Chapter 11: FUNCTIONAL ORGANIZATION OF NERVOUS TISSUE

I. STRUCTURAL/FUNCTIONAL ORGANIZATION

A. Functions of the nervous system

1. Senses environment
   a. External
   b. Internal

2. Interprets the above

3. Responds to interpretation by initiating response in muscle or gland

4. Nervous system makes _______________ homeostatic adjustments

B. Reflex arc (Fig. 12.5)

C. Role of nervous system in feedback systems

   GENERAL

   (NERVOUS SYSTEM COMPONENTS)

1. Input detectors

2. Relay to central

3. Central control center

4. Relay to effector

5. Effector
D. Nervous system divisions (Fig. 11.3)

1. Central nervous system (C.N.S.) (Fig. 11.1)

2. Peripheral nervous system (P.N.S.) (Fig. 11.2)
   a. Sensory (afferent) division
   b. Motor (efferent) division
      i. Somatic nervous system (S.N.S.)
         To skeletal muscle
         "Voluntary"
      ii. Autonomic nervous system (A.N.S.)
         To smooth muscle, cardiac muscle and glands
         "Involuntary"
            Parasympathetic division
            Sympathetic division

II. CELLS OF THE NERVOUS SYSTEM

A. Neurons

1. Nervous system cells specialized for:
   a. Excitability: Responds to a stimulus with a signal: __________
   b. Transmission: Sends message neuron to neuron
   c. But not for ______________
2. Histology of a neuron (Fig. 11.4)

3. Myelin sheath (Fig. 11.11a, 11.9)
   a. Structure: Wrapping of plasma membrane of Schwann cell (PNS) or oligodendrocyte (CNS) cell around axon
   b. Function: Insulates axon, causing rapid conduction of action potential from node of Ranvier to node of Ranvier
   c. Axons may also be unmyelinated (Fig. 11.11b)

4. Structural classification of neurons (Fig. 11.5)
   a. Multipolar
   b. Bipolar
   c. Unipolar
   d. Name is based on number of processes coming off cell body.

5. Functional classification of neurons (Fig. 12.5)
   a. Afferent (Sensory)
   b. Interneuron
   c. Efferent (Motor)

   Transmits action potentials from receptor to CNS
   Transmits action potentials within CNS
   Transmits action potentials from CNS to muscle or gland
7. Nerves: Bundles of axons in PNS
   
a. Coverings (Fig. 12.12)
      Epineurium
      Perineurium
      Endoneurium
   
b. Functional classification
      Sensory
      Motor
      Mixed

8. Gray matter:

9. White matter:

10. Ganglia: Neuron cell bodies outside CNS (___________ matter)

B. Glial cells: ("Neuroglia") "Connective tissue" cells of NS; nonconducting

1. Types and functions:
   
a. Oligodendrocytes (Fig. 11.9) Schwann cells (Fig. 11.11a)
   
b. Astrocytes (Fig. 11.6)
   
c. Ependymal cells (Fig. 11.7)
   
d. Microglial cells (Fig. 11.8)
   
e. Satellite cells (Fig. 11.10)

2. Numbers:

III. NEURON REGENERATION (Fig. 11A, p. 391 [395])

A. Axons covered by Schwann cells may regenerate if cell body remains alive. Location:

B. Axons covered by oligodendrocytes neurons do not regenerate, even if cell body remains alive. Location:
IV. NEURONS AS EXCITABLE CELLS

A. Excitability: Ability to respond to stimuli by producing action potentials

B. Action potential: An electro-chemical signal conducted without decrease along an excitable cell's membrane

C. Potential difference: Difference in positive and negative electrical charges between two points

Units:

D. Diffusion: Movement of molecules from _______ concentration to _______; _______ energy required

E. Active transport: movement of molecules from _______ concentration to _______; _______ energy required

V. THE RESTING POTENTIAL (Fig. 11.13)

A. Observation: At rest, axon is charged up"; more negative inside = -70 millivolts. "Polarized" membrane
B. Causes of resting potential (Fig. 11.14 [9th ed.] Table 11.2)

1. Negatively charged protein is trapped ________________ cell

2. Na⁺ - K⁺ "pump"
   a. Na⁺ is actively transported __________
   b. K⁺ is actively transported __________, but ______________

C. Summary at rest:

1. More Na⁺ __________
2. More protein and K⁺ __________

VI. THE ACTION POTENTIAL (Fig. 11.17, Tab. 11.4)

A. Def: All-or-none electro-chemical signal conducted without decrease along an excitable cell's membrane.

B. Stimulus: Change in environment of neuron:
   Ex.: Acetylcholine (ACh) or other neurotransmitter

   Movement       Heat      Chemicals

C. Events of the action potential (Fig. 11.18 #2)

1. Depolarization phase
   a. Threshold stimulus causes Na⁺ channels to open, __________ Na⁺ permeability.
   b. Na⁺ moves ______ by ________________
   c. Potential inside moves toward __________
   d. Final potential is actually positive = +20 mV
2. Repolarization phase (Restoration of the resting potential) (Fig. 11.18 #3)
   a. K⁺ channels open, _______ K⁺ permeability
   b. K⁺ moves __________ by __________
   c. Inside becomes more __________

3. After potential phase (Na⁺ - K⁺ pump restores Na⁺ - K⁺ balance) (Fig. 11.18 [11.21], #4)
   a. Na⁺ moves __________ by ________________
   b. K⁺ moves __________ by ________________

D. Characteristics of action potentials
   1. No action potential until a threshold stimulus occurs (Fig. 11.20)

   2. All-or-none principle:
      Threshold or supra-threshold stimulus cause same magnitude of action potential

   3. How is stronger message coded?

   4. Subthreshold stimulus causes a “graded [local] potential” (Fig. 11.16)
      Def.: A subthreshold change in membrane potential that is not all-or-none.
5. **Refractory period (Fig. 11.19)**

**Def:** Time when no action potential can be generated on the neuron

**Function:**

- **Absolute refractory period**
  - No action potential unless stronger than normal stimulus

- **Relative refractory period**

E. **Conduction of action potentials**

1. **Continuous conduction (Fig. 11.21)**
   a. Na+ diffuse in at every point on axon
   b. Action potential moves over entire membrane
   c. Occurs on unmyelinated fibers
   d. Speed:

2. **Saltatory conduction (Fig. 11.22)**
   a. Na+ diffuse in only at nodes of Ranvier
   b. Action potential “jumps” from node to node
   c. Occurs on myelinated fibers
   d. Speed:

3. **Axon diameter:** Wider axons conduct action potentials __________.
VII. SYNAPTIC TRANSMISSION

A. Def.: Transfer of information neuron to neuron via neurotransmitter

B. Purpose:

C. Structure of a chemical synapse  (Fig. 11.24)

D. Sequence of events  (Fig. 11.24)

1. Action potential on presynaptic neuron causes calcium channels to open.

2. Calcium diffuses into presynaptic neuron terminal.

3. Calcium acts as signal to release neurotransmitter from synaptic vesicles.


5. Neurotransmitter binds to receptor of postsynaptic neuron.

6. a) At some synapses, neurotransmitter-receptor interaction results in subthreshold excitation (facilitation) of the postsynaptic neuron (EPSP)

   b) At other synapses, neurotransmitter-receptor interaction results in inhibition of the postsynaptic neuron (IPSP).

NOTE: A synapse is the site of either excitation or inhibition--never both.
E. Excitatory postsynaptic potentials (EPSP's) (Fig. 11.26)

1. Location:

2. Def.: Local depolarization of postsynaptic membrane, graded (not all-or-none), dies out (not conducted without decrease)

3. Cause: Neurotransmitter-receptor interaction causes increased _________ permeability.

4. _______ moves _______; postsynaptic neuron becomes more_______

5. This is facilitation: Effect of EPSP on postsynaptic neuron is to _______ the chance for an action potential

6. EPSP's _______ chance for action potential or postsynaptic neuron by making the inside of the postsynaptic neuron more _________.

F. Summation of EPSP's (excitatory postsynaptic potentials) (11.28)

1. Temporal summation: One presynaptic neuron which quickly fires several action potentials can cause the postsynaptic neuron to reach

2. Spatial summation: Several presynaptic neurons which each fire once at the same time can cause the postsynaptic neuron to reach
G. Inhibitory postsynaptic potentials (IPSP's) (Fig.11.26)

1. Def: Hyperpolarization of the postsynaptic neuron.

2. Inside of postsynaptic neuron becomes more _______.

3. Cause: Increase in _________ permeability due to neurotransmitter- _______________ interaction.

4. _______ diffuses _________; inside of neuron becomes more _________ as _________ charge leaves.

5. Effect of IPSP: _______ chance for action potential on postsynaptic neuron

NOTE: A synapse is the site of either EPSP's or IPSP's -- never both.

H. Arrangement of neurons

1. Convergent circuit (Fig.11.29a)
   
a. Function:

   b. Ex.

1. Divergent circuit (Fig. 11.29b)
   
a. Function:

   b. Ex.:
3. Oscillating circuit (Fig.11.29c)
   a. Function:
   b. Ex.: 

I. Neurotransmitters
   1. Locations:
      a. Neuron-neuron (chemical) synapses
      b. Neuromuscular junctions
      c. Neuroglandular junctions
   2. Examples of neurotransmitters:
   3. How neurotransmitters may be affected: ACh
      a. Botulism toxin: _______ ACh release -->
      b. Curare: blocks ACh receptors -->
      c. Myasthenia gravis: antibodies damage ACh receptors-->
      d. Anti-cholinesterase: _____ ACh-->