Neurophysiology

Sleep

Fatima Ryalat, MD, PhD

Sleep

- Sleep is defined as unconsciousness from which a person can be aroused by sensory or other stimuli.
- It is to be distinguished from coma, which is unconsciousness from which a person cannot be aroused.
- Sleep is divided into two types: rapid eye movement sleep and slow wave sleep.

Sleep

- Each night, a person goes through stages of these two types of sleep that alternate with each other.
- REM sleep occurs in episodes of 5-30 minutes that occupy about 25% of the sleep time in young adults.
- each episode normally recurs about every 90 minutes.

REM (Paradoxical or Desynchronized) Sleep

- This type of sleep is not so restful.

- When a person is extremely sleepy, each bout of REM sleep is short and may even be absent.
- As the person becomes more rested through the night, the durations of the REM bouts increase.

REM Sleep

- REM sleep is a type of sleep in which the brain is quite active. However, the person is not fully aware of the surroundings.
- It is an active form of sleep usually associated with dreaming.
- The overall brain metabolism may be increased as much as 20%.

REM Sleep

- The person is even more difficult to arouse by sensory stimuli than during deep slow-wave sleep, and yet people usually awaken spontaneously in the morning during an episode of REM sleep.

- Muscle tone throughout the body is exceedingly depressed, indicating strong inhibition of the spinal muscle control areas.

REM Sleep

- Despite the extreme inhibition of the peripheral muscles, irregular muscle movements do occur in addition to the rapid movements of the eyes.

- Heart rate and respiratory rate usually become irregular, which is characteristic of the dream state.

REM Sleep

- An electroencephalogram (EEG) shows a pattern of brain waves similar to those that occur during wakefulness.

- This type of sleep is also called paradoxical sleep because it is a paradox that a person can still be asleep, despite the presence of marked activity in the brain.

Slow wave (NREM) sleep

- Most sleep during each night is of the slow-wave (NREM) variety, which is the deep, restful sleep that the person experiences during the first hour of sleep after having been awake for many hours.

Slow Wave Sleep

- This sleep is associated with decreases in peripheral vascular tone and many other vegetative functions of the body.
- For example, 10% to 30% decreases occur in blood pressure, respiratory rate, and basal metabolic rate.

- Although slow-wave sleep is frequently called “dreamless sleep,” dreams and sometimes even nightmares do occur during slow-wave sleep.

Slow Wave Sleep

- The difference between the dreams that occur in slow-wave sleep and those that occur in REM sleep is that those of REM sleep are associated with more bodily muscle activity.

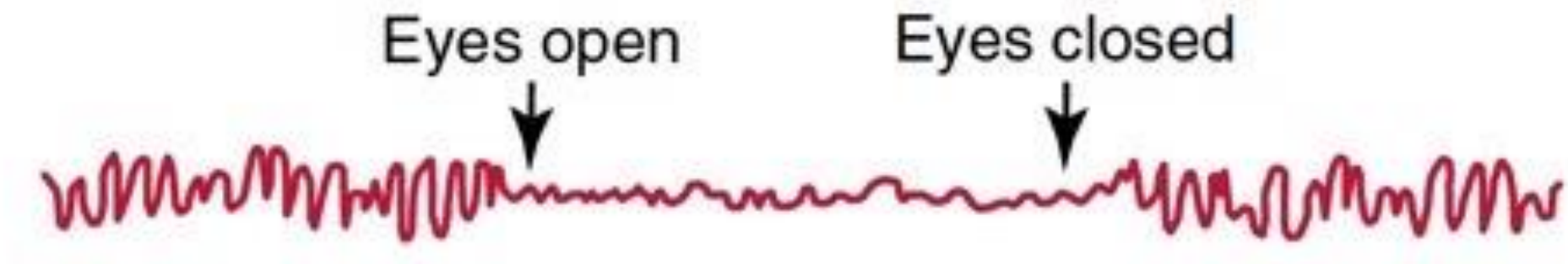
- Also, the dreams of slow-wave sleep are usually not remembered because consolidation of the dreams in memory does not occur.

Brain waves

- Electrical recordings from the outer surface of the head demonstrate that there is continuous electrical activity in the brain.

- Both the intensity and the patterns of this electrical activity are determined by the level of excitation of different parts of the brain.

- In healthy people, most waves in the EEG can be classified as alpha, beta, theta, and delta waves.


Eyes open
Eyes closed

Brain waves

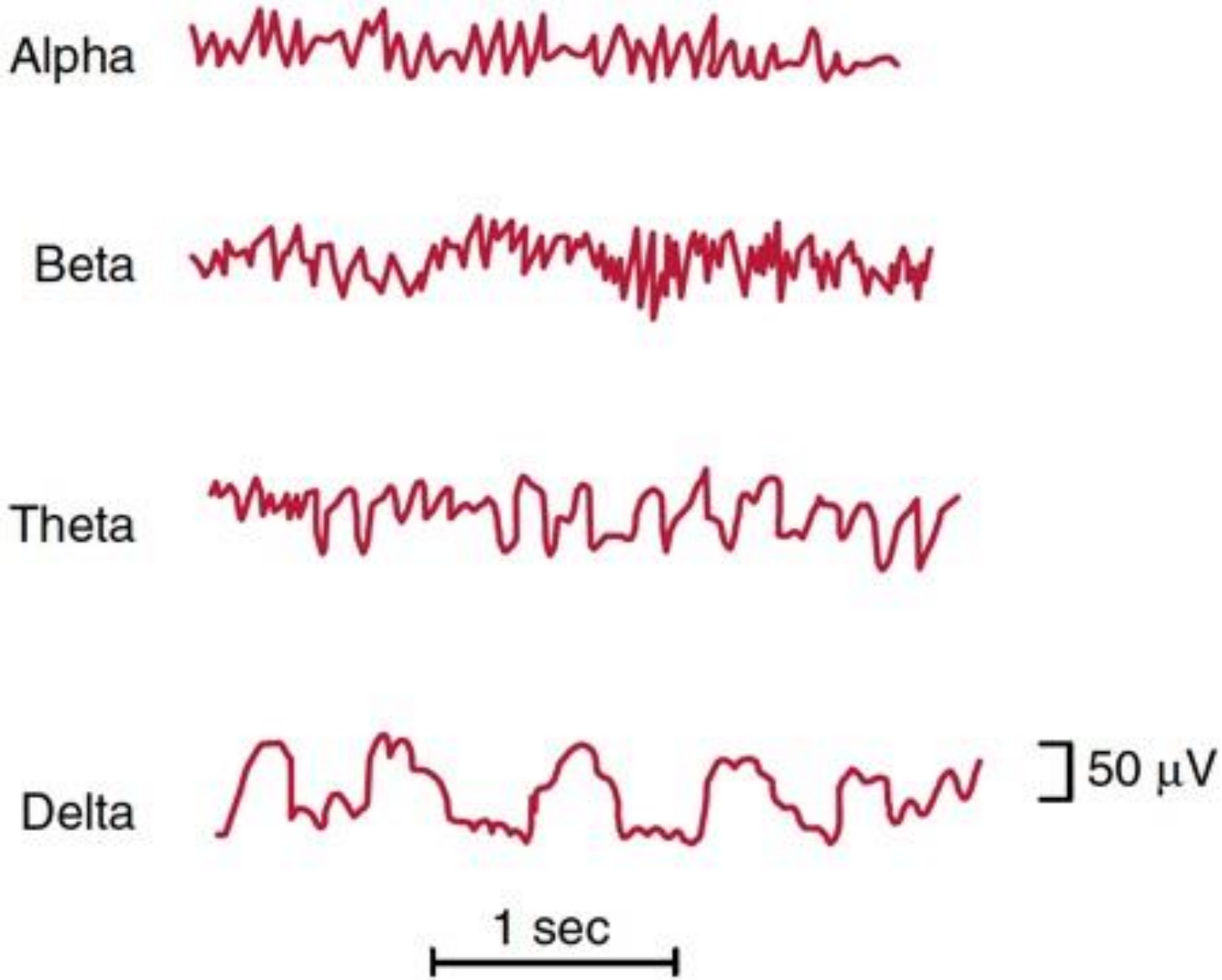
- The discharge of a single neuron or single nerve fiber in the brain can never be recorded from the surface of the head.

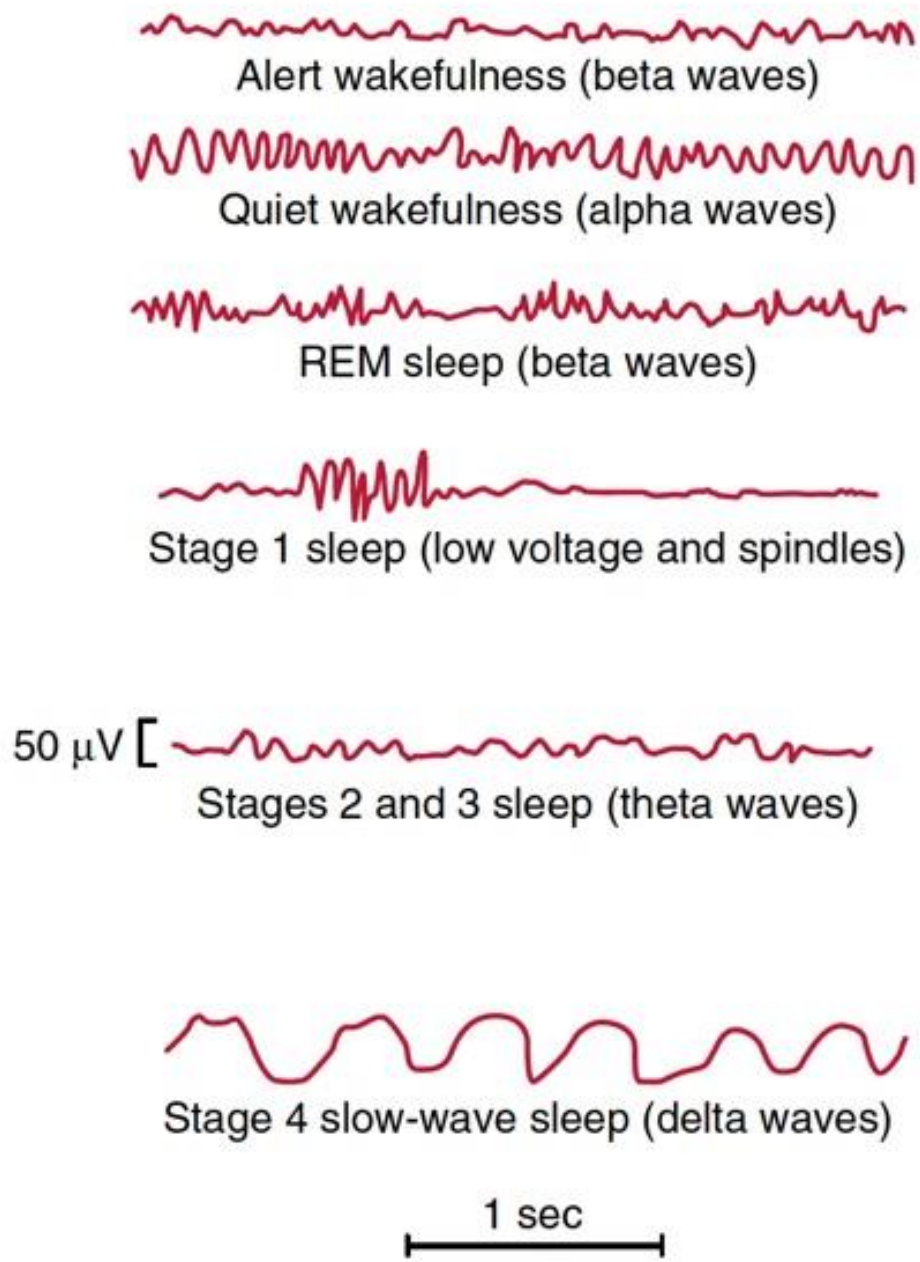
- Instead, many thousands or even millions of neurons or fibers must fire synchronously for the potentials from the individual neurons or fibers to summate enough to be recorded through the skull.

Brain waves

- Thus, the intensity of the brain waves from the scalp is determined mainly by the numbers of neurons and fibers that fire in synchrony with one another, not by the total level of electrical activity in the brain.

- In fact, strong nonsynchronous nerve signals often nullify one another in the recorded brain waves because of opposing polarities.


Alpha
Beta
Theta
Delta
50 μV
1 sec


Alert wakefulness (beta waves)
Quiet wakefulness (alpha waves)
REM sleep (beta waves)
Stage 1 sleep (low voltage and spindles)
50 μV
Stages 2 and 3 sleep (theta waves)
Stage 4 slow-wave sleep (delta waves)
1 sec

Alpha waves

- Alpha waves are rhythmical waves that occur at frequencies between 8 and 13 cycles/sec and are found in the EEGs of almost all healthy adults when they are awake and in a quiet, resting state of cerebration.
- These waves occur most intensely in the occipital region but can also be recorded from the parietal and frontal regions of the scalp.
- Their voltage is usually about 50 microvolts.
- During deep sleep, the alpha waves disappear.

Alpha waves

- alpha waves are thought to result from spontaneous feedback oscillation in this diffuse thalamocortical system, possibly including the reticular activating system in the brain stem as well.

Beta waves

- When the awake person's attention is directed to some specific type of mental activity, the alpha waves are replaced by asynchronous, higher frequency but lower voltage beta waves.
- Beta waves occur at frequencies greater than 14 cycles/sec and as high as 80 cycles/sec.
- They are recorded mainly from the parietal and frontal regions during specific activation of these parts of the brain.

Theta waves

- Theta waves have frequencies between four and 7 cycles/sec.
- They occur normally in the parietal and temporal regions in children, but they also occur during emotional stress in some adults, particularly during disappointment and frustration.
- Theta waves also occur in many brain disorders, often in degenerative brain states.

Delta waves

- Delta waves include all the waves of the EEG with frequencies less than 3.5 cycles/sec, and they often have voltages two to four times greater than most other types of brain waves.
- They occur in very deep sleep, in infancy, and in persons with serious organic brain disease.
- Therefore, delta waves can occur strictly in the cortex independent of activities in lower regions of the brain.

Delta waves

- some synchronizing mechanism can occur in the cortical neuronal system by itself—mainly independent of lower structures in the brain—to cause the delta waves.

- Delta waves also occur during deep slow-wave sleep, which suggests that the cortex then is mainly released from the activating influences of the thalamus and other lower centers.

Epilepsy

- Seizures are temporary disruptions of brain function caused by uncontrolled excessive neuronal activity.

- epilepsy is a chronic condition of recurrent seizures that can also vary from nearly undetectable symptoms to periods of vigorous convulsions.
- Epilepsy is not a single disease.
- Its clinical symptoms are heterogeneous and reflect multiple underlying pathophysiological mechanisms.

Epilepsy

- Epileptic seizures can be classified into two major types:
- (1) focal seizures (partial seizures) that are limited to a focal area of one cerebral hemisphere.
- (2) generalized seizures that diffusely involve both hemispheres of the cerebral cortex.

Focal seizures

- Focal seizures are often classified as simple partial seizures when there is no major change in consciousness or as complex partial seizures when consciousness is impaired.
- Simple partial seizures may be preceded by an aura.
- Complex partial seizures may also begin with an aura followed by impaired consciousness and strange repetitive movements.
- The time after the seizure, prior to the return of normal neurological function, is called the postictal period.

Generalized seizures

- Generalized epileptic seizures are characterized by diffuse, excessive, and uncontrolled neuronal discharges that at the outset spread rapidly and simultaneously to both cerebral hemispheres through interconnections between the thalamus and cortex.

Generalized tonic-clonic seizures

- Generalized tonic-clonic seizures, previously called grand mal seizures, are characterized by an abrupt loss of consciousness and extreme neuronal discharges in all areas of the brain—the cerebral cortex, the deeper parts of the cerebrum, and even the brain stem.
- Also, discharges transmitted all the way into the spinal cord sometimes cause generalized tonic seizures of the entire body, followed toward the end of the attack by alternating tonic and spasmodic muscle contractions called tonic-clonic seizures.

Generalized tonic-clonic seizures

- Often the person bites or “swallows” his or her tongue and may have difficulty breathing, sometimes to the extent that cyanosis occurs.
- Also, signals transmitted from the brain to the viscera frequently cause urination and defecation.
- The usual generalized tonic-clonic seizure lasts from a few seconds to 3 to 4 minutes.
- It is also characterized by post-seizure depression of the entire nervous system.

Generalized tonic-clonic seizures

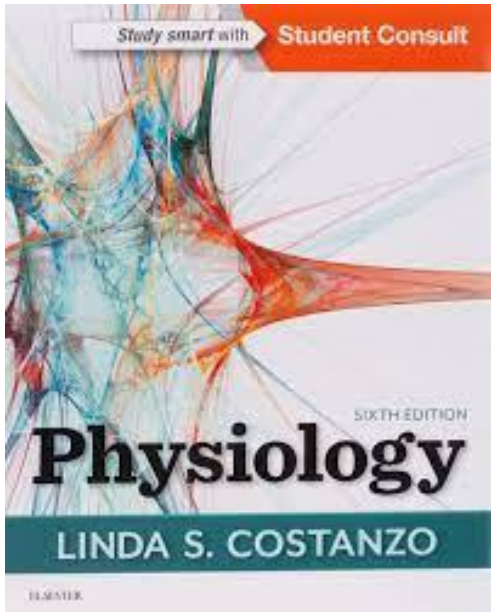
- The majority of generalized seizures are idiopathic, which means that the cause is unknown.
- factors that can increase the excitability of the abnormal “epileptogenic” circuitry enough to precipitate attacks include (1) strong emotional stimuli, (2) alkalosis caused by over-breathing, (3) drugs, (4) fever, and (5) loud noises or flashing lights.

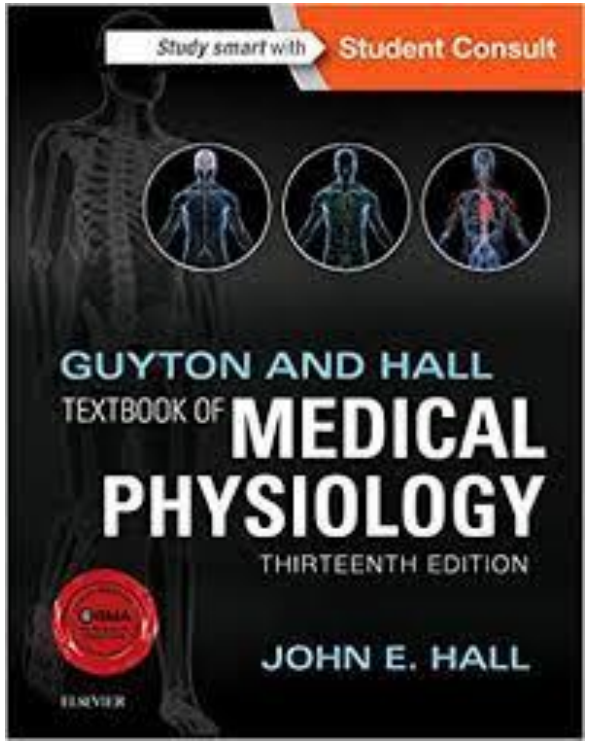
Absence seizures

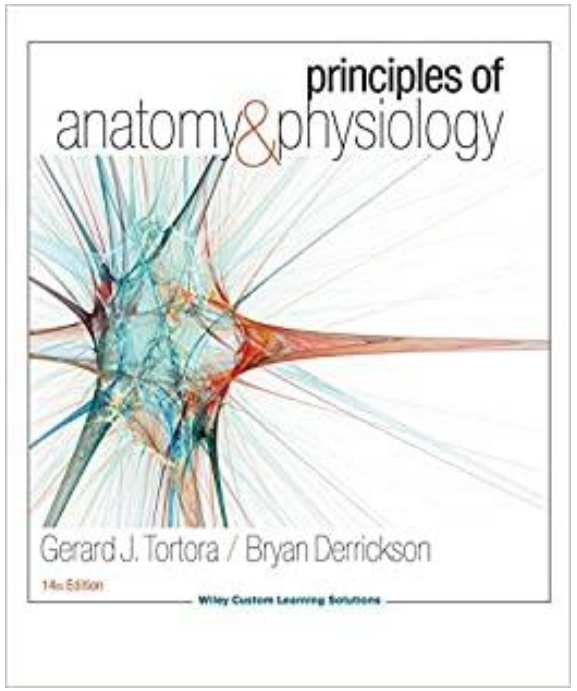
- Absence seizures, formerly called petit mal seizures, usually begin in childhood or early adolescence
- Absence seizures almost certainly involve the thalamocortical brain activating system.
- They are usually characterized by 3 to 30 seconds of unconsciousness or diminished consciousness, during which time the person often stares and has twitch-like contractions of muscles, usually in the head region, especially blinking of the eyes; this phase is followed by a rapid return of consciousness and resumption of previous activities.

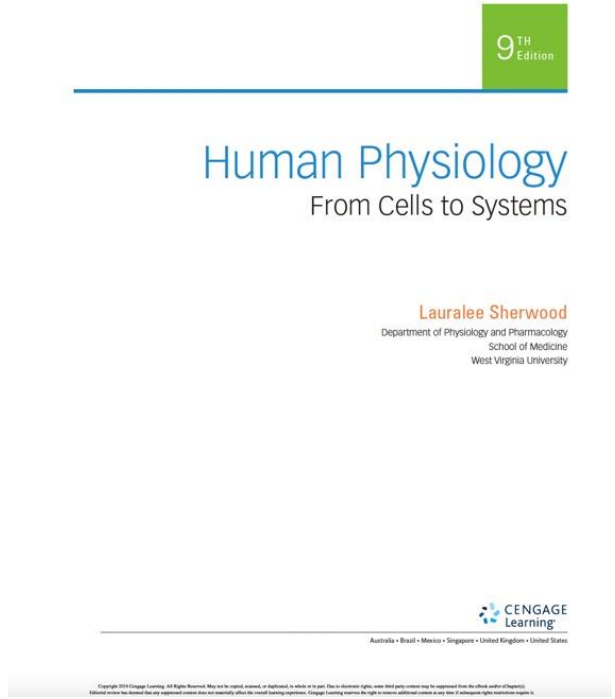
Thank you

References


Study smart with
Student Consult
SIXTH EDITION
Physiology
LINDA S. COSTANZO
ELSEVIER


Study smart with
Student Consult
GUYTON AND HALL
TEXTBOOK OF MEDICAL
PHYSIOLOGY
THIRTEENTH EDITION
JOHN E. HALL
ELSEVIER


principles of
anatomy & physiology
Gerard J. Tortora / Bryan Derrickson
14th Edition
Wiley Custom Learning Solutions


9TH Edition
Human Physiology
From Cells to Systems
Lauralee Sherwood
Department of Physiology and Pharmacology
School of Medicine
West Virginia University
CENGAGE Learning
Australia • Brazil • Mexico • Singapore • United Kingdom • United States