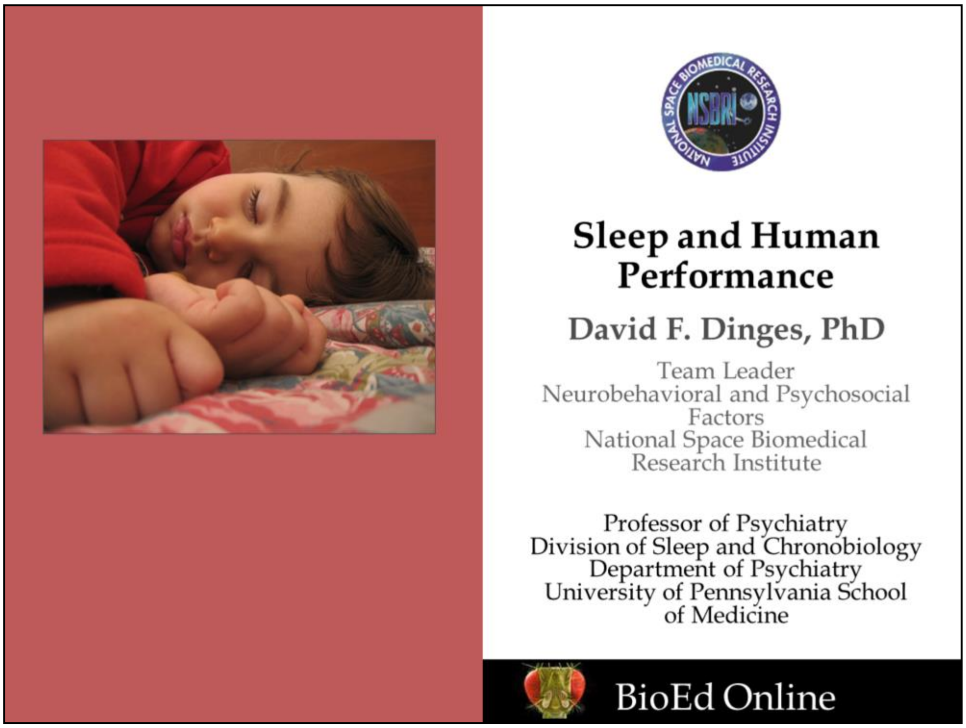
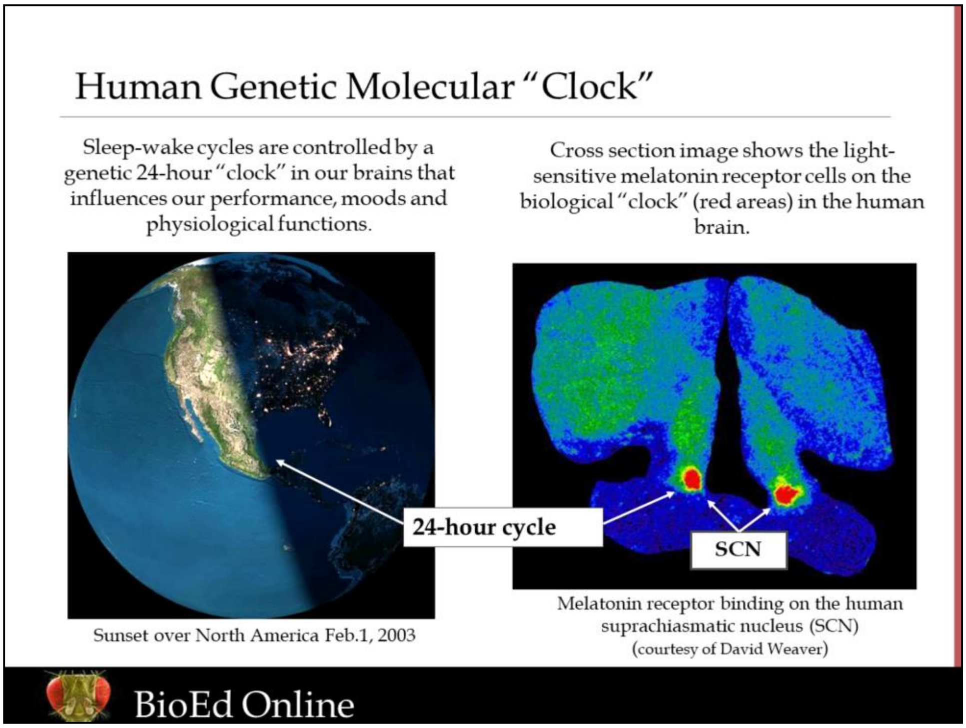


Image Reference:

Zangrilli, A. (2007). *A child sleeping.* Retrieved 4-25-07 from http://en.wikipedia.org/wiki/Image:A_child_sleeping.jpg



Slide Notes

Sleep is timed by a biological (genetic molecular) "clock" in the brain that is circadian, which means "about a day" or approximately 24 hours. This "clock" is responsible for our sleepiness and desire for sleep at night, during our natural sleep times, and it helps keep us asleep throughout the night. If we stay awake at night working or playing, our biological clock stills forces physiological changes on our brains and bodies during the night. These changes include loss of body heat via vasodilation (which results in our feeling cold), microsleeps that can lead to performance lapses, and feelings of fatigue and low mood. On the left hand of the slide, note the shorter period of daylight in the northern hemisphere (where it's winter) and the correspondingly longer period of daylight in the southern hemisphere (where it's summer). This occurs because Earth is tilted approximately 23° on its axis as it rotates around the sun. The key point is that sleep-wake cycles, and therefore, our alertness and performance, depend on both how much sleep we obtain and on our internal biological clocks, which anticipate Earth's orbital mechanic (i.e., daily rotation on its axis) and responds (resets daily) to the light-dark cycle. It is the the slow adjustment of the internal circadian clock in our brains to new schedules that makes it so difficult for us to adjust to night shift work and to jet lag (i.e., flying across time zones), as well as to the switch from sleeping late in the summer, to getting up early in the school year. The circadian biological "clocks" in our brains define us as Earthlings. In contrast, life on another planet—like Mars—would likely have an internal biological clock that anticipated the Martian day, which is 24.67 hours.

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*

Our biological need for sleep emanates from structures in our brains, one of which is called the "biological clock". This clock controls our tendency to want to sleep at night and to be awake in the day time. It also controls or modulates our performance. In fact, the connection between our biological clock and where we are located on Earth is fundamental. The biological clock in the human brain *appears on the slide as red dots. These dots are receptors for a hormone called melatonin, which is secreted by the pineal gland in the brain. Melatonin is a light sensitive hormone that is suppressed by light in the day time and secreted at night in the dark. Our biological clock, the areas marked in red on the image of the human brain, is a real clock. It actually changes our physiology through a near-exact 24-hour cycle: 24 hours and a few minutes. And of course that is the period of Earth's rotation on its axis. So as life developed on Earth, we find these biological clocks anticipate Earth's rotation through the light and dark cycle. And some animals, including humans, that have clocks phased one way are diurnal (that is, awake in the day and asleep at night). Some animals are nocturnal; they're awake at night and sleep during the day. They have a broad flat face and big eyes so they amplify light at night and hear well. And then many others are awake and asleep on the light/dark boundary. Of course the light period varies, based on where you are on the planet, and how far away from the equator you may be. It's 12 hours equal at the equator. And that's because Earth is tilted, about 23 degrees on its axis, as it rotates annually around our sun. So in the winter, the photo period, or the amount of light, is fairly short in the northern hemisphere, and is long in the southern hemisphere. These conditions are reversed in what we call summer and they call a winter in the southern hemisphere. The point is that the regulatory systems for sleep are very old biologically and are related to the actual timing of light/dark and energy availability on the planet.*

Slide Notes

Some people have thought sleep is an acquired habit that is not biologically determined. Thomas Edison—the inventor of artificial light—believed this and was eager to eliminate sleep with inexpensive indoor lighting. Scientific work over the past 100 years has shown that sleep is not only biologically determined, but is biologically essential. Thus far, no complex animal life forms (from fruit flies to humans) have been found that can survive without sleep. Sleep deprivation causes many changes to the brain and body, and death results when sleep deprivation goes on too long. Even mammals that live in aquatic environments (the cetaceans) sleep. Research has shown that some of these marine mammals—such as dolphins and orca—can swim while one of their two cerebral hemispheres sleeps. Humans and other terrestrial mammals do not have this adaptation. When they fall asleep, both cerebral hemispheres do so, which is fine if you're already in bed, problematic if you're in class, and very dangerous if you're driving.

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*

All complex animals need sleep. And that includes the common fruit fly, otherwise known as Drosophila meanogaster; birds, these are theropods, the current modern day descendants of the dinosaurs; all mammals, including placental mammals, like this leopard or like this nocturnal South American tarsier and of course chimps and humans, but also marsupials, kangaroos, and the ancient order of mammals, the monotremes, like this platypus. Even mammals that live in aquatic environments, like the whale, sea lion, porpoise, and the manatee, or sea cow, need sleep and engage in sleep. The remarkable thing about some of these cetaceans, like the porpoise and the orca, is that they sleep one half of their brain at a time. So one hemisphere of the brain, the right hemisphere, for example, might sleep while the left hemisphere keeps swimming and breathing. And then it switches. Unfortunately that's not an adaptation that land mammals have, or that humans have, although I've heard people say they'd like to have it. We have no idea what consciousness is like for the animals that do it, but it is remarkable that sleep persists even in animals that cannot afford to have both hemispheres asleep at the same time. And of course humans sleep. And they sleep a lot when they're born, they sleep somewhat less as they age and go through their lifespan. Young children, adolescents and young people need more sleep than they typically get in modern industrialized societies, in part because school start times are very early and children often are up very late with television, games and studying. We now face a sort of epidemic of sleep deprivation among children, adolescents and young adults.

Image References:

National Institutes of General Medical Sciences. *Fly.* NIH. Retrieved 04-26-2007 from www.nigms.nih.gov/Initiatives/Models/

NOVA Development Corp. (1995). *Aquatic, 270, Sea Lions.* Art Explosion, Volume 2 Clip Art.

NOVA Development Corp. (1995). *Australia, 003, Kangaroo.* Art Explosion, Volume 2 Clip Art.

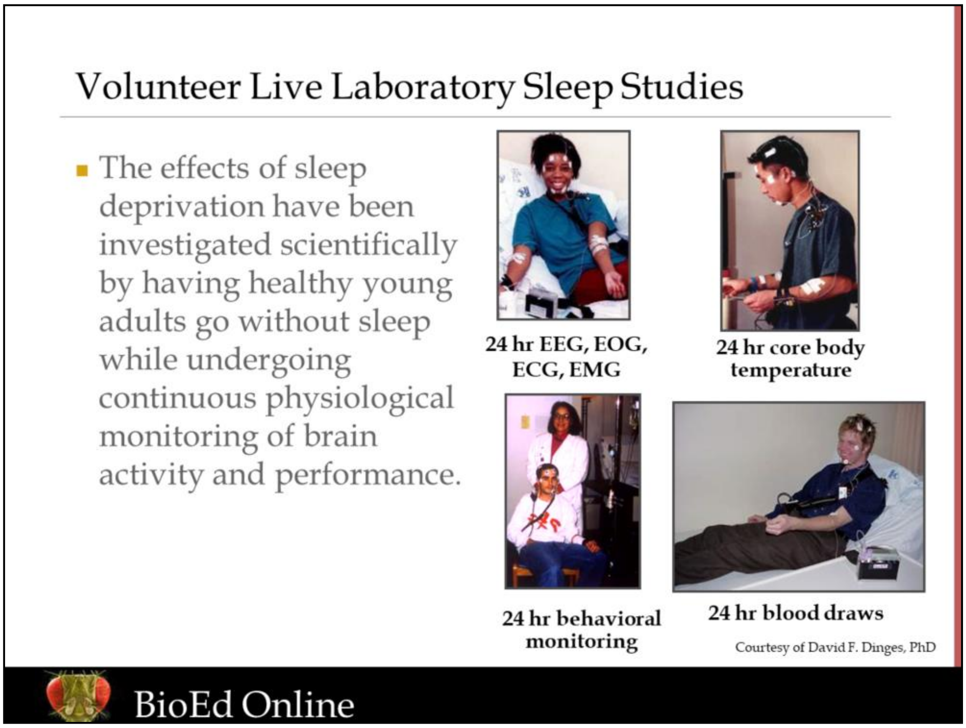
NOVA Development Corp. (1995). *Babies, 16, Chimpanzees.* Art Explosion, Volume 2 Clip Art.

NOVA Development Corp. (1995). *Wild, 389, Leopard.* Art Explosion, Volume 2 Clip Art.

NOVA Development Corp. (1995). *People-General, 360.* Art Explosion, Volume 2 Clip Art.

NOVA Development Corp. (1995). *Birds 0319, Swan.* Art Explosion, Volume 2 Clip Art.

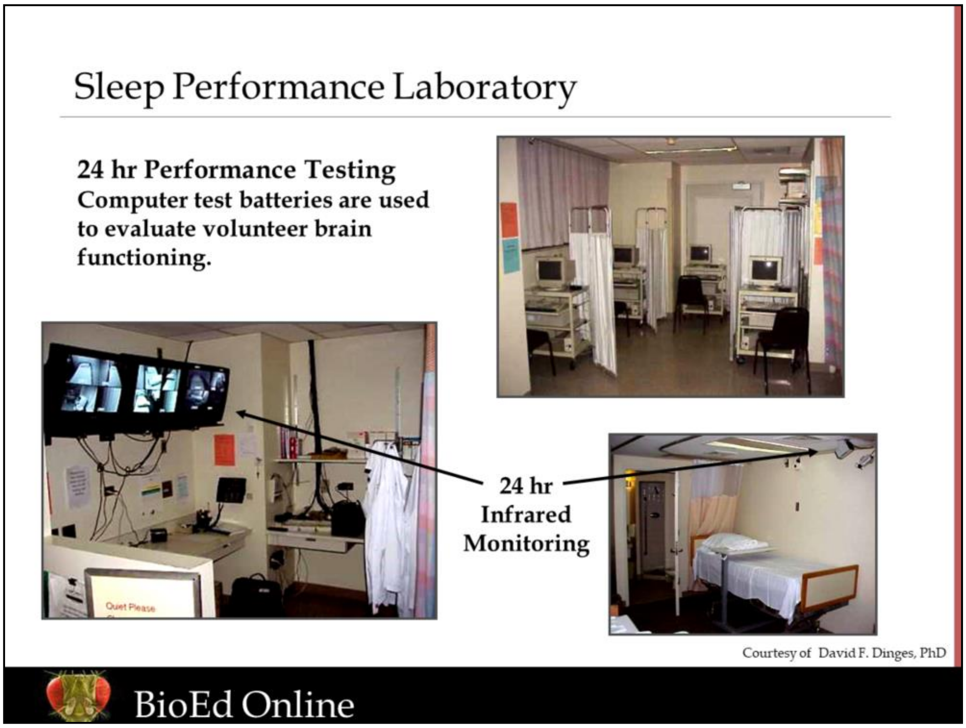
Golangco, J. G. (2006). *Philippine Tarsier*. Retrieved 04-26-2007 from http://en.wikipedia.org/wiki/Image:Philtarsier2.jpg
Kraft, S. (2004). *Platypus*. Retrieved 4-26-2007 from http://commons.wikimedia.org/wiki/Image:Platypus.jpg
Manatee in Florida waters. (2005). USGS. http://en.wikipedia.org/wiki/Image:FL_fig04.jpg
Pittman, R. (2005) *Killer whales jumping*. Retrieved 4-25-07 from
http://en.wikipedia.org/wiki/Image:Killerwhales_jumping.jpg
A yellow crossveinless forked fruit fly. Retrieved 04-26-2007 from http://en.wikipedia.org/wiki/Image:YCVF.jpg
Zangrilli, A. (2007). *A child sleeping*. Retrived 4-25-07 from http://en.wikipedia.org/wiki/Image:A_child_sleeping.jpg



Slide Notes

Studies in laboratories of sleep-deprived healthy adults have taught us much about the critical need for nightly sleep, the consequences for health and behavior of not obtaining adequate sleep, and the biological processes involved in sleep. The functions of sleep also have become increasingly clear. Healthy nightly sleep of adequate duration produces renewed alertness, enhances our ability to pay attention, consolidates our memories from the day before, improves our moods and relieves our fatigue, in addition to other biologically-mediated effects on brain and body. When sleep is disturbed or of inadequate duration, all of these functions show deficits.

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*
We know a great deal about how the sleep system affects our ability to perform, meaning our ability to think, our reaction times, and our ability to make decisions, remember the material we study, and pay close attention. We learn about sleep effects by bringing healthy young people into the laboratory. These subjects are all adults who volunteer to live in a laboratory where we control the light/dark cycle and when they sleep and when they're awake. Now, the volunteers are instrumented with brain wave recording equipment and equipment for eye movement recording and muscle activity and heart recording, cardio vascular equipment, and they may have a blood line for recording blood or saliva and activity monitor, a core body temperature monitor—all the physiological factors or systems that are regulated by the biological clock and our need for sleep.



Slide Notes

Studies in laboratories of sleep-deprived healthy adults have taught us much about the critical need for nightly sleep, the consequences for health and behavior of not obtaining adequate sleep, and the biological processes involved in sleep. The functions of sleep also have become increasingly clear. Healthy nightly sleep of adequate duration produces renewed alertness, enhances our ability to pay attention, consolidates our memories from the day before, improves our moods and relieves our fatigue, in addition to other biologically-mediated effects on brain and body. When sleep is disturbed or of inadequate duration, all of these functions show deficits.

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*

And then the volunteers live on different sleep schedules in this environment, monitored 24 hours a day by both people, staff, but also by infrared cameras and monitoring systems. In the upper right of this slide, you see the computer test batteries that are used, that they work on every couple of hours to evaluate how their brain function and their behavioral performance and then in the laboratory you'll also see other equipment for recording the physiology. The equipment that they wear is roughly a ten to fifteen thousand dollar unit that records all of this as they move around. This is the best way to identify and establish unequivocally that humans are being controlled by their need for sleep and their biological clock.

There are Differences Among People in the Duration of Sleep Needed

- Studies indicate adolescents (ages 13-21 years) generally need more sleep per day (8.5-10 hours) than do most adults (7-8 hours).
- Adolescents are vulnerable to sleep loss by having poor sleep habits due to staying up too late studying, playing or socializing.
- Excessive daytime sleepiness is a problem in adolescents; it often reflects a sleep debt resulting from inadequate sleep duration at night.
- Adolescents have sleep disorders that further limit their sleep time. These can include the following (among others).
  - **Delayed sleep phase syndrome** = unable to fall asleep until early morning and unable to wake up until late morning
  - **Insomnia** = difficulty falling asleep or staying asleep
  - **Obstructive sleep apnea** = cessation of breathing during sleep

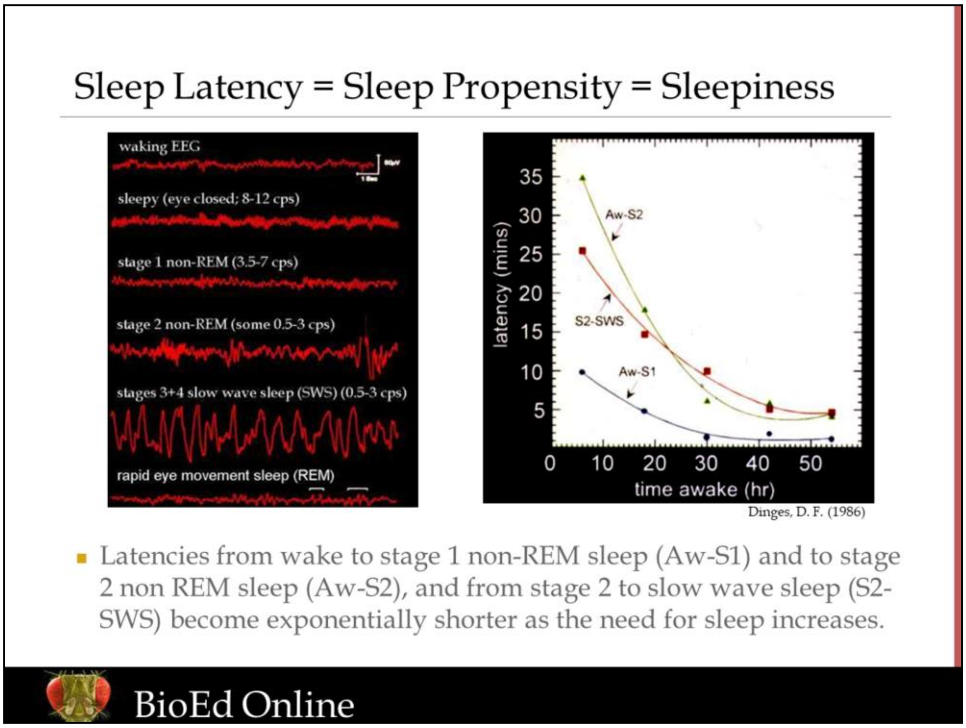
BioEd Online

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*

Now, everyone needs sleep but there are differences among people in the duration of their sleep need. The real challenging question, in addition to asking what is sleep for, is the question of how much sleep do people need. Studies indicate that adolescents, and by that I mean in the age range from 13 to 21 years of age, as defined by the national Institutes of Health, generally need more sleep per day, something like eight and a half to 10 hours, than do most adults, who are typically in the range of seven to eight hours. Now, this is a problem because the way we currently operate our school systems, the older you are, that is, the closer you are to being in high school, the earlier school start time is. And many adolescents will stay up late at night. The bottom line is they'll end up getting six, or five, or seven hours of sleep when they really need eight and a half to 10. And as you'll see in a little bit, that produces a cumulative sleep debt. Adolescents are vulnerable to sleep loss in part because in modern society there are plenty of things one can do at night. In older agrarian economies and societies, people could go to sleep when it got dark, when the animals tended to go to sleep, because there wasn't television and radio and computers and video games and telephones and a hundred ways to interact socially or to work or play. But now we have societies where millions of people are awake at night doing night shift work or traveling across time zones. Among the young adult and adolescent community, that also means work and play. The net result is that night time has become a much more active period. Midnight, after all, used to mean in the middle of the night. And now it means the time many people go to bed, or they even go to bed after midnight.

Excessive daytime sleepiness results when an adolescent or young adult—or anyone—doesn't get adequate sleep at night. It often reflects what we call a sleep debt, which is indicative of inadequate sleep duration at night. It also can mean that you've got ample sleep duration but *you have a sleep disorder that's disturbing the quality or depth of your sleep. But for most healthy people, it's simply a curtailment of total sleep time and they're not getting adequate amounts of sleep. We know that this happens because we see, for example, young adults or adolescents or older adults who shorten their sleep during the work week and then on the weekends grossly over sleep by 10 or 12 hours because there's this enormous physiologic pressure in the brain to catch up on the sleep that's been deprived.*

Now, as I mentioned earlier, you can also have poor sleep, as can adolescents, due to a sleep disorder. And this slide shows us three common disorders that can occur in adolescents. The first is, this bottom point, the delayed sleep phase syndrome. This is a problem that some adolescents and adults get into in which by staying awake until three or four in the morning, they suddenly discover they can't fall asleep before that even when they go to bed early, like at midnight. The net result is they're not only unable to fall sleep until three or four in the morning, they can't get up and out of bed to go to school or anything else until nine or ten or eleven in the morning. They're on a delayed sleep phase. The source of this problem appears to be in their circadian or biological clock, the 24-hour clock in the brain. The repair of this problem is complicated and requires medical attention to try to realign the biological clock with clock time in the social world. But it can be treated in sleep disorder centers. Another common problem is a difficulty falling asleep or staying asleep, widely known as insomnia. Many adolescents and young adults, experience stress or are light sleepers, or just have trouble being able to sustain sleep even though they may have a sleep debt and are very, very tired. And again, this could be treated by consulting a physician, particularly an expert in sleep and sleep disorders. And then finally some adolescents and children, we now know, can have something called obstructive sleep apnea, which we used to think primarily affected older adults. Obstructive sleep apnea refers to the cessation of normal breathing during sleep. The airway collapses once the brain goes to sleep. It doesn't collapse when you're awake or when you lie down, it only happens when you fall asleep. The net result is sleep is fragmented, you don't sleep deeply and the next day you can be pathologically sleepy. All three of these categories of problems can occur in young adults and adolescents as well as some other even more unusual but rarer sleep disorders. They're all treatable, but they can lead to sleep debt and problems functioning.



Slide Notes

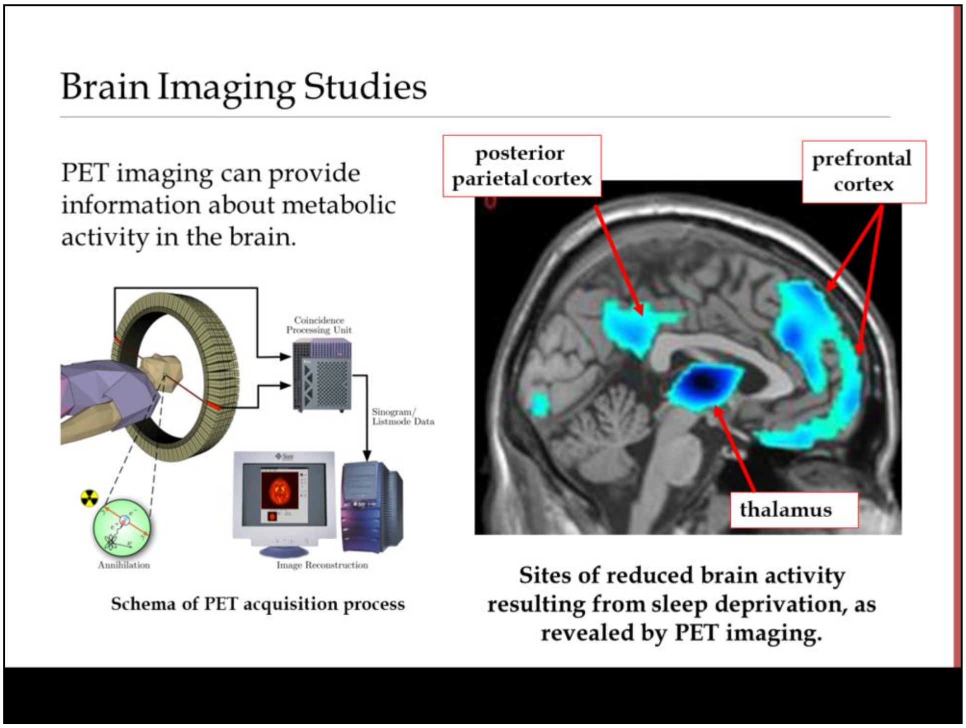
During a normal night of sleep, our brain wave (EEG) patterns change frequently as we cycle through different stages of sleep, referred to as non-rapid eye movement sleep (nonREM sleep), composed of substages 1, 2, 3 and 4, and rapid eye movement sleep (REM sleep). Stage 3 and 4 nonREM sleep show patterns of high voltage slow wave sleep (SWS), indicating the midbrain's sensory relay area (the thalamus) is no longer communicating with the upper brain's cerebral cortex. It is at this time that we are deepest asleep. REM sleep follows nonREM sleep and shows an activated brain wave pattern almost like wakefulness, but during this stage we are functionally paralyzed, which prevents us from acting out our REM dreams. When we fall asleep at night, the brain progresses more rapidly into nonREM sleep. Thus, the time it takes us to fall asleep and to enter deep nonREM sleep is a biological indication of the sleep propensity in our brains. The higher the sleep propensity, the greater the likelihood that we will be very sleepy if we attempt to stay awake. Once sleep propensity is very high, the brain will fall asleep uncontrollably (against our will) in almost any situation, but especially when we are attempting to pay attention to tasks (for example, a lecture). It is this uncontrollable onset of sleep—sometimes called microsleeps—during waking activities that can make sleepiness potentially dangerous while driving or engaged in other safety-sensitive activities.

Reference

Dinges, D. F. (1986). Differential effects of prior wakefulness and circadian phase on nap sleep. *Electroencephalography & Clinical Neurophysiology*, *64*, 224-227.

Now, we have ways of measuring biologically the pressure for sleep in the brain, and one of those is actually to measure the brain waves by electroencephalography, or EEG, shown here on the left of this graph. As you can see at the top, we've got a graph that shows the waking, or alert, EEG. It's very fast frequency and very low amplitude. Once the person starts to get drowsy or closes his or her eyes, you can see there is a shift in the amount of activity in the EEG. It's slower activity. This is called alpha, and then theta is stage one, and it's higher voltage, and ultimately, it ends up with this very high voltage, slow wave, delta sleep, shown here by the fifth red area on the left side of this slide. This slow wave stage three/four sleep is very deep, non-rapid eye movement sleep and the brain gives it a priority. When you're sleep deprived, the brain goes into this stage of sleep very rapidly. That is to say, it transitions through these other stages rapidly to get to this deep intense sleep. We know that this intense slow wave sleep is a marker for a structure in the middle of the brain, called the thalamus, which is the relay station for all your sensory systems as they project up to your upper brain, to disconnect from the upper brain. So this is the sensory input part of your brain shutting off and no longer dialoging or interconnecting with the cortex in a functional sense. So the upper part of your brain doesn't know that there's stimulation coming in because it's been disconnected, and that's part of the mechanism of insuring that you not only go to sleep but you stay asleep. You can imagine the problems though if you progress to this sleep stage and then try to wake up abruptly and function. It's very difficult. If you've ever been awakened from a very deep sleep, it's likely that it occurred in this stage and that's called sleep inertia. At the very bottom of the graph is the rapid eye movement sleep, the activated EEG that occurs when we dream, not exclusively in REM, but our most vivid dreams are in REM. This occurs after slow wave sleep periodically throughout the night, but we can't act out our dreams because during rapid eye movement sleep, even though the cortex looks like it's awake when you look at the brain waves, ironically, we are paralyzed. There are spinal motor neurons, that is, neurons in our spine; the neurons or nerve cells that control our skeletal muscles are disconnected. So we are actually paralyzed functionally during the periods of REM sleep, so we're having vivid dreams and our eyes are jerking, we're breathing rapidly, our brain's activated, but we're completely disconnected from the outside world and can't move or act out these dreams. There are disorders where people can act out the dreams that occur late in life in neurodegenerative diseases not found in younger adults.

On the right side of the slide is the latency to fall asleep, just to make the point that, (the x ordinate is time awake) the longer people are awake, the more rapidly they fall asleep. These points are latency, or how quickly you move from a wake EEG, to a sleep EEG, to a very deep sleep EEG. And what you can see is brain wave activity accelerates towards very deep sleep so that once you've been awake all night, you could fall asleep in a second and you can progress into very deep sleep very rapidly. It is this characteristic of the sleep homeostatic or sleep propensity system in the brain that it accelerates towards sleep uncontrollably and rapidly when there's slight sleep pressure that makes sleepiness so dangerous for driving. Because if you give in even a little bit to it you may find you can't pull out of the sleep that your brain goes into and you crash. I'll talk more about that in a minute.



Slide Notes

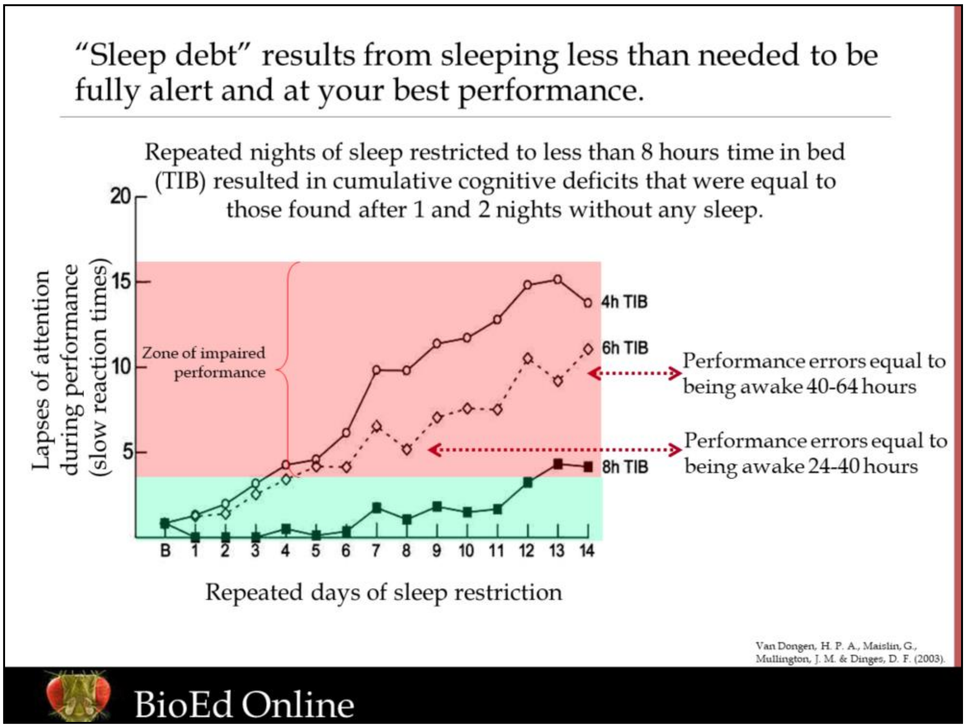
Positron emission tomography (PET) can be used to image the brain of a sleep-deprived healthy adult, using ^{18}Fluorine-2-deoxyglucose, a marker for regional cerebral metabolic rate for glucose (CMRglu) and neuronal synaptic activity. These types of experiments reveal that specific brain areas show reduced metabolism, including portions of the thalamus (the major relay center for sensory input), the prefrontal cortex and posterior parietal lobes, which perform most complex cognitive tasks, manage working memory and executive functioning, and sustain attention networks essential for a wide range of performance.

Image References:

http://upload.wikimedia.org/wikipedia/commons/c/c1/PET-schema.png

http://www.wrair-psych.org/wrair_dobb-wwd.htm

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/) When we use sophisticated scientific techniques like brain imaging—and this slide shows something called positron emission tomography, or PET imaging, where we look at the metabolic activity, glucose-based or basic sugar-based metabolism in the brain of sleep deprived people—what we see are these blue/green areas are areas of the brain that are less active when you're sleep deprived. Now, this is important because these areas are the primary areas your brain uses for thinking, reacting, paying attention, remembering and processing information. So there's reduced activity in this thalamus, the sensory relay center in the brain,* *which projects to the cortex up above, the upper brain. But there's also reduced activity in the prefrontal cortex and in the parietal lobes. Now the prefrontal cortex, if you put your hand on your forehead, that's the prefrontal cortex, right behind your forehead—that whole part of your brain is your executive attention system. It keeps track of everything you're doing. It remembers that you have to go to football practice or play in the band at five o'clock; it's the one that remembers what your assignment was in class; it's the one that makes sure you can focus on that assignment when the time comes, and that shows reduced activity during sleep loss. And the other area that's critical for compensating, for impairment of the prefrontal cortex and helps it out, is the parietal lobe back here (also shows reduced activity). So the worrisome part of this slide is the areas of your brain you most want to use for performance every day, whether it's out on the basketball court or in physics class or English class or creative writing class—those are the parts of the brain that are most affected by inadequate amounts of sleep.*



Slide Notes

Large scale, controlled laboratory experiments on healthy young adults have shown that the adverse effects of chronically sleeping less than needed to recover brain functions fully can accumulate across days of sleep restriction, reaching levels of impairment typically seen after 1 or 2 nights of acute total sleep deprivation. Interestingly, the participants in these studies were convinced they had "adapted" to the reduced sleep time (either 4 hours per night or 6 hours per night), when in fact, they were very experiencing both lapses of attention and cognitive slowing every few seconds across the entire day. Thus, their performance quickly degraded to levels well below their optimal performance capability.

References

Van Dongen, H. P. A., Maislin, G., Mullington, J. M., & Dinges, D. F. (2003). The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *SLEEP*, *26*, 117-126.

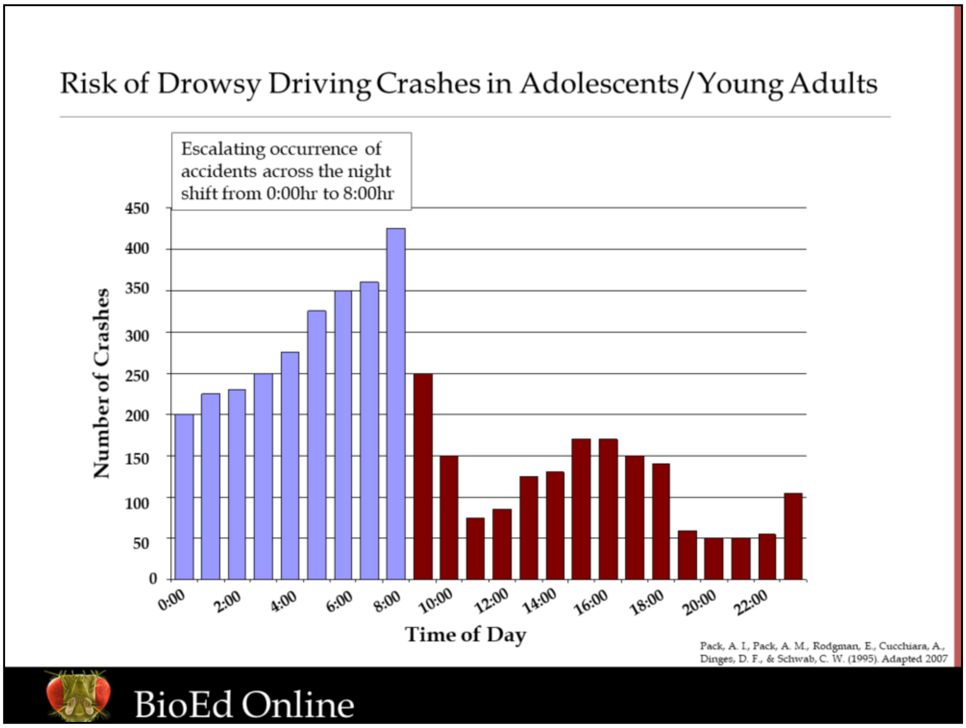
Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*

Most people become impaired by sleepiness through the way they live their lives, as I mentioned earlier, and in adolescents and young adults and in millions of other people in the world, that can mean not sleeping enough at night. There were recently completed and published major scientific studies in which healthy adults were kept in a laboratory for 20 days. This graph shows 14 of those days, plus an original baseline day. For these 14 days, a group of people were given eight hours time in bed a night for sleep. So this is the control condition. Another group was randomized, or randomly assigned, to a condition in which they got six hours time in bed at night for sleep every night for 14 consecutive nights. A final group was randomized to four hours time in bed for sleep at night. Each point is the average of all the tests' bounce, the performance test bounce, on an attention task that they completed that day from seven-thirty in the morning until midnight, each one of the groups. So thousands and thousands of points went into this experiment.

I want to remind you that people stayed in the laboratory in this study so we could control all the factors that might influence or introduce error into these assessments. We then looked at how well the subjects were able to sustain attention on simple tasks, remember things, process information. And this slide shows on the y ordinate the lapses of attention during a vigilance or sustained attention task. These are basically the number of times the signal was on, and they were holding the response button, but they failed to respond in a timely manner. And what you see is that the eight hour condition stays very near zero in the green area. This is all normal functioning. Only after about 12 days, the thirteenth to fourteenth day, does the average drift slightly above normal and that's really due to two subjects who needed more time in bed than the eight hours allowed. But remarkably, the six hour and four hour condition showed an immediate and progressive impairment developing day after day. Around the fifth or sixth day, they separated so that the four hour was even worse than the six hour, and most importantly, in both of these conditions, the people developed performance impairments equivalent to people who had been awake in another experiment without any *sleep for 24 to 40 hours. That's a full night without sleep and the next day, and they actually progressed to an area, shown here by the upper arrow, to a group that had been awake 40 to 64 hours. That's nearly three days without any sleep.*

These progressive impairments indicate that the system keeps building up what is called debt for sleep, and that the system manifests this debt in the continuing inability, ever worsening inability, to sustain attention, to remember things, to process information quickly, make good decisions, drive, etc. So it's a very sensitive homeostatic system and the only way to stop this is to get sleep. Once sleep is allowed, that's being studied now in laboratories around the world, you then see the recovery function of how much sleep nets you how much recovery. But as long as sleep is reduced, as long as you're only getting four hours or six hours, you get impairment. This tells us that most people need much more than six hours sleep and in fact they need something closer to eight hours or seven and a half hours of physiologic sleep a night.

One of the remarkable things not showing on this slide is that when people went through this experiment and we asked them every two hours, "how are you feeling, how are you doing, have you adapted, are you alert, are you fatigued," etc., they kept telling us as the experiment went on that they were fine. In other words, the first day or two they said they were a little more tired, but as the experiment went on they expressed no increase in their fatigue. They just kept saying they've adapted. Yes, they were tired, but they'd adapted and were not feeling any worse. So at the time when they were maximally impaired, around the thirteenth day, they said that they were okay, that they were normal and adapted. So this makes chronic sleep restriction, which is widespread in the world and occurs certainly in young adults and adolescents, something that's of grave concern, because people cannot introspect their impairment. They're not aware of how dangerous they are if they drive in this condition or the extent to which they're going to have trouble paying attention in class, remembering material they've read, or engaging in other activities, even physical activities like sports where reaction time matters. These, after all, are measures of slowed reaction time.



Slide Notes

Sleepiness-related motor vehicle crashes pose a serious risk to adolescents and young adults. Studies show that young people aged 16-24 years—especially males—have a higher likelihood of a drowsy driving crash than all other age groups. These crashes are also much more likely to occur between the hours of 11 p.m. and 8 a.m. that at other times of day. These are often very serious and lethal because the sleepy driver drifts out of lane and crashes without an effort to brake or avoid the crash.

Reference

Pack, A. I., Pack, A. M., Rodgman, E., Cucchiara, A., Dinges, D. F., & Schwab, C. W. (1995). Characteristics of crashes attributed to the driver having fallen asleep. *Accident Analysis & Prevention*, *27*, 769-775.

Image Reference

Pack, A. I., Pack, A. M., Rodgman, E., Cucchiara, A., Dinges, D. F., & Schwab, C. W. (1995). Characteristics of crashes attributed to the driver having fallen asleep. *Accident Analysis & Prevention*, *27*, 769-775. (Adapted 2007).

Transcript of Videotaped Presentation *(http://www.bioedonline.org/presentations/)*

Finally, I want to mention that this sleep debt does have grave implications for driving. We highlight driving relative to sleepiness because there's a significant effort in the medical and governmental communities to try and prevent drowsy driving crashes, which claim thousands of lives a year and tens of thousands of people are injured by them. Studies have shown—and this is data from one of them that we did at the University of Pennsylvania—that drowsy driving crashes are particularly likely to occur at night between 11 p.m., shown here on the right, all the way through midnight to 4 a.m., 6 a.m., and they peak in the morning. Now, of particular concern in this study was evidence that crashes were three times more likely to occur in males, and most importantly, the group that far and away had the most crashes was young adults and adolescents between the ages of 16 and 24. So males, particularly out at night driving with inadequate sleep, are at very high risk for fall asleep crashes. These crashes are particularly lethal and have high bodily injury rates because typically, the driver fails to brake or gain control of steering and avoid the collision. The driver falls asleep and hits the object, an abutment, or runs off the road and hits a tree, at full force, with the car moving at full speed. So this is an area in which prevention has been a major focus.

I want to say that these are not alcohol related crashes. They've been proven not to be. In all of these crashes in this study, there was no alcohol involved, or any other drugs. These are young people falling asleep. So even if you don't care about falling asleep in class and you don't care about falling asleep on the job—if it's not a safety sensitive job—you should care about driving, operating a motor vehicle or any safety sensitive equipment when you're sleepy, and that alone is a good enough reason to get you sleep. But frankly, everything you learn, you will remember better if you get your sleep; everything you do, you will do better if you get your sleep. And it's not enough to cheat your sleep during the work week and then try to recover on the weekend. Rather, it's much better to try to live a more disciplined schedule that assures you get as much sleep as you can during the week and avoid trying to do things like driving at night, particularly long drives at night, where you're most vulnerable to fall asleep crashes. Thank you.