This exercise summarizes the basic brain processes in sleep and the use of the EEG (electroencephalogram; "brain waves") to measure sleep stages. It includes the following topics:

- sleep as an active process and brain areas that turn it on
- the EEG: how it is recorded and what it shows about brain activity
- the EEG for the two basic kinds of sleep, slow wave sleep (SWS) and rapid eye movement sleep (REM) and their associated physiological and psychological processes
- the division of SWS into four stages
- the alternation between SWS and REM sleep during a night's sleep
- developmental changes in sleep

Sleep: An Altered State of Consciousness

When people think of altered states of consciousness, they often think of states induced by drugs, by hypnosis, or some other exotic (~unusual) process. However, each of us experiences an altered state of consciousness (almost) every day -- or rather, night. It's called sleep. It certainly qualifies as an altered state of consciousness.

Sleep is an active process generated by a specific brain system. Sleep is not just the absence of waking. It is a process that actively shuts down the brain. Most people know this from personal experience. When you haven't had enough sleep, you can doze off almost anywhere, as long as something or someone is not directly trying to keep you awake.

Several brain areas are involved in producing sleep. Two important ones are small areas in the caudal (back end of) brain stem (Vertes, 1984) and in the lower, front part of the limbic system (Sterman & Clemente, 1974). Figure 1-4i shows the locations of these structures. Damage in these locations abolishes the capacity to fall asleep, whereas electrical or chemical stimulation at these sites makes animals curl up and fall asleep, just as they do normally.

Q1. After "pulling an all-nighter," Joe dozes off at dinner with his girlfriend. What process makes him doze off?

[Hint: A name is not an explanation. What process directly produces the dozing?]

A. he's sleepy after the "all-nighter"
B. his girlfriend is boring and the food tastes blah
C. the brain slows down as a person goes to sleep
D. specific places in his lower brain stem and limbic system are active
E. dreams are active, so they shut the brain down to let them happen
F. A, B, C, D, & E are all correct

The EEG and other signals of body activity are recorded with a polygraph (poly = many; graph = writing). Hans Berger’s discovery of the electroencephalogram (EEG, or "brain waves") in 1929 opened the way for major developments in sleep research. Figure 2-4i shows how EEGs and other body processes were recorded with a polygraph.

The upper part shows electrodes stuck on the scalp to pick up the tiny electrical signals from the brain that can be detected from the scalp. Two dozen or more electrodes are used at a time. Other electrodes stuck on the skin measure eye movements, muscle activity, especially from the neck or jaw, and other body reactions. The electrical signals the electrodes pick up go to amplifiers in the polygraph.
The lower part of Figure 2-4i shows the way a traditional polygraph records the electrical signals from the skin. The amplifiers strengthen the signals so they can drive pens to move up and down. The bigger the electrical changes picked up from the scalp, the bigger the up-and-down pen movements are. The pens write on a long paper tape pulled under them at a constant rate. This draws a very long graph, with time on the long horizontal axis and with electrical signals of the EEG, eye movements, muscle tension, etc. on the vertical axis. Modern systems save the signals in digitized form for computer analysis.


Figure 3-4i shows the polygraph record of activity recorded for about 20 seconds of sleep about 45 minutes after falling asleep. The top two traces show eye movements, the third shows neck muscle tension, and the bottom three record EEG from three different locations on the scalp over different lobes of the cerebral hemisphere. The vertical axis shows changes in the electrical signals. The horizontal axis is time.

The EEG shows systematic changes over a night's sleep. An early finding was that the EEG changes when a person falls asleep. As a person (or animal) falls asleep, the EEG goes through a series of stages. During waking the EEG shows low amplitude (small), high frequency (many waves per second) activity called beta waves. As a person falls asleep, the EEG changes, showing progressively bigger and slower waves (longer lasting waves; few waves per second). This pattern of EEG activity gives this stage of sleep its common name: Slow Wave Sleep (SWS) Figure 4-4i illustrates these changes.

The brain, the mind, and the body become more and more inactive in progressively deeper stages of slow wave sleep. As you fall more deeply into SWS, the "brain waves" become slower and bigger, which is a sign of decreased brain activity. We know this from experiments on animals, which show that most neurons in the brain are relatively inactive. Associated with the increasing amount of slow wave activity is a decreasing amount of mental activity and level of conscious awareness.

Q2. You can tell when a person falls asleep from the EEG because it

A. stops showing any brain wave’s
B. shows that the brain cells are much less active
C. shows more and more low frequency (slow), high amplitude (big) activity
D. shows more and more beta waves
E. B, C, & D are all correct

The first change in the EEG appears as you relax, close your eyes, and empty your mind. The EEG now shows bursts of activity at 8 - 12 Hz, called alpha waves, and beta activity declines. As you begin to fall asleep, the alpha activity breaks up and the EEG show rather small, irregular waves, with some beta activity riding on slower brain waves. This is stage 1 of slow wave SWS. The subsequent stages show increasing amounts of slow wave activity. Stage 4 is the deepest stage of slow wave sleep. At this time the EEG shows mainly large amplitude (size) waves at low frequencies, below about 5 or 6 Hz, called delta waves.

In slow wave sleep, the body relaxes, but some muscle tone remains, and people become harder to
wake up as sleep becomes deeper. Heart rate and breathing are calm and regular indicating a low level of activity in the autonomic nervous system. The eyes show only slow, drifting movement.

! After about 60 - 90 minutes in slow wave sleep, the first episode of REM sleep begins. REM stands for Rapid Eye Movement. These are large saccades (jumpy eye movements), like those that occur as you look at something – a person's face or a line of text. Your eyes jump among important features with such saccades. These rapid, jerky eye movements give this stage of sleep its most common name: Rapid Eye Movement (REM). When you fall into REM sleep, your brain rather suddenly shift to a very different pattern of activity (Figure 8-4i). The EEG in REM sleep looks somewhere between waking and stage 1 slow wave sleep.

! Although the brain is very active during REM sleep, strong inhibition of sensory pathways and the motor control system shuts off from the rest of the body. This inhibition is triggered from a different part of the brain stem. We know this because damage to this area in experimental animals releases the inhibition and the animals behave as if they have hallucinations, like the perceptions people describe in dreams.

Q3. When a person falls into REM sleep, s/he shows
A. very active autonomic nervous system
B. EEG that looks like the awake or light sleep EEG
C. low voltage, high frequency activity in EEG
D. jerky movements of the eyes, hands, and face
E. decreased responsiveness to sensory stimuli
F. complete relaxation of somatic (body) muscle
G. all of the above are correct

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! The brain, the mind, and the body become more and more inactive in progressively deeper stages of slow wave sleep. Slow wave sleep is named for the pattern of electrical activity that is characteristic of its deepest stage. As you fall more deeply into slow wave sleep, the "brain waves" become slower and bigger, which is a sign of decreased brain activity. We know this from experiments on animals, which show that most neurons in the brain are relatively inactive. Stage 4 is the deepest stage of slow wave sleep. At this time the EEG shows mainly large amplitude (size) waves at low frequencies, below about 5 or 6 Hz, called delta waves.

In slow wave sleep, the body relaxes, but some muscle tone remains, and people become harder to wake up as sleep becomes deeper. Heart rate and breathing are calm and regular, and the eyes show only slow, drifting movement.

REM sleep is named for the rapid, jerky eye movements that appear in this stage. In this stage, many parts of the brain are very active, about as active as it is during alert waking. Many other physiological changes, mostly controlled by the action of the autonomic nervous system, also appear.

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Rapid Eye Movement. These are large saccades (jumpy eye movements), like those that occur as you look at something — a person’s face or a line of text. Your eyes jump among important features with such saccades.

The brain and body rather suddenly shift to a very different pattern of activity (Figure 8-4i). The EEG in REM sleep looks somewhere between waking and stage 1 slow wave sleep. Nerve cells in the brain are very active -- as active as during alert waking.

REM sleep was discovered when all-night EEGs were first made. In 1953, Kleitman and co-workers reported the first EEG recordings over a full night’s sleep (Aserinsky & Kleitman, 1953; Kleitman & Dement, 1957). Their nighttime records showed that sleep is not a uniform condition. Instead, they revealed two main kinds of sleep: slow wave sleep (SWS), which is shown in Figure 3-4i, and rapid eye movement sleep (REM). REM sleep has several other names as well, e.g., paradoxical, low voltage fast. REM is the standard term now.

Although the brain is very active during REM sleep, strong inhibition of sensory pathways and the motor control system shuts off from the rest of the body. This inhibition is triggered from a different part of the brain stem. We know this because damage to this area in experimental animals releases the inhibition and the animals behave as if they have hallucinations, like the perceptions people describe in dreams.

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D. jerky movements of the eyes, hands, and face
E. decreased responsiveness to sensory stimuli
F. complete relaxation of somatic (body) muscle
g. all of the above are correct

Figure 10-4i shows the changes in eye movements and muscle tension as a person goes from waking through slow wave sleep to REM sleep. The upper trace from each pair (Awake, SWS-2-3, REM) shows eye movements; the lower shows muscle tension.

During waking, the muscles are very active (the thick fuzzy line shows the sum of many muscle fibers contracting). During REM sleep, the thin line shows that the muscles are almost completely relaxed. During SWS, muscle tension is intermediate.

During waking the eyes show almost continuous movement, making both slower drifting movements and saccades large (rapid jumps). During SWS the eyes still move but show mainly drifting movements. During REM sleep, the eyes show little movement, except for bursts of saccades, which appear as the big

The main behavioral signs of the sensory and motor inhibition are:
- The (somatic) muscles of the body become completely relaxed, losing all tone.
- The brain’s response to sensory stimuli is suppressed.
- People (and animals) are hardest to wake up when in REM sleep.

The intense brain activity during REM leaks out.
- The autonomic nervous system, becomes very active: heart beat, blood pressure, and respiration (breathing) become much more active and irregular, the sex organs show increased activation, etc.
- The face, hands, and feet show bursts of twitching.
- The eyes show bouts of jerky, rapid eye movements.

Some of these changes are easily visible. You have probably noticed that the paws and face of a sleeping dog or cat occasionally show bouts of twitching. This twitching is a sign of REM.

REM sleep is produced by a complex network centered in the brain stem, which uses acetylcholine as the primary neurotransmitter. A small area in the middle of brain stem is the main trigger area that activates this cholinergic system, which activates much of the rest of the brain. Chemical stimulation with chemicals that increase acetyl choline activation immediately turns on REM sleep, and damage to it reduces REM sleep.
up-and-down swings in the record. These saccades give REM sleep its name.

**Q4.** Which of the following shows the change in polygraph signals from waking to slow wave sleep?

A. Eye movements change from a lot of both slow and fast movement to mainly a few slow drifting movements.

B. EEG changes from mostly low amplitude (height), high frequency activity to larger amplitude, low frequency.

C. Muscle tension from a very thick line with ragged edges to a moderately thick line with ragged edges.

D. A, B, and C are all correct

**During a night's sleep the periods of slow wave sleep become shallower and the periods of REM sleep become longer.** Figure 11-4i shows the duration of REM and different levels of SWS during a typical night's sleep. The first period of REM is short, lasting only about 15-20 minutes. REM reappears at about 90 minute intervals during a night's sleep. The periods of REM become longer, on the average, each time, so we do much of our REM sleep toward the end of a normal 7-hour night's sleep.

As REM sleep periods become longer, periods of SWS become shorter and less deep. You see big, slow delta waves in the EEG only early in a night's sleep. Thus, most SWS, especially the deepest, occurs early in a night's sleep, and most REM sleep occurs toward the end.

**Development from birth (and even before) to young adulthood is associated with a progressive decrease in the time spent in REM sleep.** Figure 12-4i shows the change in sleep time with age. Newborn babies spend about half their sleeping time in REM sleep. As children get older, they spend less time in REM sleep, reaching adult levels of about 20% REM sleep a night at age 15. In contrast, the amount of slow wave changes very little with age.

Premature babies have even more REM sleep than do normal newborn infants; the more premature they are, the more REM activity they show. This fact suggests that REM sleep has some special function related to developing and maintaining normal brain organization. One such function may be self-stimulation. Stimulation is required after birth for sensory systems to develop normally. Before birth, the fetus gets little sensory stimulation, so it may be generating its own.

**Q5.** [Mark EACH item True (T) or False (F)] REM sleep occurs

T F A. right after a person falls asleep

T F B. 4 or 5 times in a normal night's sleep

T F C. after periods of slow wave sleep

T F D. most very early in life and least in old age

Link to the home page of the sleep laboratories at UCLA Medical School.

Link to more information about the EEG.
This exercise briefly describes the relation between sleep stages and mental content, possible meaning of dreams, the possible functions of slow wave sleep and REM sleep, and the effects of sleep deprivation. The main points in the exercise are:

- REM and dreaming are closely tied, though other sleep stages have mental content, including dreamlike periods.
- Sleep is necessary.
- Sleep deprivation in people is associated with fatigue and considerable difficulty in many mental functions, especially ones that require paying attention for more than a short time.
- Sleep deprivation combined with stress often produces psychological disturbance.
- Even overnight sleep loss impairs performance about as much as alcohol on tasks like driving that require continuous attention.
- Sleep, especially REM sleep, is associated with fixing memories in long-term memory. Sleep deprivation interferes with recall, and brain activity during sleep matches activity during learning the day before.

The particularly interesting thing about REM sleep is that it is closely related to dreaming. Dreams have interested people for all of recorded history, and almost certainly long before. Dreams have been claimed to indicate the future, to reveal messages from God, to reveal repressed anxieties, to connect people to a different plane of experience, etc. Therefore Dement & Kleitman’s (1957) discovery of REM sleep triggered a great increase in the scientific study of dreams.

Much evidence quickly accumulated for the relation between REM sleep and dreams. For example, people spontaneously reported dreaming when awakened from REM sleep. The length of the report correlates with the length of the REM sleep before wakening. Their reports had all the qualities of dreams: they have a story, which is sometimes wildly unreal, they have imagery, and they often have emotional tone to them. Although the correlation between dream reports and REM sleep is quite strong, mental activity occur at all stages of sleep. In particular, dream-like reports are often reported during Stages 1 & 2 of SWS (slow wave sleep), when people are just beginning to fall asleep.

Deeper SWS also have mental content, including dreamlike states, which differ from what people usually call dreams. During slow wave sleep, the mental content is often more static and thought-like. People also experience dreamlike states when they nap or are just falling asleep. These are more realistic than dreams and are more closely tied to what people have been experiencing and thinking about.

Q1. If you wake up a person during a period of REM sleep, s/he will report [not show]
A. vivid mental activity with a story line and emotional qualities
B. dreaming
C. high frequency, low amplitude EEG (beta waves)
D. twitching in hands, feet, and face
E. A and B are both correct
F. A, B, C, and D are all correct

Function of Sleep

The most obvious function of sleep is that of repair, but what kind of repair remains controversial and unclear. Most people feel a lot better after a good night’s sleep, as if sleeping somehow gets rid of the effects of the day’s wear and tear. But what this repair is and how it might work remains controversial. Other proposed functions include

- a. memory consolidation
- b. removing useless information from memory
- c. restoring the brain’s energy stores from the drain of waking activity
- d. body energy conservation (smaller animals sleep more than do larger ones)

However, the support for any one theory is not strong (Rechtschaffen, 1998).

If sleep has a repair function, then the amount of activity during waking ought to affect sleep. Normal variations in activity do affect sleep, but large changes in waking activity produce only small changes in sleep patterns. People who can’t or don’t move during the day show little decrease in sleep and under some conditions they may sleep more than normal (Campbell, 1984).

Intense physical exercise is required to produce an increase in slow wave sleep, but the exercise must...
warn the brain to have an effect. Physical exercise during the day increases slow wave sleep that night only if brain temperature increases during the exercise. If participants are kept cool during their exercise, slow wave sleep does not increase. Mental activity without excess physical activity also increases slow wave sleep on the following night. People exposed to mentally demanding activities for a day increase slow wave sleep that night. (McGinty & Szymusiak, 1990).

**Sleep must be necessary.** At least two lines of evidence show this.

1. *All mammals, birds, and reptiles sleep,* even when it is potentially dangerous. For example, some sea mammals like dolphins prevent sinking and drowning while asleep by sleeping with one brain hemisphere at a time. Prey animals, like deer, fall into very short, but intense periods of sleep. Longer periods of sleep would make them very vulnerable to predators, because REM sleep inhibits reactions to external sensory input.

2. **Complete sleep deprivation can produce serious illness and even death.** Completely depriving rats of sleep for many days show that sleep is as necessary for life as are eating and drinking. If total sleep deprivation lasts longer than about two weeks, rats begin to die. If REM sleep is selectively deprived for more than about five weeks, the deprived rats begin to die (Rechtschaffen, 1998).

**REM sleep also must be necessary,** and for the same reasons.

1. *All higher animals have it, even though it can make them even more vulnerable than slow wave sleep.* For example, prey species, like deer or rabbits, are even more vulnerable to attack during REM sleep than during slow wave sleep. (Remember that during REM sleep the senses and the muscles are virtually cut off from the brain). Nevertheless they do have REM sleep, though their REM periods are very short and very intense as compared to predator species like wolves, dogs, and cats.

2. Like total sleep deprivation, *depriving rats of REM sleep selectively produces severe, potentially fatal physiological disturbance,* though it takes longer than deprivation of all sleep. Rats awakened as often but not during REM sleep show much less physiological disturbance. This means that, directly or indirectly, REM sleep must serve some sort of vital function (Rechtschaffen et al., 1983).

Deprive people and animals of sleep completely is very difficult. Food and water deprivation is easy: just make food and water unavailable. Sleep deprivation requires active intervention: you have to detect sleep and promptly wake the person or animal up. Sleep deprived individuals fall into “microsleeps” very quickly and frequently, before they can be awakened. Therefore, sleep deprivation may not be complete. Selective deprivation of REM sleep is even more difficult, because you must detect some physiological sign of REM.

**Changes in body functions start to appear after one night’s deprivation.** Even this modest sleep deprivation is probably somewhat stressful. In humans, both partial and complete sleep deprivation over a 32-hour test period affect the functioning of the hypothalamic-pituitary-adrenal cortex stress response system (see asgn4zd) (Leproult et al., 1997). The changes include temperature changes (which depend on which sleep stage was prevented); heat-seeking behavior; increased food intake; weight loss; increased metabolic (“life process”) rate; increased plasma norepinephrine; decreased plasma thyroid hormone; etc. (Everson, 1995; Rechtschaffen & Bergmann, 1995). Sleep deprivation also depresses the body's immune system, which defends against infectious.

Q2. Evidence showing that sleep is necessary comes from data show that

A. severe sleep deprivation produces a variety of abnormal body conditions.
B. severe sleep deprivation can be fatal to rats if it is complete enough and long enough.
C. all animals (except amphibians [frogs, salamanders] and fishes) sleep
D. A, B, & C are all correct
E. none of the above. People can do ok without sleep; they are just tired.

**Sleep deprivation affects psychological and behavioral performance,** but ideas about exactly what it does have changed considerably. Early studies in the middle of the 20th century were particularly interested in psychopathological consequences of sleep and dream deprivation, perhaps because of the strong influence of Freudian ideas then. Freud was particularly interested in dreams and dreaming. He claimed that dreams serve to release repressed emotional conflicts by distorting them to sneak them past the ego's "censor." So if you prevent this outlet for repressed emotional conflicts, you should see some effects on psychological health. Consistent with this expectation, early studies seemed to suggest that sleep deprivation could result in the development of psychopathology.
A well-publicized case seemed to confirm this idea. As a publicity stunt, Peter Tripp, a radio station disc jockey, was kept awake for over 200 hours in a glass booth in Times Square. After about two days he began having hallucinations. After five days he found simple metal tasks very difficult, his memory started to fail, and the hallucinations became more intense. Toward the end of the 200 hours his hallucinations merged with delusions that the physicians who were monitoring his condition were conspiring to put him in jail (Luce, 1966). Link to a detailed account of early sleep deprivation studies.

The psychopathological effects of sleep or dream deprivation have not held up. In fact, moderate sleep deprivation is sometimes used successfully to treat some forms of depression (Vogel et al., 1980). In addition, another person who was deprived of sleep for over 200 hours showed no sign of psychopathology (Dement, 2000).

Randy Gardner, a high school student, went without sleep for 211 hours to set the world record and get into the Guinness Book of Records (Dement, 2000). Sleep researchers monitored him and kept him from falling asleep, mainly by keeping him moving. The basketball hoop in the back yard always worked (though he lived in California, not Indiana).

Gardner showed no sign of psychopathology, except for getting irritated, especially in the wee hours of the morning. He held a news conference when he reached and exceeded his goal and handled himself perfectly. He then went to bed and slept for about 16 hours. The next few nights he slept somewhat longer than usual but did not come close to making up the sleep he had lost. Other studies also showed that sleep deprivation consistently produces only irritability and fatigue in normal individuals deprived in non-stressful situations.

However one recent report compared the effects of sleep deprivation to some features of schizophrenia (a severe "mental" illness). The author even proposed that sleep deprivation be used to produce a model for some aspects of this disorder. The report cites frontal lobe deficits from sleep deprivation that parallel some deficits in some forms of schizophrenia. These deficits include social withdrawal, bursts of uncontrolled laughter, and speech that resembled the loose associations of some schizophrenic speech (Horne, 1996).

It is not clear why the outcome of this study differs so much from others. Two possibilities suggest themselves: First, the procedures probably differed in how much stress the participants experienced. Second, the study that found parallels to schizophrenia may have looked harder for abnormal effects and emphasized them more. Many of you have done "all-nighters." I doubt whether you showed much unusual except some extra fatigue and difficulty in concentrating and staying awake. (Sitting in a dimly lit lecture hall with the instructor droning away puts most sleepy people out really fast. This happens to me, even after only a shortened night's sleep.)

Q3. Which of the following forms of psychopathology have been described because of sleep deprivation without external stress?
A. hallucinations and delusions
B. deficits in mental functioning that resemble some symptoms of frontal lobe deficit in some forms of schizophrenia
C. relief of symptoms of depression
D. none beyond some increased irritability and fatigue
E. A, B, C, & D are all correct

Even moderate sleep deprivation impairs psychological functions that require organizing and planning. If motivation is strong and the tasks don’t last too long, sleep-deprived participants can perform fairly well on many, but not all, kinds of tasks. They do fairly well on tasks that do not depend much on the prefrontal cortex, which supervises how attention is used. Such tasks include long, complex (but interesting) critical reasoning and other logical, "convergent" (~rule-based) tasks (Horne, 2000).

Sleep-deprived participants do poorly on tasks that require attention and concentration. Affected tasks put a load on working memory because they require recoding new information, judgment, planning actions, and initiating or inhibiting actions (Pilcher & Huffcutt, 1996). Unfortunately, these tasks are often important ones. It is interesting that partial sleep deprivation had effects that were as strong as or stronger than complete sleep deprivation. If this finding holds up, it suggests that no sleep for a night may be better that a couple hours.

Brain imaging experiments have shown that brain activity declines during sleep deprivation. The higher association areas of the frontal and parietal cortex are especially affected. These areas of the brain are especially involved in highest mental functioning, such as working memory, judgment, planning and initiating (or inhibiting) actions. These are the kinds
of tasks that sleep deprivation affects most (Lamberg, 1996), and sleep-deprived participants need to use extra effort to achieve the performance they show. As a result, they show abnormally high activation in the frontal lobes while they perform such tasks. (Drummond et al., 2000). Link to an article about how the brain recovers from sleep deprivation.

Q4. Sleep deprivation affects most psychological functions that
A. depend most on the frontal lobes.  
B. tasks that use working memory a lot.
C. tasks that make you recode information as in learning a list of words or require directed attention, choosing among alternatives, and choosing when to act and when not to.
D. A, B, and C are all correct

Practical Consequences of Sleep Deprivation

Many people don't get enough sleep, which makes them much more likely to make errors in judgment, which can be very costly. During their everyday activities, many people get less sleep than they need for days, weeks, or longer (Dement, 1997). Long haul truck drivers, interns and residents in hospitals, military personnel, and students are some groups in this condition. The effects of partial sleep deprivation add up over time (Dinges et al., 1997), making people even more sleep deprived. Sleep deprived people become ever more likely to fall asleep or go into sleep-like states, especially late at night when the body's internal clock tells your body to be asleep (see asgn4k).

Sleepiness is a major contributor to traffic accidents (Dement, 1997), because driving requires long periods of attention, but with little change in stimulation. The National Highway Traffic Safety Administration conservatively estimates that 1,500 traffic deaths and 76,000 injuries result from drivers falling asleep. The toll is probably much higher, especially among long-haul truck drivers (Barachet et al., 1998) because sleep deprivation reduces driving performance in much the same way that alcohol does. A single night of sleep deprivation decreases performance to levels shown by people who are legally drunk (Dawson & Reid, 1997).

Other kinds of complex skills become disrupted as well. For example, undergraduates deprived of sleep for 24 hours did worse on a critical thinking task than did controls who slept eight hours the previous night. Yet the deprived students thought they did better than did the controls and rated their concentration higher. Evidently the students were unaware of the objective effects of the deprivation (Pilcher & Walters, 1997).

Q5. An all-nighter will probably
A. make you drive less safely
B. affect your driving as much as several alcoholic drinks
C. make you do poorly on an essay exam that requires you to retrieve, select, and organize information
D. A, B, and C are all correct

Early research on selective REM deprivation suggested that it could trigger psychological abnormalities (Dement et al., 1967). This finding has not been confirmed (Lubin et al., 1974). Decreased REM sleep does reduce the feeling of refreshment that usually follows a night's sleep.

REM deprivation increases the frequency and decreases the latency of falling into REM sleep. Normally, people have four or five episodes of REM in a 7-hour night's sleep. The first occurs about 90 minutes after slow wave sleep starts. After REM deprivation, people fall into REM sleep much sooner, almost directly from the waking state, and they will fall into REM 50 or more times a night. On the night that REM deprivation is stopped, the amount of REM sleep increases by 50 to 100% (Dement, 1960).

Q6. Selective deprivation of REM sleep makes people
A. have symptoms of mental illness
B. fall into REM sleep faster and more frequently
C. experience very strong stress
D. walk in their sleep
E. feel more refreshed than slow wave deprivation
F. A, B, C, and D are all correct

REM sleep appears to play an important role in consolidating memory. (Smith, 1995). For example, participants who learned to decode Morse code messages had their sleep EEGs monitored the night following learning. They showed an increase in the number of REM episodes and total REM time above the preceding control night. Furthermore the better a person did on a recall test the next day, the more REM increase he showed (Mandai et al., 1989). Conversely, REM deprivation decreased recall of a story compared to equivalent slow wave sleep deprivation (Tilley & Empson, 1978). Similar results
have been reported for spatial memory in rats (Smith & Rose, 1997).

These data suggest that REM is important in somehow fixing information from the preceding day in memory. The intense activity of the brain shut off from the external world may strengthen synapses involved in the learning on the preceding day.

Several recent studies show that sleep helps fix memories for new experiences. Both animals and humans retain more information and/or show more brain change, if they sleep after new experiences than if they stay awake (Frank et al., 2001). Link to a brief summary of some of this research.

REM sleep probably plays an important role in brain development, especially before and for some time after birth. Strengthening of synapses fits with another proposed function for REM during development. (Marks et al., 1995). Recall three things:

- Newborn babies spend about half their sleeping time in REM and premature babies spend an even higher percentage. These percentages are much more than the 20% that adults spend in REM.
- Perceptual capacities that the brain has can be lost if they are not used (see asgn2q).
- Synapses that are used get stronger; synapses that are not used get weaker and can disappear entirely.

These data suggest that the brain uses REM to stimulate itself before and for some years after birth to preserve and tune its organization and connections.

Q7. REM sleep may have the function of
A. keeping the brain from falling too deeply asleep
B. fixing memories of information learned the day before
C. self stimulation during development to fix brain connections
D. preventing sleep walking and injuries that may result
E. providing dreams for psychiatrists to interpret
F. B and C have been proposed

Link to more information about REM sleep. For more about sleep, click HERE.

asgn4k -- ALTERED STATES OF CONSCIOUSNESS: Sleep
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asgn4k -- Sleep: Dreaming, Sleep Disorders, & Circadian Rhythms

Dreams and their meanings have interested people for as long as we have records. In the Bible, Joseph was elevated from prisoner to chief advisor to Pharaoh for interpreting Pharaoh's dreams. Recently, Hobson (1988). a modern brain-oriented sleep researcher, has presented an extensive historical survey of research on dreaming that attempted to use objective methods.

Sigmund Freud is by far the best known investigator of dreams. His work was based on the subjective reports of patients and on myths and other literary sources. The effectiveness of his rhetoric (not his data) made his approach dominant for at least a half century. Freud used dreams and their interpretation as a central idea in his development of psychoanalysis. One of his early descriptions of psychoanalytic theory was a book about dreams called The Interpretation of Dreams (1911).

Freud proposed that dreaming is a process by which the mind releases extremely unpleasant or dangerous psychological conflicts in symbolic form. According to Freud, everyone has such unpleasant or dangerous conflicts, which are repressed by a mental censor into the unconscious. These conflicts must be released somehow, and dreaming is one mechanism. For this reason, Freud distinguished between a dream's manifest content and its latent content. The manifest content is what a person actually
experiences and remembers in a dream. The latent content is the hidden, repressed conflict that the manifest content of a dream symbolically releases.

Link to a psychoanalytic interpretation of the impact of Freud's book on dreams.
Link to a critical evaluation of the Freudian theory of dreams.

Match following according to whether it is the manifest content or the latent content of Max’s dream

1. manifest content 2. latent content

Q1A. the dream Max actually experienced
Q1B. the repressed emotional conflict Max's dream stood for
Q1C. Max consciously believes he loves and respects his father, but Max is actually very afraid of him
Q1D. Max was floating in the air on a beautiful, sunlit day, when suddenly the sky darkened and a huge eagle dived down to grab him

Many other theories about the meaning of dreams have been proposed. Carl Jung, who was initially a follower of Freud, claimed that dreams reflect the primitive, universal unconscious mental activity of humans. In contrast to Freud, who emphasized the hidden meaning about psychopathology in dreams, Jung believed that the meaning of dreams was quite clear. He claimed that they represented a creative process, not a pathological one. Also Jung had a much less physical and physiological approach to dreaming than did Freud (Hobson, 1988, p. 65-67). Jung believed that the mind performs many activities derived from the collective unconscious each of us shares with the whole human race. As evidence, Jung pointed to the similarity of dream content among different people and different cultures. He also claims that the same symbolism that appears in dreams also appears in many cultural products: religion, arts, literature, etc.

Calvin Hall has proposed that the symbolism in dreams differs among individuals and is much less hidden than Freud believed. Some dreams require no interpretation. Most people can recall dreams in which they did things they would never do while waking. Some dreams have quite clear meaning for the dreamer. Sometimes, however, the dreamer avoids those meanings, because they are too painful. A therapist's role is to help a patient face the meaning of his/her dreams, rather than to interpret them by some universal meaning.

The Activation-Synthesis model proposes that REM sleep generates strong random activity, which the brain/mind tries to fit into a person's existing mental structures. Hobson and McCarley (1977) have proposed an activation-synthesis model, based on the physiology of the dreaming state. This model takes some well-established physiological data about REM sleep and uses them to interpret how dreams are generated. It starts with the finding that REM is triggered from the raphe nucleus in the brain stem, which is turned on by the neurotransmitter acetyl choline. (Jouvet, 1962, 1967; Vertes, 1983). Activation of the brain stem trigger makes many parts of the brain very active. At the same time it shuts down sensory input and somatic motor output, which controls body movement. This is why people are harder to wake up and have completely relaxed muscles during REM sleep (see asgn4j).

According to the activation-synthesis model, the mind creates what we experience as dreams to try to make sense of the intense, random brain activity during REM. The mind appears to create “stories” and imagery around this random activity based on what it already has in it. In other words, it is pure top down processing (asgn2v). Although these stories and images often seem bizarre by waking logic, they do seem to make some sort of sense. The mind may use many things to create its dreams: events of the past day; old memories; wishes and desires, including the very painful unconscious, socially unacceptable desires that Freud believed were so important.

The following quotation describes an example of how peoples’ personal concerns appear to affect dream content. Note that the meaning of the dreams is quite clear.

When I am invited to speak publicly, I often make it a point of asking how many people have had nightmares about nuclear war. If I poll members of peace groups, often about two-thirds of the audience raise their hands. In a group of about twenty citizens at a church in Livermore, California no hands were raised. When I once asked a group of about seventy laboratory employees, two raised their hands. (Gusterson, 1998)
Q2. Hobson’s activation synthesis hypothesis of dreaming states that dreaming reflects
A. the brain activity that is triggered during hypnosis
B. interpretation of random activity from brain’s self stimulation
C. using your own unique symbols to represent thoughts
D. anxiety reduction through working out emotional experiences
E. unresolved unconscious emotional conflict

Disorders of Sleep

Many different processes can disturb sleep. Sleep researchers have been reporting that many people do not get enough sleep and pay for it in a variety of psychological and physical problems. People spend a lot of money on sleeping medications, indicating that many people also recognize that insomnia is an important problem. A lot of this money is probably wasted, because sleep medications often do not treat the underlying problem. Sleep medications have other problems as well (Holbrook et al., 2000). Benzodiazepines (like Valium®) are probably over all still the “best” ones now available. They produce a statistically significant decrease in time to fall asleep and increase in total sleep time. However, their effect is quite modest and may not help much.

Furthermore, they tend to lose their effectiveness with continued use and are potentially addictive. Most importantly, most cases of insomnia probably respond to behavioral treatment. For these reasons, a report to the Canadian Medical Association on treating insomnia (Holbrook et al., 2000) recommends medication (benzodiazepines) as a last resort after behavioral methods have not helped. The medication should not be used longer than four weeks.

The following description of behavioral interventions for insomnia is taken from a report on the treatment of insomnia (Holbrook et al., 2000).

"These items can be variously grouped into 3 main forms of intervention - stimulus control, temporal control and sleep restriction. Stimulus control refers to the attempt to associate the bedroom with sleep rather than wakefulness. Temporal control measures recommend a constant time of waking with minimal daytime napping, and sleep restriction curtails slightly the time spent in bed and then gradually increases it as long as most of the time is spent sleeping. These behavioural therapies have been shown to be superior to placebo. Additional nonpharmacological interventions such as progressive muscle relaxation, biofeedback and cognitive-behavioural therapy may be of benefit as well but require additional expertise on the part of the provider. Many patients with insomnia do not recognize the important role that stress may play in their symptoms and, therefore, lose the opportunity to benefit from psychotherapy or behavioural therapy."

Some people have benign insomnia (benign ~ not sick; insomnia ~ failure to sleep). These people complain they sleep poorly, but they actually sleep adequately. They may worry about their sleep because they believe they sleep very little. However, objective measurements indicate that they sleep much more than they believe. The best treatment for them is to reassure them that they are getting enough sleep.

Irregular sleep habits also contribute to insomnia. People who sleep at irregular times often sleep less well, and their sleep is less refreshing. This is an especially important problem with people who work on the traditional rotating shift schedule (see below). People who don't sleep enough at night may take naps during the day. If they are short (~20 minutes) they can be helpful and refreshing. But longer naps during the day often interfere with a good night's sleep, which in turn leads to taking naps during the day. Establishing a routine of quiet activities, regular bed time, avoiding naps during the day, and avoiding caffeine or alcohol in the evenings can improve sleeping. Also, getting up and doing something else until you feel sleepy lets you develop the habit of falling asleep when you go to bed.

Sleeping medication dependency or iatrogenic insomnia (iatrogenic ~ treatment produced) is insomnia produced by medications intended to help sleep. People who suffer from this problem sleep poorly because they have been "hooked" on sleeping medications. They require medication to fall asleep, and if they do not get that medication, they sleep very poorly. Unfortunately, many of the medications for sleep induction, especially older ones, decrease the amount of REM sleep, making the night's sleep less refreshing."
Other, less common but more severe, sleep disorders include:

1. **Sleep apnea** (~stopping breathing) disturbs sleep because it wakes up the sufferer many times during a night's sleep. When they stop breathing, the carbon dioxide in their blood increases. This produces intense arousal, as most people know from trying to hold their breath underwater. So the sleep apnea sufferer wakes up frequently, which makes the night's sleep much less restful and is a potential health hazard as well.

2. **Sleep walking**, **night terrors**, and **enuresis** (bed wetting) all appear to occur mainly during slow wave sleep. All three are caused by incomplete waking from deep (stage 4) slow wave sleep (Broughton, 1967). Part of the brain wakens, but the rest remains asleep, producing confusion in sleep walking, intense fear in night terrors, and failure of bladder control in enuresis (bed wetting). These conditions are more common in children and are usually outgrown. (Night terrors far more intense than "ordinary" nightmares, often with a feeling on something pressing on the chest to prevent breathing)

3. **Narcolepsy** is a disorder in which a person has a sudden, intense desire to fall asleep during normal waking. In this condition the person falls directly into REM sleep, which sometimes produces cataplexy. In cataplexy, as in REM sleep, the body muscles lose their tone completely. Because the victim is awake (not in slow wave sleep), s/he collapses suddenly. Although episodes of narcolepsy are usually quite short (as little as a few seconds), they can be very disrupting because they are unpredictable.

Enuresis can be controlled by a procedure that uses Pavlovian conditioning. A sensor detects the beginnings of urine flow and activates an alarm. The alarm wakes the child completely, allowing him/her to go to the toilet in time. The sensations from the bladder appear to become a CS, which predicts the alarm which is the US for waking up. So the CS of the bladder sensations triggers full awakening just as the US of the alarm does.

Match the following sleep problems with the names of disorders below

**Q3A.** poor and unrefreshing sleep due to continued use of sleep medication

**Q3B.** waking up because of buildup of carbon dioxide in lungs

**Q3C.** terrifying mental experience during slow wave sleep

**Q3D.** sudden intense desire to sleep; sudden paralysis

**Q3E.** people believing they do not get enough sleep, when they do

**Q3F.** sleep walking; bed wetting

### Circadian Rhythms

*Every organism tested, from bacteria to humans, has an internal 24-hour activity-rest cycle called a circadian rhythm (circa=about, approximately; dies=day).* Most people go to sleep in the evening and get up in the morning: before artificial light at night, everyone went to bed and got up with the sun. This pattern goes with day and night, so it seems reasonable that it is controlled by the presence and absence of daylight. There is, however, an alternative possibility: organisms may have an internal clock that tells them to go to sleep or wake up.

*To study these clocks, subjects must be isolated from external cues for time.* This is easy to do with animals. Simply place an animal into a dimly lit closed chamber that automatically provides food, water and a way to measure activity. Then measure when it eats, drinks, and runs in the wheel for at least several weeks. Such measurements show that every animal species tested has a clear activity-rest cycle. Animals are active (eat drink, run) for roughly half the day and are inactive (presumably sleeping) for the rest of the day. The total duration of a full cycle is usually a bit longer than 24 hours. Therefore, an animal's activity cycle slowly drifts relative to external time.

Rats are normally active at night and sleep by day. In the absence of external cues, the active period (which begins at night) starts later and later. In a couple of weeks isolated rats are active during external day and inactive during external night. The cycle keeps drifting relative to external time, so that in a couple more weeks they are again active during external night and inactive by external day. (Of course, only the experimenter knows this; the rats don't have any cue for external time.)
Brain structures have been identified that play a crucial role in generating the biological clocks that time changes in psychological and physiological processes. One of the most important is the suprachiasmatic nucleus in the hypothalamus. The hormone melatonin played an important, though not well-understood role in circadian rhythms and sleep. It is secreted by the pineal gland in top of the brain stem. Figure 1-4k shows the location of these two structures in the human brain.

Q4. If you isolate an animal from cues for clock time, it
A. becomes active for variable periods at irregular intervals
B. goes through an activity-rest cycle once every 24 to 25 hours
C. shows circadian rhythms
D. stops sleeping normally
E. A and D are both correct
F. B and C are both correct

The same research has been done with humans. People have stayed in caves or in special apartments isolated from all external time cues for several months. They usually settle into a circadian rhythm with a cycle of about 25 hours, slightly longer than the length of the day.

Measurements of many functions besides sleep and waking follow this rhythm: During the sleep phase, body temperature is lower, hormones are either higher (e.g., growth hormone, during development) or lower (e.g., adrenal cortical hormones associated with stress [see asgn4zd]) than during waking. Even the body's reaction to drugs varies with the time of day.

Psychological functioning also varies. In the early morning hours, when the body's clock normally tells the body to be asleep, performance on various psychological tests goes down, as does performance of many practical tasks. People are much more likely to make mistakes on the jobs in the early morning hours, especially if the job demands attention and quick thinking as in a hospital emergency room. Major accidents, such as the Three Mile Island nuclear power plant accident several years ago, are much more likely to occur in the early morning hours.

Q5. People isolated from external time show
A. symptoms of mental illness
B. more errors when tested during their normal sleep period
C. cyclic changes in many different body functions
D. a sleep-activity cycle that is about 24-25 hours long
E. amnesia for events that happened while they were isolated
F. B, C, and D are all correct

Jet lag is the result of disconnecting the body clock from external time after a flight across several time zones. People who take long airplane trips from North America to Europe or Asia have probably experienced directly one major consequence of the body's circadian rhythms. Many people report feeling very fatigued for up to several days after such a trip, and they do not function at their best in this period. This is jet lag.

Jet lag is not simply the effect of flying for a long time in a crowded, inadequately ventilated cabin. If you leave Chicago at 8 PM local time and land in Paris after a 10-hour flight, your body is at 6 AM, but local time is 1 PM. Most people have some jet lag. The 10- hour east-west flight crosses 6 or 7 time zones and puts your body clock out of sync with external clock time. However, people do not experience jet lag after a 10-hour north-south flight to Latin America, which crosses few time zones. And people don't get the same kind of fatigue after much longer car, train, or bus rides that cross only 1 or 2 time zones.

Jet lag may have contributed to the failure of some critical negotiations in the Middle East during the mid 50's, when overseas jet flights were quite new. The officials who planned the trip did not anticipate its effects on the mental skills of the US negotiators, who started negotiating as soon as they arrived in the Middle East.

A recent report states that flight crews who frequently fly across many time zones have measurable loss of brain tissue and show some cognitive deficits (Cho, 2001). Crews that regularly worked long east-west flights with only five days between (outward) flights showed this loss. Crews that who had two weeks
between (outward) flights showed little or none. The 
cognitive and brain changes were correlated with the 
level of cortisol, the stress hormone in humans (see 
asgn4zd). The 5-day turn around crews had more 
cortisol in the saliva than did the 2-week turn around 
crews. Chronic (~long-lasting) elevated stress 
hormone is known to damage the brain, especially in 
the temporal lobe.

To see a brief article about jet lag, click HERE. The 
article has links to more related information.

Melatonin is a hormone that plays a major role in the 
regulation of circadian rhythms. Some people take 
tablets of this hormone to help regulate sleep and 
overcome the effects of getting the body's clock(s) 
out of synch with external clock time. It is not clear 
whether this attempt at prevention is successful. For 
more information about this hormone, click HERE.

Q6. Jet lag occurs after long east-west flights but not after long north-south flights because east-west flights 
disrupt _____, whereas north-south flights do not.
A. conversion of latent to manifest content  
B. the association between conscious and unconscious  
C. repair processes associated with sleep  
D. relation of internal time to external clock time  
E. A, B, C, and D are all correct  
F. A and C are both correct

Rotating Shift Work: blue collar jet lag

People who change shifts on the job, especially on 
the century-old traditional schedule, experience the 
poor man’s jet lag when they change shifts. This 
“shift-lag” shows up as sleepiness, fatigue, and 
irritability during the waking period and difficulty 
sleeping during the rest period. Productivity declines 
and accidents increase. Then soon after people 
adjust their body clock to the new schedule, they 
have to shift again, and they have to readjust all over.

The traditional rotating shift moves workers from day 
shift to night shift to evening shift often every week. 
This rotation is especially hard on people. It makes 
people shift their body clock forward -- go to sleep 
earlier and get up earlier. It also makes workers shift 
again soon after their bodies have adjusted to the 
new cycle. It is much harder than shifting the body 
clock back. (Which is easier: going to bed and sleeping 
earlier than usual or later than usual? Most people find it 
easier to delay falling asleep than to fall asleep early, partly 
because the circadian rhythm is a bit longer than 24 hours.)

Researchers studying circadian rhythms have helped 
companies work out a schedule that minimizes “ 
shift-lag” (Czeisler et al., 1982). The schedule that 
works best has workers changing to later shifts, 
setting their body clocks back. They are advised to 
start shifting their sleep time an hour or two later for 
several days before they change shifts, to make the 
change less abrupt. Workers also stay on a shift 
longer, so they don’t have to shift as often. This 
schedule improves morale and productivity and 
decreases accidents.

Q7. Jobs that require changing shifts from morning (8 AM-4 PM), to night (Midnight to 8 AM), 
evening (4 PM-Midnight) are especially stressful because they 
A. deprive workers of NREM (slow wave) sleep  
B. deprive workers of REM (dreaming) sleep  
C. require resetting the body clock by going to sleep sooner  
D. trigger narcolepsy attacks  
E. increase susceptibility to self hypnosis  
F. cause iatrogenic insomnia

To go to a chapter on shift work from The Human Factors Guide for Aviation Maintenance published by the 
Federal Aviation Agency, click HERE.
To go to a tutorial called Understanding Your Circadian Rhythms, click HERE.
To go to a tutorial on the treatment of sleep disorders, click HERE.