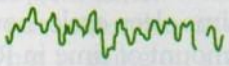
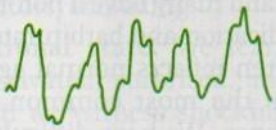
Neuroscience Tutorial: Sleep and Dreams

Discuss the following diagram with the students:

TABLE 12.2 Types and Stages of Sleep

Non–Rapid Eye Movement (NREM) Sleep		
Stage 1		Eyes are closed and relaxation begins. Thoughts flit in and out and a drifting sensation occurs; vital signs (body temperature, respiration, pulse, and blood pressure) are normal; the EEG pattern shows alpha waves; stimulation causes immediate arousal.
Stage 2		The EEG pattern becomes more irregular; *sleep spindles*—sudden, short high-voltage wave bursts occurring at 12–14 Hz—appear, and arousal is more difficult.
Stage 3		Sleep deepens, and theta and delta waves appear; vital signs begin to decline, and the skeletal muscles are very relaxed; dreaming is common; usually reached about 20 minutes after the onset of stage 1.
Stage 4		Called slow-wave sleep because the EEG pattern is dominated by delta waves (1–4 Hz); vital signs reach their lowest normal levels, and digestive system motility increases; skeletal muscles are relaxed, but normal sleepers turn approximately every 20 minutes; arousal is difficult; bed-wetting and sleepwalking occur during this phase.
Rapid Eye Movement (REM) Sleep		
		EEG pattern reverts through the NREM stages to the stage 1 pattern. Vital signs increase and digestive system activity declines; skeletal muscles (except for ocular muscles) are inhibited; the stage of most dreaming.

Marieb, E.N. (2004), *Human Anatomy & Physiology*, Pearson Education, Inc, San Francisco, CA, USA, p459

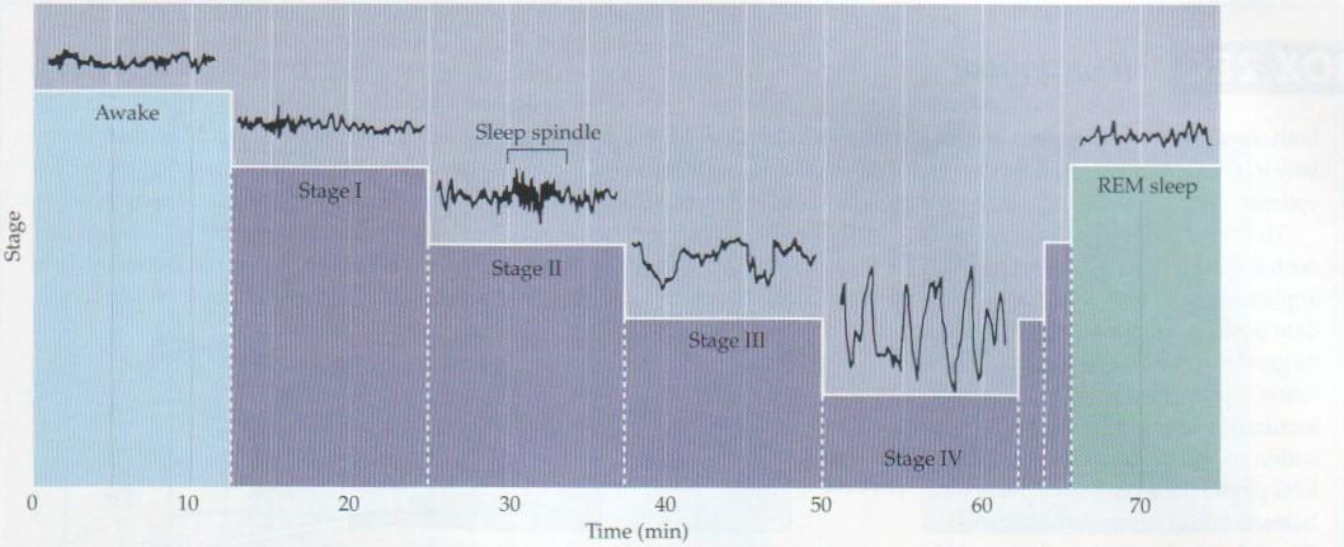


Figure 28.6 EEG recordings during the first hour of sleep. The waking state with the eyes open is characterized by high-frequency (15–60 Hz), low-amplitude activity (~30 μV) activity. This pattern is called beta activity. Descent into stage I non-REM sleep is characterized by decreasing EEG frequency (4–8 Hz) and increasing amplitude (50–100 μV), called theta waves. Descent into stage II non-REM sleep is characterized by 10–12 Hz oscillations (50–150 μV) called spindles, which occur periodically and last for a few seconds. Stage III non-REM sleep is characterized by slower waves at 2–4 Hz (100–150 μV). Stage IV sleep is defined by slow waves (also called delta waves) at 0.5–2 Hz (100–200 μV). After reaching this level of deep sleep, the sequence reverses and a period of rapid eye movement sleep, or REM sleep, ensues. REM sleep is characterized by low-voltage, high-frequency activity similar to the EEG activity of individuals who are awake. (Adapted from Hobson, 1989.)

Purves, D., Augustine, G.J., Fitzpatrick, D., Hall, W.C., LaMantia, A.-S., McNamara, J.O. and White, L.E. (2008), *Neuroscience*, 4th edn, Sinauer Associates, Inc, Sunderland, MA, USA, p715

Answer the following questions:

Sleep

1) What is the behavioural definition of sleep?

Sleep is a reversible unconsciousness state, lack of mobility and increased arousal threshold.

2) During what part of the night is slow wave sleep seen?

It is more prominent during the first third of the night

3) When does the first REM period typically occur?

Usually at the end of the first sleep cycle
-approximately 70-120 minutes after sleep onset
-(depending on age and other factors)

4) What happens to REM periods across the course of the night?

REM periods progressively increase in length

5) What % of total sleep in adults is composed on NREM?

75-80% of sleep time

6) What % of sleep in adults is composed of REM sleep?

20-25% of sleep time

7) What happens to the distribution of the stages of sleep in the elderly population?

- decrease in slow wave sleep
- lighter NREM sleep
- more fragmented night-time sleep, more time spent awake

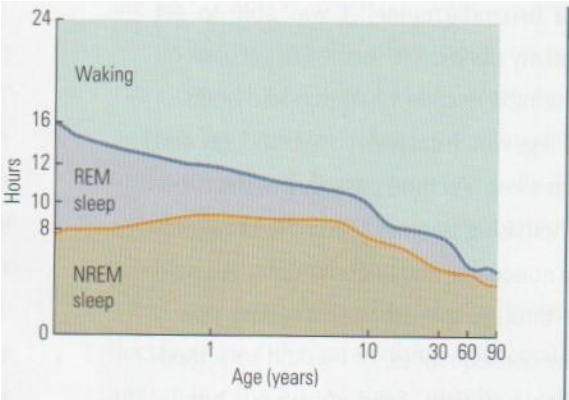


Figure 12-13

Sleeping and Waking over the Life Span The amount of time that humans spend sleeping decreases with age. The amount of REM sleep is especially high in the first few years of life. Adapted from "Ontogenetic Development of the Human Sleep-Dream Cycle," by H. P. Roffward, J. Muzio, and W. C. Dement (1966), *Science, 152.*

Kolb, B. and Whishaw, I.Q. (2004), *An Introduction to Brain and Behaviour*, 2nd edn, Worth Publishers, New York, USA, p457

8) What are *zietgebers*?

Environmental variables that are capable of entraining circadian rhythm. Most potent zietberger is exposure to bright daylight. Weaker zietbergers are exercise, social stimuli, temperature and feeding.

9) What is 'microsleep'?

Microsleep is a transient physiologic sleep (3-14 seconds of EEG pattern change from wakefulness to stage 1) with or without rolling eye movements or behavioural sleep (drooping and nodding of head).

10) What neurotransmitters are associated with the REM-on state?

Cholinergic system-releases neurotransmitter acetylcholine.

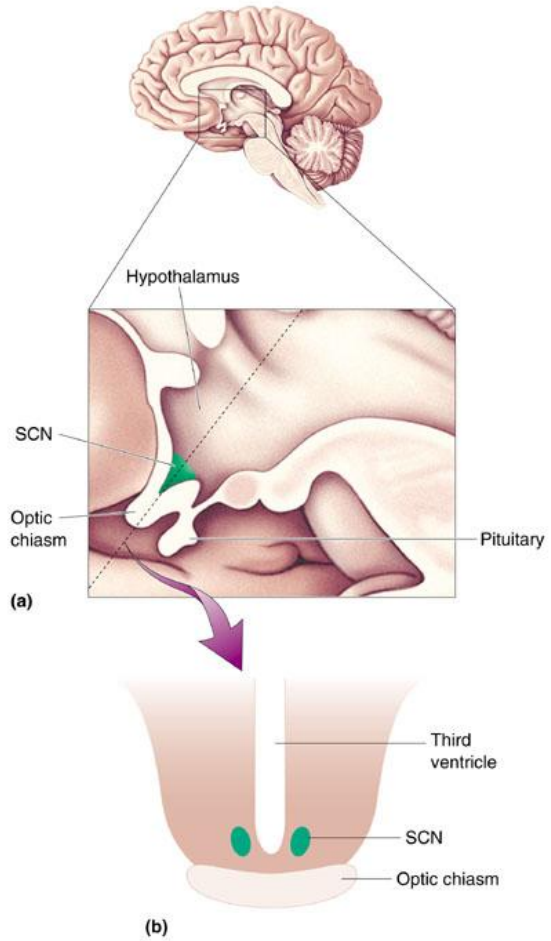
11) What neurotransmitters are associated with the REM-off state?

The adrenergic system, including norepinephrine and serotonin. Also histamine.

12) Where is the suprachiasmatic (SCN) nuclei located? Describe its role in circadian rhythms.

Located in the anterior hypothalamus dorsal to optic chiasm.
Retinohypothalamic tract sends input directly to the SCN to help modulate circadian rhythms.

Figure 19.17
The human suprachiasmatic nuclei. There are two suprachiasmatic nuclei (SCN) within the hypothalamus, just above the optic chiasm and next to the third ventricle. (a) Sagittal view. (b) Frontal view, sectioned at the broken line in part a.



13. Summarise the neurotransmitters that are thought to be involved in wakefulness and sleep and their site of release.

Neurotransmitters Involved in Wakefulness and Sleep

NEUROTRANSMITTER	SITE OF RELEASE
Wakefulness	
Norepinephrine*	Locus coeruleus and lateral tegmental area
Dopamine	Ventral tegmental area
Acetylcholine†	Basal forebrain, pedunculopontine tegmental nucleus, and latero-dorsal tegmental nuclei
Histamine	Posterior hypothalamus
Glutamate	Reticular formation and cortical projection neurons
Non–rapid-eye-movement (NREM) sleep	
Serotonin*	Dorsal raphe nucleus (midbrain, pons, medulla)
Adenosine	Present in extracellular region as degradation product of adenosine triphosphate (ATP)
	Hypothalamus and basal forebrain
	May be a neuromodulator that accumulates during wakefulness and enhances slow-wave sleep
Gamma-aminobutyric acid	Reticular formation, diencephalon, basal forebrain, hypothalamus, and thalamus (reticular nucleus)
Rapid-eye-movement (REM) sleep	
Acetylcholine†	Basal forebrain, pedunculopontine tegmental nucleus, and latero-dorsal tegmental nuclei
Adenosine	Present in extracellular region as degradation product of adenosine triphosphate (ATP)
	Hypothalamus and basal forebrain
	May be a neuromodulator that accumulates during wakefulness and enhances slow-wave sleep

*Norepinephrine and serotonin are REM-off cells.
†Acetylcholine is a REM-on cell.

(Adapted from: Stevens: Sleep Medicine Secrets: 2004, Hanley & Belfus, p30)

14. What are some wake-promoting factors found in cerebrospinal fluid (CSF) and blood?

CSF: substance P, cortico-tropin releasing factor, thyrotropin-releasing factor, vasoactive intestinal peptide, and neurotensin.

Blood: epinephrine, cortisol, histamine, corticotropin, thyrotropin.

15. What are some factors in the CSF and the blood that are thought to promote sleep?

CSF: enkephalin, endorphin, dynorphin, alpha-melanocyte-stimulating hormone, growth hormone-releasing factor, prostaglandin D2, and interleukin.

Blood: Insulin, cholescystokinin, and delta sleep inducing peptide.

Polysomnogram

1. What is a polysomnogram?

Test consisting of EEG, EOG, EMG, ECG and respiratory, blood oxygen saturation and audiovisual data.

Figure 19.1
A subject in a sleep research study. This is American sleep researcher Nathaniel Kleitman, codiscoverer of REM sleep. The white patches on his head are pieces of tape holding EEG electrodes, and those next to his eyes hold electrodes that monitor his eye movements. (Source: Carskadon, 1993.)

2. What sleep disorders require polysomnograpy for diagnosis?

Sleep-related breathing disorders- sleep apnea.

3. What are the indicators of polysomnography in patients with insomnia?

PSG is indicated when symptoms of insomnia are not adequately diagnosed by obtaining a sleep history, assessing sleep hygiene, and reviewing sleep diaries.

4. When is polysomnography indicated in patients with parasomnias?

PSG and extended EEG channels is indicated when sleep disruption is thought to be seizure related. PSG indicated in evaluating sleep-related behaviours that are violent & unusual.

Dreams

1) Define dreaming.

Internally generated perceptual experiences during sleep and appears at that time as reality.

Ho: Function of REM sleep:

- unlearning of unnecessary information
- release of pent-up emotions or anxieties
  that develop during waking hours

2) Since dreaming takes place during sleep, how can it be studied objectively?

- REM associated with dreams
- Neurones of the visual system fire intensely during REM sleep
  - likely because visual scenes in dreams

- Most people can remember their dreams if awakened during REM
- EEG of REM sleep resemble waking EEG
- Identify states of REM:
  - EEG shows low voltage, high frequency activity indicating high brain activation
  - EMG shows drop in muscle tone &
  - EOG: presence of rapid saccadic eye movement

- Reports captured on tape for later analysis

3) Is a sleep walker acting out his or her dreams?

No, sleepwalkers are aroused early from first or second cycle of non-REM sleep before dreaming has taken place.

4) Do brain imaging studies help the understanding of dreaming?

Identifies brain areas involved.

PET (Positron Emission Tomography):

- reveal a higher level of activity in the amygdala & paralimbic system during REM sleep
- this implicates the involvement of long term memory system

5) Discuss your understanding of a nightmare?

* a nightmare is a dream that is frightening enough to awaken the sleeper

* common in children

* increase in frequency after stressful events and are a hallmark symptom of posttraumatic stress disorder

* Can be treated by application of cognitive behavioural therapy

6) How does a night terror differ from a nightmare?

* Night terror is associated with non-REM while a nightmare occurs during REM sleep.

* Night terror occurs mainly in young children, within firsthour of sleep before first REM period.

* In night terror there is a glazed eye, screaming and an increased heart rate

* Dream content is not reported in nightmare and there is no recall of the episode on awakening

* Run in families with the prevalence doubling when both parents are affected as children

* Night terrors reduce in frequency during adolescence and are disorders of arousal and not dreams

Answer the following questions

1. Physiological functions of the body change according to daily cycles known as:

    a) biological rhythms
    b) circadian rhythms
    c) daily rhythms
    d) nocturnal rhythms

b)

2. During non-REM sleep your EEG pattern is:

    a) low voltage, fast
    b) low voltage, slow
    c) high voltage, slow
    d) high voltage, fast

c)

3. REM accounts for most of our sleep.

    a) true
    b) false

b)

4. What is the primary zeitberger for mammals?

    a) light-dark
    b) gravity
    c) temperature
    d) time

a)

5. What do people with REM sleep disorder do?

    a) rarely sleep
    b) sleep too much
    c) act out their dreams
    d) do not experience REM sleep

c)

6. A sudden muscular paralysis while consciousness is maintained is known as _____.

    a) narcolepsy
    b) atony
    c) aphoria
    d) cataplexy

d)

7. Somnabulism is also known as:

    a) night terrors
    b) nightmares
    c) sleepwalking
    d) dreams

c)

8. Somniloquy is also known as:

    a) sleep walking
    b) sleep talking
    c) dreams
    d) nightmares

b)

9. Night terrors can often be a symptom of a psychiatric disorder.

    a) true
    b) false

b)

10. Of the four of five REM periods each night, in which do dreams occur?

    a) 1
    b) 2 & 3
    c) 4 & 5
    d) all

d)