

Inquiry into Life

Eleventh Edition

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Chapter 17 Lecture Outline

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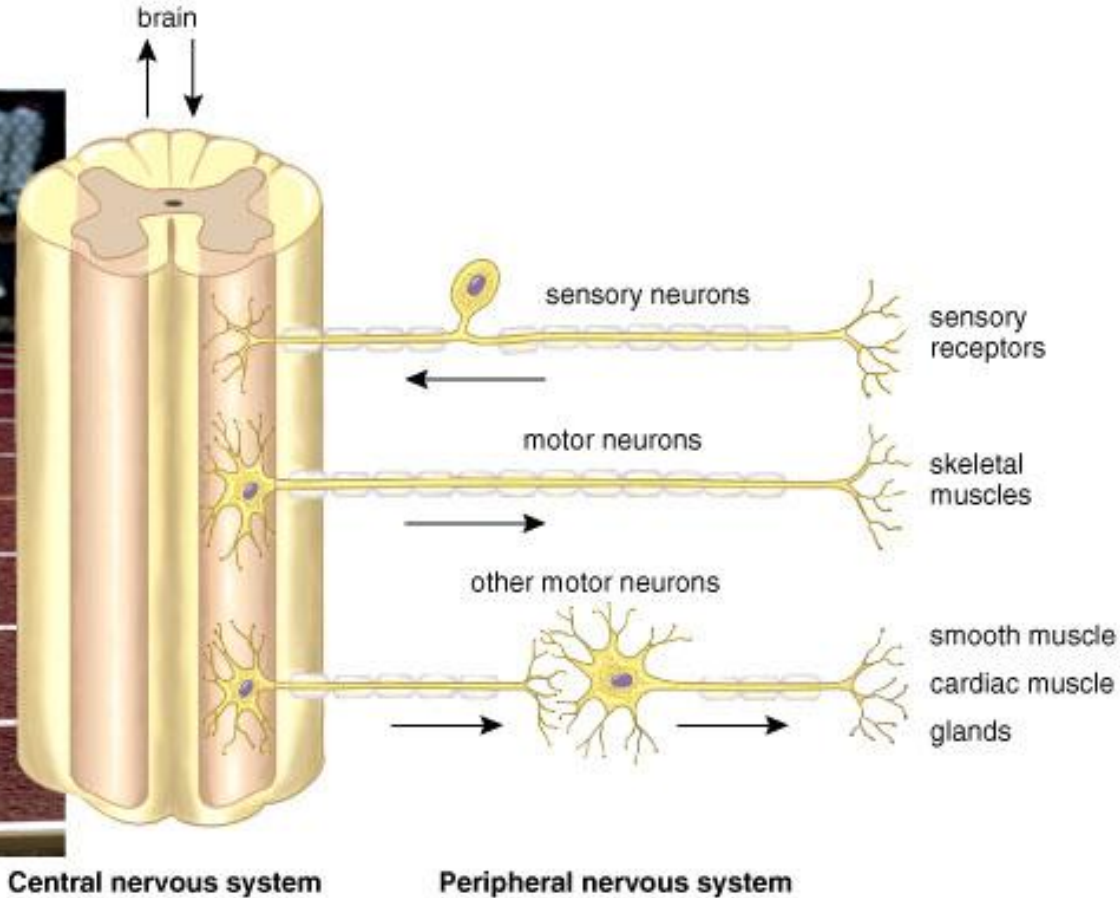


17.1 Nervous tissue

- Nervous system
 - Central nervous system (CNS)
 - Brain and spinal cord
 - Peripheral nervous system (PNS)
 - Sensory and motor nerves
 - Nervous tissue contains 2 types of cells
 - Neurons-specialized for conduction of information
 - Neuroglia-support and nourish neurons

Organization of the nervous system

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a.

b.

- Fig. 17.1

Nervous tissue cont'd.

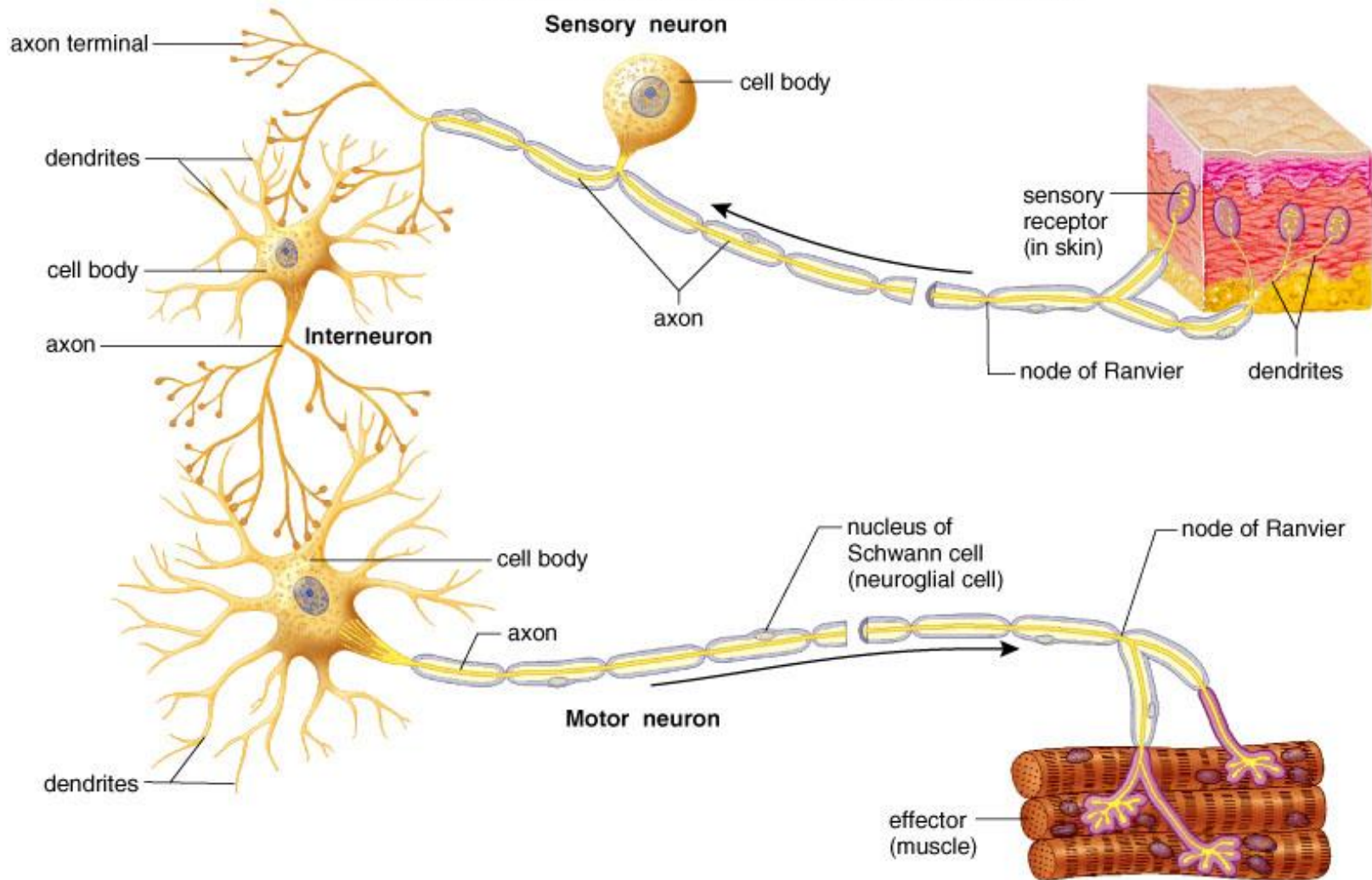
- Neuron structure
 - 3 classes of neurons
 - Sensory
 - Takes messages to CNS
 - May have specialized sensory receptors
 - Interneuron
 - Lies entirely within CNS
 - Receives input from sensory neurons and other interneurons
 - Summarizes messages
 - Communicates with motor neurons
 - Motor neurons
 - Take messages from CNS to effector organs
 - Effector organs can be muscles, glands, or organs

Nervous tissue cont'd.

- Neuron structure cont'd.
 - 3 parts of a neuron
 - Cell body
 - Contains nucleus and most organelles
 - Dendrites
 - Extensions leading toward cell body
 - Receive signals from other neurons
 - Send them to cell body
 - Axon
 - Conducts impulses away from cell body
 - Toward other neurons or effectors

Types of neurons

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• Fig. 17.2

Nervous tissue cont'd.

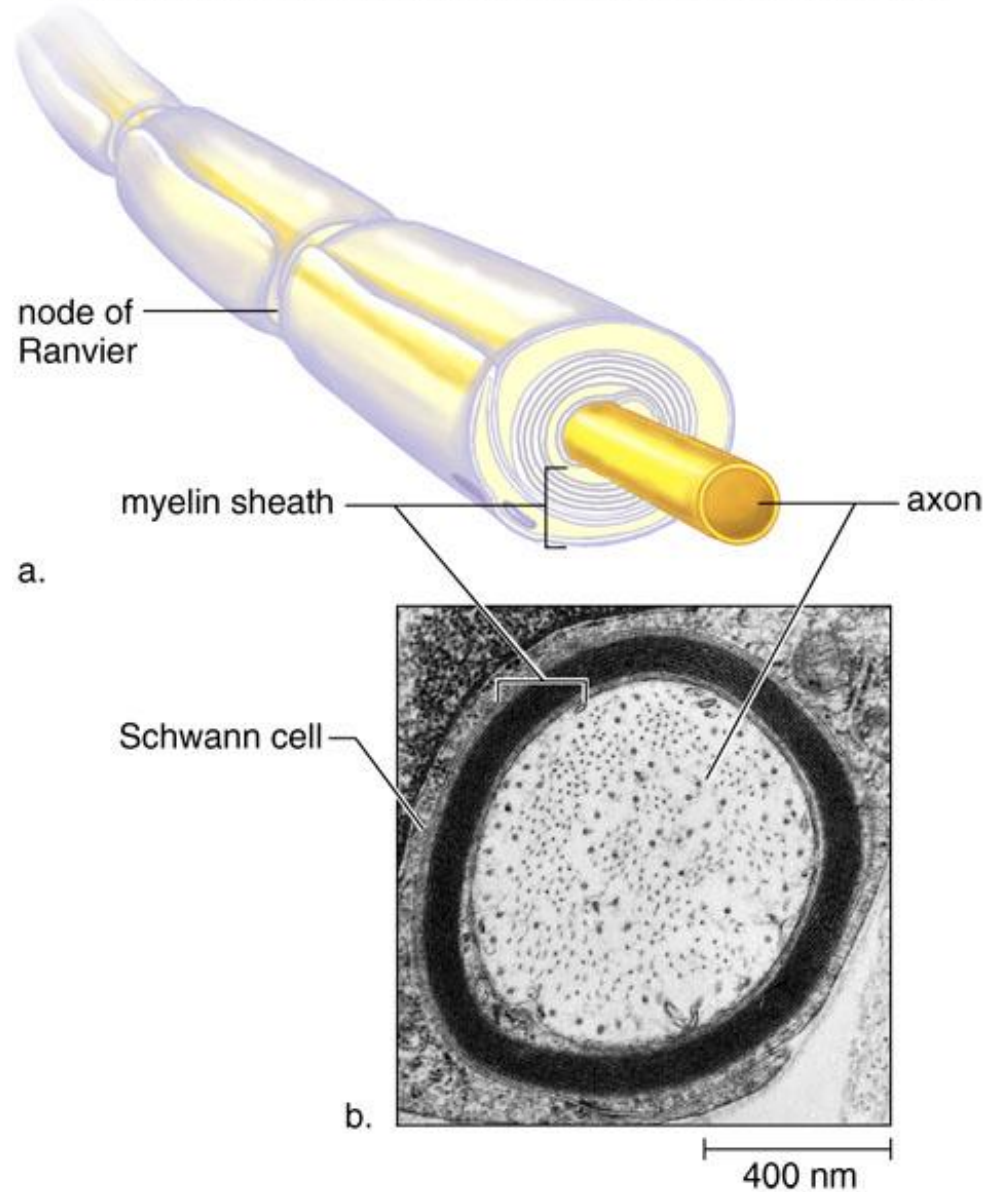
- Neuron structure cont'd.
 - Myelin sheath
 - Covers some axons
 - Gives whitish appearance
 - Formed by Schwann cells in PNS
 - Lipid substance- electrical insulator
 - Schwann cells wrap around axons
 - Leave gaps between them
 - Called nodes of Ranvier
 - Important in nerve regeneration
 - Sheath serves as pathway for new axon growth
 - In CNS neurons with short axons are nonmyelinated
 - Make up gray matter

Nervous tissue cont'd.

- Neuron structure cont'd.
 - Some CNS neurons have myelinated axons-white matter
 - Brain
 - Surface layer of brain is gray matter
 - White matter lies deep
 - Spinal cord
 - Central portion is gray matter
 - White matter surrounds the gray matter

Myelin sheath

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• Fig. 17.3

Nervous tissue cont'd.

- The nerve impulse
 - Resting potential
 - Inside of axon is electronegative with respect to outside
 - -65mV
 - Resting potential is due to
 - Unequal distribution of ions across membrane
 - » More sodium outside than inside
 - » More potassium inside than outside
 - Resting potential is maintained by
 - Unequal permeability of membrane
 - » More permeable to potassium than sodium at rest
 - » Membrane tends to “leak” positive charges
 - Sodium-potassium pump-maintains concentrations of sodium and potassium

Nervous tissue cont'd.

- **Action potential**
 - Rapid change in polarity across membrane as impulse occurs
 - All or none phenomenon
 - Threshold stimulus
 - Causes axomembrane (axon membrane) to depolarize to threshold level
 - Generates an action potential
 - Intense stimulus causes axon to fire more often in a given time interval
 - Requires 2 types of gated channel proteins
 - Sodium channel
 - Potassium channel

Nervous tissue cont'd.

- Events of an action potential
 - Sodium gates open
 - Sodium flows down gradient into axon
 - Membrane potential changes from -65mV up to $+40\text{mV}$
 - Called *depolarization* because inside changes from negative to positive
 - Gates close
 - Potassium gates open
 - Potassium flows down its gradient out of the axon
 - Brings potential back to -65mV
 - Called *repolarization* because it returns to original polarity
 - Gates close
 - These events occur in only 1 millisecond

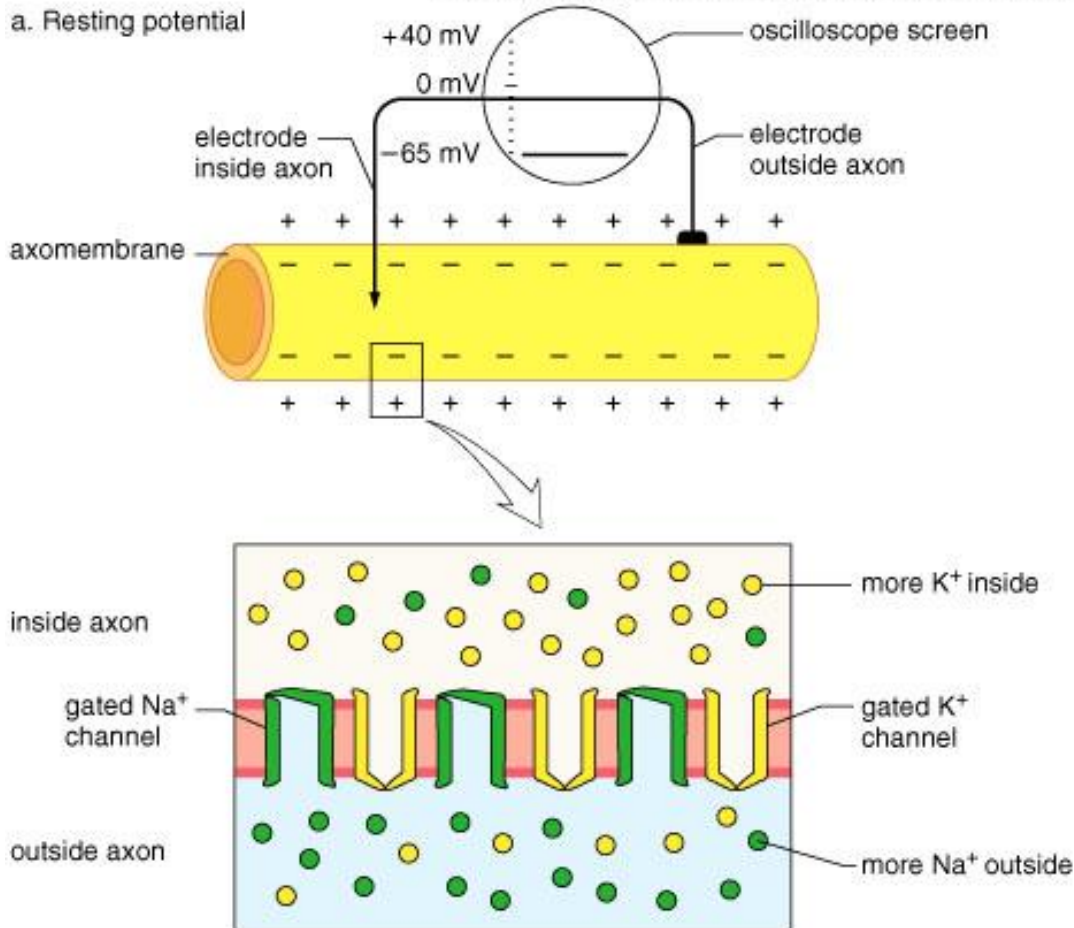
Nervous tissue cont'd.

- Conduction of an action potential
 - Nonmyelinated axons
 - travels down axon one small segment at a time
 - As soon as action potential moves on, the previous section undergoes refractory period
 - Sodium gates cannot reopen
 - Prevents retrograde transmission
 - During this time sodium-potassium pump restores ions to original positions
 - Myelinated axons
 - Gated ion channels concentrated in nodes of Ranvier
 - Action potential travels faster
 - “Jumps” from node to node- saltatory conduction

Resting and action potential

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a. Resting potential



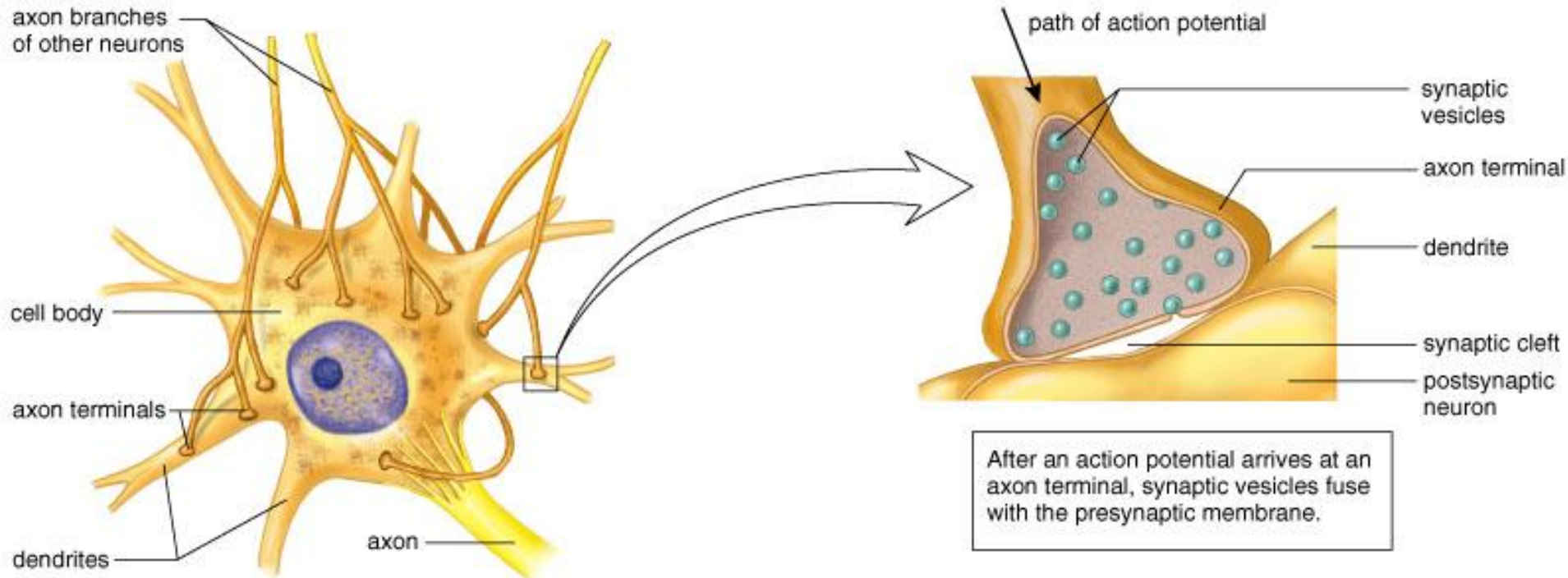
b. Experimenter using oscilloscope



- Fig. 17.4

Synapse structure and function

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Nervous tissue cont'd.

- **Transmission across a synapse**
 - Axon branches into many endings
 - Each has an axon terminal
 - Each terminal lies close to dendrite or cell body of another neuron
 - Region of proximity-synapse
 - No actual contact-space is synaptic cleft
 - Membrane of first neuron-presynaptic membrane
 - Membrane of second-postsynaptic membrane

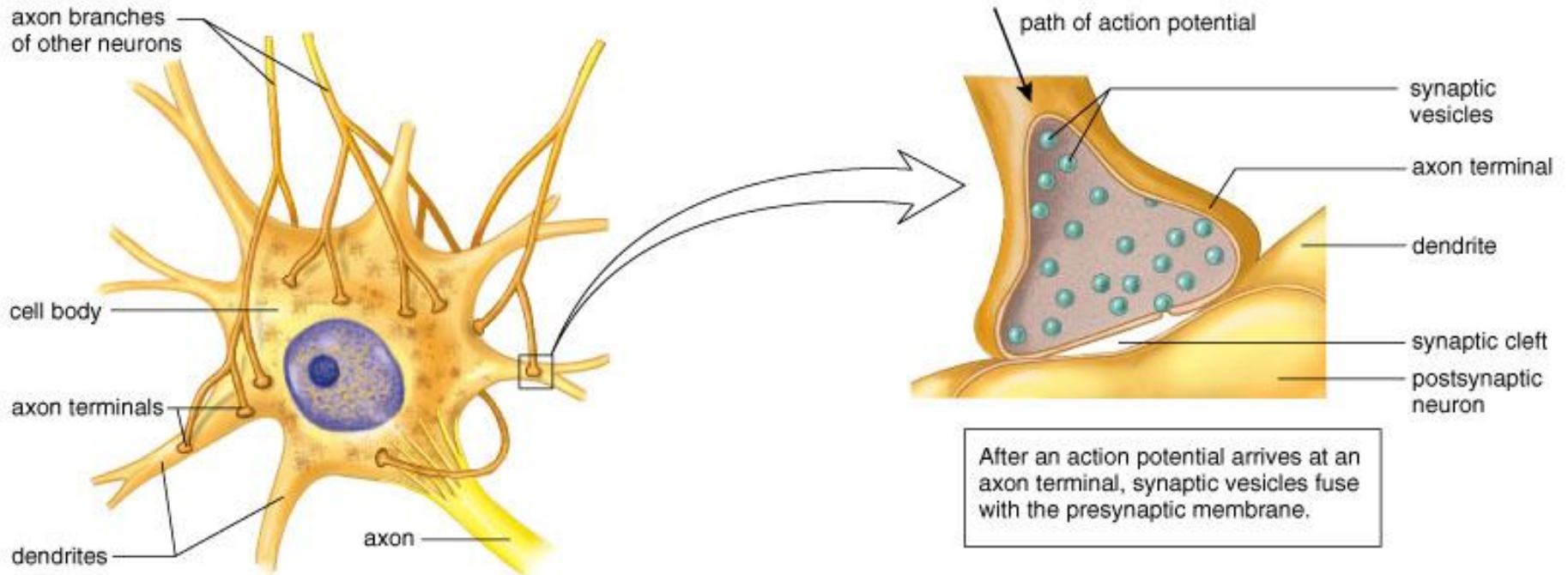
Nervous tissue cont'd.

– Neurotransmitter

- Chemical stored in synaptic vesicles in presynaptic neuron
- Communication across synapse
- **Release of neurotransmitter**
 - Presynaptic axon depolarizes
 - Calcium channels open and calcium moves in
 - Causes synaptic vesicles to bind to membrane
 - » Neurotransmitter released into cleft
 - » Diffuses across and binds to postsynaptic receptors
- **Response of postsynaptic membrane**
 - Depends on neurotransmitter
 - » Can be excitatory and cause an action potential
 - » Can be inhibitory and prevent an action potential

Synapse structure and function

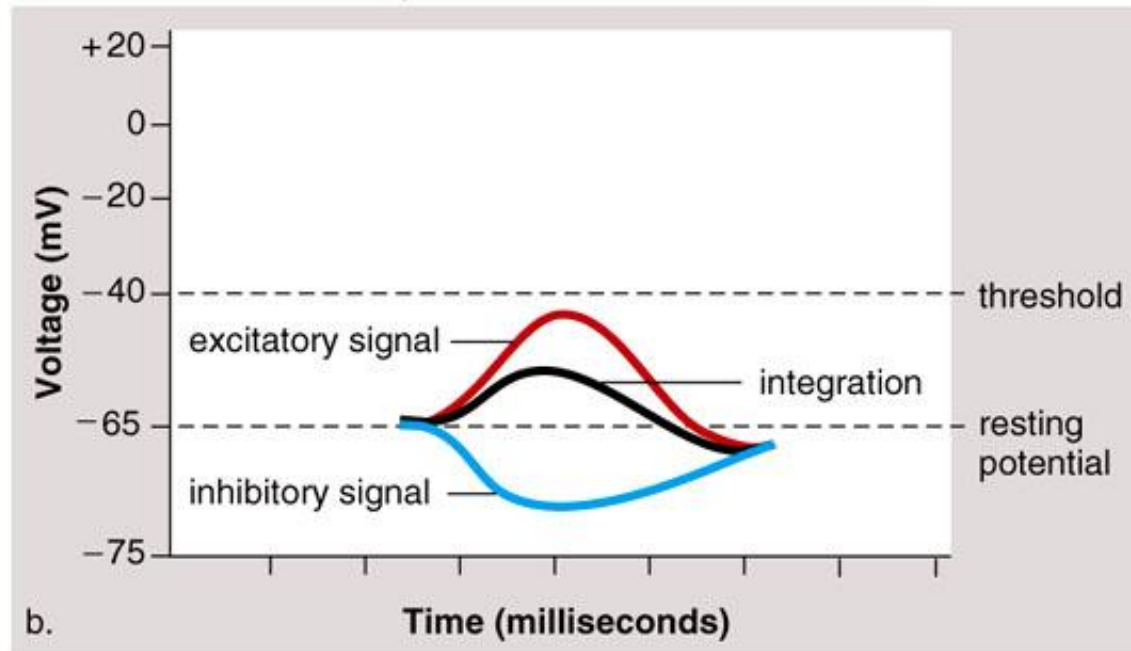
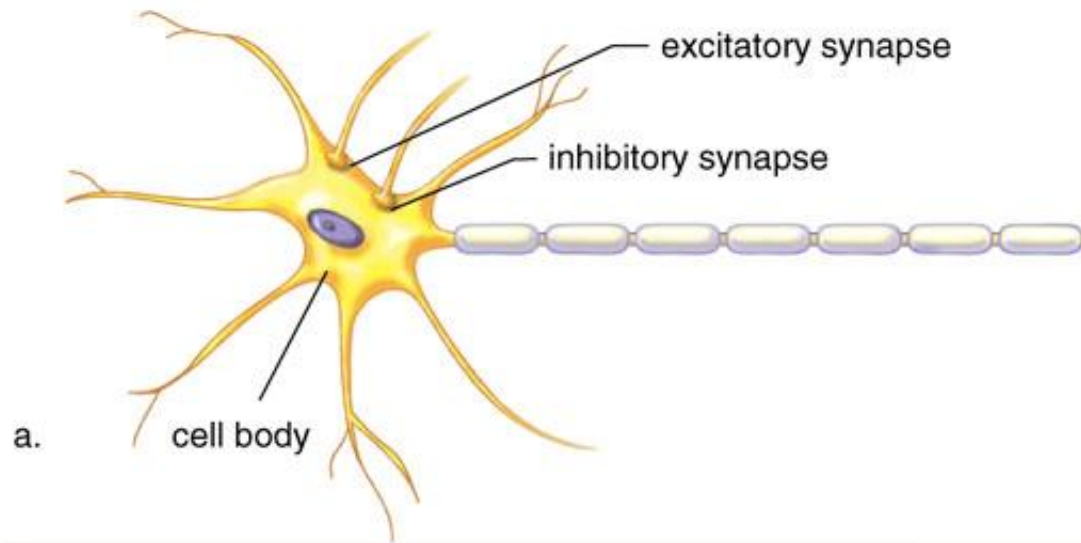
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• Fig. 17.5

Integration

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- Fig. 17.6

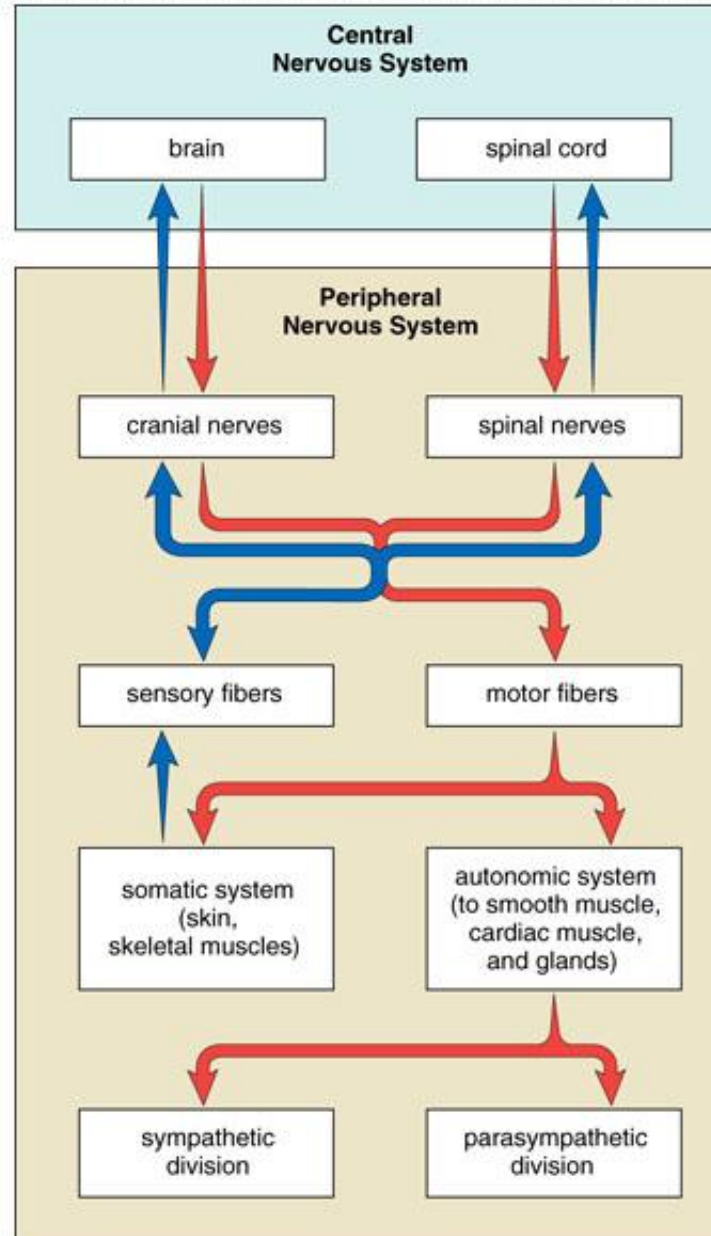
Nervous tissue cont'd.

- Neurotransmitter molecules

- Acetylcholine (Ach) and norepinephrine (NE) are examples
 - Both are excitatory neurotransmitters
- Once released and responses initiated, neurotransmitters are removed from cleft
 - Some removed by enzymes
 - Ach is removed by acetylcholinesterase
 - Others are taken back up by presynaptic neuron
 - Prevents repeated stimulation of postsynaptic membrane
- Many drugs affect nervous system
 - Interfere or potentiate neurotransmitters
 - Can enhance or block release
 - Can interfere with removal from cleft

Organization of the nervous system

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- Fig. 17.7

17.2 The central nervous system

- Spinal cord

- Structure

- Extends from base of brain into vertebral canal
 - Protected by vertebrae
 - Intervertebral disks cushion and separate
 - Cross-sectional anatomy
 - Central gray matter
 - » Shaped like letter “H”
 - » Dorsal root- sensory fibers entering gray matter
 - » Ventral root-motor fibers leaving gray matter
 - » Dorsal and ventral roots join as spinal nerve
 - » Interneurons in gray matter
 - » Fluid-filled central canal

The central nervous system cont'd.

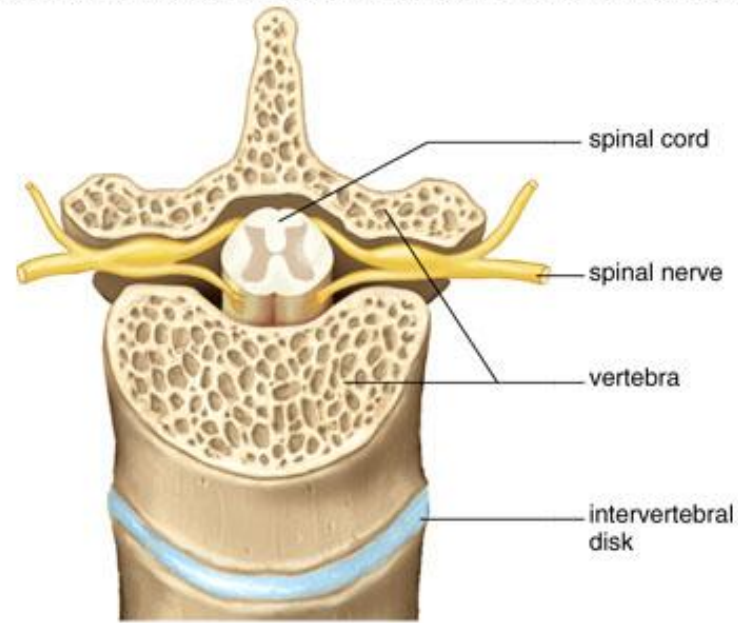
- Spinal cord cont'd.

- White matter

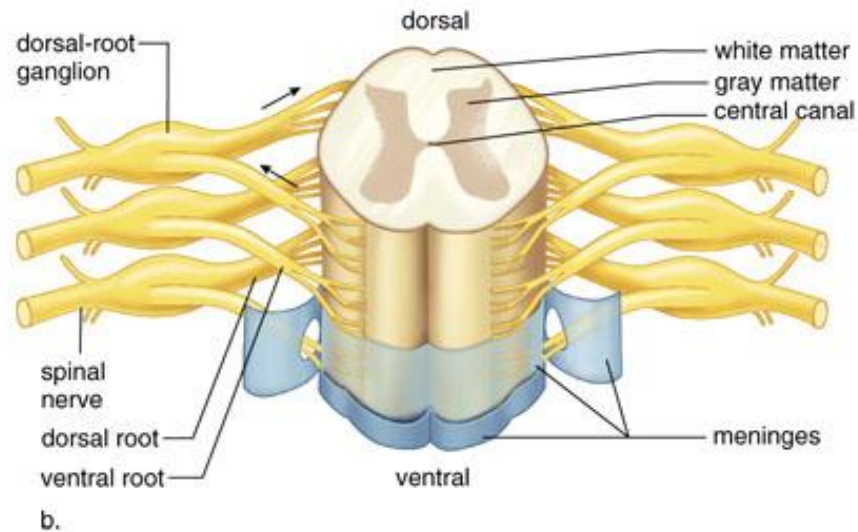
- In areas around gray matter
 - Ascending and descending tracts
 - Ascending located dorsally
 - » Sending axons up to brain
 - Descending located ventrally
 - » Sending axons from brain to spinal nerves
 - » Many tracts cross over to opposite side
 - » Left side of brain controls right side of body and vice versa

Spinal cord

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a.



b.

- Fig. 17.8

The central nervous system cont'd.

- Functions of spinal cord
 - Communication between brain and body
 - Center for many reflex arcs
 - Sensory receptor generates impulse
 - Sensory neuron transmits impulse to cord
 - Synapses with interneurons in cord- integration
 - Transmitted to motor neuron
 - Motor neuron carries impulse to effector

The central nervous system cont'd.

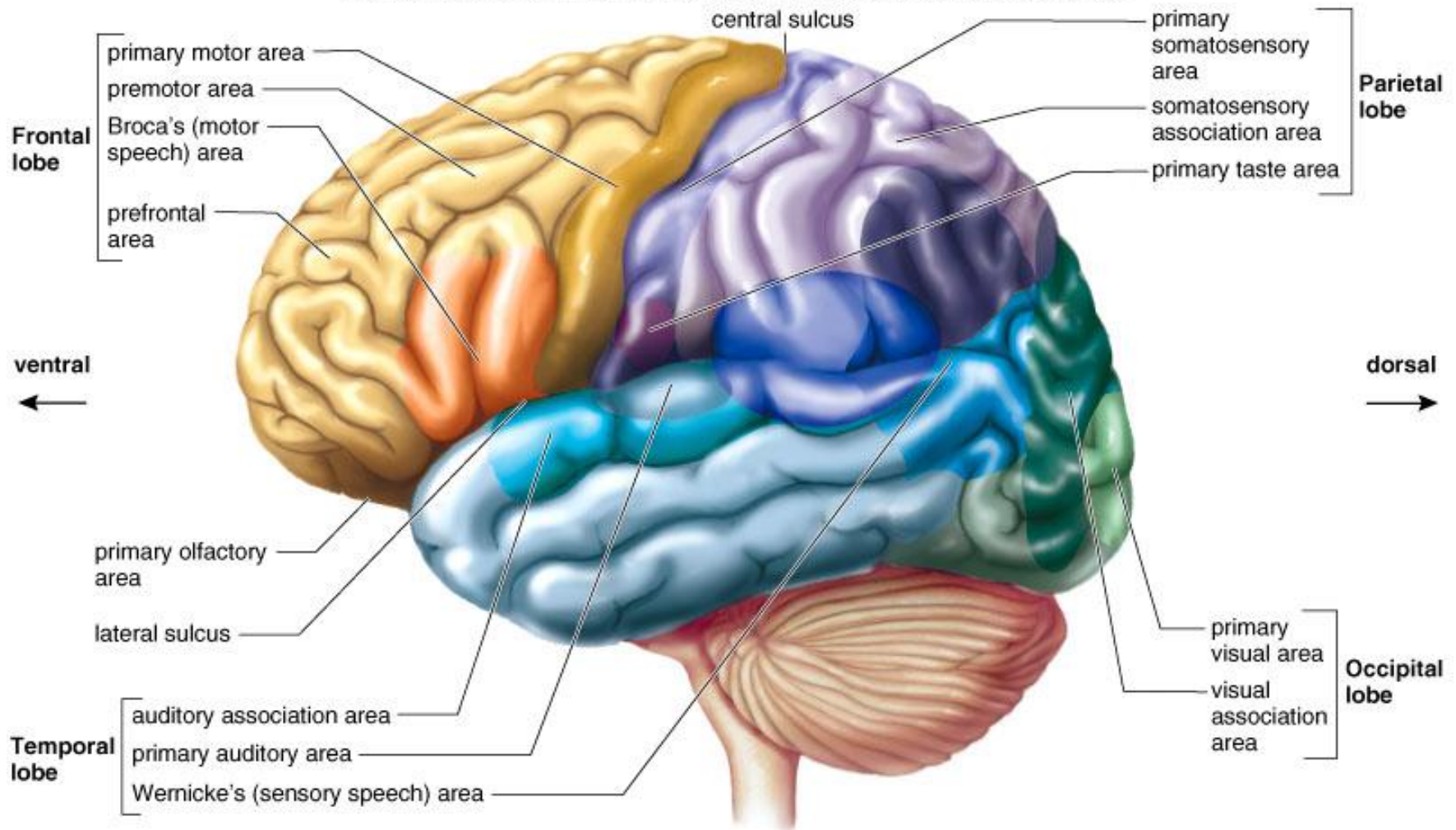
- **The brain**
 - **Cerebrum**
 - 2 cerebral hemispheres
 - Connected by corpus callosum
 - Higher thought processes, learning, language, speech
 - **Cerebral hemispheres**
 - Divided by longitudinal fissure
 - Folded surface
 - Sulci (sulcus)- shallow grooves
 - » Divide each hemisphere into 4 lobes

The central nervous system cont'd.

- The cerebral lobes
 - Frontal lobe
 - Most ventral lobe
 - Complex thought processes
 - Primary motor cortex
 - Parietal lobe
 - Dorsal to frontal lobe
 - Primary sensory cortex
 - Occipital lobe
 - Most dorsal lobe
 - Primary visual cortex
 - Temporal lobe
 - Inferior to frontal and parietal lobes
 - Primary auditory cortex

The lobes of the cerebral cortex

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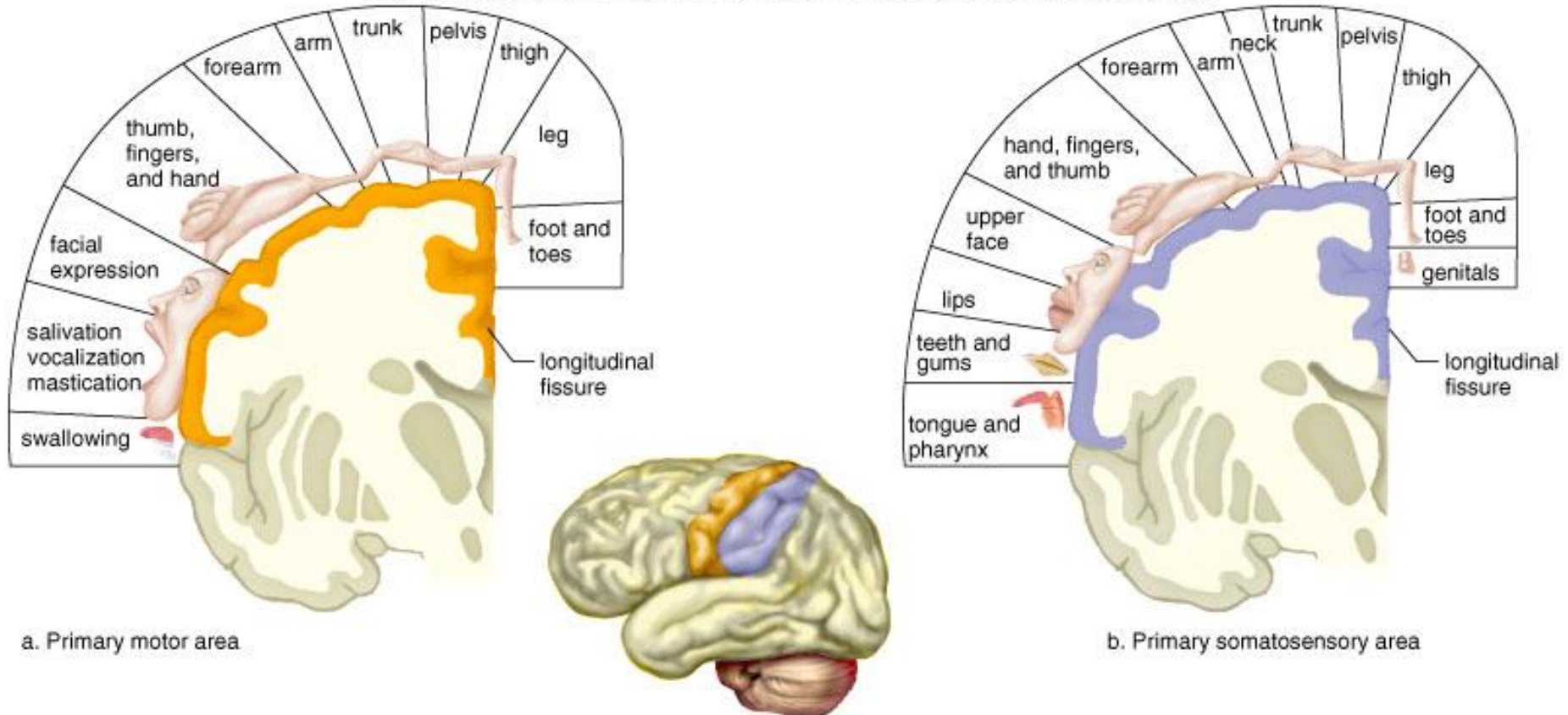
• Fig. 17.10

The central nervous system cont'd.

- **Primary motor and sensory areas of the cortex**
 - **Primary motor area**
 - In frontal lobe ventral to central sulcus
 - All voluntary motor movements originate here
 - Each body part is controlled by a specific section
 - **Primary somatosensory area**
 - In parietal lobe dorsal to central sulcus
 - Receives sensory information from skin and skeletal muscles
 - Touch, temperature, pressure, localization of pain
 - **Primary visual area- occipital lobe**
 - **Primary auditory and olfactory areas- temporal lobe**
 - **Primary taste area-parietal lobe**

The primary motor area and somatosensory area

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• Fig. 17.11

The central nervous system cont'd.

- **Processing centers**
 - Receive information from all association areas
 - Perform higher-level analytical functions
 - Integration here accounts for critical thinking abilities
 - **Our ability to speak is governed by 2 processing centers**
 - Wernicke's area-dorsal part of left temporal lobe
 - Understanding of written and spoken words
 - Broca's area- left frontal lobe
 - Directs motor actions for speech
 - Grammatical refinements

The central nervous system cont'd.

- **The diencephalon**
 - Forms a ring around the third ventricle
 - Composed of both the hypothalamus and the thalamus
 - **The hypothalamus is a homeostatic control center**
 - Thermoregulation
 - Water balance
 - Hunger and satiety
 - Sleep
 - **The thalamus is a sensory relay center**
 - Receives incoming information and sends it to appropriate area
 - Arousal of cerebrum
 - Memory, emotional responses

The central nervous system cont'd.

- The cerebellum

- Separated from brainstem by 4th ventricle
- Receives both sensory and motor input
- Can compare actual movements with intended movements
- Functions to assure smooth, coordinated motor movements

- The brain stem

- Midbrain, pons, and medulla oblongata
 - Midbrain- relay center for tracts passing between cerebrum, cerebellum, and breathing, reflex movements of the head
 - Medulla oblongata-autonomic control center
 - Heart rate, breathing, blood pressure, swallowing, coughing, vomiting

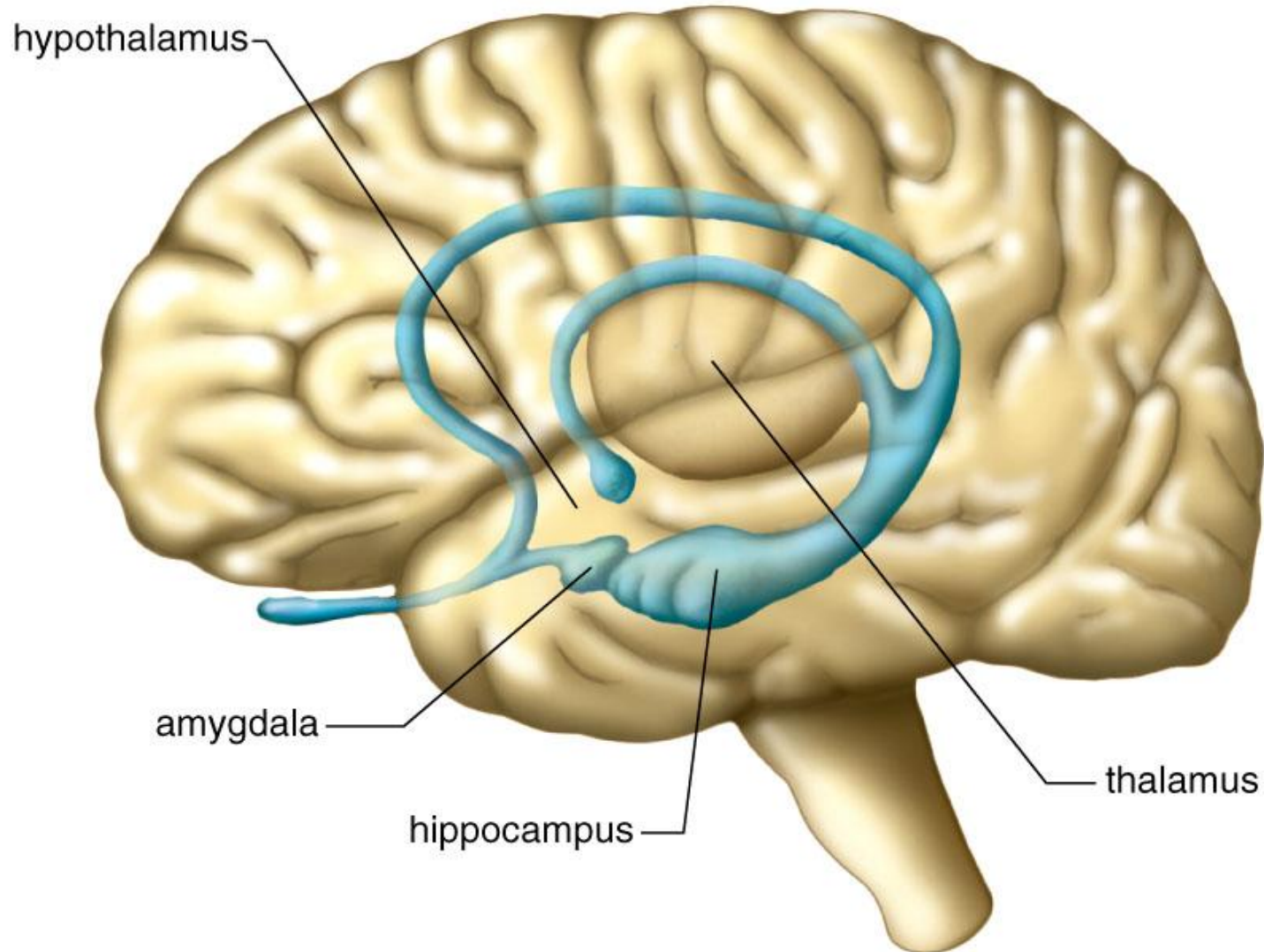
17.3 The limbic system and higher mental functions

- The limbic system

- Complex network of tracts and nuclei deep in cerebrum
- Blends primitive emotions (fear, aggression, pleasure) with higher mental functions (reasoning, memory)
- Hippocampus
 - Communicates with frontal lobe
 - Learning and memory
 - May convert wrote memory to learning
- Amygdala
 - Anger, defensiveness, fear
 - Coordinates release of epinephrine (adrenalin)

The limbic system

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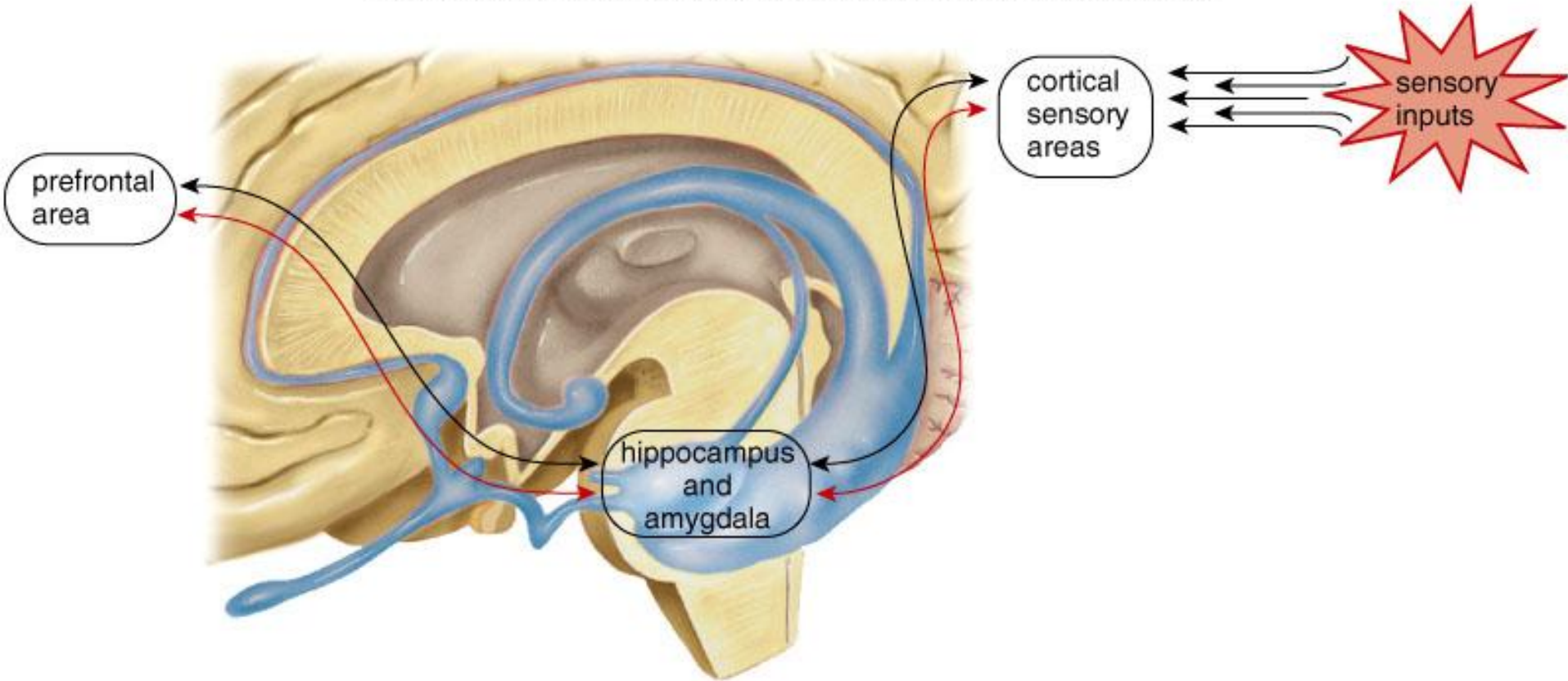
• Fig. 17.12

The limbic system and higher mental functions cont'd.

- **Memory and learning**
 - Memory is the ability to hold on to or recall a piece of information
 - Learning is the ability to retain and apply past memories
- **Types of memory**
 - **Short-term memory**
 - Retained for short period like a phone number you look up
 - **Long-term memory**
 - Retained for long period, perhaps for life
 - Combination of semantic memory (words, numbers) and episodic memory (people, events, etc.)
 - **Skill memory**
 - Combinations of motor activities like swimming, using scissors, etc.

Long-term memory circuits

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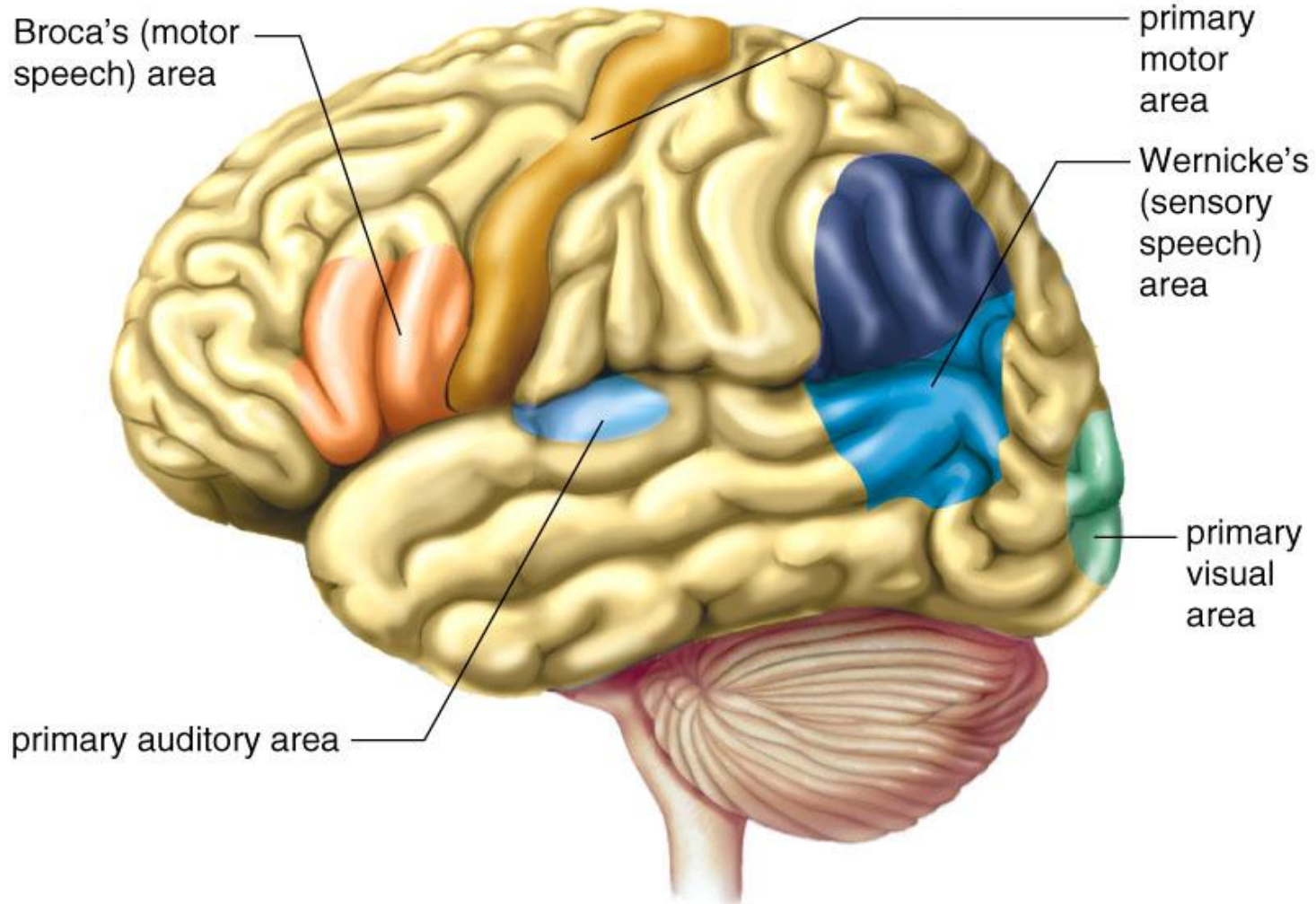
• Fig. 17.13

The limbic system and higher mental functions cont'd.

- Language and speech
 - Language is dependent upon memory
 - Seeing and hearing words- dependent upon primary visual and auditory center functions
 - Speaking words-depends upon primary motor cortex function
 - Left and right cerebral hemispheres have different functions related to language and speech
 - Broca's and Wernicke's areas are only in the left hemisphere
 - Broca's- ability to speak
 - Wernicke's- ability to comprehend speech
 - Both hemispheres process information, but differently
 - Left is very specific
 - Right is very global

Language and speech

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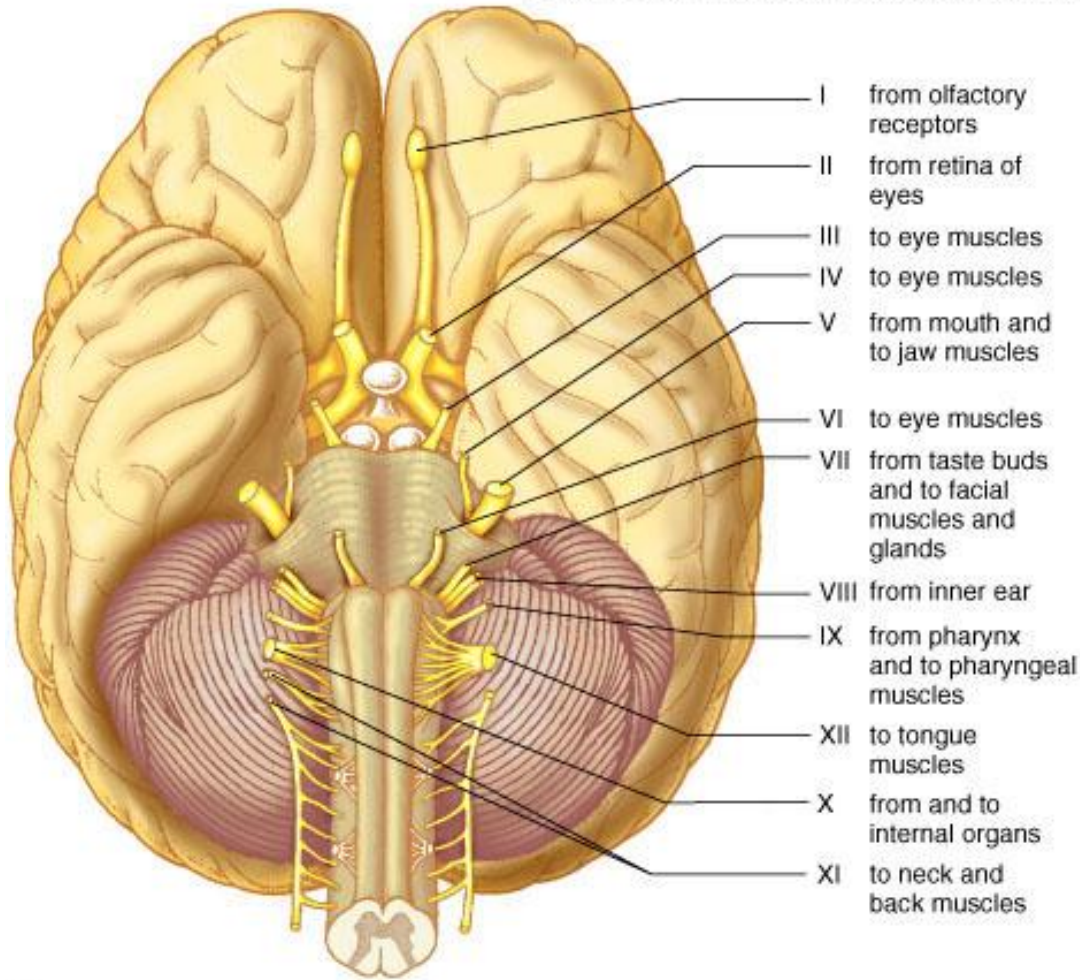
- Fig. 17.14

17.4 The peripheral nervous system

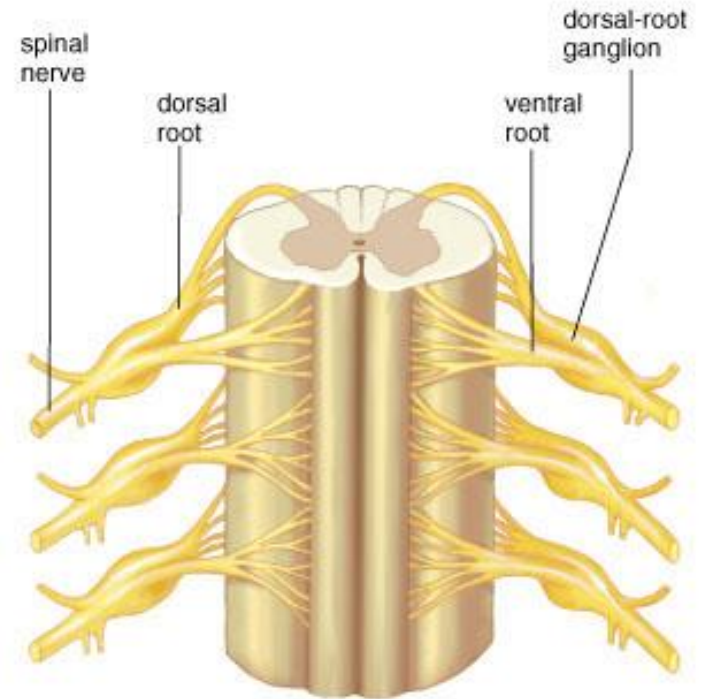
- **Organization of the PNS**
 - Composed of nerves (bundles of axons) and ganglia (swellings associated with nerves that contain cell bodies)
 - **Cranial nerves- 12 pairs**
 - Attached to the brain
 - Some are purely sensory, some motor, and some are mixed
 - Largely concerned with head, neck, and face with the exception of the vagus nerve (X) which extends to thorax and abdomen
 - **Spinal nerves- 31 pairs**
 - Emerge from spinal cord between vertebrae
 - All are mixed nerves
 - Cell bodies of sensory neurons are located in dorsal root ganglia
 - Ventral roots contain axons of motor neurons

Cranial and spinal nerves

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a.



b.

- Fig. 17.15

The peripheral nervous system cont'd.

- Somatic nervous system

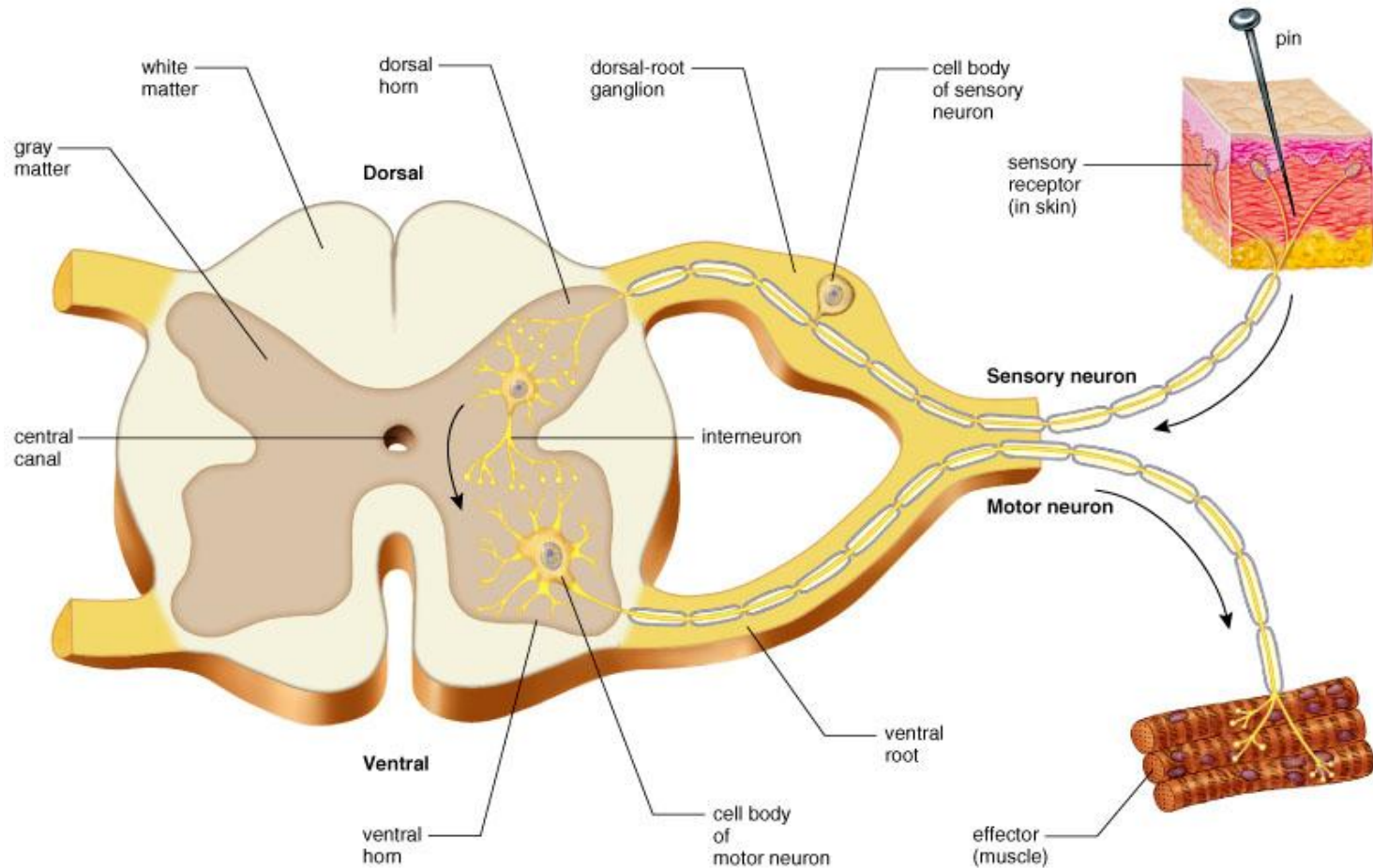
- A division of the PNS
- Serves the skin, muscles, and tendons
- Includes nerves that carry sensory information from receptors to the CNS and nerves that carry motor responses back to periphery
- Many actions are reflex activities
- Reflex
 - A programmed response to a stimulus that is automatic
 - Can be conscious or unconscious but not mentally willed
 - Protective functions

The peripheral nervous system cont'd.

- **The reflex arc- components**
 - **Sensory receptor**- at tip of dendrites
 - Responds to specific stimulus
 - **Sensory neuron**
 - Carries the stimulus to the spinal cord
 - Cell body located in dorsal root ganglion
 - Axon enters spinal cord through dorsal root
 - **Interneuron(s)**
 - In central gray matter of cord
 - May synapse with one or many interneurons depending on reflex
 - **Motor neuron**
 - Cell body in ventral horn
 - Axon leaves in ventral root
 - **Effector** organ-carries out response

A reflex arc showing the path of a spinal reflex

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• Fig. 17.16

The peripheral nervous system cont'd.

- The autonomic nervous system (ANS)
 - 2 divisions
 - Sympathetic and parasympathetic nervous systems
 - Features in common
 - Function automatically and generally are involuntary
 - Innervate all internal organs
 - Pathway consists of 2 motor neurons that synapse at a ganglion
 - The first is the preganglionic neuron and its cell body is in the CNS
 - The second is the postganglionic neuron and its cell body is in the ganglion
 - ANS regulates cardiac muscle, smooth muscle and glands
 - Important homeostatic reflexes

Comparison of somatic motor and autonomic motor pathways

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TABLE 17.1 COMPARISON OF SOMATIC MOTOR AND AUTONOMIC MOTOR PATHWAYS

	Somatic Motor Pathway	Autonomic Motor Pathways	
		<i>Sympathetic</i>	<i>Parasympathetic</i>
Type of control	Voluntary/involuntary	Involuntary	Involuntary
Number of neurons per message	One	Two (preganglionic shorter than postganglionic)	Two (preganglionic longer than postganglionic)
Location of motor fiber	Most cranial nerves and all spinal nerves	Thoracolumbar spinal nerves	Cranial (e.g., vagus) and sacral spinal nerves
Neurotransmitter	Acetylcholine	Norepinephrine	Acetylcholine
Effectors	Skeletal muscles	Smooth and cardiac muscle, glands	Smooth and cardiac muscle, glands

- Table 17.1

The peripheral nervous system cont'd.

- The sympathetic division of the ANS
 - Cell bodies of preganglionic neurons are in the thoracic and lumbar regions of the spinal cord
 - Preganglionic neurons are short
 - Synapse in spinal ganglia which lie along the spinal cord
 - Postganglionic neurons are long
 - Primary neurotransmitter is norepinephrine
 - Mediates the “fight or flight” response
 - Increases heart rate and contractility, dilates bronchi
 - Inhibits the digestive tract
 - Stimulates release of epinephrine from adrenals

The peripheral nervous system cont'd.

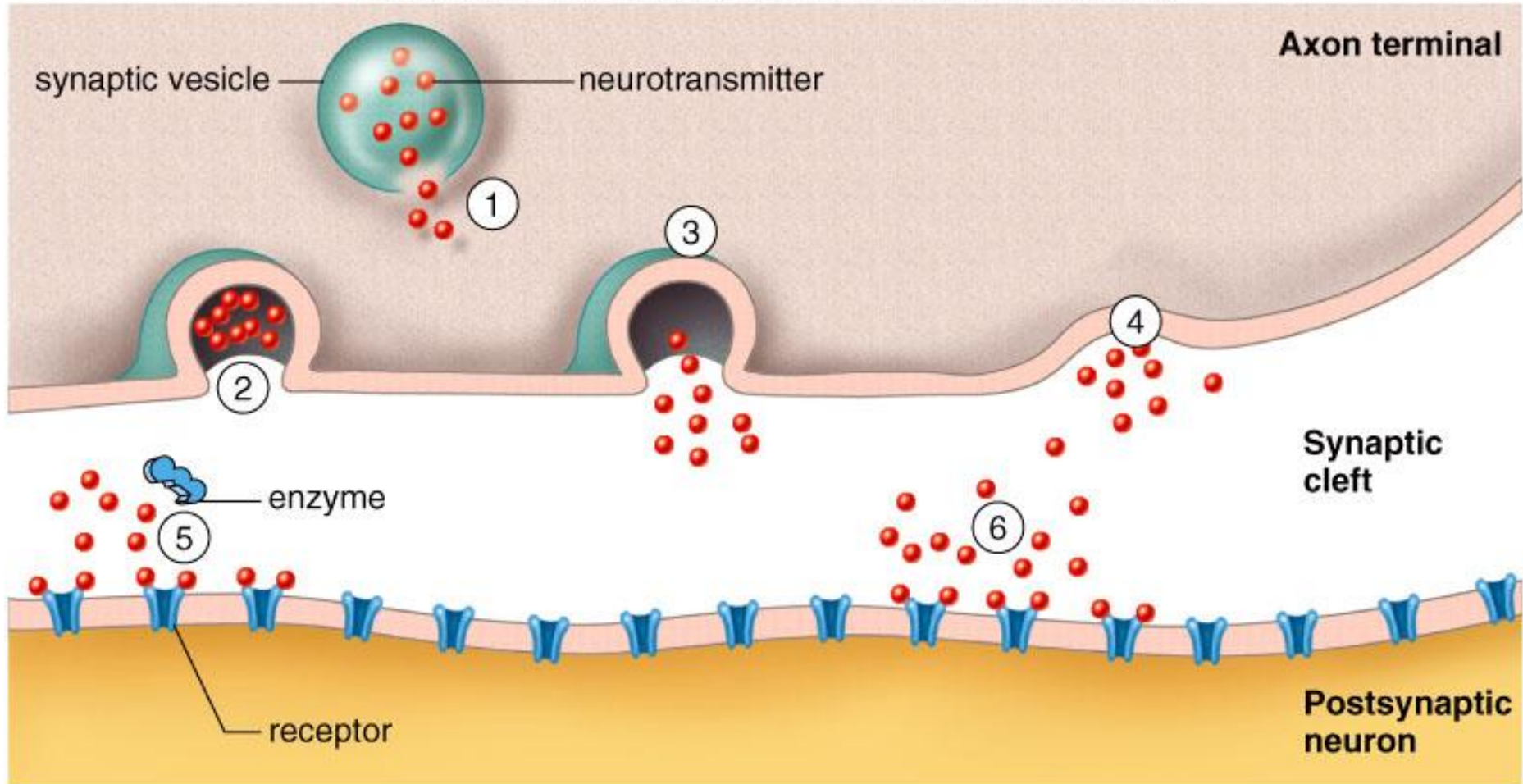
- The parasympathetic division of the ANS
 - Cell bodies in the brain and sacral portion of the spinal cord
 - Long preganglionic neurons
 - Synapse in collateral ganglia in the walls of effector organs
 - Short postganglionic neurons
 - Neurotransmitter is acetylcholine
 - Mediates “rest and digest” functions
 - Promotes digestion
 - Decreases heart rate

17.5 Drug abuse

- **Drugs and the nervous system**
 - 2 main mechanisms of action
 - Affect the limbic system
 - Affect neurotransmitter activity
 - Drug abuse
 - Takes levels above therapeutic doses
 - Generally under circumstances that increase harmful effects
 - Physical dependency
 - Person develops tolerance to drug
 - More is needed for desired effect
 - Withdrawal symptoms when drug removed
 - Psychological dependency
 - Person thinks about the drug constantly
 - Preoccupied with obtaining the drug

Drug actions at a synapse

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• Fig. 17.18

Drug abuse cont'd.

- Alcohol

- Influences GABA (inhibitory neurotransmitter) and glutamate (excitatory neurotransmitter)
- Metabolized in the liver
 - Prevents liver from breaking down fats
 - Fat accumulates in liver-after only 1 night of drinking!!!!
 - First stage of damage
 - Reversible
 - Continued consumption causes fibrous scar tissue formation
 - Still reversible
 - Long term consumption causes cirrhosis
 - Liver cells die
 - irreversible

Drug abuse cont'd.

- Alcoholism

- Alcohol is a carbohydrate
- Can be used as energy source
 - Lacks vitamins, minerals, essential amino acids, fatty acids
- Alcoholics are vitamin-deficient, undernourished, and prone to illness
- Fetal alcohol syndrome
 - Alcohol crosses the placenta
 - Affects physical and mental development of fetus
 - **NO AMOUNT OF ALCOHOL CONSUMPTION IS SAFE DURING PREGNANCY**
 - Mental retardation and physical defects

Drug abuse cont'd.

- Nicotine

- Alkaloid derived from tobacco
- Found in cigarettes, snuff, chewing tobacco, cigars
- Nicotine causes neurons to release dopamine
 - Excess dopamine causes dependence
- Nicotine stimulates the same receptors as acetylcholine
 - Increased skeletal muscle activity
 - Increases heart rate and blood pressure
 - Stimulates digestive tract motility
- Withdrawal characterized by headache, stomach pain, irritability, insomnia
- **SMOKING IN PREGNANCY RESULTS IN INCREASED INCIDENCE OF STILLBIRTHS AND LOW BIRTH WEIGHT**

Drug abuse cont'd.

- Cocaine

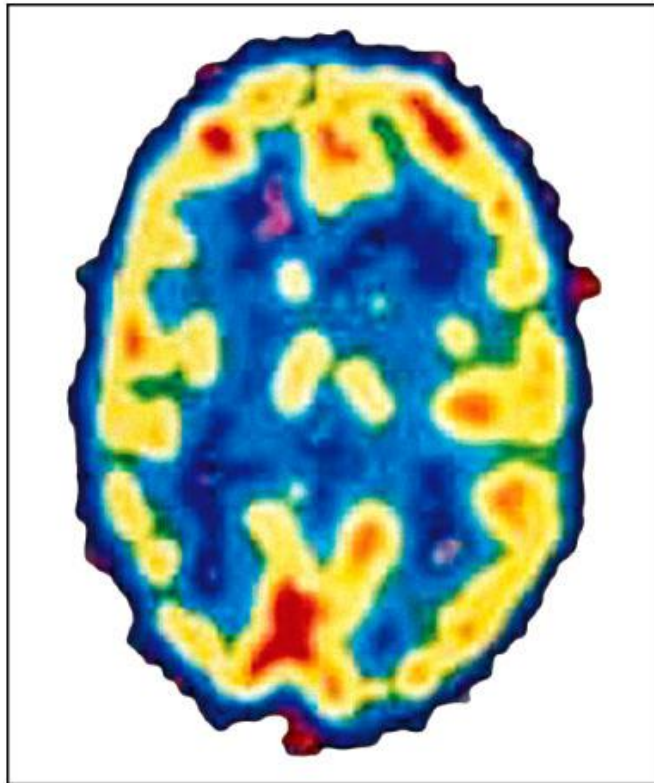
- An alkaloid derived from the shrub *Erythroxylon coca*
- Prevents synaptic uptake of dopamine
 - Accounts for state of euphoria
- Binge phase of cocaine use
 - Hyperactivity, decreased appetite, increased sex drive
- Crash phase
 - Depression, irritability, decreased sex drive (impotency in males)
- Cocaine causes extreme physical dependence
- Overdose- cardiac and respiratory arrest
- **FETAL DEPENDENCY DURING PREGNANCY-NEWBORNS UNDERGO WITHDRAWAL**

Drug abuse

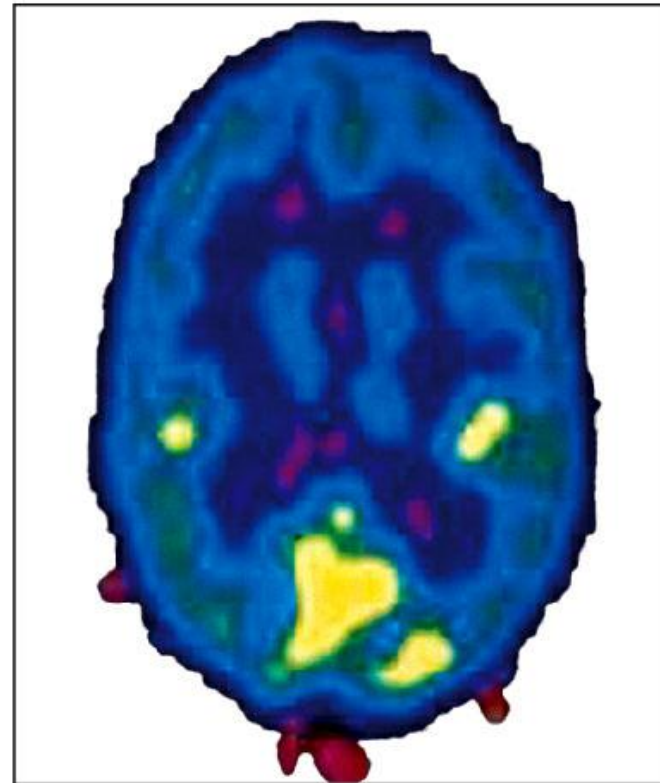
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brain inactivity →



Before cocaine use, brain is more active.



After cocaine use, brain is less active.

- Fig. 17.19

Drug abuse cont'd.

- Heroin

- Derived from morphine which is an alkaloid of opium
- Heroin binds to endorphin receptors
 - Produces euphoria, pain relief
 - Side effects include nausea, vomiting, restlessness, anxiety, mood swings
 - Over time body stops producing natural endorphins
- Tolerance develops-must take more drug just to prevent withdrawal symptoms
 - Perspiration, tremors, dilated pupils, cramps, increased blood pressure and respiratory rate
- **CAUSES FETAL DEPENDENCE IN PREGNANCY AND NEWBORNS ARE BORN ADDICTED**

Drug abuse cont'd.

- Marijuana

- From dried leaves, stems, and flowers of *Cannibus sativa*
- Resins contain THC- tetrahydrocannabinol
- Binds to receptors for anandamide
 - Short-term memory processing
 - Creates feeling of contentment
- Short term use causes mild euphoria, alterations in judgement and motor incoordination
- Heavy use causes anxiety, paranoia, psychotic symptoms
- Long-term use leads to brain impairment
- **USE IN PREGNANCY CAUSES FETAL CANNABIS SYNDROME WHICH RESSEMBLES FAS**