

Unit 7: The Nervous System

I. Functions of the Nervous System

A. Sensory input—gathering information

1. To monitor changes occurring inside and outside the body
2. Changes = stimuli

B. Integration

1. To process and interpret sensory input and decide if action is needed

C. Motor output

1. A response to integrated stimuli
2. The response activates muscles or glands

II. Structural Classification of the Nervous System

A. Central nervous system (CNS)

1. Brain
2. Spinal cord

B. Peripheral nervous system (PNS)

1. Nerves outside the brain and spinal cord
 - a. Spinal nerves
 - b. Cranial nerves

III. Functional Classification of the Peripheral Nervous System

A. Sensory (afferent) division

1. Nerve fibers that carry information to the central nervous system

B. Motor (efferent) division

1. Nerve fibers that carry impulses away from the central nervous system
2. Two subdivisions
 - a. Somatic nervous system = voluntary
 - b. Autonomic nervous system = involuntary

IV. Nervous Tissue: Support Cells

A. Support cells in the CNS are grouped together as "neuroglia"

- B. Function: to support, insulate, and protect neurons
- C. Astrocytes

1. Abundant, star-shaped cells
 2. Brace neurons
 3. Form barrier between capillaries and neurons
 4. Control the chemical environment of the brain
- D. Microglia
1. Spiderlike phagocytes
 2. Dispose of debris
- E. Ependymal cells
1. Line cavities of the brain and spinal cord
 2. Circulate cerebrospinal fluid
- F. Oligodendrocytes
1. Wrap around nerve fibers in the central nervous system
 2. Produce myelin sheaths
- G. Satellite cells
1. Protect neuron cell bodies
- H. Schwann cells
1. Form myelin sheath in the peripheral nervous system
- V. Nervous Tissue: Neurons
- A. Neurons = nerve cells
1. Cells specialized to transmit messages
 2. Major regions of neurons
 - a. Cell body—nucleus and metabolic center of the cell
 - (1) Nissl substance
 - (a) Specialized rough endoplasmic reticulum
 - (2) Neurofibrils
 - (a) Intermediate cytoskeleton
 - (b) Maintains cell shape
 - (3) Processes—fibers that extend from the cell body
 - (4) Nucleus
 - (5) Large nucleolus
 - b. Processes outside the cell body
 - (1) Dendrites—conduct impulses toward the cell body
 - (2) Axons—conduct impulses away from the cell body
3. Axons end in axonal terminals
 - a. Axonal terminals contain vesicles with neurotransmitters
 - b. Axonal terminals are separated from the next

- neuron by a gap
 - c. Synaptic cleft—gap between adjacent neurons
 - d. Synapse—junction between nerves
- 4. Myelin sheath—whitish, fatty material covering axons
 - a. Schwann cells—produce myelin sheaths in jelly roll-like fashion
- 5. Nodes of Ranvier—gaps in myelin sheath along the axon
- B. Neuron Cell Body Location
 - 1. Most neuron cell bodies are found in the central nervous system
 - a. Gray matter—cell bodies and unmyelinated fibers
 - b. Nuclei—clusters of cell bodies within the white matter of the central nervous system
 - 2. Ganglia—collections of cell bodies outside the central nervous system
- c. Functional Classification of Neurons
 - 1. Sensory (afferent) neurons
 - a. Carry impulses from the sensory receptors to the CNS
 - (1) Cutaneous sense organs
 - (2) Proprioceptors—detect stretch or tension
 - 2. Motor (efferent) neurons
 - a. Carry impulses from the central nervous system to viscera, muscles, or glands
 - 3. Interneurons (association neurons)
 - a. Found in neural pathways in the central nervous system
 - b. Connect sensory and motor neurons
- D. Structural Classification of Neurons
 - 1. Multipolar neurons—many extensions from the cell body
 - 2. Bipolar neurons—one axon and one dendrite
 - 3. Unipolar neurons—have a short single process leaving the cell body
- E. Functional Properties of Neurons
 - 1. Irritability
 - a. Ability to respond to stimuli
 - 2. Conductivity
 - a. Ability to transmit an impulse
- VI. Nerve Impulses
 - A. Resting neuron

1. The plasma membrane at rest is polarized
 2. Fewer positive ions are inside the cell than outside the cell
- B. Depolarization
 1. A stimulus depolarizes the neuron's membrane
 2. A depolarized membrane allows sodium (Na^+) to flow inside the membrane
- C. Action potential
 1. If the action potential (nerve impulse) starts, it is propagated over the entire axon
 2. Impulses travel faster when fibers have a myelin sheath
 3. The exchange of ions initiates an action potential in the neuron
- D. Repolarization
 1. Potassium ions rush out of the neuron after sodium ions rush in, which repolarizes the membrane
 2. The sodium-potassium pump, using ATP, restores the original configuration
- VII. Transmission of a Signal at Synapses
 - A. Impulses are able to cross the synapse to another nerve
 1. Neurotransmitter is released from a nerve's axon terminal
 2. The dendrite of the next neuron has receptors that are stimulated by the neurotransmitter
 3. An action potential is started in the dendrite
- VIII. The Reflex Arc
 - A. Reflex—rapid, predictable, and involuntary response to a stimulus
 1. Occurs over pathways called reflex arcs
 - B. Reflex arc—direct route from a sensory neuron, to an interneuron, to an effector
 - C. Simple Reflex Arc
 1. Types of Reflexes and Regulation
 - a. Somatic reflexes
 - (1) Activation of skeletal muscles
 - (2) Example: When you move your hand away from a hot stove
 - b. Autonomic reflexes

- (1) Smooth muscle regulation
 - (2) Heart and blood pressure regulation
 - (3) Regulation of glands
 - (4) Digestive system regulation
 - c. Patellar, or knee-jerk, reflex is an example of a two-neuron reflex arc
- ix. **Central Nervous System (CNS)**
- A. **CNS develops from the embryonic neural tube**
 - 1. The neural tube becomes the brain and spinal cord
 - 2. The opening of the neural tube becomes the ventricles
 - a. Four chambers within the brain
 - b. Filled with cerebrospinal fluid
 - B. **Regions of the Brain**
 - 1. Cerebral hemispheres (cerebrum)
 - 2. Diencephalon
 - 3. Brain stem
 - 4. Cerebellum
- x. **Regions of the Brain: Cerebrum**
- A. **Cerebral Hemispheres (Cerebrum)**
 - 1. Paired (left and right) superior parts of the brain
 - 2. Includes more than half of the brain mass
 - 3. The surface is made of ridges (gyri) and grooves (sulci)
 - 4. Lobes of the cerebrum
 - a. Fissures (deep grooves) divide the cerebrum into lobes
 - b. Surface lobes of the cerebrum
 - (1) Frontal lobe
 - (2) Parietal lobe
 - (3) Occipital lobe
 - (4) Temporal lobe
 - 5. Specialized areas of the cerebrum
 - a. Primary somatic sensory area
 - (1) Receives impulses from the body's sensory receptors
 - (2) Located in parietal lobe
 - b. Primary motor area
 - (1) Sends impulses to skeletal muscles
 - (2) Located in frontal lobe

- c. Broca's area
 - (1) Involved in our ability to speak
- 6. Cerebral areas involved in special senses
 - a. Gustatory area (taste)
 - b. Visual area
 - c. Auditory area
 - d. Olfactory area
- 7. Interpretation areas of the cerebrum
 - a. Speech/language region
 - b. Language comprehension region
 - c. General interpretation area
- 8. Layers of the cerebrum
 - a. Gray matter—outer layer in the cerebral cortex composed mostly of neuron cell bodies
 - b. White matter—fiber tracts deep to the gray matter
 - (1) Corpus callosum connects hemispheres
 - c. Basal nuclei—*islands* of gray matter buried within the white matter
- xI. Regions of the Brain: Diencephalon
 - A. Sits on top of the brain stem
 - B. Enclosed by the cerebral hemispheres
 - c. Made of three parts
 - 1. Thalamus
 - 2. Hypothalamus
 - 3. Epithalamus
 - D. Thalamus
 - 1. Surrounds the third ventricle
 - 2. The relay station for sensory impulses
 - 3. Transfers impulses to the correct part of the cortex for localization and interpretation
 - E. Hypothalamus
 - 1. Under the thalamus
 - 2. Important autonomic nervous system center
 - a. Helps regulate body temperature
 - b. Controls water balance
 - c. Regulates metabolism
 - F. Hypothalamus (continued)

1. An important part of the limbic system (emotions)
 2. The pituitary gland is attached to the hypothalamus
- g. Epithalamus
1. Forms the roof of the third ventricle
 2. Houses the pineal body (an endocrine gland)
 3. Includes the choroid plexus—forms cerebrospinal fluid
- xii. Regions of the Brain: Brain Stem
- A. Attaches to the spinal cord
- B. Parts of the brain stem
1. Midbrain
 2. Pons
 3. Medulla oblongata
- c. Midbrain
1. Mostly composed of tracts of nerve fibers
 2. Has two bulging fiber tracts—cerebral peduncles
 3. Has four rounded protrusions—corpora quadrigemina
 4. Reflex centers for vision and hearing
- D. Pons
1. The bulging center part of the brain stem
 2. Mostly composed of fiber tracts
 3. Includes nuclei involved in the control of breathing
- E. Medulla Oblongata
1. The lowest part of the brain stem
 2. Merges into the spinal cord
 3. Includes important fiber tracts
 4. Contains important control centers
 - a. Heart rate control
 - b. Blood pressure regulation
 - c. Breathing
 - d. Swallowing
 - e. Vomiting
- F. Reticular Formation
1. Diffuse mass of gray matter along the brain stem
 - a. Involved in motor control of visceral organs
 - b. Reticular activating system (RAS) plays a role in awake/sleep cycles and consciousness

xiii. Regions of the Brain: *Cerebellum*

- A. Two hemispheres with convoluted surfaces
- B. Provides involuntary coordination of body movements

xiv. Protection of the Central Nervous System

- A. Scalp and skin
- B. Skull and vertebral column
- C. Meninges
- D. Cerebrospinal fluid (CSF)
- E. Blood-brain barrier

xv. Protection of the Central Nervous System

A. Meninges

- 1. Dura mater
 - a. Double-layered external covering
 - (1) Periosteum—attached to inner surface of the skull
 - (2) Meningeal layer—outer covering of the brain
 - b. Folds inward in several areas
- 2. Arachnoid layer
 - a. Middle layer
 - b. Web-like
- 3. Pia mater
 - a. Internal layer
 - b. Clings to the surface of the brain

B. Cerebrospinal Fluid (CSF)

- 1. Similar to blood plasma composition
- 2. Formed by the choroid plexus
- 3. Forms a watery cushion to protect the brain
- 4. Circulated in arachnoid space, ventricles, and central canal of the spinal cord
- 5. Ventricles and Location of the Cerebrospinal Fluid
- 6. Hydrocephalus in a Newborn
 - a. Hydrocephalus
 - (1) CSF accumulates and exerts pressure on the brain if not allowed to drain

C. Blood-Brain Barrier

- 1. Includes the least permeable capillaries of the body
- 2. Excludes many potentially harmful substances
- 3. Useless as a barrier against some substances

- a. Fats and fat soluble molecules
- b. Respiratory gases
- c. Alcohol
- d. Nicotine
- e. Anesthesia

xvi. Traumatic Brain Injuries

A. Concussion

- 1. Slight brain injury
- 2. No permanent brain damage

B. Contusion

- 1. Nervous tissue destruction occurs
- 2. Nervous tissue does not regenerate

C. Cerebral edema

- 1. Swelling from the inflammatory response
- 2. May compress and kill brain tissue

D. Cerebrovascular Accident (CVA)

- 1. Commonly called a stroke
- 2. The result of a ruptured blood vessel supplying a region of the brain
- 3. Brain tissue supplied with oxygen from that blood source dies
- 4. Loss of some functions or death may result

E. Alzheimer's Disease

- 1. Progressive degenerative brain disease
- 2. Mostly seen in the elderly, but may begin in middle age
- 3. Structural changes in the brain include abnormal protein deposits and twisted fibers within neurons
- 4. Victims experience memory loss, irritability, confusion, and ultimately, hallucinations and death

xvii. Spinal Cord

A. Extends from the foramen magnum of the skull to the first or second lumbar vertebra

B. 31 pairs of spinal nerves arise from the spinal cord

C. Cauda equina is a collection of spinal nerves at the inferior end

D. Spinal Cord Anatomy

- 1. Internal gray matter is mostly cell bodies

- a. Dorsal (posterior) horns
 - b. Anterior (ventral) horns
 - c. Gray matter surrounds the central canal
 - (1) Central canal is filled with cerebrospinal fluid
 - d. Exterior white matter—conduction tracts
 - (1) Dorsal, lateral, ventral columns
 - 2. Meninges cover the spinal cord
 - 3. Spinal nerves leave at the level of each vertebrae
 - a. Dorsal root
 - (1) Associated with the dorsal root ganglia—collections of cell bodies outside the central nervous system
 - b. Ventral root
 - (1) Contains axons
- xviii. Peripheral Nervous System (PNS)
- A. Nerves and ganglia outside the central nervous system
 - B. Nerve = bundle of neuron fibers
 - c. Neuron fibers are bundled by connective tissue
- xix. PNS: Structure of a Nerve
- A. Endoneurium surrounds each fiber
 - B. Groups of fibers are bound into fascicles by perineurium
 - c. Fascicles are bound together by epineurium
 - D. PNS: Classification of Nerves
 - 1. Mixed nerves
 - a. Both sensory and motor fibers
 - 2. Sensory (afferent) nerves
 - a. Carry impulses toward the CNS
 - 3. Motor (efferent) nerves
 - a. Carry impulses away from the CNS
 - E. PNS: Cranial Nerves
 - 1. 12 pairs of nerves that mostly serve the head and neck
 - 2. Only the pair of vagus nerves extend to thoracic and abdominal cavities
 - 3. Most are mixed nerves, but three are sensory only
 - F. PNS: Cranial Nerves
 - 1. I Olfactory nerve—sensory for smell
 - 2. II Optic nerve—sensory for vision
 - 3. III Oculomotor nerve—motor fibers to eye muscles
 - 4. IV Trochlear—motor fiber to eye muscles

5. V Trigeminal nerve—sensory for the face; motor fibers to chewing muscles
 6. VI Abducens nerve—motor fibers to eye muscles
 7. VII Facial nerve—sensory for taste; motor fibers to the face
 8. VIII Vestibulocochlear nerve—sensory for balance and hearing
 9. IX Glossopharyngeal nerve—sensory for taste; motor fibers to the pharynx
 10. X Vagus nerves—sensory and motor fibers for pharynx, larynx, and viscera
 11. XI Accessory nerve—motor fibers to neck and upper back
 12. XII Hypoglossal nerve—motor fibers to tongue
- xx. PNS: Spinal Nerves
- A. There is a pair of spinal nerves at the level of each vertebrae for a total of 31 pairs
 - B. Formed by the combination of the ventral and dorsal roots of the spinal cord
 - C. Named for the region from which they arise
 - D. PNS: Anatomy of Spinal Nerves
 1. Spinal nerves divide soon after leaving the spinal cord
 - a. Dorsal rami—serve the skin and muscles of the posterior trunk
 - b. Ventral rami—form a complex of networks (plexus) for the anterior
 - E. PNS: Spinal Nerve Plexuses
 1. PNS: Distribution of Major Peripheral Nerves of the Upper and Lower Limbs
 2. PNS: Autonomic Nervous System
 - a. Motor subdivision of the PNS
 - (1) Consists only of motor nerves
 - b. Also known as the involuntary nervous system
 - (1) Regulates activities of cardiac and smooth muscles and glands
 - c. Two subdivisions
 - (1) Sympathetic division
 - (2) Parasympathetic division

F. PNS: Differences Between Somatic and Autonomic Nervous Systems

1. Nerves

- a. Somatic: one motor neuron
- b. Autonomic: preganglionic and postganglionic nerves

2. Effector organs

- a. Somatic: skeletal muscle
- b. Autonomic: smooth muscle, cardiac muscle, and glands

3. Neurotransmitters

- a. Somatic: always use acetylcholine
- b. Autonomic: use acetylcholine, epinephrine, or norepinephrine

G. PNS: Anatomy of the Sympathetic Division

1. Originates from T1 through L2

- 2. Ganglia are at the sympathetic trunk (near the spinal cord)
- 3. Short pre-ganglionic neuron and long post-ganglionic neuron transmit impulse from CNS to the effector
- 4. Norepinephrine and epinephrine are neurotransmitters to the effector organs

H. PNS: Anatomy of the Parasympathetic Division

1. Originates from the brain stem and S1 through S4

- 2. Terminal ganglia are at the effector organs
- 3. Always uses acetylcholine as a neurotransmitter

I. PNS: Autonomic Functioning

1. Sympathetic—"fight or flight"

- a. Response to unusual stimulus
- b. Takes over to increase activities
- c. Remember as the "E" division
 - (1) Exercise, excitement, emergency, and embarrassment

2. Parasympathetic—"housekeeping" activities

- a. Conserves energy
- b. Maintains daily necessary body functions
- c. Remember as the "D" division
 - (1) digestion, defecation, and diuresis

xxi. Development Aspects of the Nervous System

- A. The nervous system is formed during the first month of embryonic development
- B. Any maternal infection can have extremely harmful effects
- C. The hypothalamus is one of the last areas of the brain to develop
- D. No more neurons are formed after birth, but growth and maturation continues for several years
- E. The brain reaches maximum weight as a young adult