Chapter 7: The Nervous System

Objectives

• Discuss the general organization of the nervous system
• Describe the structure & function of a nerve
• Draw and label the pathways involved in a withdraw reflex
• Define depolarization, action potential, and repolarization
• Discuss the role of position receptors in the control of movement

Objectives

• Describe the role of vestibular apparatus in maintaining equilibrium
• Discuss the brain centers involved in voluntary control of movement
• Describe the structure and function of the autonomic nervous system
General Nervous System Functions

1. Control of the internal environment
   - Nervous system works with endocrine system
2. Voluntary control of movement
3. Programming spinal cord reflexes
4. Assimilation of experiences necessary for memory and learning

Organization of the Nervous System

- **Central nervous system (CNS)**
  - Brain and spinal cord
- **Peripheral nervous system (PNS)**
  - Neurons outside the CNS
    - Sensory division
      - Afferent fibers transmit impulses from receptors to CNS
    - Motor division
      - Efferent fibers transmit impulses from CNS to effector organs

Divisions of the Nervous System

[Diagram showing the divisions of the nervous system]

Fig 7.1
Relationship Between PNS and CNS

Structure of a Neuron

- **Cell body**
- **Dendrites**: Conduct impulses toward cell body
- **Axon**
  - Carries electrical impulse away from cell body
  - May be covered by Schwann cells
    - Forms discontinuous myelin sheath along length of axon
- **Synapse**: Contact points between axon of one neuron and dendrite of another neuron
Electrical Activity in Neurons

- Neurons are “Excitable Tissue”
  - Irritability: ability to respond to a stimulus and convert it to a neural impulse
  - Conductivity: transmission of the impulse along the axon

- Resting membrane potential
  - At rest, the neurons are negatively charged
  - Determined by concentrations of ions (Na⁺, K⁺, Cl⁻) across membrane

- Action potential
  - Occurs when depolarization reaches threshold
    - Permeability of the membrane changes, allowing Na⁺ into the cell, making the interior positively charged

- Repolarization
  - Change in membrane permeability, restoring resting membrane potential
Neurotransmitters and Synaptic Transmission

- Neurons communicate across synapses using neurotransmitters
  - Released from presynaptic membrane
  - Binds to receptor on post synaptic membrane

Excitatory postsynaptic potentials (EPSP)
- Causes depolarization which may or may not reach threshold
- Temporal summation: summing several EPSPs from one presynaptic neuron
- Spatial summation: summing from several different presynaptic neurons

Inhibitory postsynaptic potentials (IPSP)
- Causes hyperpolarization
Sensory Information

• Proprioceptors
  – Proprioception: ability to determine position of joint
  – Kinesthesia: sensation of joint motion or acceleration

• Muscle Chemoreceptors
  – Sensitive to changes in the chemical environment surrounding a muscle

Proprioceptors

• Provide CNS with information about body position and joint angle
  – Free nerve endings – touch & pressure
  – Golgi-type receptors – in ligaments & joints
  – Pacinian corpuscles – in tissues around joints

• Strongly stimulated then adapt

Muscle Chemoreceptors

• Provide CNS with information regarding the metabolic rate of muscular activity
  – Hydrogen ion concentration
  – Carbon dioxide (CO₂)
  – Potassium (K⁺)
Reflexes

- Rapid, unconscious means of reacting to stimuli
- Order of events:
  1. Sensory nerve sends impulse to spinal column
  2. Interneurons activate motor neurons
  3. Motor neurons control movement of muscles
- Reciprocal inhibition
  - EPSPs to muscles to withdraw from stimulus
  - IPSPs to antagonistic muscles

A Reflex Arc Illustrating Reciprocal Inhibition

Somatic Motor Function

- Somatic motor neurons of PNS
  - Responsible for carrying neural messages from spinal cord to skeletal muscles
- Motor unit
  - Motor neuron and all the muscle fibers it innervates
- Innervation ratio
  - Number of muscle fibers per motor neuron
Vestibular Apparatus and Equilibrium

- Located in the inner ear (Semi-circular canals)
- Responsible for maintaining general equilibrium and balance
- Sensitive to changes in linear and angular acceleration

Vestibular Apparatus in Maintaining Equilibrium

[Diagram showing the vestibular apparatus and its interactions with the eye, vestibular nuclei, cerebellum, and spinal cord.]

Fig 7.9

Fig 7.10
Motor Control Functions of the Brain

• Brain stem: responsible for
  – Many metabolic functions
  – Cardiorespiratory control
  – Major structures
    • Medulla
    • Pons
    • Midbrain
    • Reticular formation – a series of complex neurons scattered throughout the brain stem

Motor Control Functions of the Brain

• Cerebrum
  – Cerebral cortex
    • Organization of complex movement
    • Storage of learned experiences
    • Reception of sensory information
  – Motor cortex
    • Most concerned with voluntary movement
• Cerebellum
  – Monitors complex movement

Motor Functions of the Spinal Cord

• Withdrawal reflex
• Contains groups of neurons capable of controlling certain aspects of motor activity
• Spinal tuning
  – Voluntary movement is translated into appropriate muscle action
Control of Motor Function

- Subcortical and cortical motivation areas
  - Sends a "rough draft" of the movement
- Cerebellum and basal ganglia
  - Converts "rough draft" into movement plan
  - Cerebellum: fast movements
  - Basal ganglia: slow, deliberate movements
- Motor cortex through Thalamus
  - Forwards message sent down spinal neurons for "Spinal tuning" and onto muscles
  - Feedback from muscle receptors and proprioceptors allows fine-tuning of motor program

Structures and Processes Leading to Voluntary Movement

- Subcortical and cortical areas
- Association cortex
- Basal ganglia
- Cerebellum
- Thalamus
- Motor cortex
- Motor units

Autonomic Nervous System

- Responsible for maintaining internal environment
  - Effector organs not under voluntary control
    - Smooth muscle, cardiac muscle, glands
- Sympathetic division
  - Releases norepinephrine (NE)
  - Excites an effector organ
- Parasympathetic division
  - Releases acetylcholine (ACh)
  - Inhibits effector organ
Exercise Enhance Brain Health

- A recent five-year study in humans has concluded that exercise improves brain function and reduces the risk of cognitive impairment associated with aging.
- It is clear that regular exercise can protect the brain against disease (e.g. Alzheimer’s) and certain types of brain injury (e.g. stroke).