

Chapter 12 Nervous System Cells

I. Organization of the Nervous System

- a. Consists of:
 - i. Blood Vessels
 - ii. Connective Tissue
 - iii. Neural Tissue (Neurons)
- b. Central & Peripheral Nervous System
 - i. Central Nervous System (CNS) – Brain & Spinal Cord
 1. Spinal cord begins at the foramen magnum and ends at L₁ & L₂
 2. Integrates incoming sensory information
 - ii. Peripheral Nervous System (PNS)
 1. Nerve tissue in periphery or “outer regions:

2. Cranial nerves originate from the brain
3. Spinal nerves originate from the spinal column

- c. Afferent & Efferent Divisions
 - i. Afferent division consists of all incoming sensory, or afferent, pathways (gathers information)
 - 1. Carries towards spinal cord
 - ii. Efferent division consists of all outgoing motor, or efferent pathways
 - 1. Carry away to effectors
 - 2. effectors can be muscles, glands or tissues
- d. Somatic & Autonomic Nervous System
 - i. Somatic Nervous System (SNS)
 - 1. carry information to the somatic effectors (skeletal muscles)

2. includes afferent pathways that make up the somatic sensory division – provides feedback from somatic effectors
 3. includes integrating centers that receive sensory information and generate the efferent response signal
- ii. Autonomic Nervous System (ANS)
1. carries info to autonomic, or visceral effectors – smooth and cardiac muscle, and glands
 2. governs itself – autonomous of voluntary control
 3. influenced by conscious mind

4. efferent (motor functions) pathways are divided
 - a. sympathetic division
– made up of pathways that exit the middle portion of the spinal cord → produces fight or flight response
 - b. parasympathetic division – pathway exits at the brain or lower portions of the spinal cord → coordinates body's normal resting activities
 - c. efferent brings an effect
5. efferent pathways belong to the visceral sensory division

- a. carries feedback to autonomic integrating centers in CNS
- b. Functions to integrate impulses by CNS; can be conscious or subconscious decisions

- II. Cells of the Nervous System
 - a. Neuroglia (Glial) Cells
 - i. Supports function of neurons
 - ii. Provide framework
 - iii. Can provide nutrients for neuron and aid in sending and receiving information
 - iv. Take care of neurons “nurse cells”
 - v. 5 major types
 - 1. astrocytes – found only in CNS
 - a. largest and most numerous
 - b. functions as a conduit and stabilizer supporting capillaries and neurons
 - 2. microglia – small stationary cells

- a. when inflamed they are in constant motion and act as macrophages
 - b. function independently of nervous system cells
3. ependymal cells – resemble epithelial cells (cuboidal)
- a. line fluid filled cavities in brain and spinal cord
4. oligodendrocytes – cell with few branches
- a. does not regenerate
 - b. cytoplasm extension that can wrap around axon to form myelin
 - i. degeneration of myelin results in Multiple Sclerosis

5. Schwann Cells – only in PNS
 - a. Wrapped around axon – this creates multiple layers
 - b. Double layered cell membrane
 - c. Made up of lipids (fat)
 - d. Multiple layer is myelin – acts as an insulation
 - e. Outer layer – neurilemmal sheath – the actual Schwann Cell
 - f. Nodes of ranvier – gaps between Schwann Cells
 - g. White Matter – groups of neurons that are myelinated

- h. Gray Matter – lack of myelin (in brain & spinal cord)
- b. Neurons
 - i. Respond to physical or chemical changes or stimulus
 - ii. Transmits information as electrochemical changes = nerve impulses which travels along a nerve fiber, or nerve cell
 - iii. Synapse = gap between neurons – information jumps the gap via neurotransmitters
 - iv. 3 parts
 - 1. cell body
 - a. where cell organelles are located
 - b. has nissl bodies – large number of

ribosomes connected together

2. Dendrite – can be multiple in number
 - a. Branched
 - b. First to receive a stimulus, or information
 - c. Provide connections to other neurons
 - d. Plays an important role in integration of information
 - e. Sensory endings are attached to the end
3. Axon – only 1
 - a. Extends off the neuron
 - b. Axon hillock is the “bump”; area where the axon originates

- c. Directs the impulse away from the cell body
 - d. Presence of myelin affects speed of impulse conduction
 - e. Multiple branching produces axon collaterals
- c. Classification of Neurons
- i. Structural Classification
 - 1. multipolar – has only one axon but several dendrites; brain & spinal cord
 - 2. bipolar – has 2 dendrites coming into the cell body; least numerous; sight, hearing, smelling – carries information to the

brain, but does not require a motor response

3. unipolar – single dendrite, bypasses cell and body and goes directly to the axon; associated with sensory neurons

a. ganglion – accumulation of cell bodies, usually associated with unipolar neurons

ii. Functional Classification

1. sensory neurons – impulses to the brain from a receptor

a. afferent neurons

b. AKA ganglion cells

2. interneurons – gray matter in CNS

- a. integrates between sensory & motor neurons
- 3. motor neurons - carry neural impulses away from CNS
 - a. efferent neurons
 - b. originates in gray matter
 - c. axons are myelinated and terminate in skeletal muscles
 - d. maintain voluntary control over skeletal muscles
- d. Reflex Arc
 - i. Arrangement of neurons
 - ii. Signal conduction route to and from CNS

- iii. 3-neuron arc – consists of an afferent neuron, and interneuron and an efferent neuron
- iv. 2-neuron arc – signal conduction from receptors to CNS and out to effectors; i.e. Feedback loop

III. Nerve Impulses

- a. Membrane Potentials
 - i. All living cells (including neurons) maintain a difference in the concentration of ions across their membranes
 - ii. Neuron is polarized – positive outside & negative inside axon
 - 1. A lot of potassium inside, little outside – positive outside
 - 2. A lot of sodium outside, little inside 3

3. imbalance is created by active transport (fig 12-13)
- iii. Difference in electrical charge is called potential because it is stored as energy
- b. Resting Membrane Potential
 - i. Resting means it is not conducting an electrical signal
 - ii. Measured in mV (millivolts = one thousandth of a volt)
 - iii. 70mV = difference between outside and inside potential
 - iv. Maintained as long as the sodium-potassium pumps continue to operate
 1. form of active transport
- c. Local Potentials
 - i. Slight shift away from Resting membrane potential (RMP) in a specific region

- ii. When a stimulus occurs, the cell depolarizes and sodium is allowed in
 - 1. the outside becomes negative – opposite of how it was being maintained previously
- iii. Depolarization during action potential causes Na^+ channels to open – they only function in one direction
 - 1. all neurons have this depolarization
- iv. polarized cell is a result of:
 - 1. number of negatively charged ions on both sides of the membrane
 - 2. more cations (positive) on outside than inside;
More positive on outside = imbalance (comparing

potassium and sodium ions)

IV. Action Potential

- a. Process
 - i. Action Potential = The membrane potential of an active neuron
 - ii. When a stimulus creates a change in this neuron, a certain strength exists and the cell membrane changes
 - iii. The sodium channel opens and potassium channel closes – reverse of what was seen previously
 - iv. The inside becomes positive and the outside becomes negative
 - v. Once the impulse is done, it repolarizes and goes back to

the resting state and gets rid of positive ions

1. polarity reverses again and goes back to resting state
 2. the same process occurs in muscles
- vi. “All or None Principle” when a cell depolarizes that’s it

b. Refractory Period

- i. Refractory – cannot be stimulated to depolarize again
- ii. Impulse can only move in 1 direction
- iii. frequency of impulse creates a strength

c. Conduction of the Action Potential

- i. Neurons can conduct impulses in 2 ways

1. fast – within myelin sheath; fatty tissue increases speed
 2. slow – unmyelinated fibers
- ii. Saltatory Conduction – impulse jumps from node to node (myelinated)
 1. spinal nerves traveling to and from brain

V. Synaptic Transmission

- a. Synapse – between 2 nerves
- b. Types of Synapses
 - i. Electrical – occurs where 2 cells are joined end to end by gap junctions
 1. between cardiac cells and between some type of smooth muscles
 - ii. Chemical Synapse

1. use a chemical, or neurotransmitter to send a signal from the presynaptic cell
2. contains 3 structures
 - a. synaptic knob – bulb shaped structure at end of axon; contains neurotransmitter
 - b. synaptic cleft – space between a synaptic knob & plasma membrane of postsynaptic neuron
 - c. Plasma membrane of postsynaptic neuron – has protein molecules embedded in it opposite each synaptic knob; serves as receptors for

neurotransmitter
molecules to bind

VI. Mechanism of Synaptic Transmission

- a. Action Potential stops at axon terminals
 - i. Action potential cannot cross synaptic clefts
 - ii. Neurotransmitters are released from synaptic knobs, cross the cleft & bring a response by the postsynaptic neuron
- b. Excitatory neurotransmitters cause depolarization of postsynaptic membrane
- c. Inhibitory neurotransmitters cause hyperpolarization of post synaptic membrane

VII. Neurotransmitters

- a. Method by which neurons “talk” to one another
- b. Classification
 - i. By Function
 1. Excitatory
 2. Inhibitory
 - ii. By Chemical Structure
 1. small-molecule transmitters (main chemical class)
 - a. Acetylcholine – synthesized in neuron
 - b. Amines – synthesized from amino acids
 - c. Amino Acids – most common neurotransmitters in CNS

- d. Other small molecules – recently discovered
- 2. Large – Molecule Neurotransmitters
 - a. Neuropeptides – chains of amino acids strung together by peptide bonds

VIII. Classifying Neurons and Nerve Fibers

- a. General Somatic Motor (efferent) Fibers/Neurons
 - i. Skin, skeletal muscles
 - ii. Associated with body wall
 - iii. Moves from CNS to skeletal muscles
- b. General Visceral Motor (efferent) Fibers/Neurons
 - i. Smooth muscles
 - ii. Glands

- c. General Somatic Sensory
(afferent) Fibers/ Neurons
 - i. Skin, skeletal muscles
 - ii. Move towards CNS
 - d. General Visceral Sensory
(afferent) Fibers/Neurons
 - i. Moves toward CNS
 - ii. Blood vessels
- (Only found in cranial nerves)
- e. Special Visceral Motor
(efferent) Fibers/Neurons
 - i. Swallowing, chewing
 - ii. Speaking, facial expressions
 - f. Special visceral Sensory (afferent)
Fibers/Neurons
 - i. Taste and smell
 - g. Special Somatic Sensory
(afferent) Fibers/Neurons
 - i. Sight, hearing
 - ii. balance