8

The Nervous System
The Nervous System

OUTLINE:

- Organization of the Nervous System
- The Central Nervous System
- The Peripheral Nervous System
- Disorders of the Nervous System
Organization of the Nervous System

- Two major divisions of the nervous system:
  - Central Nervous System (CNS)
    - Consists of the brain and spinal cord
    - Integrates incoming information and coordinates all voluntary and involuntary nervous functions
  - Peripheral Nervous System (PNS)
    - Consists of ganglia and the nerves that branch from the CNS
    - Keeps the CNS in contact with the rest of the body
Organization of the Nervous System

- Subdivisions of the PNS based on function
  - Somatic nervous system: receives sensory information and directs voluntary movements
  - Autonomic nervous system: regulates involuntary activities
    - Sympathetic nervous system: in charge during emergencies
    - Parasympathetic nervous system: adjusts bodily functions during restful times
Figure 8.1 An overview of the nervous system.
The Central Nervous System

- Protection of the CNS
  - Bones of the skull and vertebral column
  - Three connective tissue membranes that form the meninges
    - Dura mater—outermost layer
    - Arachnoid—middle layer
    - Pia mater—innermost layer
  - Meningitis (inflammation of the meninges) is caused by bacteria and viruses and can lead to encephalitis (inflammation of the brain)
- Cerebrospinal fluid
- Blood-brain barrier
Protection of the Central Nervous System

- Cerebrospinal fluid
  - Space between meninges
  - Ventricles (internal cavities of brain)
  - Central canal (cavity within spinal cord)
- Functions
  - Shock absorption
  - Support
  - Nourishment and waste removal
Protection of the Central Nervous System

- Blood-brain barrier
  - Structure
    - Formed by tight junctions between cells in the walls of capillaries supplying the CNS
  - Function
    - Protects the CNS by selecting the substances that can enter the cerebrospinal fluid from the blood
    - Inhibits many potentially life-saving, infection-fighting, or tumor-suppressing drugs that are not lipid soluble from reaching brain tissue
Figure 8.2 *The central nervous system.*

- The bones of the skull and vertebral column are hard cases that protect the brain and spinal cord.
- The meninges are three membranes that protect the brain and spinal cord.
- Ventricles of the brain
- Cerebrospinal fluid cushions the brain and spinal cord.
Brain: Command Center

- Cerebrum
  - The thinking, conscious part of the brain
  - Accounts for 83% of total brain weight
  - Separated into two hemispheres by the longitudinal fissure
    - Each hemisphere receives sensory information from and directs movements of the opposite side of the body
    - Each hemisphere has a thin outer layer called the cerebral cortex
      - Outer layer of gray matter
      - White matter layer beneath
Figure 8.3 A section through the brain from front to back.

- **Cerebrum**
  - Contains sensory areas for skin senses, vision, hearing, olfaction
  - Motor areas for voluntary control of movement
  - Association areas for interpreting sensations, language, thinking, decision making, self-awareness, creativity, and storage of memories

- **Corpus callosum**
  - Allows left and right cerebral hemispheres to communicate with one another

- **Medulla oblongata**
  - Contains autonomic centers for heart rate and digestive activities
  - Relays sensory information to thalamus

- **Cerebellum**
  - Coordinates sensory–motor voluntary movement
  - Stores memory of learned motor patterns

- **Midbrain**
  - Relays information between the cerebellum or spinal cord and the cerebrum
  - Integrates sensory input

- **Pons**
  - A bridge between higher and lower brain centers

- **Thalamus**
  - Processes all sensory information (except olfaction)
  - Relays information to appropriate higher brain centers

- **Hypothalamus**
  - Controls heart rate, blood pressure, breathing rate, body temperature, food intake
  - Is a center for emotions
  - Serves as “master biological clock”
Brain: Command Center

- **Gray matter**
  - Includes neuroglial cells, nerve cell bodies, and unmyelinated axons

- **White matter**
  - Consists mostly of myelinated axons
  - Allows for communication between various areas of the brain, and between the brain and spinal cord

- **Corpus callosum**
  - Band of white matter that connects the two cerebral hemispheres
Brain: Command Center

- Grooves on the surface of the brain mark the boundaries of four lobes on each hemisphere:
  - Frontal lobe
  - Parietal lobe
  - Temporal lobe
  - Occipital lobe
Figure 8.4 The cerebral cortex.
Brain: Command Center

- Contains sensory, motor, and association areas
  - Sensory areas
    - Primary somatosensory area receives sensory information from the body
  - Motor areas
    - Primary motor area controls the skeletal muscles
    - Premotor cortex coordinates learned motor skills
  - Association areas
    - Communicate with the sensory area, motor areas, and other parts of the brain to analyze and act on sensory input
    - Prefrontal cortex enables us to reason and think
Figure 8.5 The primary motor and the primary somatosensory regions of the cerebral cortex.
Brain: Command Center

- **Thalamus**
  - Serves as the relay station of the brain for all sensory information except smell
  - Also directs motor activity, cortical arousal, and memory

- **Hypothalamus**
  - Maintains homeostasis by regulating blood pressure, heart rate, breathing rate, digestion, and body temperature
  - Coordinates the nervous and endocrine systems by influencing the pituitary gland
  - Regulates emotions (part of the limbic system)
Brain: Command Center

- Cerebellum
  - Integrates information from the motor cortex and sensory pathways to produce smooth, well-timed voluntary movements
    - Comparison (compares actual position of a body part to where it ought to be)
    - Prediction (calculates future positions of a body part during a movement)
  - Controls equilibrium and posture
Brain: Command Center

- The brain stem includes
  - Medulla oblongata
  - Midbrain
  - Pons
Brain: Command Center

- Medulla oblongata
  - Contains reflex centers to regulate the rhythm of breathing, force and rate of the heartbeat, and blood pressure
  - Serves as the pathway for
    - All sensory messages going to the higher brain centers
    - All motor messages leaving the brain
Brain: Command Center

- Midbrain
  - Processes information about sights and sounds
  - Controls simple reflex responses to these stimuli, such as turning your head toward a loud sound

- Pons
  - Means “bridge”
  - Connects the spinal cord and cerebellum with the cerebrum, thalamus, and hypothalamus
  - Has a region that assists the medulla in regulating respiration
Brain: Command Center

- Limbic system
  - Defined on the basis of function rather than anatomy
  - Includes several brain structures that produce emotions and memory
- The storage and retrieval of information take place in two stages:
  - Short-term memory: holds a small amount of information for a few seconds or minutes
  - Long-term memory: stores limitless amounts of information for hours, days, or years
    - The hippocampus and amygdala are involved
Figure 8.6 The limbic system and reticular activating system.

- Cerebrum
- Thalamus
- Hypothalamus
- Hippocampus
- Amygdala
- Olfactory bulb
Brain: Command Center

- Reticular activating system (RAS)
  - An extensive network of neurons that runs through the medulla and projects to the cerebral cortex
  - Filters sensory input and keeps the cerebral cortex in an alert state
Spinal Cord: Message Transmission and Reflex Center

- **Structure**
  - Tube of neural tissue (central canal within)
  - Protected by stacked vertebrae of the vertebral column
  - White matter toward surface; gray matter in center

- **Function**
  - Conducts messages between the brain and the body
  - Serves as a reflex center
Figure 8.7 The spinal cord.

(a) Spinal nerves conduct sensory and motor information between the central nervous system and a specific region of the body.

(b) Pairs of spinal nerves leave through openings between the vertebrae.

(c) A micrograph of a cross section of the spinal cord. The white matter transmits messages to and from the brain. The gray matter (shaped like a butterfly) functions as a reflex center.

(d) The anatomy of a nerve.
A reflex is an automatic response to a stimulus in a pre-wired circuit called a reflex arc

- Parts of the circuit
  - Receptor
  - Sensory neuron
  - Interneuron (at least one)
  - Motor neuron
  - Effector

- Spinal reflexes are decisions made by the spinal cord when a speedy reaction is safer
Reflex Arcs

A reflex is an automatic response to a stimulus, prewired in a circuit of neurons called a reflex arc. In this tutorial, we'll examine how a reflex arc helps to limit potential tissue damage caused by a painful stimulus.

Press "PLAY" to begin Animation.
Figure 8.8 A reflex arc.

Step 1: A stimulus initiates a pain sensation.

Step 2: Sensory messages are carried to the spinal cord by a sensory neuron.

Step 3: Interneurons in the spinal cord integrate information from sensory neurons and stimulate the appropriate motor neurons.

Step 4: Motor neurons stimulate the appropriate muscles.

Step 5: Leg muscles contract, causing them to lift the foot off the glass.
The Peripheral Nervous System

- Includes
  - Spinal nerves that originate from the spinal cord
  - Cranial nerves that originate from the brain

- Spinal nerves
  - 31 pairs, each pair services a specific region of the body
  - All carry both sensory and motor fibers
    - Sensory fibers enter the dorsal side of the spinal cord in a bundle called the dorsal root
    - Axons of motor neurons leave the ventral side of the spinal cord in a bundle called the ventral root
Figure 8.9 (a) Spinal and (b) cranial nerves.
The Peripheral Nervous System

- Cranial nerves
  - 12 pairs
  - Service the structures of the head and certain body parts, including the heart and diaphragm
  - Some carry only sensory fibers, others carry only motor fibers, and still others carry both types of fibers
The Peripheral Nervous System

Cranial and Spinal Nerves

The central nervous system (CNS) communicates with the rest of the body through cranial and spinal nerves. There are twelve cranial nerves, which carry sensory information toward, and sometimes motor information away from, regions of the head. Likewise, 31 pairs of spinal nerves relay sensory and motor information between the body and spinal cord. This tutorial highlights the 12 cranial nerves and reviews the general organization of the spinal nerves. Press "PLAY" to begin Animation.
Subdivisions of the PNS

- Somatic nervous system: governs conscious sensations and voluntary movements
- Autonomic nervous system: governs unconscious, involuntary internal activities
  - Sympathetic nervous system: prepares the body for fight-or-flight
  - Parasympathetic nervous system: adjusts body functions so that energy is conserved during restful times
- The two subdivisions have antagonistic effects
Subdivisions of the PNS

The Autonomic Nervous System

As part of the body’s system of homeostasis, the autonomic nervous system (ANS) adjusts the activities of our internal organs so that the proper internal conditions are maintained. In this tutorial, we will review the principal features of the autonomic nervous system.

Press "PLAY" to begin Animation.
Figure 8.10 Structure and function of the autonomic nervous system.
Disorders of the Nervous System

- Headaches
  - Tension headaches
    - Caused by muscle contraction in the head, face, and neck
  - Migraine headaches
    - Caused by an imbalance in the brain’s chemistry
      - Low levels of the neurotransmitter serotonin
Disorders of the Nervous System

- **Stroke (cerebrovascular accident)**
  - Caused by an interruption of blood flow to a region of the brain, such that nerve cells die
  - The extent and type of impairment caused by a stroke depend on the affected region of the brain

- **Common causes**
  - Blood clot blocks a vessel
  - Fatty deposits block a vessel
Coma

- Caused by trauma to neurons in regions of the brain responsible for stimulating the cerebrum (reticular activating system)

- Person is totally unresponsive to all sensory input and cannot be awakened
  - Differs from deep sleep
Disorders of the Nervous System

- Spinal cord injury
  - Results in loss of function below site of injury
  - Depending on which nerve tracts are damaged, injury may result in paralysis, loss of sensation, or both
  - If the cord is completely severed, then there is complete loss of sensation and voluntary movement below the level of the cut
You Should Now Be Able To:

- Describe the organization of the nervous system
- Define the major components of the central nervous system
- Describe the structure and function of the peripheral nervous system
- List the major disorders of the nervous system: headaches, stroke, coma, and spinal cord injury