

The Nervous System

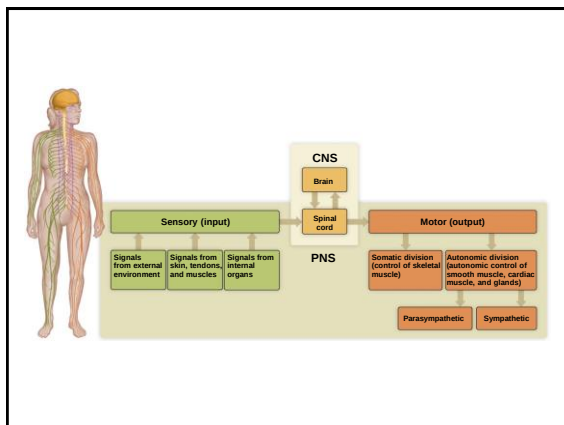


1

Nervous System Has Two Principal Parts

- **Central nervous system (CNS)**
 - Components: brain and spinal cord
 - Functions: receives, processes, and transfers information
- **Peripheral nervous system (PNS)**
 - Components: nerves outside CNS
 - Sensory division: carries information toward the CNS
 - Motor division: carries information away from CNS

2



3

Neurons: Communication Cells of the Nervous System

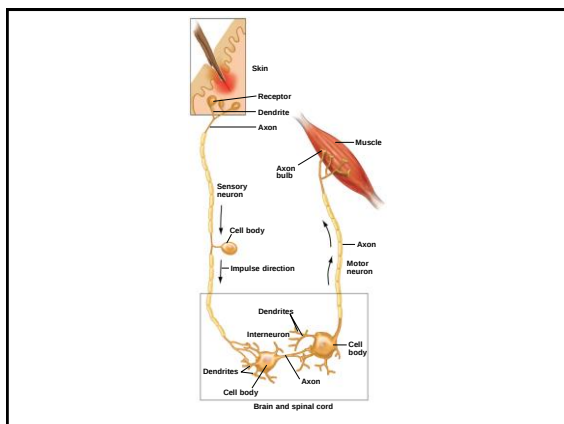
- Neurons are specialized cells for communication
 - Generate and conduct electrical impulses
- Types of neurons
 - **Sensory neurons**: neurons found in the PNS that receive stimuli and transmit information to the CNS
 - **Interneurons**: transmit information between components of the CNS
 - **Motor neurons**: neurons found in the PNS that transmit information away from the CNS

4

Neurons: Cell Structure

- **Three parts of the neuron**
 - **Cell body**: main part of the cell, has the nucleus and most of the cytoplasm and organelles
 - **Dendrites**: small slender extensions of the cell body, receive incoming information
 - **Axon**: long slender extension, specialized to conduct electrical impulses away from the cell body

5



6

Neurons Initiate Action Potentials

- Neurons generate and transmit action potentials
- An action potential is basically an electrical impulse
- Primary means of communication throughout the nervous system

7

Neuroglial Cells Support/Protect Axons

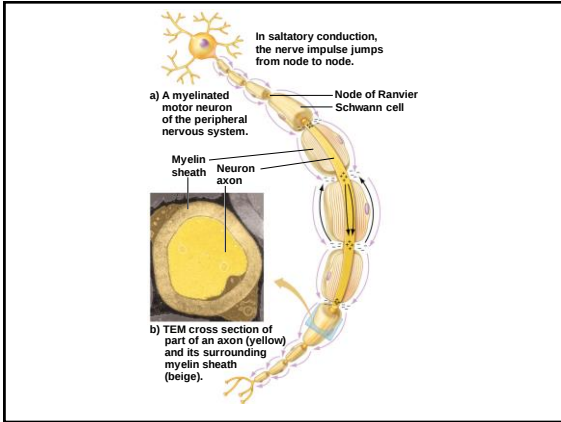
- Neuroglial cells make up 80% of nervous system
 - Function
 - Support
 - Protection
 - Do NOT transmit action potentials
 - Two types
 - Schwann cells
 - Oligodendrocytes

8

Neuroglial Cells: Form Myelin Sheath on Neurons

- **Schwann cells**
 - Form myelin sheath in PNS
 - Save the neuron energy
 - Speed up the transmission of impulses
 - **Saltatory conduction:** leaping pattern of action potential conduction
 - Help damaged or severed axons regenerate
- **Oligodendrocytes**
 - Form myelin sheath in CNS

9



10

Demyelinating Diseases

- Disorders associated with degeneration of myelin sheaths
 - **Multiple sclerosis (MS)**
 - Progressive damage to myelin sheaths in brain and spinal cord
 - Weakness, visual impairment, incontinence
 - **Amyotrophic lateral sclerosis (ALS)**
 - Lou Gehrig's disease
 - Progressive damage to myelin sheaths in motor area of spinal cord
 - Progressive weakening and wasting of skeletal muscle

11

Information Is Transferred from Neuron to Target

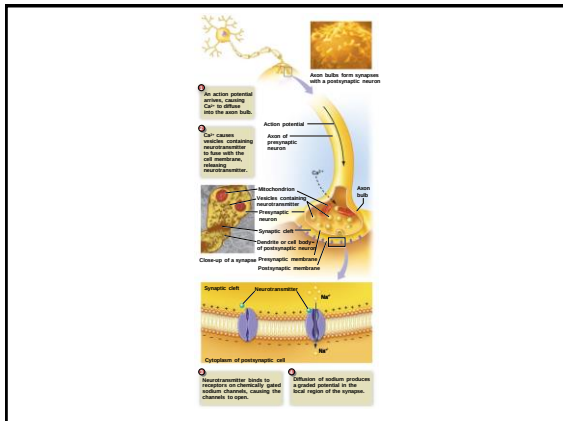
- Targets
 - another neuron, muscle cell, or gland
- **Synapse**
 - special junction between axon terminus and target cell
- Synaptic transmission
 - Process of transmission of impulse from sending (presynaptic neuron) across synaptic cleft to receiving (postsynaptic) target
 - Involves release and diffusion of chemical neurotransmitter

12

Synaptic Transmission: Neurotransmitter Release

- Action potential arrives at axon terminus, causing Ca^{2+} to diffuse into axon bulb
- Ca^{2+} causes release of neurotransmitter from vesicles
- Neurotransmitter diffuses across synaptic cleft
- Neurotransmitter binds to receptors on target (postsynaptic) membrane and opens gated channels

13



14

Neurotransmitters Exert Excitatory or Inhibitory Effects

- Response of postsynaptic target cell depends on
 - Type of neurotransmitter (>50 types)
 - Type of receptors
 - Type of gated ion channels

15

Table 11.1 Actions of common neurotransmitters

Neurotransmitter	Sites where released	Principal actions
Acetylcholine	Neuromuscular junctions, autonomic nervous system, brain	Excitatory on skeletal muscles; excitatory or inhibitory at other sites, depending on receptors
Norepinephrine	Areas of brain and spinal cord, autonomic nervous system	Excitatory or inhibitory, depending on receptors; plays a role in emotions
Serotonin	Areas of brain, spinal cord	Usually inhibitory; involved in moods, sleep cycle, appetite
Dopamine	Areas of brain, parts of peripheral nervous system	Excitatory or inhibitory, depending on receptors; plays a role in emotions
Glutamate	Areas of brain, spinal cord	Usually excitatory; major excitatory neurotransmitter in brain
Endorphins	Many areas in brain, spinal cord	Natural opiates that inhibit pain; usually inhibitory
Gamma-aminobutyric acid	Areas of brain, spinal cord	Usually inhibitory; principal inhibitory neurotransmitter in brain
Somatostatin	Areas of brain, pancreas	Usually inhibitory; inhibits pancreatic release of growth hormone

© 2012 Pearson Education, Inc.

- This is just to show the names of some neurotransmitters
 - Do not worry about the 'site where released' or 'principal actions'

16

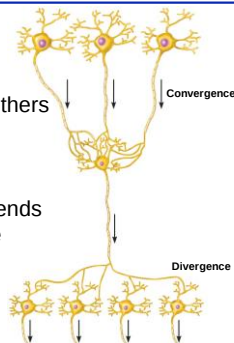
Postsynaptic Neurons Integrate and Process Information

- Response in postsynaptic cell depends on
 - How many neurons are forming synapses with it
 - Whether the neurons forming synapses with it are excitatory or inhibitory

17

Postsynaptic Neurons Integrate and Process Information

- Convergence
 - occurs when one neuron receives input from many others
- Divergence
 - occurs when one neuron sends action potentials to multiple other neurons



18

Peripheral Nervous System Relays Information Between Tissues and CNS

- Nerve
 - contains axons of many neurons wrapped together in a protective sheath
 - Carries information to and from the CNS
- Cranial nerves
 - 12 pairs
 - Connect directly to brain
- Spinal nerves
 - 31 pairs
 - Connect to spinal cord

19

Sensory Neurons Provide Information to the CNS

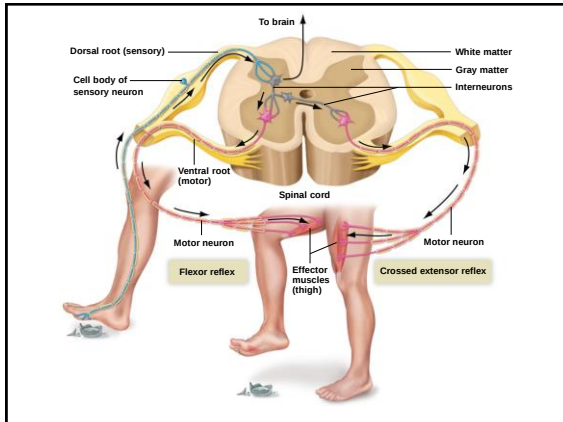
- Provide information for both the somatic and autonomic motor divisions of the PNS
- Incoming information arrives at the CNS as action potentials from sensory neurons located throughout the body

20

Somatic Division Controls Skeletal Muscles

- Functions
 - Voluntary
 - Conscious control of skeletal muscles
 - Involuntary (Reflexes)
 - **Spinal reflexes:** Involuntary responses mediated primarily by spinal cord and spinal nerves, with little brain involvement
 - flexor (withdrawal) reflex
 - crossed extensor reflex
 - stretch reflex: important in maintaining upright posture, movement

21



22

The Autonomic Division

- Part of the motor output of the PNS
- Controls automatic body functions of many internal organs
- Consists of two divisions
 - Sympathetic division
 - Parasympathetic division
- Both sympathetic and parasympathetic neurons enervate each organ

23

The Sympathetic and Parasympathetic Autonomic Divisions Oppose Each Other

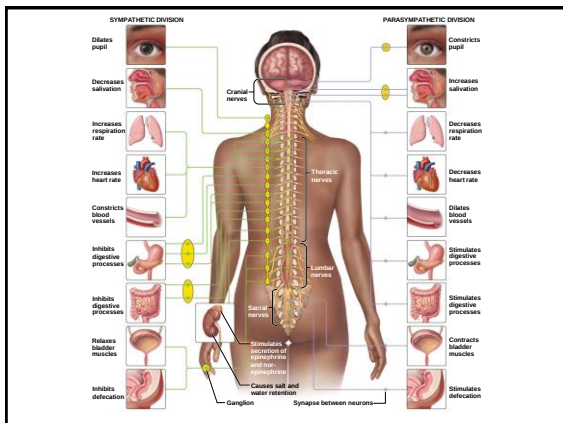
- Sympathetic division
 - Prepares the body for emergencies
 - Norepinephrin is the key neurotransmitter
 - Produces fight-or-flight response
 - Increases heart rate and respiration
 - Raises blood pressure
 - Dilates pupils
 - Slows digestion and urine production
 - Generally produces a unified response in all organs at once
 - Opposes parasympathetic division

24

The Sympathetic and Parasympathetic Autonomic Divisions Oppose Each Other

- Parasympathetic division
 - Relaxes the body
 - Opposes sympathetic division
 - Acetylcholine is the key neurotransmitter
 - Actions:
 - lowers heart rate and respiration
 - increases digestion
 - permits defecation and urination
- Sympathetic and parasympathetic divisions work antagonistically to maintain homeostasis

25



26

Table 11.2 The somatic and autonomic divisions of the PNS

	Somatic division	Autonomic division	
		Sympathetic	Parasympathetic
Functions	Serves skeletal muscles	Fight or flight; arouses body to deal with situations involving physical activity, mental alertness	Relaxes body; promotes digestion and other basic functions
Neurotransmitter	Acetylcholine	Norepinephrine	Acetylcholine
Number of neurons required to reach the target cell	One	Two (preganglionic and postganglionic)	Two (preganglionic and postganglionic)

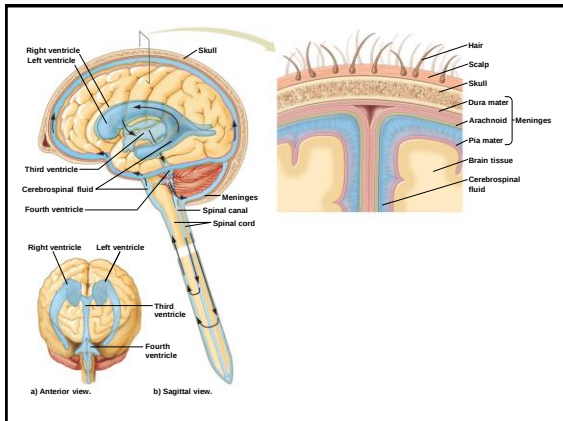
© 2012 Pearson Education, Inc.

27

Brain and Spinal Cord Constitute the CNS

- CNS protection
 - **Bone:** skull and vertebrae
 - **Meninges:** protective membranes
 - Dura mater, arachnoid, and pia mater
 - **Cerebrospinal fluid:** bathes the brain, spinal cord
 - Shock absorber
 - Produced within the ventricles of the brain
 - **Blood-brain barrier:** prevents entry of certain chemicals and pathogens

28

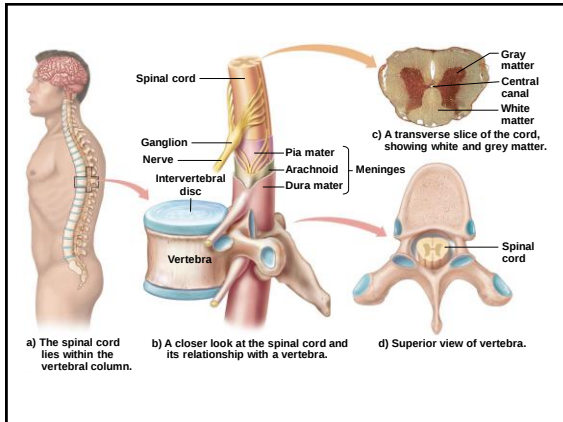


29

The Spinal Cord Relays Information

- Spinal cord is a superhighway for action potentials between the brain and the rest of the body
- White matter
 - Outer portion of spinal cord
 - Consists of myelinated ascending (sensory) and descending (motor) nerve tracts
- Gray matter
 - Center portion of spinal cord
 - Contains cell bodies, dendrites

30

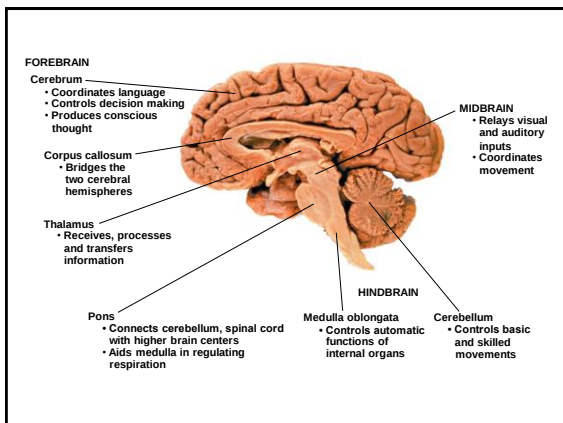


31

The Brain Processes and Acts on Information

- Brain: command center of the body
- Three major anatomical/functional divisions
 - **Hindbrain:** coordinates basic, automatic, and vital tasks
 - **Midbrain:** coordinates muscle groups and responses to sight and sound
 - **Forebrain:** receives, integrates sensory input, determines complex behavior

32



33

Hindbrain: Medulla Oblongata

- Connects to spinal cord
- Controls vital automatic functions of internal organs
 - Cardiovascular center: regulates heart rate and blood pressure
 - Respiratory center: adjusts respiration in response to CO₂ and O₂ levels
- Motor nerves cross over in medulla oblongata
 - Right forebrain controls left side of body
 - Left forebrain controls right side of body

34

Hindbrain: Cerebellum

- Coordinates basic body movements
- Stores and replicates sequences of skilled movements
 - Examples
 - Tying a shoe
 - Swinging a bat
 - Using a keyboard

35

Hindbrain: Pons

- Connects higher brain centers and the spinal cord
- Coordinates the flow of information between the cerebellum and higher brain centers
- Aids medulla oblongata in regulating respiration

36

Midbrain: Vision and Hearing

- Coordinates movements of the head related to vision and hearing
- Controls movement of eyes and size of pupils

37

Forebrain: Emotions and Conscious Thought

- Receives and integrates information concerning emotions and conscious thought
- **Hypothalamus**
 - Helps regulate homeostasis
- **Thalamus** ("Grand Central Station")
 - Receiving, processing, and transfer center
- **Limbic system**
 - Pathways involved in emotions and memory
- **Cerebrum**
 - Language, decision making, conscious thought

38

Forebrain: Cerebrum

- Structure
 - Right and left **hemispheres**
 - Hemispheres connected by **corpus callosum**
 - Nerve tracts in corpus callosum allow two hemispheres to share information
 - Cerebral cortex
 - gray matter, the outer layer of the cerebrum

39

A Closer Look at the Cerebral Cortex

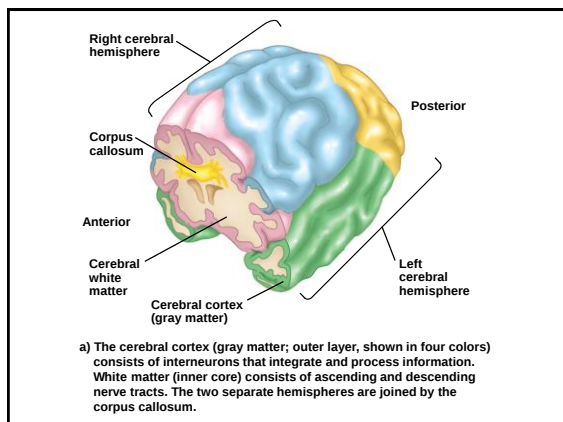
- **Functions**
 - memory storage
 - abstract thought
 - conscious awareness
 - conscious control of skeletal muscle

40

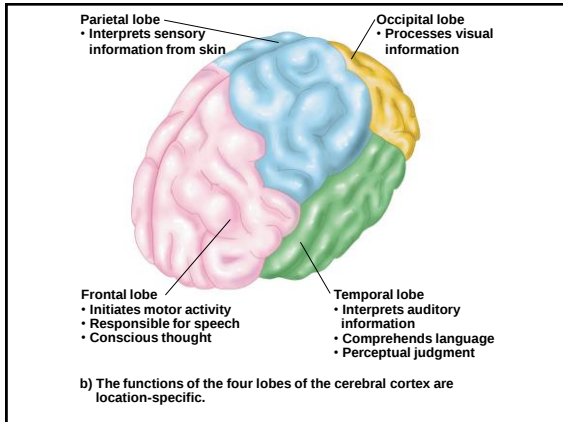
A Closer Look at the Cerebral Cortex

- Divided into four lobes
 - **Occipital lobe**
 - processes visual information
 - **Temporal lobe**
 - interprets auditory information, comprehends spoken/written language
 - **Parietal lobe**
 - receives and interprets sensory information from the skin
 - **Frontal lobe**
 - initiates motor activity, responsible for speech, conscious thought
- All four lobes: memory storage

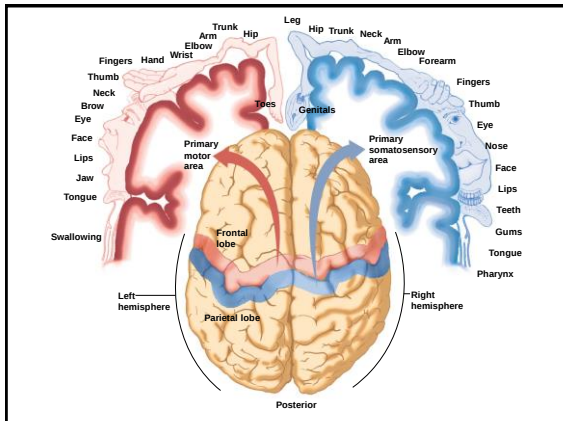
41



42



43

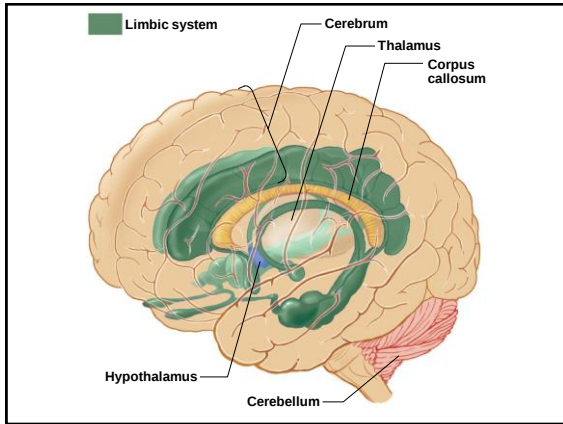


44

Limbic System: Site of Emotions and Basic Behaviors

- Includes all neuronal structures that together control emotional behavior and motivational drives
- Hypothalamus serves as a gateway to and from limbic system
- Emotions
 - Fear, anger, sorrow, love, etc.
- Basic behavior
 - Seeking food, satisfying thirst
 - Sexual gratification
- Behaviors modified by cerebrum
- Short-term memory

45



46

Memory: Storing and Retrieving Information

- Short-term
 - Working memory
 - Information from previous few hours
 - Stored in the limbic system
- Long-term
 - Information from previous days to years
 - Involves permanent changes in neurons and synapses in the cerebral cortex

47

Psychoactive Drugs Affect Higher Brain Functions

- Psychoactive drugs
 - Affect states of consciousness, emotions, or behavior
- Action
 - Able to cross blood-brain barrier
 - Influence concentrations or actions of neurotransmitters
 - Affect higher brain functions

48

Psychoactive Drugs

- Psychological dependence
 - User craves the feeling associated with the drug
- Tolerance
 - Requires more of the substance to achieve the same effect
- Addiction
 - The need to continue obtaining and using a substance
 - No free choice
- Withdrawal
 - Physical symptoms that occur upon stopping the drug

49

Disorders of the Nervous System

- Trauma
 - Physical injury to brain or spinal cord
 - Concussion
 - Blow to the head may lead to unconsciousness
 - Disruption of electrical activity in the brain
 - Risk of subdural hematoma
 - Spinal cord injuries
 - Impairment of sensation and function below site of injury

50

Disorders of the Nervous System

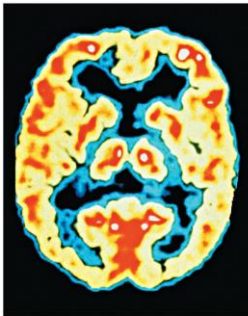
- **Infections:** Caused by viruses or bacteria that manage to pass through the blood-brain barrier
 - **Encephalitis**
 - Inflammation of the brain caused by viral infection
 - **Meningitis**
 - Inflammation of the meninges caused by viral or bacterial infection
 - **Rabies**
 - Infectious viral disease
 - Spread by bite or saliva of infected animal
 - Virus spreads from bite to brain via sensory neurons
- **Brain tumors:** abnormal growth in or on the brain

51

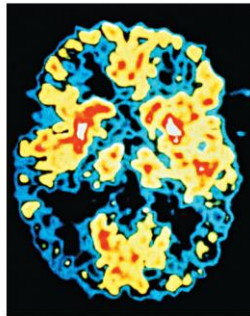
Disorders of the Nervous System

- Disorders of neural and synaptic transmission
 - **Epilepsy**
 - Recurring episodes of abnormal electrical activity (seizures)
 - **Alzheimer's disease**
 - Shortage of acetylcholine
 - Accumulation of abnormal protein, beta amyloid
 - Progressive memory lapses and dementia
 - **Parkinson's disease**
 - Loss of dopamine-releasing neurons
 - Progressive degenerative disorder affecting motor activity

52



a) A PET scan of a healthy brain.



b) A PET scan of a patient with Alzheimer's disease, showing decreased activity and an irregular pattern.

53
