who is in deep NREM sleep. NREM is made up of 4 sleep stages (Stages 1, 2, 3 and 4). As a rule, the higher the stage number (1-4), the deeper the sleep. Note: The eyes are so quiet that in this example, the eye sensors are actually showing brain wave activity from the frontal lobe (front of the brain).

Figure 3

What is Sleep?

REM Sleep
(Image courtesy of K. P. Wright)



During REM sleep, the brain shows a pattern of theta activity which is slower than the EEG observed during wakefulness but faster than that observed during deep NREM sleep. The eyes exhibit rapid movements.

Figure 4

What is Sleep?

Additional examples of the sleep EEG can be found on the World Wide Web at
http://www.sleephomepages.org/sleepsyllabus/a.html

Brain Mechanisms of Sleep and Wakefulness

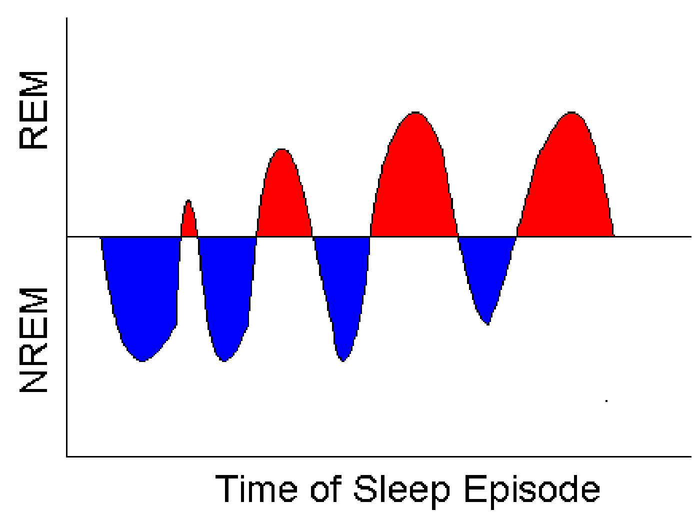
As noted, the brain does not simply shut off during sleep. In fact, **different regions of the brain actively produce either wakefulness or sleep**. **There are specific cells in the brain that are predominantly active during wakefulness that make you alert. Stimulating these brain cells will awaken a sleeping animal.**

There are also specific cells in the brain that turn on during NREM or during REM sleep. Some of these cells also inhibit (turn off) the brain areas that promote active wakefulness. Electrically stimulating brain regions that turn on during NREM or REM sleep can produce NREM or REM sleep.

The Pattern of Sleep Across The Night

In healthy adult humans NREM and REM sleep alternate throughout the night approximately every 80 to 100 minutes. Figure 5 shows the cyclic nature of NREM and REM sleep across the

(Image courtesy of K. P. Wright)



Every 80 to 100 minutes the pattern of sleep alternates between NREM (bottom) and REM (top) sleep. **NREM sleep is more prevalent in the first half of the night and REM sleep is more prevalent in the second half.**

Figure 5

What is Sleep?

night. In addition to changes in brain-wave activity, there are many physiological and behavioral differences between the various sleep stages and wakefulness.

Muscle activity is highest during wakefulness, generally decreases during NREM sleep and is **absent during REM sleep, except for the eye muscles**. During REM, cells in the brain stem block motor signals from the brain to the spinal cord, producing a state of muscle atonia or muscle paralysis. This muscle atonia prevents the animal from acting out it's dreams. Scientists measure muscle atonia by recording muscle activity of the chin muscles in humans.

Eye movements are rapid and oscillating during wakefulness, as we pay attention to objects in the environment. When someone falls asleep, the eyelids close, and the eyes move more slowly. During deep NREM sleep, the eyes are relatively quiet with little movement. REM sleep is characterized by rapid eye movements underneath closed eyelids; however, there can also be times during REM sleep when the eyes show little movement.

Heart rate and respiration are rapid and variable during wakefulness, slow down when someone falls asleep, and are regular and slow during NREM sleep. **During REM sleep, the heart beats fast and irregularly and respiration is more variable, both of which indicate an aroused state.**

Increased blood flow to the genitalia occurs in men and women during REM sleep resulting in penile and clitoral erections. These erections are not related to any sexual content of dreaming but are normal physiological characteristics of REM sleep. Sleep disorder laboratories commonly test for erections during sleep in males to determine if there is a physiological or psychological basis to impotence.

Waking, Consciousness and Dreaming during sleep During alert wakefulness we process information and respond to stimuli in the environment. Conscious thinking, learning, and the formation of new memories all occur during wakefulness. During sleep, the brain can still process stimuli in the environment; however, unless we wake up, we typically do not remember what happened. The sleeping brain appears to be unable to form new memories; however, classical conditioning may occur during sleep. The fact that new memories cannot be formed during sleep explains why some people do not report that they dream. Unless you awaken from a dream, you will not remember it. When awakened from REM sleep people report a vivid dream about 80% of the time. If awakened from NREM sleep, people typically report that they were thinking, but dream reports also occur. The fact that new memories cannot be formed during sleep indicates that you should not spend your money or time on products that claim you can learn a new skill while you sleep. **There is no scientific evidence indicating that people can learn new information while asleep. Importantly though, research has shown that the retention or memory for**

information learned during wakefulness is improved by subsequent REM sleep. These data suggest that people who study at least for several days before a test and get a good night's sleep before taking a test will perform much better than someone who pulls an "all-nighter" and crams at the last minute. Other research shows that, in addition to studying the material prior to the night before an exam, reviewing the material the morning of and immediately before a test also helps to improve test performance. These and other research findings suggest that one of the functions of sleep, specifically REM sleep, is the processing and storage of information acquired earlier during the waking day (see below).

Hypotheses about the Function of Sleep

Sleep is an evolutionary survival strategy. This hypothesis states that sleep evolved to keep animals out of harm's way (e.g., the visual system of many animals, including humans, does not function well in the dark) and to be active when food is available.

Energy conservation: This hypothesis states that sleep saves energy and allows the body to recover. However, **sleep does not appear to be necessary for the body to rest or recover**. The body can conserve the same amount of energy just by resting.

Rest for the brain: This hypothesis states that sleep is for brain restoration and recovery**. Sleep does appear to be more important for brain than for body function**. However, what sleep does for brain restoration is unknown. Replenishment of neurotransmitters? Protein synthesis? Removal of waste products that result from wakefulness?

Important for brain development early in life: Because infant humans sleep nearly twice as long as adults and have twice as much REM sleep, this hypothesis states that sleep is important for development.

Memory consolidation: This hypothesis states that during sleep, the brain processes information collected during wakefulness. A related hypothesis is that sleep serves to remove unnecessary information from memory – e.g., clean shop. REM sleep serves as a time to facilitate or relearn old memories/instinctual behaviors. For example, dogs seem to dream of chasing or playing with another animal, as they bark, whine and kick their legs during REM sleep (Dogs are not completely paralyzed during REM sleep, as are humans).

Sleep as a safe place to release intense emotions: During REM sleep, we can have all the physiological arousal associated with emotion and yet not remember it unless we awaken.

Sleep Hypnogram

This figure shows a detailed typical sleep pattern for a healthy young male across one night of sleep. In this example, the individual entered stage 1 sleep about 10 minutes after going to bed. The individual then quickly passed into stages 2, 3 and 4 sleep. After about 30 minutes of stage 4 sleep, the person returned to stage 2 and then went into REM sleep. This period of REM sleep is relatively short and the sleep returned to stage 2. This pattern of oscillation among the sleep stages continued throughout the night. In general, the amount of Stage 3 and 4 sleep were high during the first half of the night whereas the amount of REM sleep was highest in the second half of the night.

(Image courtesy of K. P. Wright)

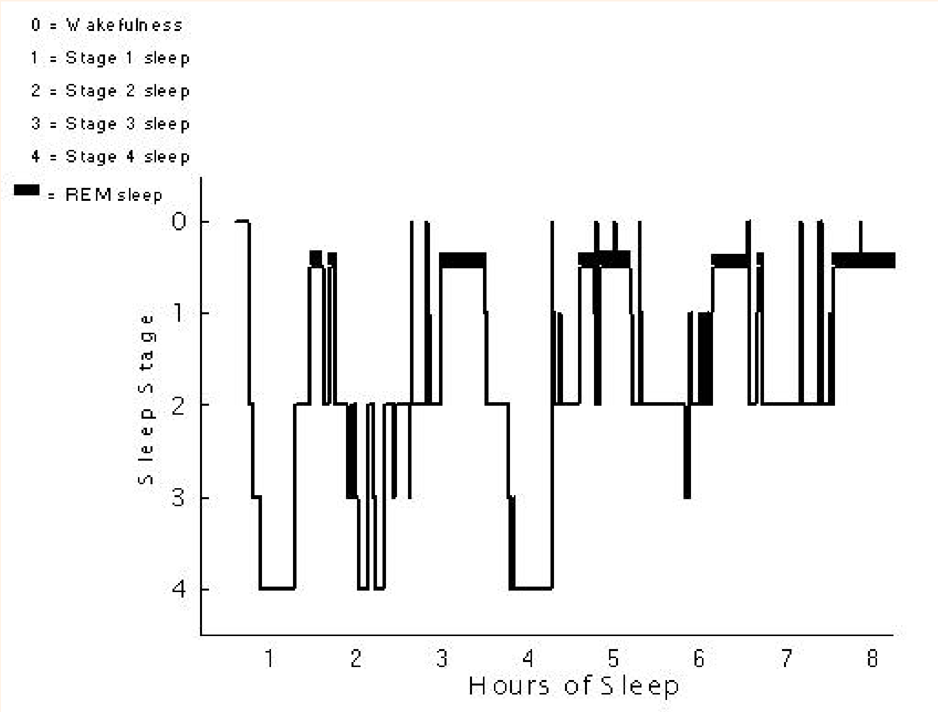


Figure 1 - Hypnogram

There are also specific EEG patterns that are unique to sleep. Sleep spindles and K-complexes are brain wave patterns that occur during stage 2 sleep. K-complexes and sleep spindles are thought to be inhibitory waveforms that promote the continuation of sleep. During REM sleep the brain is active showing a fast, low amplitude pattern similar to that seen during wakefulness or stage 1 sleep, however, REM sleep can be as difficult to awaken from as is deep stage 3 / 4 sleep. Most dreaming occurs during REM sleep. However, dreaming may also occur in other sleep stages. Dreaming is defined as the bizarre, fantasy-like images in the mind not directly evoked by sensory stimuli. Thinking occurs in all stages of sleep.

Ions and Impulses

ION MOVEMENTS PRODUCE THE RESTING POTENTIAL AND NERVE IMPULSE

(Adapted with permission from Mary's Mystery, Minority Faculty Development Department HMS)

Introduction

Resting potential. Cells, in general, have a potential difference (voltage) across their cell membranes. When cells are not generating electrical signals, this voltage is steady and is called the resting potential. In most cells the resting potential is in the range 0.04-0.09 volts (40-90 millivolts; abbreviated as mV) with the inside of the cell negative with respect to the outside. A typical value for neurons is -70 mV.

Neuronal action potentials. Action potentials, are produced by nerve, muscle and gland cells (and by some protozoan and plant cells). The action potential is one of the major electrical signals generated by these cells. In neurons it is often referred to as the nerve impulse. The action potential is a transient change from the resting voltage, usually about 100 mV in amplitude and lasting about one thousandth of a second (1 millisecond; abbreviated as msec). The action potential (nerve impulse) is self-propagating and rapidly informs one part of a cell that something has happened in another part of the cell. This is especially important in the nervous system where the axons of some neurons can be more than a meter in length – for example, extending from the tip of a toe to the base of the brain; in this case the nerve impulses might be carrying information to the brain about pressure on the toe (most axons are much shorter than this and many axons extend only a few millimeters). The speed of propagation of the action potential can vary dramatically from one axon to another, depending on the diameter of the axon and whether it has a myelin sheath. Larger axons conduct impulses more rapidly, but a much greater increase in speed occurs when an axon becomes myelinated. The largest myelinated axons, like those of motor neurons that activate contraction of voluntary muscles, conduct impulses at 80-100 meters/second (ca. 200 miles per hour [you might ask students to make this conversion from meters/sec to miles/hour]). In contrast, the smallest diameter, unmyelinated, axons (like those that carry information about painful stimuli) conduct impulses at less than 1 meter/sec, the pace of a slow walk. The myelinated axons carrying impulses evoked by pressure on the toe are of intermediate diameter and propagate their impulses at about 50 meters/second (you might ask students to calculate the time it takes an impulse, traveling at 50 meters/second, to go from the tip of a toe to the medulla, at the base of the brain [ans., about 30 msec]; note that our awareness of the world lags behind actual events).

Muscle action potentials. The muscle fibers that make up voluntary (skeletal) muscles also conduct action potentials. These muscle action potentials are an essential step in a long sequence of events that cause a muscle fiber to contract. We can break into this sequence at the point at which an action potential is traveling along a motor axon that extends from the spinal cord to the specific muscle it innervates. (This action potential has been evoked in the motor neuron [in the spinal cord] by synaptic inputs from other parts of the central nervous system.)

In the muscle, the motor axon branches repeatedly and terminates on a number of muscle fibers, In one branch (each making a cluster of endings) per fiber. Consider the motor axon terminals on one of these muscle fibers. The arrival of the action potential causes the release, from the axon terminals, of the neurotransmitter, acetylcholine. The acetylcholine combines with receptors (large protein molecules)

Ions and Impulses

This property of membranes that allows them to pass certain substances, while retaining others, is called **selective** permeability. This remarkable specialization is basic to life. It allows the cytoplasm to maintain its huge array of complex biochemical reactions separate from the extracellular fluid and, yet, permits the required movements of certain molecules between the two compartments. Selective permeability for ions is due to the presence in the membrane of specific channels composed of proteins. The existence of protein channels was hypothesized even before they were identified, because of the following consideration. The basic structure of the membrane is a bimolecular layer of fatty, lipid molecules (they are hydrophobic). Ions, which are highly soluble in water, are practically insoluble in lipid (they are hydrophilic). Because the hydrophilic ions can't dissolve in the hydrophobic membrane, they need a special conduit to get them across. This conduit, or channel, has to be hydrophobic on the outside (to reside in the lipid membrane) and hydrophilic on the inside (to allow ions to move into and through the channel). Nature has constructed channels with just these properties by taking advantage of the fact that some amino acids, the building blocks of proteins, are hydrophobic while others are hydrophilic. The protein chains that form a channel fold up in such a way that the hydrophobic amino acids are on the outside and the hydrophilic amino acids are on the inside, lining the pore. Moreover, the structure of the hydrophilic pore is very particular and precise. Because of this, one type of channel may have a pore structure that makes it selectively permeable to K^+ (relatively impermeable to Na^+), while another type (with a different amino acid composition) may be selectively permeable to Na^+ (relatively impermeable to K^+).

We can now restate, in terms of channels, the observation made above about the selective permeability of the resting membrane for K^+: The resting membrane has channels selectively permeable to K^+ but lacks channels permeable to An^-. This simple fact provides an explanation for the resting potential. To see how this works, initially ignore all other ions except K^+ and An^-, both of which are at high concentration in the cytoplasm. Let's also assume, to start with, that there is no potential difference across the membrane (i.e. no resting potential). K^+ begins to diffuse out of the cell, down its steep concentration gradient (see Table 1) because the membrane has K^+ channels. But, An^- can't accompany the K^+ because the membrane lacks An^- channels. This separates K^+ from An^- and, therefore, positive charges from negative charges. The stored energy of the concentration gradient is being tapped to do electrical work. The process leaves an excess of negative charge (An^-) inside and an excess of positive charge (K^+) outside. This separation of positive from negative charges gives rise, of course, to a potential difference across the membrane.

As K^+ flows out, more and more charge is separated, and the membrane potential increases. How long will the net outflow of K^+ continue? How large a potential difference will be generated? Note that the developing potential difference tends to oppose the outflow of K^+. The direction of the potential gradient sharply (a large number of additional K^+ channels open), leading to the falling phase. This increasing negativity then turns off the enhanced K^+ permeability and also removes sodium inactivation, completing the cycle. The channels are now ready to produce another action potential.

Ions and Impulses

Notice that in this intricate mechanism there are circular interactions (a kind of positive feedback followed by a kind of negative feedback). We saw that an increase in Na^+ permeability causes the membrane potential to become more positive (because Na^+ ions enter). But, this positive-going change in membrane potential causes an increase in Na^+ permeability. This, in turn, will cause an additional increase in positivity which will cause an additional increment in Na^+ permeability, and so on in a spiraling, "explosive" increase in both Na^+ permeability and membrane positivity. This explosive (positive feedback) aspect explains why the rising phase of the action potential is so rapid and also accounts for the all-or-nothing property of the action potential. During the falling phase there is a kind of negative feedback. The delayed inactivation of the Na^+ permeability and the secondary increase in the K^+ permeability, although caused by *positive-going* changes in membrane potential, give rise to *negative-going* changes in membrane potential and the restoration of the resting condition. The sodium inactivation and the rise in K^+ permeability also account for the refractory period of the action potential.

How do changes in membrane potential open, close and inactivate channels? Channels consist of large multi-unit protein complexes with a pore through the center. Movement of ions through the pore is controlled by "gates". These gates are parts of the channel proteins that can move. In one position they block the pore (channel closed); in another position they leave the pore unblocked (channel open). The gating components of the channel proteins bear multiple electrical charges. Changes in membrane potential will, therefore, exert a strong electrical force on these components, by electrostatic attraction and repulsion, causing them to move (into or out of the blocking position). The activation and inactivation of the Na^+ channels are controlled by separate gates. Both the activation and inactivation gates are moved by positive-going changes in voltage but with opposite effects. The positive-going voltage shifts the activation gate *out* of its blocking position (opening the channel) and, more slowly, shifts the inactivation gate *into* its blocking position (closing the channel).

The table on the next two pages shows the diversity of channels that are present in neurons (and other cells) and indicates several different schemes by which channels can be classified.

Ions and Impulses

The Classification of Ionic Channels

The cell membrane channels through which inorganic ions leave or enter cells generate the currents that underlie the variety of electrical signals in the nervous system. These signals are the currency that neurons use in going about their business. Channels can be classified in several ways:

I. One classification is by the type of **GATING MECHANISM**. Channels can be:

A. **UNGATED** (i.e., always open, like resting K^+ channels), or

B. **GATED** by various agents, such as:

1. **CHANGES IN MEMBRANE POTENTIAL** (e.g. the Na^+ and K^+ channels of the action potential), or

2. **CHEMICAL LIGANDS** (e.g. transmitters) that act at synapses,

   a. **DIRECTLY** on an integral receptor/channel complex, or by way of

   b. **SECOND MESSENGERS** and/or **G-PROTEINS** (providing interaction between separate receptors and channels; this is a rich topic needing its own classification scheme), or by

3. **SENSORY STIMULI**, such as

   a. **MECHANICAL DEFORMATION** (e.g. touch, stretch, pressure or deflection of the stereocilia of hair cells),

   b. **RADIANT ENERGY** (e.g. heat, light or electrical fields), or

   c. **CHEMICALS** (e.g. tasty, smelly or corrosive molecules).

II. Another classification is by **ION SELECTIVITY**:

A. Some open channels pass only **CATIONS** (positively charged ions), with either:

1. **LOW SELECTIVITY** (e.g. the directly gated channels opened by ACh at neuromuscular junctions; these pass both Na^+ and K^+ [and some Ca^{2+}] and generate excitatory post-synaptic potentials [EPSPs]), or with

2. **HIGH SELECTIVITY** (e.g. the voltage-gated Na^+ and K^+ channels involved in generating the action potential; or many K^+ channels controlled by second messengers.)

B. Other open channels pass only **ANIONS** (negatively charged ions; e.g. channels opened by GABA or glycine in the brain; these pass predominantly Cl^- and generate inhibitory post-synaptic potentials [IPSPs]).

Ions and Impulses

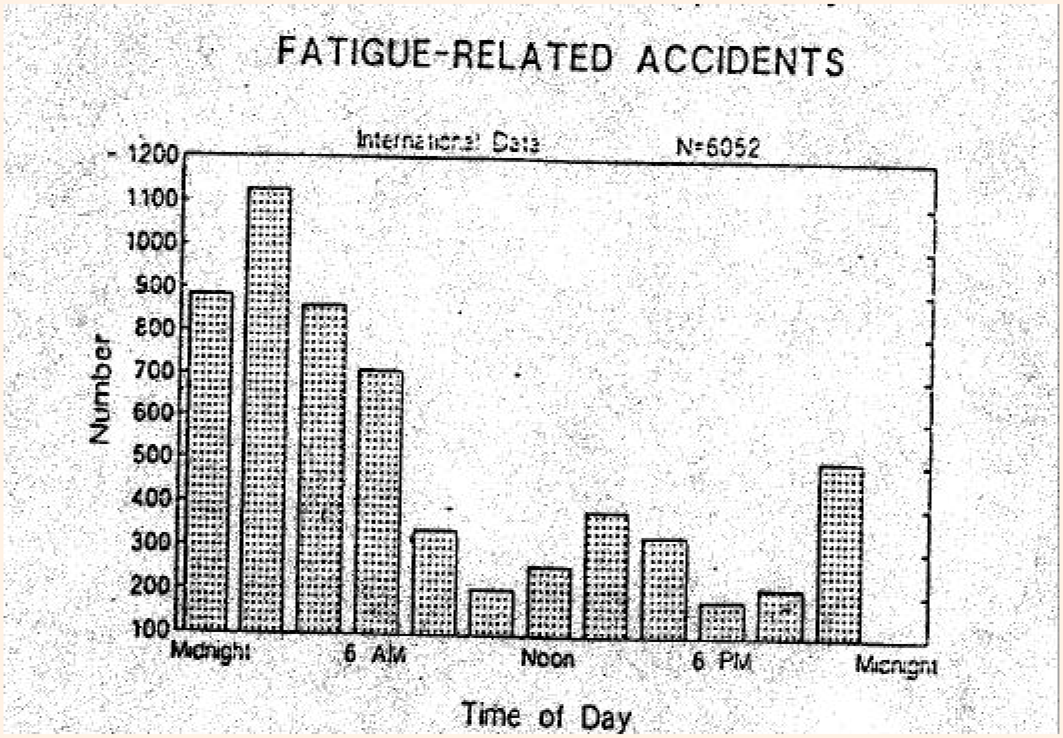
III. A third way of classifying "channels" is based on **ENERGY REQUIREMENTS**:

A. Some open channels (those described above) allow ions to flow **DOWN** their electrochemical gradients (passive diffusion).

B. Ion pumps (e.g. the Na^+/K^+ ATPase) are channel-like structures that transport ions **UP** their electrochemical gradients (and require the expenditure of energy supplied by hydrolysis of ATP).

Fatigue-Related Accidents

(Image courtesy of “Sleep”)



Vehicluar accidents due to fatigue plotted as a function of the time of day. This figure combines data from Lavie et al. (1986; Israel: n=390), Langlois et al. (1985; Texas: n=4994) and Duff (Unpublished observations; New York: n=668).

Figure reprinted with permission from MM Mitler, MA Carskadon, CACzeisler, WC Dement, DF Dinges and RC Graber (1988). Catastrophes, Sleep and Public Policy: Consensus Report. 11: 100-109.

At what times of day are the most cars on the road?

Is that when most fatigue-related accidents occur?

Appendix 9:

HELPING YOURSELF TO A GOOD NIGHT'S SLEEP

(Used with permission from the National Sleep Foundation)

Introduction

Difficulty falling or staying asleep is a common problem. About half of Americans report sleep difficulty at least occasionally, according to National Sleep Foundation surveys. These woes - called insomnia by doctors – have far-reaching effects: a negative impact on concentration, productivity and mood.

Fortunately, there are many things you can do to improve your sleep. The first step requires some detective work. You will need to examine your diet, exercise patterns, sleeping environment, personal habits, lifestyle and current concerns. As you begin to see the connection between, for example, what and/or when you eat and nights of poor sleep, you can develop your own good sleep plan.

Keep in mind that good sleep doesn't always just happen. Like a successful play, a restful night of ZZZ's demands a strong director's hand and a stage set appropriately. If you've been sleeping poorly for some time, you may have fallen into some bad sleep habits that reinforce your problem. Read on to learn more about sleep.

Just Say No...to Caffeine and Alcohol?

All too often, we eat and drink without thinking about the effects. That afternoon cup of coffee seems like a good idea at the time. The dinnertime wine may appear a fitting celebration of the day's success. But that same drink can prove an enemy of restful sleep.

Coffee contains caffeine, as do many teas, chocolate and cola drinks. Caffeine is a stimulant, which means it has an alerting or wake-up effect. For some people, a small amount of caffeine early in the day can cause problems falling asleep ten to 12 hours later. Others have learned to avoid caffeine-containing drinks and foods within six hours of bedtime.

How you respond to caffeine is individual; it is also related to how much caffeine you have regularly. For example, the more coffee you drink each day, the less powerful its effect as a stimulant.

How to determine caffeine's effect on you? Try eliminating caffeinated food and drink after lunch for a few weeks. Are you sleeping better? If so, you may have identified the culprit.

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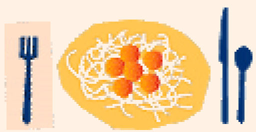
Alcohol, in contrast, is often thought of as a sedative: a calming drug. However, while alcohol may speed the beginning of sleep, it actually increases the number of times you awaken in the later half of the night. If your sleep isn't restful, alcohol (beer, wine, hard liquor) may be the cause. Skip the nightcap and see if your sleep improves.

Are You What You Eat?



Caffeine and alcohol aren't the only substances that affect your sleep. Everything you eat can affect nighttime slumber. For example, tomato products and spicy foods give many people heartburn (as does eating too fast). What does heartburn have to do with sleep? Lying down makes heartburn worse, and heartburn itself makes falling asleep more difficult. Heartburn also awakens sleepers with middle-of-the-night discomfort.

Drinking too much of any beverage can lead to more awakenings because of the need to urinate during the night. Also, the older we get, the more we experience these nighttime awakenings.

Try to restrict your fluids before bedtime to help promote an uninterrupted night's sleep. If the problem persists, talk to your doctor.

Another cause of sleep problems can be eating too much - of any food – that can make sleep difficult. A heavy meal close to bedtime may make you less comfortable when you settle down for your night's rest. At the same time, going to bed hungry can be just as disruptive to sleep as going to bed too full.

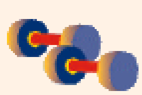
Bedtime Snack Facts

- Do not eat or drink too much close to bedtime.
- Consider a small snack to ease bedtime hunger pains.

Saying Goodbye to Tobacco?

Smokers and nonsmokers alike may not be aware that nicotine, like caffeine, is a stimulant. And when smokers go to sleep, they experience nicotine withdrawal. Research suggests that nicotine is linked to difficulty falling asleep and problems waking up. Smokers may also experience more nightmares. Giving up smoking may cause more sleep problems at first, but the long-term effect on sleep and health is much better. So kick those cigarettes goodbye.

Exercise Has Many Benefits



The next place to look for the cause of a sleep problem is your exercise routine. Exercise can be a boon for good sleep, especially when done regularly in the afternoon and not too close to bedtime. If you don't exercise regularly, add good sleep to a long list of reasons why you should take up the practice.

Why not try an afternoon brisk walk, run or bicycle ride instead of a coffee break? Consider combining aerobic (activity that increases the heart rate) exercise with a weight-bearing or resistance workout. (Be sure to check with your physician before beginning any exercise routine.) Research suggests that exercise at this

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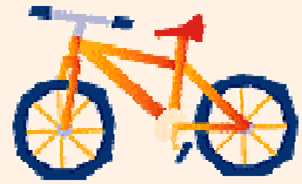
time can help deepen your sleep, which means that you spend more time in deeper stages of sleep. During the lighter stages of sleep, awakenings are more common. Also, people who exercise may take less time to fall asleep than people who don't.



When you exercise, whether you are physically fit and a regular or occasional exerciser, the type of exercise you select, and your age or sex may all affect sleep. Some studies suggest that exercise 2-3 hours before bedtime can keep sleep at bay.

Traditionally, sleep experts have cautioned people to avoid strenuous exercise right before sleep and even up to three hours before bedtime. That's because exercise has an alerting effect and raises your body temperature. This rise leads to a corresponding fall in temperature five to six hours later, which makes sleep easier then. That's why late afternoon may be the perfect time for your exercise. If you've been exercising close to bedtime and having trouble falling or staying asleep, try to arrange your workout earlier in the day.

Sleep Tips

Want a better night's sleep? Try the following:

- Consume less or no caffeine and avoid alcohol.
- Drink less fluids before going to sleep.
- Avoid heavy meals close to bedtime.
- Avoid nicotine.
- Exercise regularly, but do so in the daytime, preferably after noon.
- Try a relaxing routine, like soaking in hot water (a hot tub or bath) before bedtime.
- Establish a regular bedtime and waketime schedule.

Keep a sleep diary before and after you try these tips. (See NSF Sleep Diary.) If the quality of your sleep does not improve, share this diary with your doctor.

Is It Hot...or Humid Enough for You?

Finding and maintaining the right temperature for sleep sounds easy...but isn't. Even sleep researchers fail to agree on the ideal temperature. In general, most sleep scientists believe that a slightly cool room contributes to good sleep. That's because it matches what occurs deep inside the body, when the body's internal temperature drops during the night to its lowest level. (For good sleepers, this occurs about four hours after they begin sleeping.)

But how cool should the bedroom be? And what should couples do who share a bed but disagree about the desired sleep temperature? Turning the thermostat down at night in cold weather saves on fuel bills and sets the stage for sleep. Blankets or comforters can lock in heat without feeling too heavy or confining. An electric blanket may help. Or the heat-seeking partner might dress in warmer bedclothes (even socks!), while the warmer partner might shun sleep clothes or bed covering.

In summer, a room that's too hot can also be disruptive. In fact, research suggests that a hot sleeping environment leads to more wake time and light sleep at night, while awakenings multiply. An air conditioner or fan can help. Remember the common summer complaint: It's not the heat, it's the humidity? If excess humidity is a problem, consider a dehumidifier.

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If too dry an environment is your problem, consider a humidifier. Clues like awakening with a sore throat, dryness in your nose, or even a nose bleed are signs of too little humidity. Note: Be sure to change the water daily.

Body Heating and Sleep

Interestingly, body-heating can have a very different effect from a warm room during sleep. Some studies suggest that soaking in hot water (such as a hot tub or bath) before retiring to bed can ease the transition into a deeper sleep.

This may be due to a temperature shift (core body temperature drops after leaving the tub, which may signal the body it's time to sleep). Or the sleep improvement may be related to the water's relaxing properties, which may also have sleep-promoting effects.

A pre-bedtime bath may set the mood for children and adults alike. Why not try soaking in hot water to ease your journey to sleep?

Are You Enlightened About Light...and Dark?

People who work at night know all too well the problem of trying to sleep when the world around them is wide awake. When the sun's rays come streaming in, it's even harder. But the sun is more than a sign that it's daytime. Light - strong light, like sunlight - is the most powerful regulator of our biological clock. The biological clock influences when we feel sleepy and when we are alert.

When do you get your sunlight exposure? People who are housebound get little. In fact, the cause of your sleep difficulty may be just that: too little exposure to sunlight.

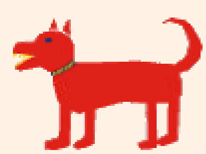
If you find yourself waking earlier than you'd like, why not try increasing your exposure to bright light in the evening? If sunlight isn't available, consider a lightbox (or light visor) available from a specialty store. Either way, as little as one to two hours of evening bright light exposure appears to help you to sleep longer in the morning. This may be especially helpful for the elderly.

During sleep, bright lights can distrub your sleep. Keep your bedroom dark (consider light-blocking shades, lined drapes, even an eye mask) so light doesn't interfere with your passage to slumber.

A sleep specialist can help determine whether changing your exposure to light might improve your sleep, and when would be the best time for you to experience bright light.

What's All the Noise About?

Do you find your sleep disrupted by noises such as the screech of sirens, the rumble of trains, the rise and fall of conversation, airplanes overhead, a dog's barking, or a partner's snoring? You may be surrounded by a steady stream of noise or it may occur in sudden peaks.



Older people may be particularly bothered by noise. Because their sleep may be frail, it is more likely to be disturbed by lower levels of noise.

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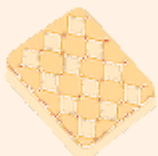
HELPING YOURSELF TO A GOOD NIGHT'S SLEEP

Noise Control

If noise is disturbing your sleep, consider:

- ear plugs
- white noise, which comes from a noise-making machine such as a fan or generator
- rugs
- heavy curtains or drapes
- double-pane windows
- relaxing music or tapes

Is Your Bed All that It Can Be?



Many people change where they live or what they drive more often than they change their mattress or pillows. Yet nothing lasts forever.

Although there isn't much published research on mattresses, mattress quality may affect how sleep feels to the sleeper. Discomfort can make falling asleep more difficult and lead to restless slumber.

Does your mattress provide the support you like? Do you wake with your back aching? Is there enough room for you and your sleep partner? Do you sleep better, or worse, when you sleep away from home?

Mattresses may be made of inner springs, foam, fabric, water or air. They may be firmer or more responsive to your body. This, in turn, may affect body temperature and humidity, as well as comfort.

What Does Your Bed Mean to You?

If you can fall asleep easily on your sofa or chair, and it is difficult to fall asleep in your own bed, you may be associating your bed with everything but sleep. Do you use your bed for work? Balance your checkbook while propped against the pillows? Watch television there? These are ways to tell your body to be alert in bed, not to go to sleep.

To teach patients to associate their bed and bedroom with sleep, sleep specialists advise a strategy called stimulus control, performed under the supervision of a specialist. Patients learn to use their bed only for sleep and to follow a regular wake-up schedule.

Another effective approach involves restricting your time in bed, initially, to the number of hours you actually sleep. Then, as you can rely on sleeping these hours regularly, you increase your time in bed by 15-30 minutes per night. A less dramatic approach would be to decrease your time in bed by 30 to 60 minutes.

Reclaiming Your Bed for Sleep

- Use your bed only for sleep and sex.
- Only get into bed when you're tired.
- If you don't fall asleep within 15 minutes, get out of bed. When you're sleepy, go back to bed.
- While in bed, don't dwell on not sleeping or your anxiety will increase.

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- Think relaxing thoughts: picture yourself soothed in a tub of hot water, or drifting to sleep, each muscle relaxed.

Are You Trying Too Hard?

Some sleep specialists say that anxiously watching the clock while focusing on how much time you have yet to sleep may actually cause insomnia. Try setting your alarm, then hiding it and your watch before you go to bed.

Are You Playing by the Numbers?

The time you go to sleep and the time you rise may sometimes seem beyond your control. Consistent bedtimes and wake times are advisable for those experiencing insomnia. Sleeping in may make for a more enjoyable weekend, but Monday morning - and Sunday bedtime - may suffer as a result. You choose: sleep late on the weekends...or feel refreshed and alert every morning?

Napping Notes

To nap or not to nap, that is the question. If you suffer from insomnia, try not taking a nap. If the goal is to sleep more during the night, napping may steal hours desired later on. However, napping can help promote short-term alertness, for example, to prepare for driving or in the middle of a long car trip.

Napping Tips

- Plan on a nap of just 20-30 minutes.
- If driving, nap in a safe place, such as in your locked car in a well-lit rest stop.
- Don't use a nap to try to substitute for a good night's sleep. If you're a regular napper, and experiencing difficulty falling or staying asleep at night, give up the nap and see what happens.

How Can You Relax?

Relaxing may mean choosing the bedtime ritual that's right for you. Does gentle music lull you to sleep? A calming soak in a warm bath or hot tub? Cozy pajamas? Cuddling with your partner? Meditation or a prayer? Find what works for you...and do it! Sweet dreams.

If you find your thoughts turning to worries when bedtime approaches, keep a worry book by your bedside. Jot down a brief note about what's on your mind. Schedule time the next day to focus on the problem and a solution. Problems often seem smaller in the daylight. However, if problems persist, consider talking to your doctor or a psychotherapist.

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Getting Help

If your sleep problem persists, there may be an underlying cause that can be successfully treated or controlled once properly diagnosed. Sleep centers are staffed by physicians and other medical professionals who specialize in helping people with persistent sleep problems.

Write to the National Sleep Foundation (NSF) or visit the NSF Web site for more information.

National Sleep Foundation
729 Fifteenth St., NW, Fourth Floor
Washington, DC 20005

The NSF thanks the following:
Reviewers: Thomas Roth, PhD, James Walsh, PhD
Writer: Joan Rachel Goldberg
Editor: Pat Britz
Designer: Mary Ann Bruce
Illustrator: Lisa Toji

Appendix 10:

HOW SLEEPY ARE YOU? 1999 U.S. SLEEP SURVEY SHOWS DISTURBING TRENDS IN DAYTIME SLEEPINESS

(Used with permission from the National Sleep Foundation)

More than Ever, Tired Americans, Young and Old, Are Experiencing Consequences

WASHINGTON, DC (March 24, 1999) - A 1999 national survey released today at The National Press Club finds millions of Americans are suffering from daytime sleepiness so pervasive that it interferes with their daily activities. As a wake-up call to the importance of sleep in the lives of Americans, experts at the National Sleep Foundation (NSF) discussed the serious national problems highlighted by the survey.

The second annual "Sleep in America" survey was sponsored by the National Sleep Foundation to launch National Sleep Awareness Week, March 29 - April 4, 1999. The survey was conducted in December 1998 and early 1999 through telephone interviews with 1,014 Americans.

"This trend in daytime sleepiness should raise concerns among parents, health care professionals, educators, safety experts and employers," says Thomas Roth, Ph.D., Health and Scientific Advisor of the National Sleep Foundation. "Lack of sleep and sleep problems can have serious, life-threatening consequences-not to mention a significant impact on productivity."

The Sobering Realities of Daytime Sleepiness

According to the National Sleep Foundation's "1999 Sleep in America" poll, 40% of adults say that they are so sleepy during the day that it interferes with their daily activities. Of critical concern is the effect of sleepiness on driving. Drowsy driving causes at least 100,000 crashes in the United States each year, according to National Highway Traffic Safety Administration reports. In NSF survey responses, 62% of adults (72% of men and 54% of women) reported driving while feeling drowsy; and 27% (36% of men and 20% of women) said they have dozed off while driving in the past year.

School-Age Children, Especially Teens, Are Overtired

The NSF poll also found that daytime sleepiness is at an unexpectedly high rate among children at school. According to parent reports, 60% of children under the age of 18 complained of feeling tired during the day, and 15% admitted to falling asleep at school.

Teenagers are more likely to complain of being tired during the day than are younger children (23% of teenagers vs. 11% of younger children).

Poor Sleep Quality Reported Among Americans

The NSF survey found that more than sixty percent of Americans (62%) experience problems sleeping a few nights a week or more. Fifty-six percent of adults report experiencing one or more symptoms of insomnia, including difficulty falling asleep, waking during the night, waking too early, or waking feeling unrefreshed.

Smokers and people who use alcohol as a sleep aid are more likely to have problems sleeping. According to the NSF survey, of the 28% who said they smoke, 46% reported experiencing symptoms of insomnia, compared to 35% of nonsmokers. And of the 14% of adults who reported using alcohol to help them sleep, 64% said they wake frequently during the night, compared to 32% of those who never use alcohol as a sleep aid.

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HOW SLEEPY ARE YOU?
1999 U.S. SLEEP SURVEY SHOWS DISTURBING TRENDS IN DAYTIME SLEEPINESS

(Used with permission from the National Sleep Foundation)

The Disparity Between Experiencing Sleep Problems and Being Treated for Them

Despite the fact that 70% of adults surveyed said they are aware that most sleep problems do not go away without treatment, only a small fraction (4%) of adults who experience frequent sleep problems are currently seeing a doctor or healthcare provider for advice or treatment. And nearly two thirds (61%) of U.S. adults have not been asked by their doctor how well they sleep.

Of those who are diagnosed with sleep problems or disorders, only a small percentage are being treated. According to this year’s poll, only half of those people told by a doctor that they have insomnia have received treatment for their condition. Similarly, only 35% of those people told by a doctor that they have sleep apnea have received treatment for their condition.

Knowledge of sleep continues to be poor among both men and women, across all ages and occupations, and regardless of the level of education achieved. Eighty-three percent of the adult public failed NSF’s test of sleep knowledge.

Appendix 11:

FALL-ASLEEP CRASHES ARE COMMON AMONG YOUNG PEOPLE

(Used with permission from the National Sleep Foundation)

Washington, DC, July 23, 1997 — A tired driver is a deadly driver. Sadly, the people of Alabama learned this tragic lesson first-hand Monday morning, when a 19-year-old University of Alabama student ran into a Greyhound bus outside Crawford, Alabama. He killed himself and injured all 21 passengers on the bus. According to a spokesperson for the Alabama State Troopers, investigating officers suspect that fatigue may have played a significant role in the crash.

The National Highway Traffic Safety Administration (NHTSA) currently estimates that at least 100,000 crashes and 1,500 deaths annually are the direct result of drowsiness/fatigue. These crashes cost the U.S. $12.5 billion in diminished productivity and property loss. Drowsiness also plays a role in crashes attributed to other causes. NHTSA estimates that another one million crashes (one-sixth of all crashes) - are produced by driver inattention. Clinical studies show that sleep deprivation and fatigue make such attention lapses more likely to occur.

According to a 1995 National Sleep Foundation-sponsored Gallup Poll, 52% of all adults surveyed reported driving a car or other vehicle while feeling drowsy in the prior year. Other data collected in England found seven to ten percent of all accidents may be caused by driver “tiredness”.[1] A North Carolina State study found that 55% of fall-asleep crashes involved people under the age of 26. 78% were males.

The National Sleep Foundation provides free brochures and fact sheets about the warning signs and consequences of sleep deprivation and disturbed sleep as part of its DRIVE ALERT ... ARRIVE ALIVE national campaign on drowsy driving. To receive information, people should send a self-addressed, $.55-stamped envelope with to the National Sleep Foundation, Dept. DD, 729 Fifteenth Street, NW, Fourth Floor, Washington, DC 20005, or visit the NSF Web site at www.sleepfoundation.org.

For more information on drowsy driving and the Drive Alert national campaign, contact NSF Drive Alert Program Director Darrel Drobnich at (202) 347-3471.

1. Maycock, G. Driver Sleepiness as a Factor in Car and HGV Accidents. Report No. 169 for Transport Research Laboratory. Britain. 1995

2. Pack et al. Characteristics of Crashes Attributed to the Driver Having Fallen Asleep. Accident Analysis and Prevention. Vol. 27, No. 6, pp. 769-775. 1995

Physiological and Behavioral Characteristics of Sleep and Wakefulness

	Wakefulness	NREM	REM
Brain waves	Fast, low amplitude	Slow, high amplitude	Fast, low amplitude
Muscle activity	High	High, low or none.	Absent (Atonia)
Eye movements	Rapid	Slow, rolling	Rapid
Heart Rate	Rapid, variable	Slow, regular	Rapid, variable
Respiration	Rapid, variable	Slow, regular	Rapid, variable
Penile Erections	Variable	Infrequent	Frequent
Clitoral Erections	Variable	Infrequent	Frequent
Cognition	Conscious thinking	Some thinking	Dreaming, some thinking

The table above shows physiological and behavioral differences between wakefulness, NREM and REM sleep. Many of the physiological measures in Table 1 are recorded in sleep laboratories around the world and in space to study sleep and assist in the diagnosis of sleep disorders.

Appendix 13:

DOZING OFF IN CLASS?

(Used with permission from the National Sleep Foundation)

Poll Shows U.S. Children Complain of Daytime Sleepiness, Fall Asleep at School

WASHINGTON, DC — A National Sleep Foundation survey finds a substantial portion of children are sleepy during the day. According to parents' reports in the 1999 nationwide omnibus survey, "Sleep in America," 60% of children under the age of 18 complained of being tired during the day in the past year, and 15% of children reported falling asleep at school during the past year. Teenagers are more likely to complain of being tired during the day than are younger children, according to parent reports (23% of teenagers vs. 11% of younger children).

"Our research has shown that biological changes during puberty affect an adolescent's internal sleep-wake clock. Many adolescents are physiologically not ready to fall asleep until 11:00 pm or later," explains Mary A. Carskadon, Ph.D., Sleep Research Lab Director at Bradley Hospital/Brown University, Providence, RI, and National Sleep Foundation Pediatric Council Chair. "The average teen needs about nine hours of sleep, but many students sleep less than seven hours, in part because they need to get to school by the 7:30 am or earlier start time. As a result, many teens experience problem sleepiness during the day."

Setting Later School Hours Favored by Some Parents, Policymakers

One in four parents surveyed (24%) said they favored adjusting school hours so teenagers can sleep later in the morning. This statistic climbed to 39% among parents whose children reported having fallen asleep at school during the past year.

"Teens are paying a heavy price for following the old adage, 'early to bed, early to rise,'" says U.S. Representative Zoe Lofgren (D-Calif.), sponsor of the "Zzz's to A's" bill in Congress. "It's time for high schools to synchronize their clocks with their students' body clocks so that teens are in school during their most alert hours and can achieve their full academic potential." Rep. Lofgren has introduced legislation in Congress to encourage school districts to set later starting times-not shorten the school day-and includes a federal grant to help cover administrative and operating costs associated with changing school hours.

Nearly three out of four parents (73%) believe that children should spend as much time learning about good sleep habits as they do about good nutrition and the benefits of exercise. Not surprisingly, this percentage is even higher among parents whose children admitted to falling asleep at school during the past year (84%).

Sixty percent of parents who have children old enough to drive say that they have not discussed the dangers of falling asleep at the wheel with their children who drive. According to National Highway Traffic Safety Administration reports, drowsy driving causes at least 100,000 crashes in the United States each year.

The National Sleep Foundation's 1999 "Sleep in America" omnibus survey was conducted in December 1998 and early 1999 through telephone interviews with 1,014 Americans. The survey was released to launch National Sleep Awareness Week, March 29-April 4, 1999, a campaign to educate the public about the importance of good sleep. During National Sleep Awareness Week, more than 300 community sites will host sleep education events and activities to teach adults and children about sleep and sleep disorders. For more information, call **1-888-NSF-SLEEP**.

Appendix 14:

SLEEPING BETTER IN SPACE: SLEEP STUDIES AND CLINICAL TRIALS OF MELATONIN AS A HYPNOTIC

(Used with permission from the NASA Shuttle Web)

Astronauts can have difficulty sleeping during space flight. Most likely, a combination of factors contributes to these sleep problems. These factors include the novelty and excitement of space flight itself, ambient noise in the close confines of the spacecraft, and the absence of normal day/night cycles. In fact, the sun rises and sets every 90 minutes in low Earth orbit.

Sleep disruption can lead to fatigue and decrements in performance for astronauts. To improve sleep quality, many astronauts take sleep aids such as the benzodiazepine hypnotic Restoril. These medications, however, may have undesirable side effects on performance and mental alertness. In the search for a better sleep aid, researchers have targeted melatonin, a naturally occurring hormone produced in the pineal gland of the brain. Ground-based research indicates that melatonin may facilitate sleep, an attribute that is particularly important if astronauts are scheduled to sleep at a time of day when their bodies are not producing the hormone.

The investigation, Clinical Trial of Melatonin as a Hypnotic, will determine whether the use of melatonin improves the quality of sleep for astronauts during space flight, thereby improving their ability to perform the mentally challenging and physically rigorous tasks required of them. Although melatonin is currently available in health food stores as a food supplement, the dosages available are typically 10-20 times greater than levels found in the human body. This study is designed to evaluate whether a near-physiologic dose of the hormone can be effective in promoting sleep.

Aside from improving the sleep quality of astronauts during space flight, this research has direct application for many people here on Earth. Sleep disorders affect a wide range of people from those who perform challenging jobs involving night shift work to the many Americans who often experience sleep disorders as they age. This investigation will be the first to assess the effects of space flight on the sleep patterns of an older astronaut.

The sleep quality and mental functions of crewmembers will be assessed before, during, and after flight. Before each sleep period of the mission, crewmembers will take an unmarked capsule that contains either melatonin or placebo. The crewmembers will wear an unobtrusive wrist actigraph to monitor their sleep-wake cycle. In addition, astronauts' sleep will be characterized more completely via recordings that assess several sleep parameters. During each of the four intensive monitoring sessions, crewmembers will wear an electrode net on their heads . These electrodes will be connected to a Digital Sleep Recorder that monitors brain waves, eye movements, muscle tension, body movements, and respiration. Astronauts will be assisted in troubleshooting this high-tech setup by an artificial intelligence computer system developed jointly by the Massachusetts Institute of Technology and NASA Ames.

Other factors related to sleep quality, such as mental performance and environmental parameters, will also be assessed to complement data collected with the sleep recorder. After each night of wearing the electrode net, crewmembers will use a laptop computer to fill out a record of sleep quality and complete a 20-minute battery of cognitive performance and subjective mood tasks. Body temperature will be recorded continuously from flight day 2 through flight day 9 using an ingested radio-telemetry pill. These readings will be compared with similar recordings pre- and postflight. Ambient light levels in work and rest areas will

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SLEEPING BETTER IN SPACE: SLEEP STUDIES AND CLINICAL TRIALS OF MELATONIN AS A HYPNOTIC

also be measured to correlate environmental light cues with sleep patterns. Crew members will don the electrode net for six nights of monitoring before flight and three nights of monitoring after flight to complement the data collected inflight.

Points of Contact:

Principal Investigator

Charles A. Czeisler, Ph.D., M.D.
Harvard Medical School and Brigham and
Women's Hospital
Boston, MA

Co-Investigators

Rod J. Hughes, Ph.D.
Joseph M. Ronda, M.S.
Harvard Medical School and Brigham and
Women's Hospital
Boston, MA David

F. Neri, Ph.D.
NASA Ames Research Center
Mountain View, CA

John B. West, M.D., Ph.D.
G. Kim Prisk, Ph.D.
Ann R. Elliott, Ph.D.
University of California, San Diego
San Diego, CA

Laurence R. Young, Sc.D.
Massachusetts Institute of Technology
Cambridge, MA

Appendix 15:

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PUTTING TOGETHER THE SLEEP PUZZLE

Amazingly, we spend about 24 years (one third) of our lives sleeping, yet relatively little is known about this critical daily routine. In fact, in relation to other biological research, it is only recently that scientists have begun to unlock some of the many mysteries of sleep.

As part of a cooperative effort between Hilton Hotels Corporation and the National Sleep Foundation (NSF), a group of some of the nation's top sleep experts gathered in recently for a first-ever discussion on sleep, its effect on travelers and potential information-based solutions for the general public. Much remains to be studied and learned. And with the development of unique partnerships such as these, new insights will be obtained to help people sleep more comfortably when traveling. This brochure incorporates the group's findings and shares its advice on what travelers can do now to help get a better night's sleep.

JET LAG: *THE TRAVELING SLEEP DISORDER*

Every day, millions of travelers struggle against one of the most common sleep disorders—jet lag. For years, jet lag was considered merely a state of mind. Now, studies have shown that the condition actually results from an imbalance in our body's natural "biological clock" caused by traveling to different time zones. Basically, our bodies work on a 24-hour cycle called "circadian rhythms." These rhythms are measured by the distinct rise and fall of body temperature, plasma levels of certain hormones and other biological conditions. All of these are influenced by our exposure to sunlight and help determine when we sleep and when we wake.

When traveling to a new time zone, our circadian rhythms are slow to adjust and remain on their original biological schedule for several days. This results in our bodies telling us it is time to sleep, when it's actually the middle of the afternoon, or it makes us want to stay awake when it is late at night. This experience is known as jet lag.

TAKING THE AIR OUT OF JET LAG

Some simple behavioral adjustments before, during and after arrival at your destination can help minimize some of the side effects of jet lag.

- Select a flight that allows early evening arrival and stay up until 10 p.m. local time. (If you must sleep during the day, take a short nap in the early afternoon, but no longer than two hours. Set an alarm to be sure not to over sleep.)
- Anticipate the time change for trips by getting up and going to bed earlier several days prior to an eastward trip and later for a westward trip.
- Upon boarding the plane, change your watch to the destination time zone.
- Avoid alcohol or caffeine at least three to four hours before bedtime. Both act as "stimulants" and prevent sleep.
- Upon arrival at a destination, avoid heavy meals (a snack - not chocolate is okay).

- Avoid any heavy exercise close to bedtime. (Light exercise earlier in the day is fine.)
- Bring earplugs and blindfolds to help dampen noise and block out unwanted light while sleeping.
- Try to get outside in the sunlight whenever possible. Daylight is a powerful stimulant for regulating the biological clock. (Staying indoors worsens jet lag.)
- Contrary to popular belief, the type of foods we eat have no effect on minimizing jet lag.

WORRYING ABOUT SLEEP

According to experts, stress or the potential for stress is another problem that can lead to sleeplessness. Two common travel related stress conditions are the "First Night Effect" and the "On-Call Effect." The first condition occurs when trying to sleep in a new or unfamiliar environment. The second is caused by the nagging worry that something just might wake you up, such as the possibility of a phone ringing, hallway noise or another disruption.

Try these tips on you next trip to help avoid travel-related stress and subsequent sleeplessness.

Bring elements or objects from home like a picture of the family, favorite pillow, blanket or even a coffee mug) to ease the feeling of being in a new environment.
Check with the hotel to see if voice mail services are available to guests. Then, whenever possible, have your calls handled by the service.
Check your room for potential sleep disturbances that may be avoided, e.g. light shining through the drapes, unwanted in-room noise, etc.
Request two wake-up calls in case you miss the first one.

QUIET PLEASE!

The Sleep Environment

The most common environmental elements affecting sleep are noise, sleep surface, temperature or climate, and altitude. Your age and gender also play a part in determining the level of sleep disturbance caused by these factors. One study found that women are more easily awakened than men by sonic booms and aircraft noise, while other research indicates that men may be more noise sensitive. Children are generally insensitive to extreme noise levels. However, this high threshold declines with age.

Noise

We have all experienced that dripping faucet, the barking dog or that blaring stereo next door that has kept us awake. Indeed, experts say the intensity, abruptness, regularity, intrusiveness, familiarity and regularity of noises all affect sleep.

Noises at levels as low as 40 decibels or as high as 70 decibels generally keep us awake. Interestingly, however, the absence of a familiar noise can also disrupt sleep. City dwellers may have trouble falling asleep without the familiar sounds of traffic. Or a traveler may find it difficult to sleep without the familiar tick, tick, tick of the alarm clock at home.

Some noises although annoying at first can gradually be ignored, allowing sleep to follow. Studies show people can get used to noises such as city traffic in about one week. However, important noises, like a parent's baby crying, a smoke alarm or even one's own name being called, are not easily assimilated and generally snap us awake.

Experts are also studying the ability of certain sounds to induce sleep. "White noise," such as caused by a fan, air conditioner, or radio static, can often block out unwanted noise and encourage sleep.

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Sleep Surface

Little research is available and not surprisingly on how much sleeping surfaces affect our slumber. For the most part, we know people sleep better when horizontal and not cramped by space. As with noise, however, women and more mature people appear more sensitive to variations in sleep surfaces.

Temperature/Climate

The point at which sleep is disturbed due to temperature or climate conditions varies from person to person. Generally, temperatures above 15 degrees Fahrenheit and below 54 degrees will awaken people.

Altitudes

The higher the altitude, the greater the sleep disruption. Generally, sleep disturbance becomes greater at altitudes of 13,200 feet or more. The disturbance is thought to be caused by diminished oxygen levels and accompanying changes in respiration. Most people adjust to new altitudes in approximately two to three weeks.

SNOOZE CUES

Behavioral

Modifying your behavior and taking sleeping pills are both commonly accepted measures used to minimize certain sleep disorders.

As mentioned, certain behaviors can help your body better adjust to new time zones and surroundings. Although there are no guarantees to a fast and sound sleep, simple adjustments in your behavior when traveling may help you get the quality of rest needed to start the day refreshed.

0ver-The-Counter Sleeping Pills

According to a recent Gallup survey, more than one-fourth (29 percent) of people with sleeping problems take over-the-counter (OTC) sleeping pills. In addition, many people use prescription drugs. While pills do not resolve the biological imbalance caused by jet lag, they may help manage short-term insomnia brought on by travel.
Be sure to discuss the use of sleeping pills with your doctor before you try them. Sleep medication can cause side effects.

Melatonin

One OTC product receiving a lot of attention lately is melatonin. Melatonin is a naturally secreted hormone in humans that affects the body's circadian rhythms. There is some evidence that when administered during the day, melatonin increases the tendency to sleep, but at night, the amount of sleep is unaffected. Currently, melatonin is largely available only in health food stores and is not regulated. Therefore, melatonin is, at present, an experimental approach to sleep problems and travelers should consult their physicians before using it.

THE BUSINESS OF SLEEP

Because hotels are directly connected to the idea of sleep and traveling, some of the nation's preeminent hospitality companies, such as Hilton Hotels, are now working to learn more about the mysteries of sleep and discover new ways to maximize the sleep potential of guests. It is estimated that more than 125 million

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Americans crisscross the country every year on business or leisure trips, so it is no wonder that discovering the secret to better sleep has tremendous implications for the hospitality industry.

Many airlines are also examining travel-related sleep disorders and the impact they have on their customers, as well as on their own pilots and flight attendants who face time-zone travel on a regular basis.

One of the most interesting areas of sleep study involves the effect of sleeplessness on the body's mental and physical performance. As more is learned about the impact of sleep in this area, businesses that require their employees to travel a great deal will ultimately begin seeking ways to obtain peak performance from executives when they are on the road.

WHAT'S THE FUTURE OF SLEEP?

Although experts agree that a variety of analytical and anecdotal data exists about sleep, significant gaps still remain. Few definitive studies exist in the area of travel and sleep, making it impossible to know how prevalent travel-related areas of environmental and stress effects.

Through the support of corporations like Hilton Hotels Corporation, which has extensive data and experience regarding travelers and their sleep needs, the NSF plans to expand its research and unravel more mysteries locked in the realm of sleep.

DON'T GO TO BED YET...

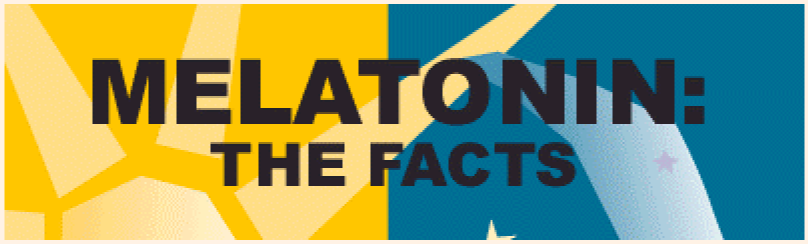
Since we spend a good portion of our lives sleeping, this quiz should be easy. Answer true or false to the following statements:

1. Jet lag can be controlled by carefully managing your dietary intake several hours before a flight.
2. "White Noise," such as that caused by a fan or radio static, can block out noise and actually promote sleep in some cases.
3. According to sleep experts, sleeping pills are not an accepted method of sleep control and should be avoided.
4. Small amounts of alcohol prior to bedtime can be an effective way to induce sleep.
5. Due to the most recent research and studies regarding sleep, many of the mysteries surrounding that field have been solved.

Answers:

1. **False**. There is no conclusive evidence that diet can in any way minimize jet lag.
2. **True**. Studies indicate that "white noise" may help induce sleep.
3. **False**. Experts say, if taken as directed, sleeping pills can be an effective sleep manager. However, they have no effect on re-aligning the body's biological imbalance caused by traveling to a different time zone.
4. **False**. Although alcohol may initially cause sleepiness, later in the evening it acts as a "stimulant" and can keep you awake.
5. **False**. Scientists agree that more studies are needed to confirm or disaffirm what relatively little is known about sleep.

Appendix 16:



(Used with permission from the National Sleep Foundation)

WHAT IS MELATONIN?

MELATONIN IS A NATURAL hormone made by your body's pineal (pih-knee-uhl) gland. The pineal gland lies at the base of the brain. And when the sun goes down, and darkness comes, the pineal gland "goes to work." As melatonin production rises, you begin to feel less alert. Body temperature starts to fall as well. Sleep seems more inviting. Then melatonin levels drop quickly with the dawning of a new day. Levels are so low during the day that scientists often have difficulty detecting melatonin then.

Melatonin levels go hand in hand with the light-dark cycle, not just for people, but for plants and animals that keep alert during the day. Melatonin production is also related to age. Children manufacture more melatonin than the elderly do. But melatonin production begins to drop at puberty.

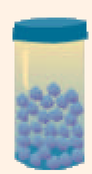
If you're curious about melatonin, it's not surprising. There has been a lot of attention paid to the hormone in popular magazines and books, scholarly journals, and advertisements. You may have heard claims that melatonin cures everything from jet lag to insomnia to aging.

And chances are good that you've seen melatonin in healthfood stores, heard it being discussed, or seen an advertisement or article about it. But what is sold in stores is not the same substance as that produced in your body.

Healthfood stores sell synthetic (artificial) or, on occasion, animal melatonin. Synthetic melatonin is made in factories where the manufacturing process is not controlled by the U.S. Food and Drug Administration (FDA). Melatonin is one of only two hormones not regulated by the FDA and sold over-the-counter without a prescription. (DHEA, or dehydroepiandrosterone, is the other.)

WHY ISN'T MELATONIN CONSIDERED A DRUG?

BECAUSE MELATONIN does appear naturally in some foods, the U.S. Dietary Supplement Health and Education Act of 1994 allows it to be sold as a dietary supplement. And dietary supplements (like vitamins and minerals), do not need to be approved by the FDA or controlled in the same way drugs are. Melatonin makers are only limited in what they can say. They can't say melatonin can cure, treat or lower the risk of a disease. But they can say something more general, like that it can help promote sleep.



Appendix 16:

WHAT DOES THIS MEAN TO YOU?

- Few studies have been done on melatonin's safety, side effects, interactions with drugs, and long-term effects. (Unlike products recognized as "drugs, melatonin does not require extensive testing in animals and people before being sold in the U.S.)
- How much to take, when to take it, and melatonin's effectiveness for many groups of people are also unknown.
- Information about reported side effects do not have to be listed on the product's packaging.
- Yet worsened fatigue and depression, constriction of the arteries to the heart (which could increase the risk of heart attack), and possible effects on fertility have been reported.
- The manufacturers of melatonin do not have to follow the rigorous procedures and safety checks that the manufacturers of "drugs" do. Problems with disease-causing impurities are more likely than with FDA-recognized drugs.
- Listed doses may not be accurate. (In fact, one batch tested contained far more than the amount listed on the label.) And no one knows which dosage level might be the most effective.

WHY DO PEOPLE TAKE MELATONIN?

GIVEN THE FACT THAT so many questions remain unanswered about melatonin, why have so many people tried it?

Mostly to promote sleep or fight jet lag. Older people may think of mela-tonin as "replacement therapy." But one study found that the same dose of melatonin caused very different blood levels of the substance in those over 50. High levels may lower body temperature or increase levels of other chemicals. How this affects health is not known.

UNDERSTANDING INSOMNIA

ABOUT HALF OF American adults have trouble sleeping at one time or another or all of the time, according to the 1995 National Sleep Foundation Gallup Poll: Sleep in America. The trouble experienced may be difficulty falling asleep or staying asleep. Emotional stress is a major cause of why people can't sleep. Feelings of sadness or worries can make it hard to fall asleep or stay asleep. Certain behaviors can affect sleep too. For example, drinking caffeinated beverages or having alcohol too late in the day can make it harder to sleep. So can exercising too close to bedtime, waking and going to sleep at different times each time, or concentrating on work right before trying to fall asleep. And shift work, a fact of life for about 25 percent of American workers, can lead to difficulty asleep when desired.

If you have trouble sleeping, try to put your finger on the cause.

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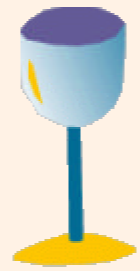
TEN QUESTIONS TO ASK YOURSELF



- Is your bedroom too hot or too cold?
- Is it too noisy or too filled with light?
- Is your bed comfortable?
- Are you experiencing any physical problems that may be related to your sleep problem, such as heartburn, menopausal hot flashes, arthritis, headache or back pain?
- Do you take any medications that may cause sleeping problems as a side effect?
- Do you drink caffeinated drinks in the afternoon or evening?
- Are you drinking alcohol before you go to bed?
- Do you exercise within three hours of going to bed?
- Are you napping during the day?
- Do you work in bed or just before going to bed?

If you've answered yes to any of the above questions, you may have found a reason for your sleeping troubles. Try changing your behavior and see if your sleep improves. If it doesn't, your doctor or sleep specialist may be able to help you.

WHAT WE KNOW ABOUT MELATONIN FOR INSOMNIA

THE STUDY OF MELATONIN has become a hot area of research. Yet most studies fail to include people who actually experience sleep difficulties. In addition, melatonin is often given by researchers during the day rather than at night; the fact is that most people with insomnia want to sleep at night. These are some of the reasons why we don't know as much as we'd like.

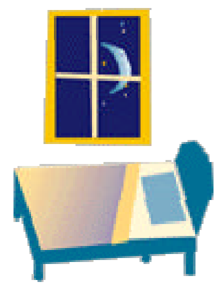
WHAT WE CAN LEARN FROM CURRENT STUDIES

- When melatonin was given to people near the normal sleep time, the results differed from one study to the next.
- In studies that focused on melatonin and sleepiness, simply standing up reduced feelings of sleepiness after taking melatonin.
- Of the few studies involving people with insomnia, one found that people (all over 65) reported more sleep and better next-day alertness after two weeks of nightly melatonin use. But there was no laboratory measurement of their sleep.
- A study that did use laboratory measurements of sleep found no improvement.

OTHER TREATMENTS FOR INSOMNIA

Appendix 16:

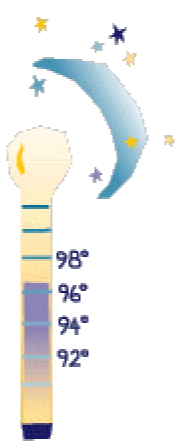
CURRENTLY, THERE ARE several prescription sleep aids available to treat insomnia, and there is a great deal of research about how they work. Government agencies that regulate the use of drugs (such as the FDA) have published guidelines that call for a maximum of two to four weeks of use. Of the variety of drugs available, newer drugs show clear, measurable benefits with a minimum of risks. They can shorten the time it takes to fall asleep and reduce awakenings, which adds to total time spent asleep. Possible side effects that are related to the dose taken of some prescription sleep aids include feeling tired or drowsy the next day, memory loss and problems with performance. In addition, when you stop taking these drugs, you may experience what's called a withdrawal syndrome, including insomnia that's worse than what you experienced before taking them.



Many people reject prescription sleep aids out of concern that they may become dependent on them (or addicted). Yet more is known about the safety and effectiveness of these drugs than about that of melatonin. Addiction does not seem to be a problem for most of those taking a sleep aid.

Ask your doctor about medications that may be right for you to try if your insomnia continues despite changes in your behavior or immediate circumstances. Some drugs help you fall asleep faster than others. Others may affect how you function the next day. A doctor or sleep specialist can help patients avoid most side effects as well difficulty sleeping when the drug is discontinued.

UNDERSTANDING JET LAG



OUR BODIES RESPOND to sunlight and darkness, and shifts in melatonin levels, with climbing and falling alertness and body temperature. These changes basically occur in a 24-hour cycle known as a circadian rhythm. When we travel and cross time zones, we need to adjust. Our bodies slowly shift from "home time" to the new time; the more time zones we cross, the longer it takes to shift the body clock to the new "home time." Meanwhile, we feel sleepy, alert and hungry at the wrong times. This is called jet lag.

Jet lag is not "all in your head." It is a physical condition caused by the disturbance of our circadian rhythms. And it's a common problem with real consequences. A National Sleep Foundation survey found that about half of all business travelers experience jet lag. They report that their performance and productivity are negatively affected. Interestingly, the problem was worse for the women than for the men questioned in the survey.

Does melatonin work well to promote sleep in those crossing time zones? Read on for some answers.

Appendix 16:

WHAT WE KNOW ABOUT MELATONIN FOR JET LAG

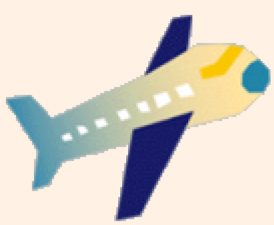
SADLY, WE DON'T KNOW near as much as we'd like to know about melatonin and jet lag. For scientists to believe that melatonin helps fight jet lag, studies have to:

- demonstrate that melatonin relieves the effects of jet lag in a measurable way
- compare the effects of melatonin in two groups of people suffering from jet lag with all conditions the same except that one group takes melatonin while the other receives a sugar pill or placebo
- exclude the effects of light, which has a more powerful effect on the body's circadian rhythms
- objectively measure sleepiness, alertness, sleep and circadian rhythms (such as temperature): This can be done with laboratory measures that have been developed, tested and accepted by scientists rather than by simply asking people to report on their feelings or experiences.

Do existing studies of melatonin do all of these things? No. More studies are needed. As for studies of melatonin's effects to advance or delay the biological clock, the picture remains dim. No study has been designed and carried out so that the effect of light could be ruled out. Since light is known to be a more powerful way to reset body rhythms than melatonin, it is impossible to be sure that any effect was due to melatonin and not to light.

OTHER TREATMENTS FOR JET LAG

DOES THIS PHRASE sound familiar? Time heals all ills. This is certainly true for jet lag. But the point is that most people don't want to wait. They want to feel better now. Using the power of the sun (or other source of bright light) to reset your body clock is one thing that you can do. If you're traveling west, try to get at least an hour's worth of morning sunlight after you reach your destination. And before you travel, try waking and going to sleep an hour later for each time zone you'll cross. (For a New York to California trip, try to shift your bedtime and wake time an hour later for each of three nights before you leave. This would mean that instead of sleeping from 11 p.m. to 7 a.m., you would sleep from midnight to 8 a.m., then 1 a.m. to 9 a.m. and - on the third night – from 2 a.m. to 10 a.m. - not always easy to do.)
If you're traveling east, try doing the opposite.



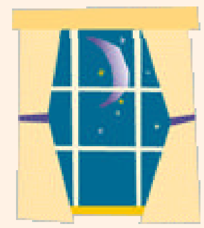
Also try to arrive in the early evening and don't go to sleep until at least 10 p.m. local time. Be sure to avoid alcohol and caffeine at least three to four hours before you go to bed. And save the (caffeine-filled) chocolate on your pillow for a daytime snack.

Appendix 16:

CAN MELATONIN TREAT DELAYED SLEEP PHASE SYNDROME?

JET LAG ISN'T THE ONLY disorder of circadian rhythms. Some people are only able to fall asleep late into the night or early in the morning. Delayed Sleep Phase Syndrome (DSPS) is what this condition is called. Not common in adults, the syndrome is quite common among adolescents. A small amount of early data suggests that melatonin may be of help for this condition. You may want to talk to your doctor or sleep specialist about this problem becasue there are a variety of effective treatments.

WHEN TO SEE YOUR DOCTOR



REMEMBER, WHEN YOU'RE not getting the sleep you need, you're at risk...and so are those around you. Inadequate sleep increases your risk for falling asleep at the wheel, accidents on the job, and problems at home. Fatigue is a warning sign. If changes in your lifestyle don't make a difference, see your doctor.

WHAT IS A SLEEP CENTER?

SOMETIMES, CHANGING YOUR sleep-related behavior isn't enough. Not all physicians are educated about insomnia and other sleep disorders. Sleep specialists have additional training in sleep medicine and can both diagnose and treat a variety of sleep disorders. Many sleep specialists work at sleep centers, where sleep laboratories offer overnight (and, sometimes, at-home) testing. The American Sleep Disorders Association evaluates sleep centers and offers "accreditation," a kind of seal of approval, to those who meet its guidelines.

- Author: Joan Rachel Goldberg
- Design: Mary Ann Bruce
- Illustration: Lisa Toji
- Reviewers: Fred Turek, PhD; Thomas Roth, PhD

FOR MORE INFORMATION

WRITE TO THE National Sleep Foundation (NSF) or visit the NSF Web site: www.sleepfoundation.org. For a list of accredited centers, send a stamped, self-addressed envelope to:

National Sleep Foundation
729 15th St., NW, 4th Fl.
Washington, DC 20005