Chapter 7

The Nervous System: Structure & Control of Mvt

Objectives

1. Discuss the general organization of the nervous system.
2. Describe the structure and function of a nerve.
3. Draw and label the pathways involved in a withdrawal reflex.
4. Define depolarization, action potential & repolarization.

Objectives

5. Discuss the role of position receptors in the control of mvt.
6. Describe the role of the vestibular apparatus in maintaining equilibrium.
7. Discuss the brain centers involved in voluntary control of mvt.
8. Describe the structure and function of the autonomic nervous system.

General Nervous System Functions

Organization of the Nervous System

Anatomical Divisions of the Nervous

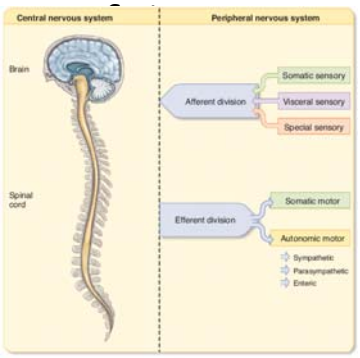

Figure 7.1

Relationship Between PNS & CNS

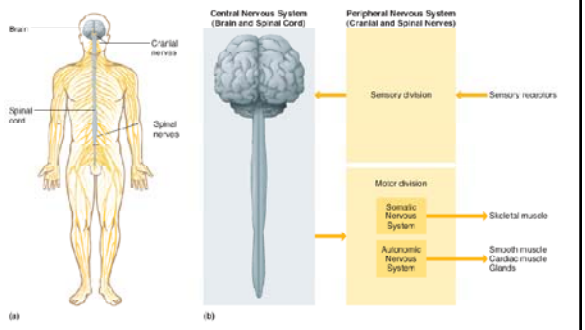

Figure 7.2

Structure of a Neuron

The Parts of a Neuron

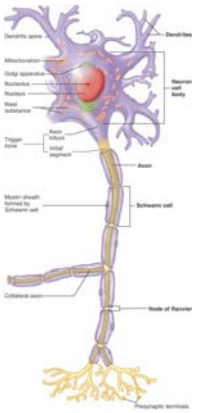

Figure 7.3

Synaptic Transmission

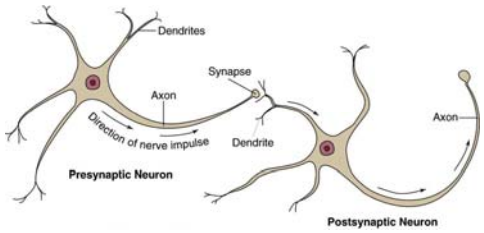

Figure 7.4

Electrical Activity in Neurons

- Neurons are an “excitable tissue”
- Irritability
- Conductivity

Resting Mb Potential

- Negative charge inside cells at rest
- Determined by:

The Resting Mb Potential in Cells

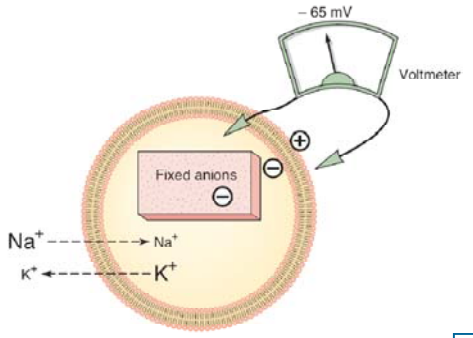

Figure 7.5

Concentrations of Ions Across a Cell Mb

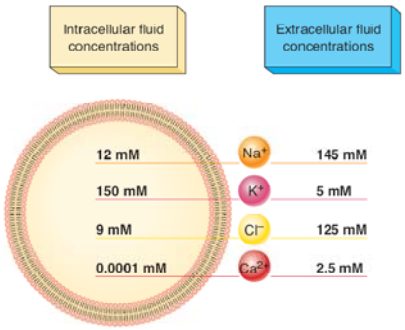

Figure 7.6

Illustration of Ion Channels

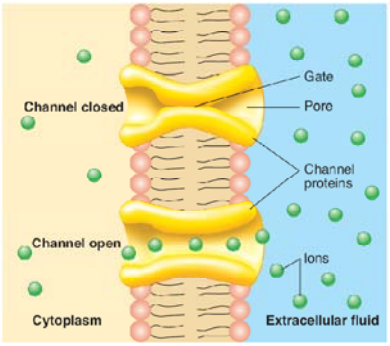

Figure 7.7

The Na^+/K^+ Pump

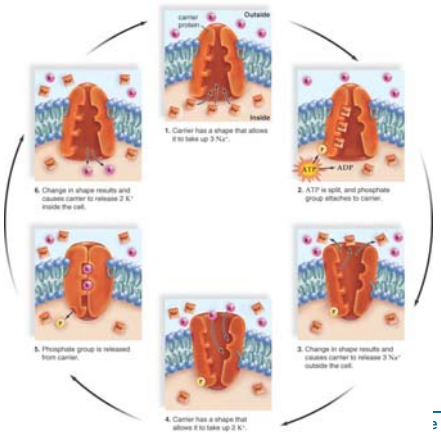

Figure 7.8

Action Potential

- Occurs when a stimulus of sufficient strength depolarizes the cell

An Action Potential

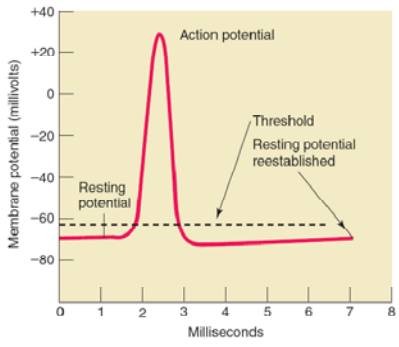

Figure 7.9

Depolarization & Repolarization of a Nerve Fiber

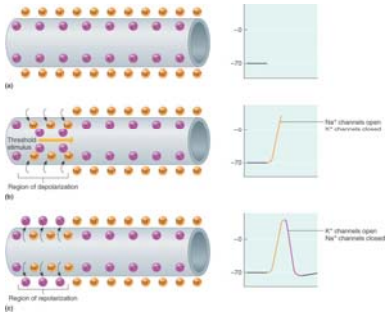

Figure 7.10

Neurotransmitters & Synaptic Transmission

- Synapse
  - Small gap b/n presynaptic neuron & postsynaptic neuron
- Neurotransmitter
  - Chemical messenger released from presynaptic mb
  - Binds to receptor on postsynaptic mb
  - Causes depolarization of postsynaptic mb

Basic Structure of a Chemical Synapse

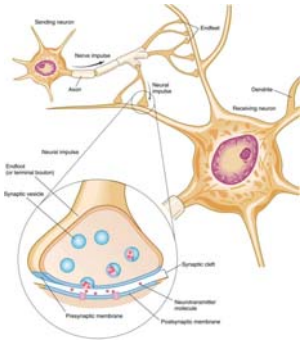

Figure 7.11

Neurotransmitters & Synaptic Transmission

- Excitatory postsynaptic potentials (EPSP)
  - Causes depolarization
  - 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 & Reflexes

- Proprioceptors
  - Receptors that provide CNS w/ information about body position
  - Located in joints & muscles
- Kinesthesia
  - Conscious recognition of the position of body parts
  - Limb mvt rates

Joint Proprioceptors

- Free nerve endings
  - Sensitive to touch & pressure
  - Initially strongly stimulated, then adapt
- Golgi-type receptors
  - Found in ligaments & around joints
  - Similar to free nerve endings
- Pacinian corpuscles
  - In tissues around joints
  - Detect rate of joint rotation

Muscle Proprioceptors

- Provide sensory feedback to nervous system
  - Tension development by muscle
  - Account of muscle length
- Muscle spindle
- Golgi tendon organ

Muscle Spindle

- Responds to Δs in muscle length
- Consists of:

- Stretch reflex
  - Stretch on muscle causes reflex contraction

Structure of Muscle Spindles

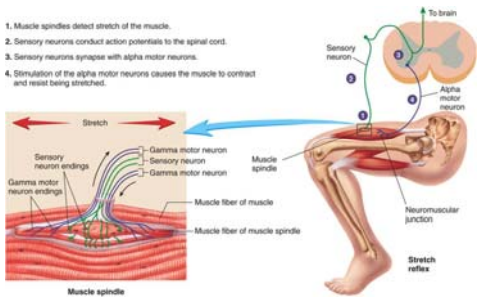

Figure 7.12

Golgi Tendon Organ (GTO)

- Monitors tension developed in muscle
  - Prevents muscle damage during excessive force generation
- Stimulation results in reflex relaxation of muscle
  - Inhibitory neurons send IPSPs to muscle fibers
- Ability to voluntarily oppose GTO inhibition may be related to gains in strength

The Golgi Tendon Organ

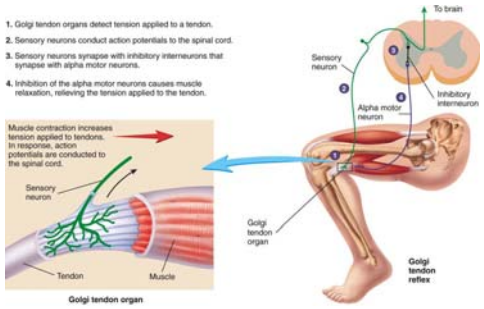

Figure 7.13

Muscle Chemoreceptors

- Sensitive to Δs in the chemical env't surrounding a muscle
- Provide CNS about metabolic rate of muscular activity

Reflexes

- Rapid, unconscious means of reacting to stimuli
- Order of events:
  - Sensory nerve sends impulse to spinal column
  - Interneurons activate motor neurons
  - Motor neurons control mvt of muscles
- Reciprocal inhibition
  - EPSPs to muscles to withdraw from stimulus
  - IPSPs to antagonistic muscles
- Crossed-extensor reflex
  - Opposite limb supports body during withdrawal of injured limb

The Crossed-Extensor Reflex

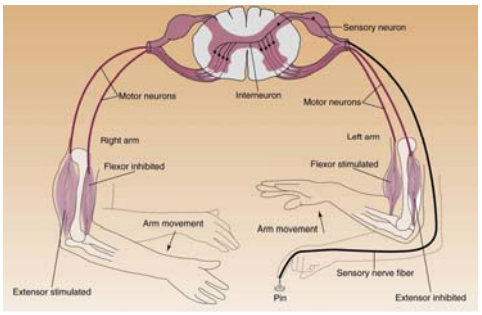

Figure 7.13

Somatic Motor Function

- Somatic motor neurons of PNS
- Motor unit
- Innervation ratio

Illustration of a Motor Unit

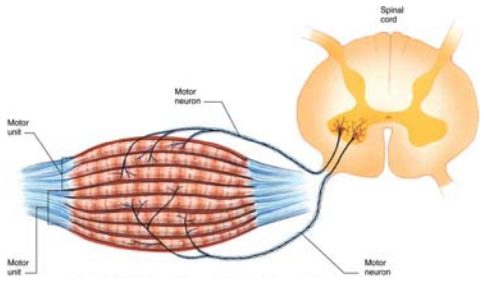

Figure 7.15

Vestibular Apparatus

- Located in the inner ear
- Responsible for maintaining general equilibrium & balance
  - Maintains head position
- Sensitive to Δs in linear & angular acceleration
  - Stimulated by head mvt
- Also controls head & eye mvt during exercise

Role of the Vestibular Apparatus in Maintaining Equilibrium & Balance

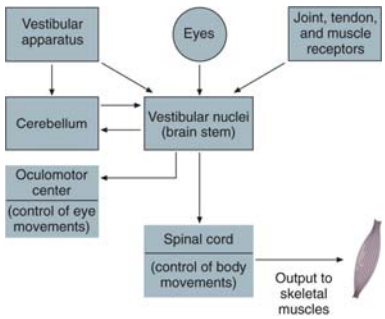

Figure 7.16

Brain Stem

- Responsible for:
- Major structures:

Cerebrum

- Cerebral cortex
- Motor cortex

Cerebellum

- Coordinates and monitors complex mvt
- Has connections to:

Clinical Applications 7.2

Head Injuries in Sports

- A forceful blow to the head can result in brain injury
  - Major or minor, depending on extent of damage
- Intracranial hemorrhage
  - Hard blow to head results in blood vessel damage
  - Leading cause of death in athletes
- Concussion
  - Clinical syndrome characterized by impairment of neural functions
    - Loss of consciousness, disturbed vision, loss of equilibrium

The Cerebrum, Cerebellum & Brain Stem

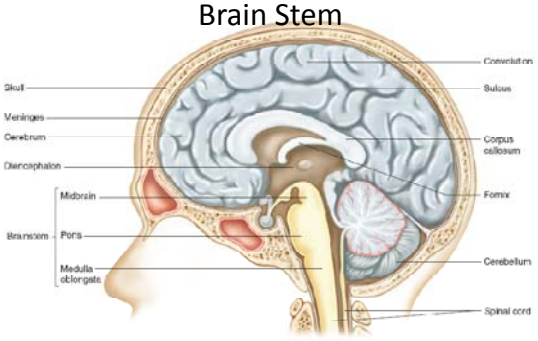

Figure 7.17

Motor Functions of the Spinal Cord

- Withdrawal reflex
- Other reflexes
  - Important for the control of voluntary mvt
- Spinal tuning
  - Voluntary mvt translated into appropriate muscle action
    - Higher brain centers concerned w/ general parameters of mvt
    - Details of mvt refined in spinal cord

Control of Motor Function

- Subcortical and cortical motivation areas
- Cerebellum and basal ganglia
- Motor cortex through thalamus

Structures and Processes Leading to Voluntary Mvt

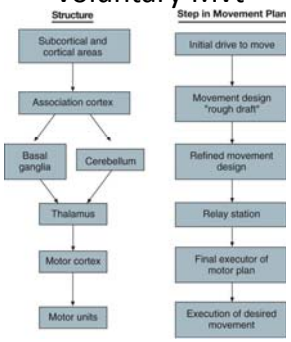

Figure 7.18

Autonomic Nervous System

Neurotransmitters of the Autonomic Nervous System

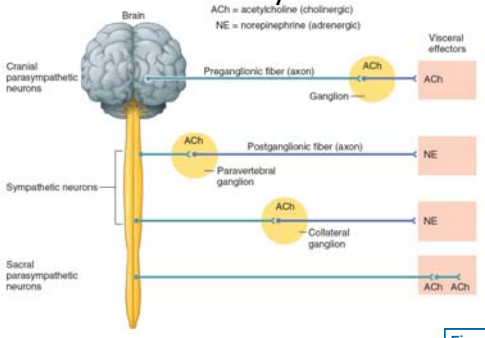

Figure 7.19

Exercise Enhances Brain Health

- Exercise improves brain function & reduces the risk of cognitive impairment associated w/ aging
- Regular exercise can protect the brain against:
  - Disease (Alzheimer's)
  - Certain types of brain injury (stroke)
- How does exercise enhance brain health?
  - Enhances learning and memory
  - Stimulates formation of new neurons
  - Improves brain vascular function & bld flow
  - Attenuates mechanisms driving depression
  - Reduces peripheral factors for cognitive decline
    - Inflammation, hypertension, and insulin resistance

Exercise Has Broad Positive Benefits on Brain Health

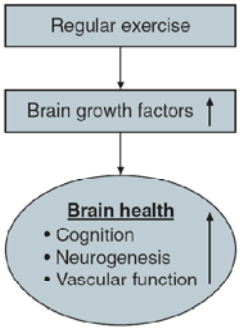

Figure 7.20

Study Questions

1. Identify the location and functions of the central nervous system.
2. Draw a simple chart illustrating the organization of the nervous system.
3. Define *synapses*.
4. Define *membrane potential* and *action potential*.
5. Discuss an IPSP and an EPSP. How do they differ?
6. What are proprioceptors? Give some examples.
7. Describe the location and function of the vestibular apparatus.
8. What is meant by *spinal tuning*?
9. List the possible motor functions played by the brain stem, the motor cortex, and the cerebellum.

Study Questions

10. Describe the divisions and functions of the autonomic nervous system.
11. Define the terms *motor unit* and *innervation ratio*.
12. Briefly describe the positive benefits of exercise on brain function.
13. How does regular exercise maintain neuronal health?
14. Describe the withdrawal reflex.
15. Outline the functions of both muscle spindles and the Golgi tendon organ.
16. Describe the general anatomical design of a muscle spindle and discuss its physiological function.
17. Discuss the function of Golgi tendon organs in monitoring muscle tension.